Appendix

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Namoi River Flood Impact Assessment

CONTINUATION OF BOGGABRI COAL MINE – NAMOI RIVER FLOOD IMPACT ASSESSMENT

FOR

HANSEN BAILEY
22 December 2009

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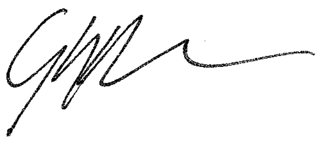
For and on behalf of
WRM Water & Environment Pty Ltd



Greg Roads
Director

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1 INTRODUCTION

Boggabri Coal Pty Limited (Boggabri Coal) is seeking a Project Approval under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to continue its open cut mining and associated activities largely consistent with its existing operation for a further 21 years (the Project). As part of this approval, Boggabri Coal proposes to construct a 17km rail line to haul coal from the mine across the Namoi River floodplain to the Werris Creek Mungundi Railway, approximately 9 km north of Boggabri. The existing haul road across the Namoi River floodplain will be widened and Therribri Road will be upgraded to overpass the haul road. The locations of the mining areas, the rail line and haul road are shown in Figure 1.1.

WRM Water & Environment Pty Ltd was requested to prepare a flood study to be incorporated in the Environmental Assessment (EA) to support the Project Approval application. The study was to determine whether the proposed rail bridge, haul road upgrade and Therribri Road overpass on the Namoi River floodplain would constrict flows sufficiently to cause increased flooding or potentially cause erosion along the river and floodplain. To undertake the study, a TUFLOW two dimensional hydraulic model was developed of the Namoi River and its floodplain for existing conditions and with the proposed rail bridge and road upgrades in place. The 5 year, 20 year and 100 year average recurrence interval (ARI) design discharges were used for the impact assessment.

This report is structured as follows.

- Section 2 describes the characteristics of the Namoi River catchment and the drainage characteristics of the river channel and floodplain in the vicinity of the two roads and rail bridge crossing. Descriptions of the haul road, Therribri Road upgrades and the proposed rail bridge are also provided.
- Section 3 presents the Namoi River design discharges.
- Section 4 presents the methodology and results of the hydraulic modelling undertaken to determine design flood levels, flood extents and flood velocities for existing and proposed conditions.
- Section 5 summarises the findings of the study.
- Section 6 is a list of references.
- Appendix A provides the technical drawings of the existing mine haul road crossing of the Namoi River.
- Appendix B provides the technical drawings of the proposed rail line and crossing of the Namoi River.
- Appendix C provides maps that show the existing and proposed conditions flood depths and changes in flood depths in the study area for the range of flood events investigated.
- Appendix D provides maps that show the existing and proposed conditions flood velocities and changes in flow velocities in the study area for the range of flood events investigated.

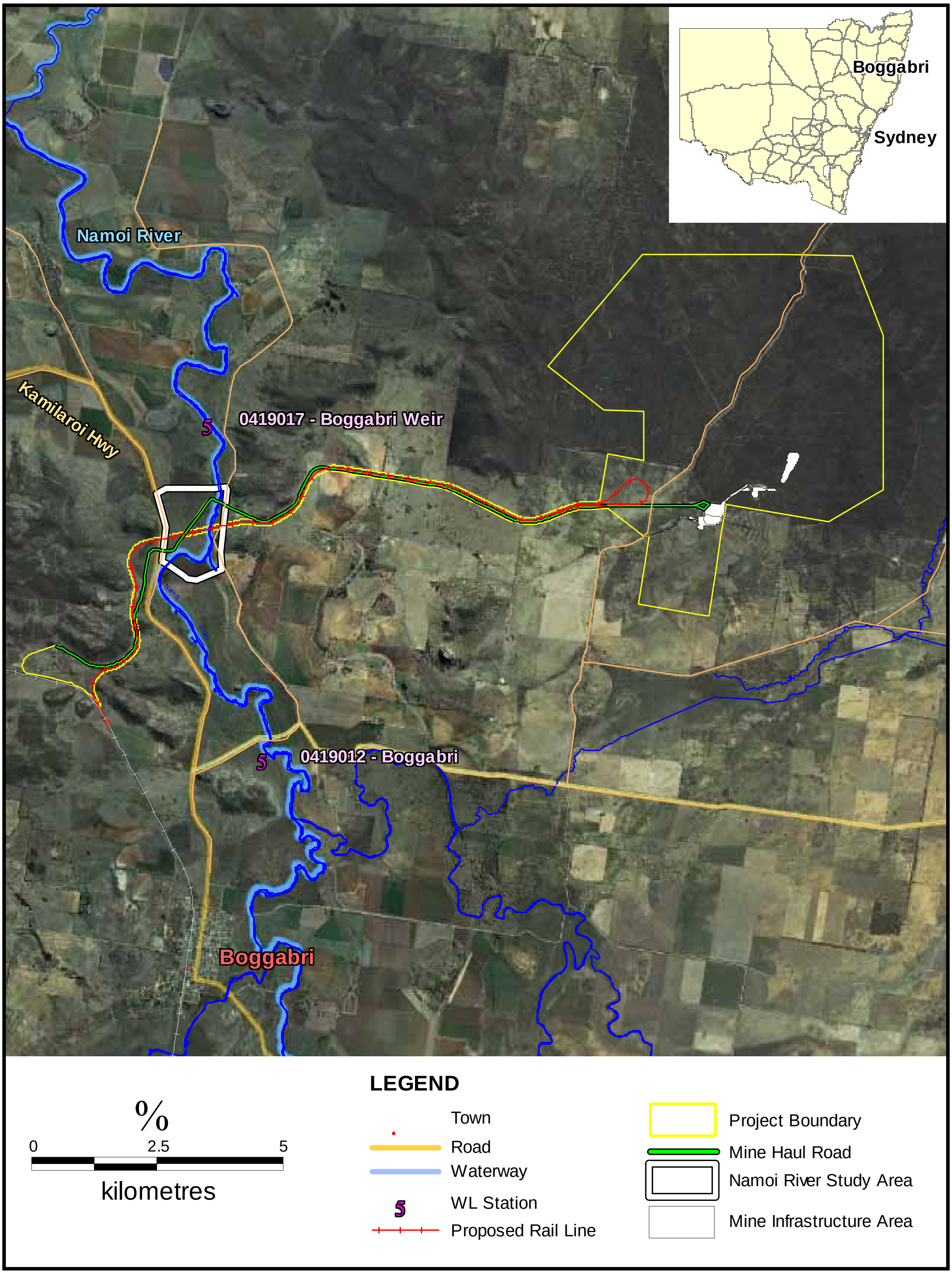


Figure 1.1 Boggabri Coal Mine Project Locality

2 BACKGROUND

2.1 CATCHMENT CHARACTERISTICS

The Namoi River begins in the Great Dividing Range and extends for over 350km west where it discharges into the Barwon River near Walgett. It has a total catchment area of approximately 42,000km^2. The major tributaries of the Namoi River include the Peel River, Mooki River, Manilla River, Coxs Creek, Baradine Creek and Pian Creek. There are a number of major storages in the catchment, namely Keepit, Chaffey and Split Rock Dams located on the Namoi, Peel and Manilla Rivers respectively. Keepit Dam, the main water storage in the catchment, is located approximately 70km upstream of the study area and was constructed in 1960.

The Namoi River has a catchment of about 22,700km^2 to the proposed rail bridge crossing, which is located approximately 9km downstream of the township of Boggabri. The Namoi River flows in a northerly direction through the study area.

2.2 NAMOI RIVER STREAM FLOWS

Figure 1.1 shows the locations of two stream flow gauges on the Namoi River operated by the NSW Office of Water (previously Department of Water and Energy (DWE)) in the vicinity of the Project. Details of the two stations are given in Table 2.1. The flow recorded at both gauges would be representative of the flow at the proposed rail bridge crossing because the catchment areas are relatively similar. However, the Boggabri gauge has a much longer period of record than the Boggabri Weir gauge and the rating curve, which is used to convert recorded water level to flow, is also more reliable because it has been gauged up to a much higher flood level.

The largest recorded flood event at the Boggabri Gauge occurred in February 1955. This flood had a peak discharge of 4,300m^3/s and caused widespread inundation and damage. At Narrabri, over 1000 homes were affected by floodwater, some inundated to their rooftops during this flood. Other large floods have occurred in January 1971, February 1956, January 1976 and February 1984.

The Namoi River water levels at Boggabri are heavily regulated by the upstream dams. Releases are made from Keepit Dam, the most downstream dam, during the summer months to supply irrigators, most of which are located downstream of Boggabri to the west of Narrabri. Keepit Dam releases are much lower through the winter months when there is less irrigation demand. The unregulated sections of the river downstream of Keepit Dam, including from the lower catchment of the Peel River, Mooki River and Coxs Creek are characterised by long periods of low to no flows with intermittent bursts of higher flows following storm events. The Namoi River flood flows take about two days to travel from Gunnedah to Boggabri, a distance of some 40km.

Table 2.1 Streamflow Gauges

	Boggabri 419012	Boggabri Weir 419017
Catchment Area to gauge	22,600km^2	22,700km^2
Period of operation	1911-present	1936-1951
Continuous Data Available	1979-present	n/a
Max. Gauged Stage	8.32m	4.78m
Distance from proposed rail bridge	5km upstream	2km downstream

2.3 NAMOI RIVER CHANNEL AND FLOODPLAIN CHARACTERISTICS

The proposed rail bridge crossing is located within a natural constriction of the Namoi River floodplain formed between two small hills on either side of the Namoi Valley. The floodplain width is about 1.2km at this location and it remains relatively confined for a distance of about 5km downstream of the proposed rail bridge crossing before it expands out to a width of about 4km. The upstream floodplain has a width of about 3.5km and includes several remnant channels of the Namoi River. Intensive cropping is evident on both upstream and downstream floodplains.

The main channel of the Namoi River in the vicinity of the proposed rail bridge crossing has a base width of between 30m and 50m and is about 6-7m deep. The banks of the river are quite steep ranging from 1V:1H to 1V:3H on the outside of the bends and 1V:3H to 1V:4H on the inside bends. Some erosion of the outside bends is evident. However, both the inside and outside banks are vegetated with large, mature red gums indicating that bank erosion is slow and not significant. The river bed appears stable with large pools of water separated by minor deposits of silty sand and large woody debris. Figure 2.1 shows a photograph of the Namoi River in the vicinity of the proposed rail bridge crossing taken in May 2009.

2.4 EXISTING HAUL ROAD

Boggabri Coal constructed a private haul road to transport coal from the mine to the Boggabri Coal Terminal to the west of the Kamilaroi Highway in 2006. The haul road incorporates the following on the Namoi River floodplain:

- A haul road bridge over the Namoi River consisting of four 15m wide spans with three concrete piers located within the waterway;
- An elevated road about 0.5m to 1m above the floodplain; and
- A Kamilaroi Highway overpass several metres above the floodplain.

The configuration of the existing haul road bridge is given in Appendix A. A picture of the bridge taken during the December 2008 flood event is shown in Figure 2.2. This flood, which had an annual recurrence interval (ARI) of between 2 and 5 years (see Section 3) was conveyed under the bridge with minimal difference in water level upstream and downstream of the structure. This flood was generally confined to the river at this location.

It is proposed to widen the haul road across the floodplain as part of The Project. The haul road would remain at the same elevation as the existing haul road and the existing bridge would remain unchanged.

Figure 2.1 Namoi River channel in the vicinity of the proposed rail bridge crossing

Figure 2.2 Boggabri Coal Haul Road Bridge during the Namoi River December 2008 Flood

2.5 PROPOSED THERRIBRI ROAD OVERPASS

It is proposed to upgrade Therribri Road to include an overpass across the haul road. The overpass will have a minimum of 5.3m clearance over the haul road and 100m approaches on either side. The remainder of Therribri Road will be left at grade.

2.6 PROPOSED RAILWAY BRIDGE CROSSING

It is proposed to construct a 17km rail spur and loop from the Werris Creek to Mungundi rail line to the mine infrastructure area as shown in Figure 1.1. The rail line would include the construction of an elevated rail overpass across the Namoi River floodplain. The rail overpass would consist of a rail line on 73 piers equally spaced across the floodplain with the bridge undercroft constructed above the Namoi River 100 year ARI design flood level. Three piers would be constructed within the Namoi River channel with the central pier slightly larger than the others. The rail spur would also include the construction of a rail overpass bridge over the Kamilaroi Highway. The configuration of the proposed railway bridge over the Namoi River floodplain is shown in Appendix B.

3 NAMOI RIVER DESIGN DISCHARGES

3.1 GENERAL

Namoi River design discharges at the proposed haul road and rail bridge crossings were estimated for a range of design events from the 2 year to the 100 year Average Recurrence Interval (ARI). For the impact assessments, the proposed rail bridge crossing and haul road upgrade were assessed using the 5 year, 20 year and 100 year ARI design discharges.

Design discharges were estimated from an annual series flood frequency analysis of the recorded flows at Boggabri (GS419012). These flows were compared with Namoi River design discharges obtained from the Boggabri Coal Rail Crossing Pre-feasibility Study (PB, 2008), which was used to determine the flood immunity of the proposed new rail bridge crossing.

3.2 PRE-FEASIBILITY STUDY ESTIMATES

The pre-feasibility study for the proposed rail line and bridge for the Project prepared by PB (2008) assessed flood flow data collected from a variety of sources including the Environmental Impact Statement 1989 (EIS) for Boggabri Coal, DWE stream flow records and DWE flood information reports. The design flows at the proposed rail bridge crossing adopted in the report were taken from estimates made by Kinhill Engineers (1993) and are shown in Table 3.1. Estimates of peak discharges during two historical flood events in 1955 and 1984 are also shown.

Table 3.1 Namoi River Design Discharges and historical design flows adopted by PB (2008)

Flood Event	Design Discharge (m^3/s)
5 Year ARI	1,000
10 Year ARI	1,750
20 Year ARI	2,750
50 Year ARI	4,400
100 Year ARI	6,000
1955 Flood Event	4,300
1984 Flood Event	2,430

3.3 FLOOD FREQUENCY ANALYSIS

The methodology recommended in Australian Rainfall and Runoff (IEAust, 1987) was used to fit a Log-Pearson Type III distribution to an annual series of peak flood discharges recorded for the Namoi River at Boggabri (419012). The estimated flood frequency distribution for the gauge, including the 5% and 95% confidence limits for a range of average recurrence intervals (ARIs) are given in Table 3.2. Figure 3.1 shows the plot of the historical peak flows together with the adopted flood frequency distribution and the design flows adopted by PB. The following is of note with regards to the flood frequency analysis:

- The annual data is presented for standard calendar years (January-December).
- The distribution is based on 73 years of data from 1937 to 2009 inclusive.
- The recorded water level data was read manually prior to 1979 and has not been fully quality checked. However, it is considered suitable for the purposes of this study.

The flood frequency analysis of the Boggabri flows gives an estimated peak 20 Year ARI discharge of 4,408m^3/s and has a confidence limit of between 2,576m^3/s and 7,545m^3/s. The estimated 100 Year ARI discharge is 6,226m^3/s and has a reliable range of between 3,269 m^3/s and 11,856m^3/s.

Table 3.2 Flood Frequency Analysis Results, Namoi River at Boggabri

ARI Years	Estimated Peak Discharge (m^3/s)			PB (2008) Study Estimate
	95% Confidence Limit	Estimated Value	5% Confidence Limit	
2	246	**321**	419	-
5	708	**943**	1258	1,000
10	1180	**1653**	2315	1,750
20	1738	**2624**	3962	2,750
50	2576	**4408**	7545	4,400
100	3269	**6226**	11856	6,000

3.4 ADOPTED DISCHARGES

Table 3.2 shows that the peak discharges adopted in the PB (2008) study closely match the estimated values from the flood frequency analysis. Given that the PB (2008) estimates were based on an analysis taken some 16 years ago, the results are remarkably close. Although a thorough investigation of the raw data to correct rating curve errors and gap fill missing data have not been undertaken, the similarity between the previous estimates given in the PB (2008) study and the above design discharges gives confidence in the adopted values. Given that the purpose of this study is to assess the flood impact of the haul road widening, Therribri Road overpass and rail bridge crossings and not estimate design flood levels, the PB (2008) design discharge estimates for the 5 year, 20 year and 100 year ARI events have been adopted for this study for consistency.

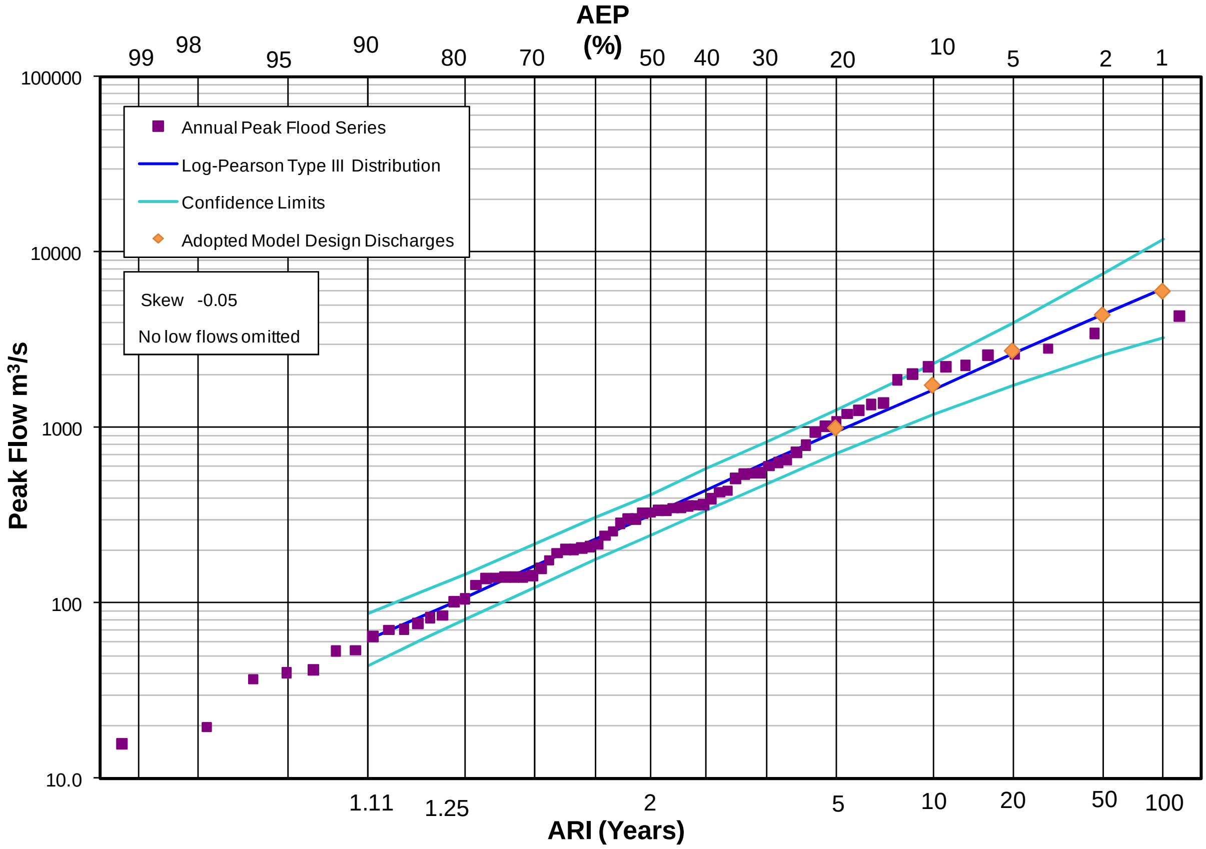


Figure 3.1 Comparison of PB (2008) Study Discharges and Flood Frequency Distribution, Namoi River at Boggabri

4 HYDRAULIC MODELLING

4.1 GENERAL

The 5 year, 20 year and 100 year ARI design flood levels, flood extents and flood velocities were estimated along the Namoi River in vicinity of the proposed rail bridge for the following scenarios.

- **Pre-mine conditions** for model verification/calibration purposes. (Note that calibration data for the model was limited to a single flood mark of the 1955 flood event.)
- **Existing conditions,** which include the existing haul road and existing bridge crossing, and
- **Proposed conditions**, which includes the proposed new rail bridge crossing, proposed Therribri Road overpass and the upgraded haul road. The existing haul road bridge will not be altered and the existing haul road across the floodplain will be widened but not raised for proposed conditions.

The model results were used to determine whether the proposed works would constrict flows sufficiently to cause increased flooding or cause erosion along the Namoi River and floodplain.

4.2 MODEL SELECTION

The Namoi River channel in the vicinity of the haul road and rail bridge crossings traverses from the western edge of the floodplain to the eastern edge. A significant proportion of flood flows drain over bank and not within the channel during major floods. To effectively ensure that the movement of water across the floodplain is adequately represented and the impact of the proposed rail bridge and haul road upgrade is fully assessed, a TUFLOW fully two dimension hydrodynamic model (WBM, 2008) was developed.

TUFLOW estimates flood levels on a fixed grid pattern by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions within the study area. It is also capable of linking with a one-dimensional model (ESTRY) to ensure accurate simulation of both in-bank and overbank flows. For this study, all structures and channels were modelled within the 2D domain.

4.3 TUFLOW MODEL CONFIGURATION

4.3.1 Spatial Extent

Figure 4.1 shows the spatial extent of the Namoi River TUFLOW model used for the pre-mine conditions topography. The modelled study area covers approximately 202ha and includes the Namoi River channel and overbank areas both upstream and downstream of the proposed rail bridge crossing. A 5m grid size and a 2 second time step were adopted for the two dimensional model area.

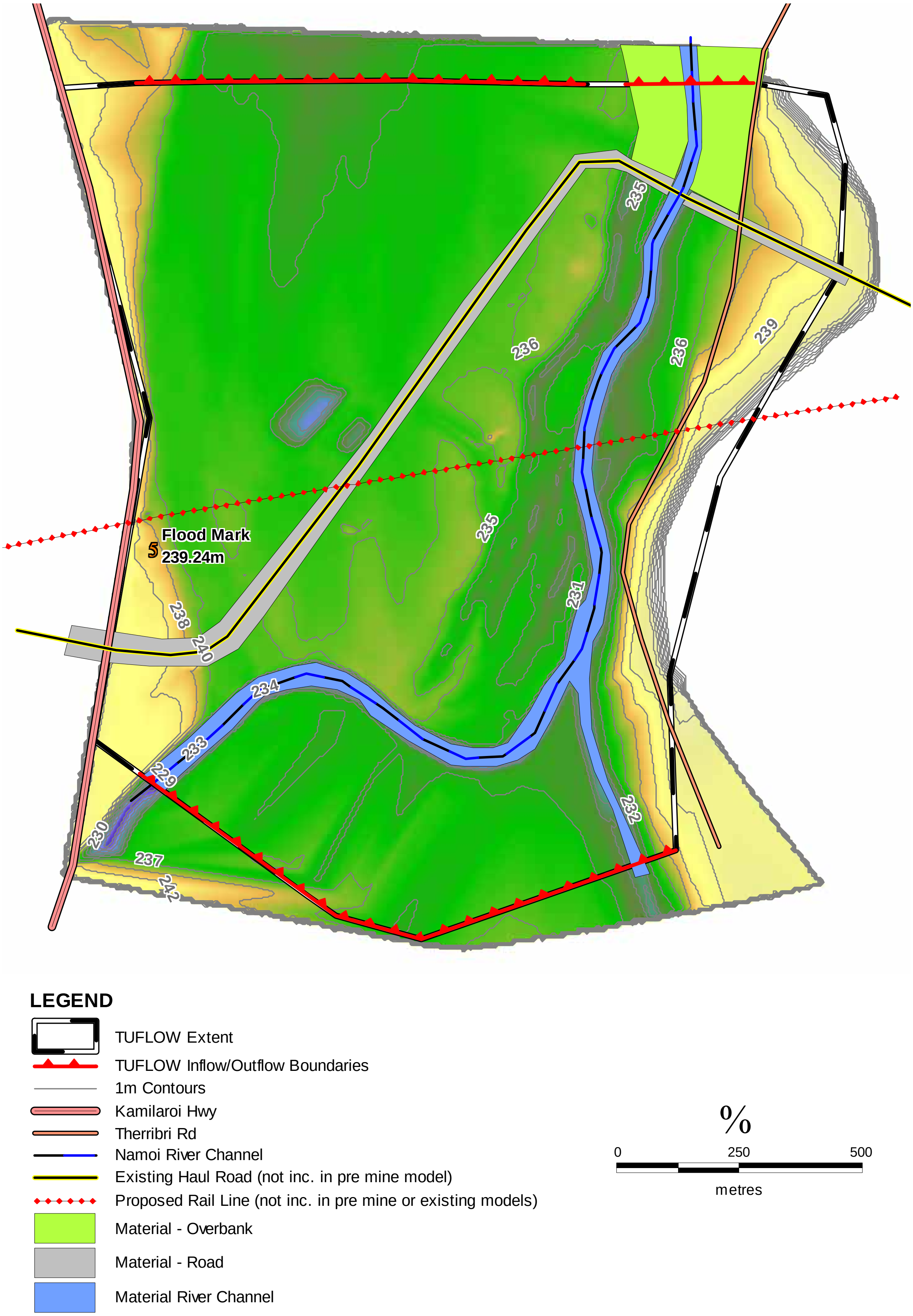


Figure 4.1 TUFLOW Model Configuration for the Pre-Mine Conditions Topography

4.3.2 Available Survey Data

Ground level data was obtained from a GPS survey of the left bank (western) floodplain and six cross sections of the channel and eastern floodplain undertaken by Stewart Surveys in June 2009. The available survey data was combined to create a single digital terrain model of the area as shown in Figure 4.1. The following is of note:

- The ground levels on the right bank (eastern) floodplain were interpolated in between the cross sections. Given that the eastern floodplain upstream of the proposed rail bridge crossing is topographically flat and is very narrow adjacent to the crossing, this approximation is considered sufficiently accurate to assess the impact of the proposed rail bridge crossing.
- The survey extended to the Kamilaroi Highway to the west and Therribri Road to the east. No data was available to the west of the Kamilaroi Highway or east of Therribri Road.
- Ground levels to the east of Therribri Road were approximated by extrapolating from the cross section data.

4.3.3 Adopted Manning's 'n' Values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). In the absence of sufficient calibration data for the hydraulic model, Manning's 'n' values were selected based on typical published values (for example, those of Chow (1959)). The adopted Manning's 'n' values are given in Table 4.1 and their locations are shown in Figure 4.1.

Table 4.1 Adopted Manning's 'n' values

Location	Adopted Manning's 'n'values
Floodplain Area	0.055
River Channel	0.060
Overbank Area	0.045
Roadway	0.025

4.3.4 Inflow and Outflow Boundaries

Figure 4.1 shows the locations of the inflow and outflow boundaries used in the TUFLOW model. Two outflow boundaries and a single inflow boundary were used as follows:

- The design inflows, given in Section 3, drain into the TUFLOW model at the 'Namoi_in' boundary. The shape of the flood hydrograph (flow versus time relationship) was based on the recorded 1984 historical flood hydrograph at Boggabri factored to achieve the required peak discharge.
- A "TUFLOW" generated rating curve was adopted for each of the downstream boundaries. A hydraulic gradient of 0.5% was applied to 'Namoi_Out' based on the slope of the channel and an adopted hydraulic gradient of 0.1% was applied to 'Side_Out' based on the slope of the floodplain.

Note that the adopted downstream boundary conditions impacts on the design flood levels at the proposed rail bridge crossing. Substantially more ground level survey downstream of the model would be required to overcome this. Again, the assumptions adopted at the downstream boundary are considered sufficient to allow the impact of the rail bridge crossing to be assessed.

4.4 PRE-MINE CONDITIONS MODEL VERIFICATION

The pre-mine conditions model was validated using the available data for the 1955 historical event. The available 1955 historical flood data consists of a single flood mark, which was surveyed by Stewart Surveys in June 2009 at the location shown in Figure 4.1. The accuracy of the flood mark is not known. A peak discharge of 4,300 m^3/s was adopted for this event based on Water Resource Commission flood information reports cited in PB (2008). This event had a flood severity of about 50 Years ARI.

Table 4.2 shows a comparison between the recorded and predicted peak water levels at the surveyed flood mark. The predicted flood level peak is about 0.3m lower than the recorded flood mark. Given that flood depths across the floodplain are of the order of 3m for this event and the one surveyed flood mark is 44 years old, the validation of the pre-mine conditions model was considered acceptable.

Table 4.2 Recorded and Predicted Peak Water Level at Flood Mark, 1955 flood event.

Event	Peak Level (m AHD)		Difference in Peak Level (m AHD)
	Recorded	Predicted	
1955	239.24	238.93	0.31

4.5 EXISTING CONDITIONS MODEL

The existing conditions model consists of the pre-mine conditions model plus the existing haul road and bridge. The configuration of the existing haul road is shown in Appendix A and the digital terrain model of the study area including the existing haul road is shown in Figure 4.2. Note that the haul road bridge was designed to be overtopped by large and medium sized floods.

The existing haul road bridge was modelled as a flow constriction. Table 4.3 shows the flow configuration data adopted for the existing haul road bridge.

Table 4.3 Existing Haul Road Bridge Configuration Data

Road Bridge Properties	
Min. Bridge Deck Level	236.8m AHD
Bridge Deck Depth	1m
Bridge Length	60m
Number of Piers	5
Pier Diameter	720mm
Approx Distance between Piers	15m
Estimated Pier Blockage Factor	5%
Rail guard height	0.5m
Rail guard blockage Factor	80%

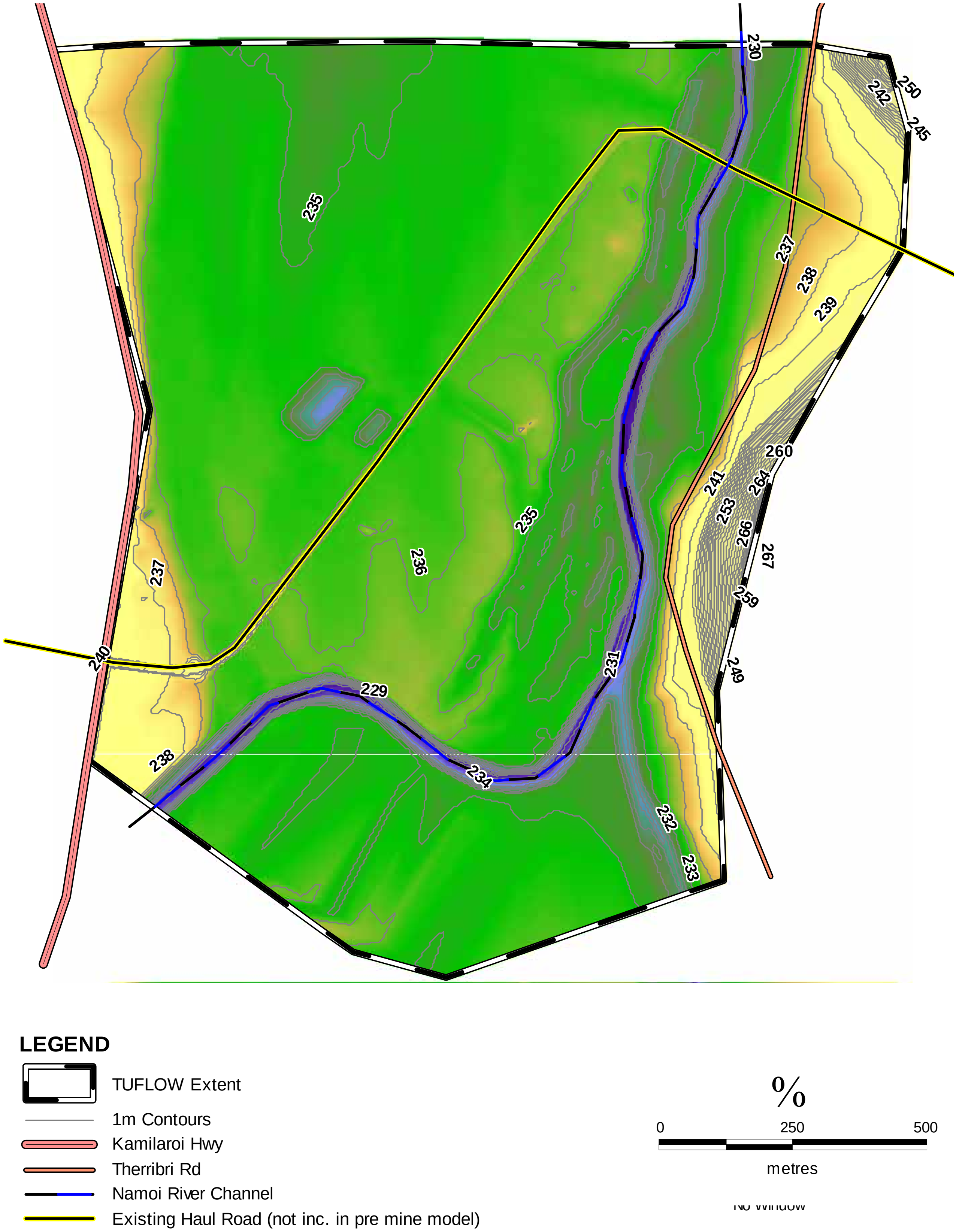


Figure 4.2 Existing Conditions Topography including the Haul Road

4.6 PROPOSED CONDITIONS MODEL

The proposed conditions model includes the existing conditions model together with the upgraded haul road, the proposed railway bridge crossing and Therribri Road overpass (as shown in Figure 4.3). The haul road is proposed to be wider than the existing road but would be at the same grade and elevation. In effect, the proposed changes to the haul road across the Namoi River would cause no additional constriction of flows than the existing road. Therefore the haul road configuration across the Namoi River floodplain in the existing conditions TUFLOW model has not changed for the proposed conditions model.

The proposed railway bridge and piers (as shown in Appendix B) were included in the proposed conditions model as a flow constriction in a similar manner to the existing haul road bridge. The rail bridge crossing is proposed to be above the 100 year ARI design level and therefore, the impact of the proposed bridge is limited to the piers and the abutment adjacent to the Kamilaroi Highway. The abutment was modelled by modifying the ground level in the TUFLOW grids. The piers were modelled by blocking a proportion of each 2D cell in both the x and y directions and then adding an additional form factor to take into account possible eddying effects. An additional 10% blockage factor was applied to the centre pier in the middle of the Namoi River to account for the possibility of debris build up. The data used to model the proposed rail bridge is given in Table 4.4.

Table 4.4 Proposed Rail Bridge Configuration Data

Rail Bridge Properties	
Min. Bridge Deck Level	243m AHD
Bridge Length	1,320m
Number of Piers	87
X direction Blockage factor	80%
Y direction Blockage Factor	3.3%
Additional Form Factor	0.1
Pier Diameter	720mm
Approx Distance between Piers	15m

The Therribri Road overpass was modelled by modifying the ground levels in the TUFLOW grid in a similar manner to the rail overpass embankment.

Figure 4.3 Proposed Conditions Topography including the Proposed Rail Line and Therribri Rd Overpass

4.7 HYDRAULIC MODEL RESULTS

4.7.1 Existing Conditions

Figure 4.4 shows the 5 year, 20 year and 100 year ARI design flood extents for the Namoi River under existing conditions. Figures C1-C3 in Appendix C show the 5 year, 20 year and 100 year design flood depths. Figures D1-D3 in Appendix D show the 5 year, 20 year and 100 year ARI design velocities. The following is of note:

- All three design floods exceed the capacity of the Namoi River channel.
- The difference in flood extents between the three design floods particularly along the eastern bank of Namoi River is minimal.
- All three floods, particularly the 100 year ARI design flood, extend beyond the extent of the model. More survey would be required to determine the full extent of the three design floods. The constricted model used in this study is expected to slightly overestimate design flood levels but is not expected to affect the assessment of impacts.
- Floodplain flood depths in the vicinity of the proposed rail bridge crossing generally vary from about 0.5m to 1.5m for the 5 year ARI design flood, 2m to 3m for the 20 year ARI design flood and 3m to 4m for the 100 year ARI design flood. Main channel flood depths are between 8.5m and 11m.
- Floodplain velocities in the vicinity of the proposed rail bridge crossing are generally around 0.5m/s for the 5 year ARI design flood, 1.0m/s for the 20 year ARI design flood and 1.5m/s for the 100 year ARI design flood. Main Channel flood velocities are 0.5m/s to 3.0m/s.
- The existing haul road and bridge are overtopped by all design floods investigated. The haul road is almost fully inundated by the 5 year ARI flood and has only a minor impact on the distribution of flows. The haul road bridge is fully inundated by the 100 year ARI design flood.

4.7.2 Proposed Conditions

Figure 4.5 shows the 5 year, 20 year and 100 year ARI design flood extents for the Namoi River under proposed conditions. Figures C4-C6 in Appendix C show the 5 year, 20 year and 100 year design flood depths. Figures D4-D6 in Appendix D show the 5 year, 20 year and 100 year ARI design flood velocities. The following is of note:

- The proposed rail bridge, haul road widening and Therribri Road overpass have no measureable impact on upstream or downstream flood extents for any of the three design floods.
- The proposed rail bridge abutment adjacent to the Kamilaroi Highway is located in relatively ‘still’ water behind the haul road overpass and as such does not form a large obstruction to flow.
- The proposed Therribri Road overpass is located in relatively ‘still’ water at the edge of the flood extents parallel to the flow and again has little impact on the flood extent.
- 100 year ARI design flood levels at the proposed rail bridge crossing vary from 239.3m AHD at the Namoi River channel to 239.1m AHD at the Kamilaroi Highway.
- 100 year ARI design flood levels at the haul road/Therribri Road intersection is 238.5m.

4.7.3 Impact on Flood Levels and Flood Velocities

Figure 4.6 shows the difference in flood depths between existing and proposed conditions for the 100 year ARI Namoi River design flood. Figures C7-C9 in Appendix C show the changes in the 5 year, 20 year and 100 year ARI design flood depths. Figures D7-D9 in Appendix D show the changes in the 5 year, 20 year and 100 year ARI design velocities between existing and proposed conditions. The following is of note:

- Flood depths immediately upstream of the proposed rail bridge are increased by approximately 0.01m and 0.04m for the 5 year and 100 year ARI events respectively. These flood depth increases, although insignificant, extend upstream of the proposed rail bridge crossing to the upstream boundary of the model.
- There would be a minor decrease in flood depth for the three design floods downstream of the proposed rail bridge crossing. The differences are generally less than 0.01m for the three design floods, which is insignificant given the existing flood depths.
- There would be a minor increase in the flood depth for the 20 year and 100 year ARI design floods in a small area to the east of the northern most Therribri Road overpass embankment of approximately 0.05 to 0.15m and a minor decrease to the flood depth on the western side of the embankment. It appears that the northern most embankment would moderately constrict flood flows draining back into the river for these larger events.
- There would be a minor decrease in flood velocities for the three design floods downstream of the proposed rail bridge crossing and in a number of areas upstream both within the Namoi River channel and the floodplain.
- There would be a minor increase in flood velocities (less than 0.2m/s) for both the 20 year and 100 year ARI design floods on the eastern floodplain of the Namoi River immediately upstream of the proposed rail bridge crossing. It is possible that the adopted blockage rate on the piers of the proposed rail bridge crossing located within the Namoi River channel is causing some of the channel flows to distribute onto the eastern floodplain. The 20 year and 100 year ARI flood velocities in this area are approximately 0.5m/s and 1m/s respectively.
- There would be a minor increase in flood velocities (0.4m/s) to the west and east immediately adjacent to the Therribri Road overpass embankments.
- There is a minor increase in flood velocities adjacent to the Kamilaroi Highway abutment. However, even the 100 year ARI velocities for proposed conditions are low at about 0.45m/s.

4.8 DISCUSSION OF IMPACTS AND MITIGATION MEASURES

The hydraulic modelling of the Namoi River floodplain for existing and proposed conditions shows the following:

- The existing road bridge and haul road are overtopped by the 5 year ARI design flood for both existing and proposed conditions. The widening of the haul road would not change the existing flooding characteristics in the study area.
- The haul road bridge performed adequately during the December 2008 flood, which had an ARI of between 2 and 5 years. No further works are proposed for the haul road bridge for the Project.

- The proposed rail bridge crossing would have an insignificant impact on flood levels and flood extents for all floods investigated. That is, no additional overbank flooding is expected as a result of the rail bridge crossing.
- The proposed rail bridge crossing, haul road expansion and Therribri Road overpass would have an insignificant impact on flood velocities and therefore on the erosion potential across the floodplain for floods up to and including the 100 year ARI design flood.
- The model predicts localised velocity increases around the bridge piers of only about 0.05m/s. However higher localised velocity increases would be expected. It is recommended to provide scour protection at the base of each pier to minimise the potential scour and to improve the integrity of each pier.
- The change in the distribution of flow that may occur if flood debris built up on the bridge piers within the waterway would be minor and likely to cause no additional erosion or flood impacts. Notwithstanding, scour protection on the banks of the Namoi River under the bridge is recommended in case a significant blockage occurs. Any debris blocking the bridge would be removed as soon as practicable.
- The minor increase in flood velocity adjacent to the Therribri Road overpass embankments is not likely to cause erosion as the proposed velocities are only in the order of 1m/s over the existing haul road.
- The minor increase in flood velocity adjacent to the Kamilaroi Highway abutment is not likely to cause erosion because the proposed velocities are only of the order of 0.45m/s.

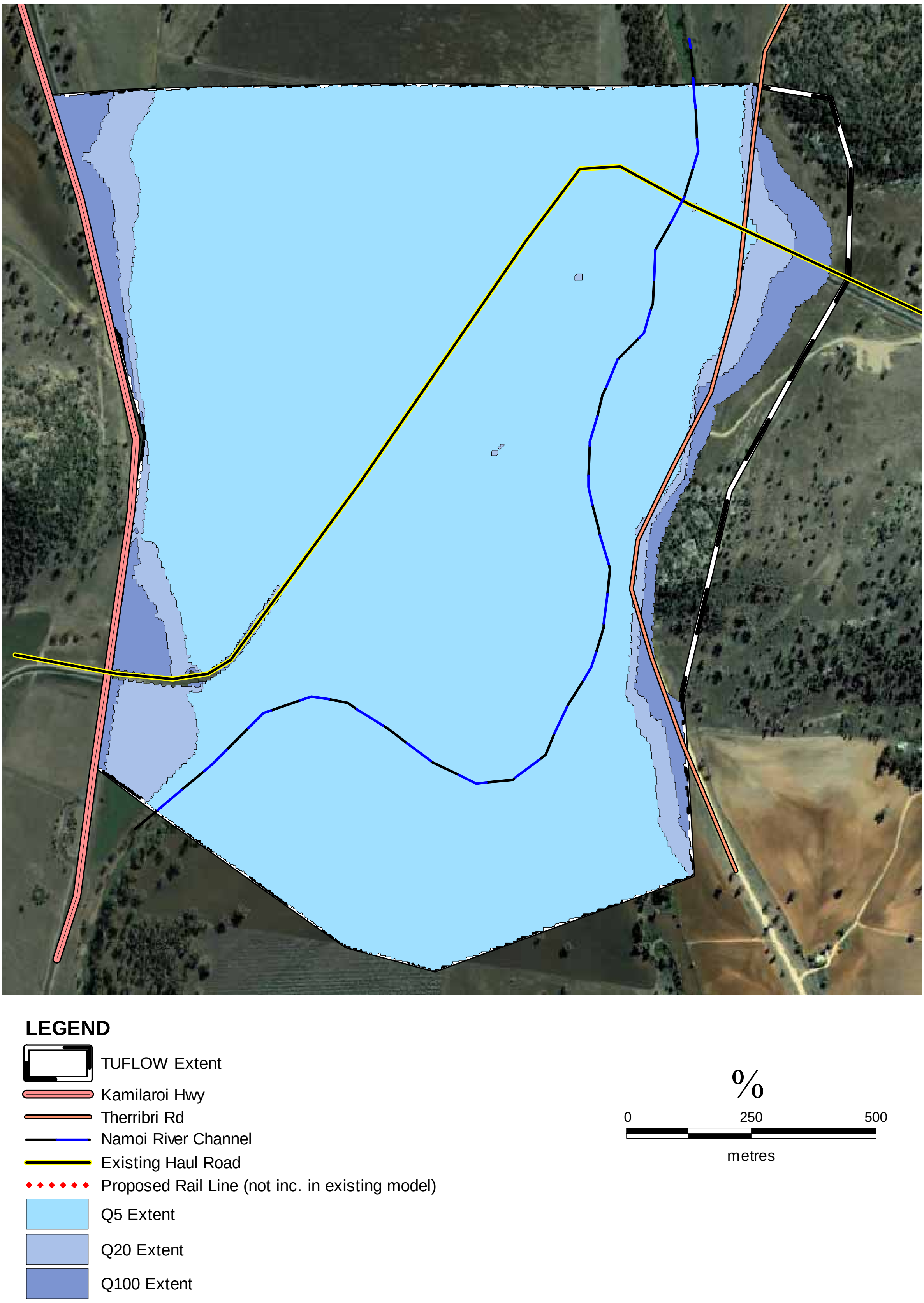


Figure 4.4 Namoi River Existing Conditions Flood Extent, 5 year, 20 Year and 100 Year ARI Events

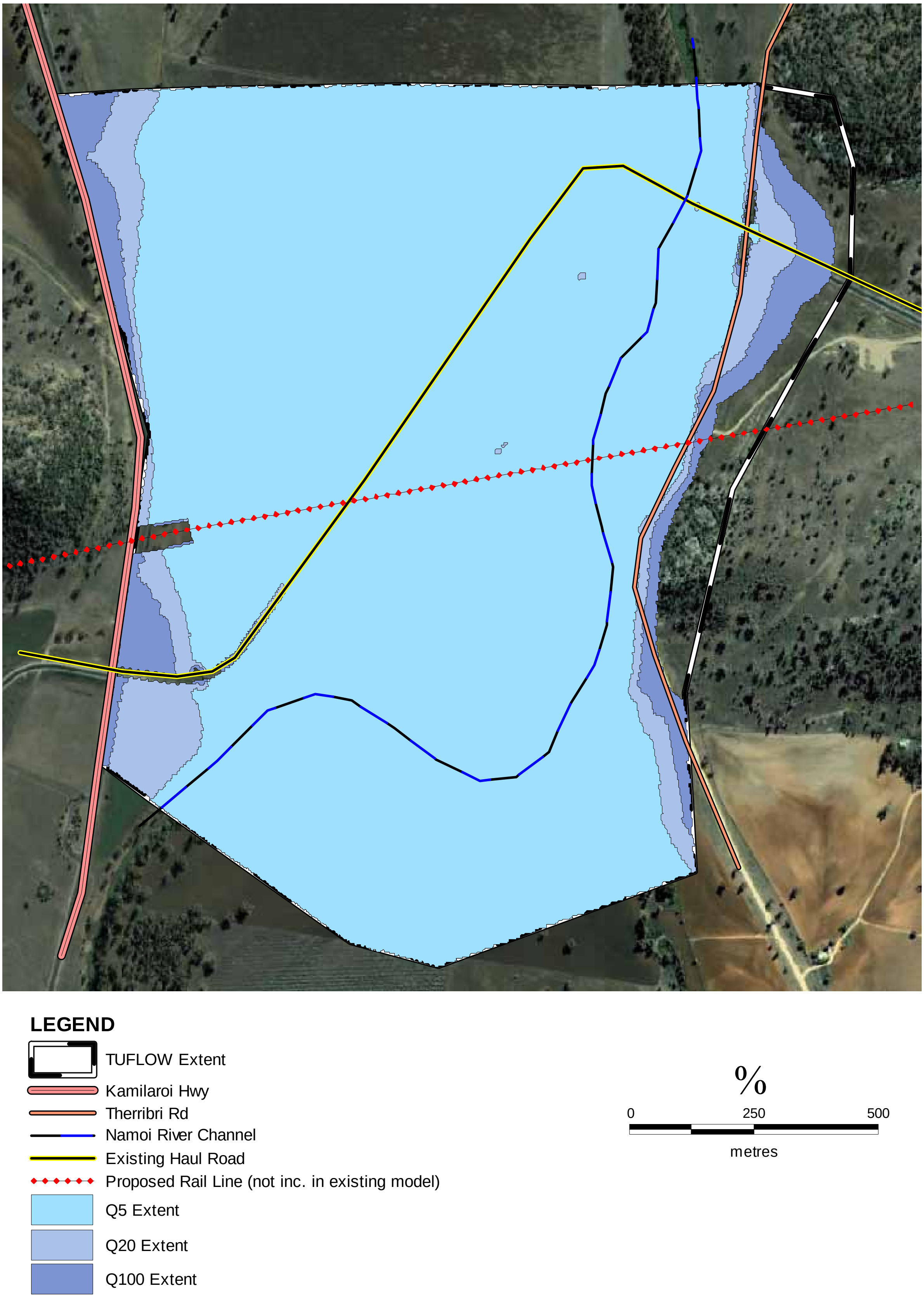


Figure 4.5 Namoi River Proposed Conditions Flood Extent, 5 Year, 20 Year and 100 Year ARI Events

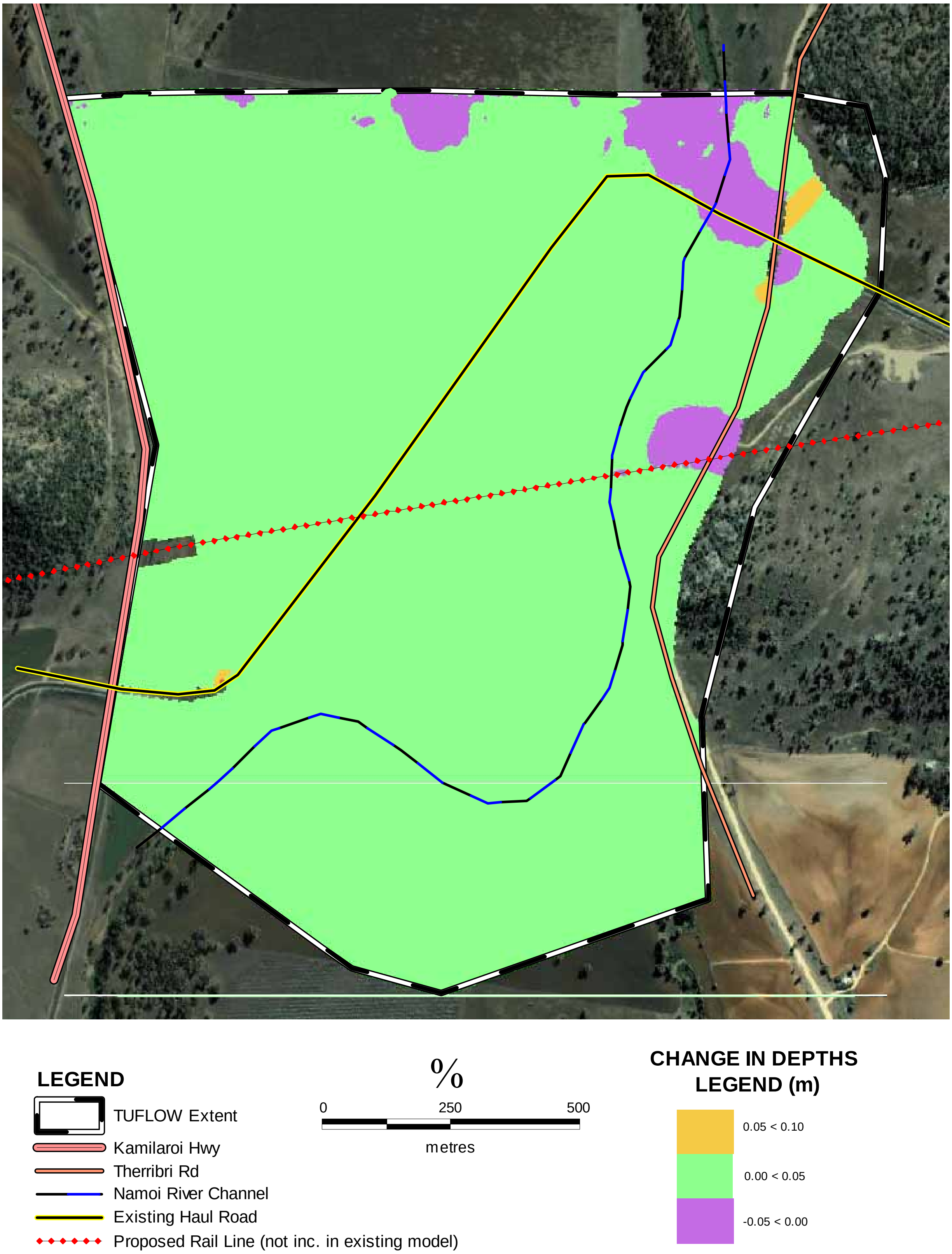


Figure 4.6 Namoi River Design Flood Depth Difference, 100 Year ARI

5 SUMMARY OF FINDINGS

Boggabri Coal is seeking a Project Approval under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to continue its open cut mining and associated activities largely consistent with its existing operation for a further 21 years. As part of this approval, Boggabri Coal proposes to construct a 17km rail line to haul coal from the mine across the Namoi River floodplain to the Werris Creek Mungundi Railway, approximately 9 km north of Boggabri. The existing haul road across the Namoi River floodplain will also be widened and an overpass on Therribri Road constructed in place of the existing grade intersection.

WRM Water & Environment Pty Ltd was requested to prepare a flood study to determine whether the proposed works on the Namoi River floodplain would constrict flows sufficiently to cause increased flooding or potentially cause erosion along the river and floodplain. To undertake the study, a TUFLOW two dimensional hydraulic model was developed of the Namoi River and its floodplain for existing conditions and for proposed conditions with the proposed works in place.

The results of the hydraulic modelling of the Namoi River floodplain are as follows:

- Existing and proposed floodplain flood depths in the vicinity of the proposed rail bridge generally vary between 0.5m and 1.5m for the 5 year ARI design flood, 2m and 3m for the 20 year ARI design flood and between 3m and 4m for the 100 year ARI design flood. Main Channel flood depths are between 8.5m and 11m.
- Existing and proposed floodplain velocities in the vicinity of the proposed rail bridge crossing are generally around 0.4m/s for the 5 year ARI design flood, 0.75m/s for the 20 year ARI design flood and 1.25m/s for the 100 year ARI design flood. Main Channel flood velocities are 1.5m/s to 1.9m/s.
- The existing haul road and bridge are overtopped by all design floods investigated. The haul road is almost fully inundated by the 5 year ARI flood and has only a minor impact on the distribution of flows. The haul road bridge is fully inundated by the 100 year ARI design flood. The widening of the haul road is not expected to change the existing flooding characteristics. No works are proposed for the haul road bridge.
- The proposed rail bridge crossing would have an insignificant impact on flood levels (maximum of 0.03m) and no measurable impact on flood extents for all floods investigated. That is, no additional overbank flooding is expected as a result of the rail bridge crossing.
- 100 year ARI design flood levels at the proposed rail bridge vary from 239.4m AHD to 239.6m AHD.
- The 100 year ARI design flood level at the Therribri Road/haul road intersection is 238.5m AHD.
- The proposed rail bridge crossing would have an insignificant impact on flood velocities and therefore on the erosion potential across the floodplain for floods up to and including the 100 year ARI design flood.
- The proposed Therribri Road overpass would have an insignificant impact on flood depths and velocities across the floodplain for floods up to and including the 100 year ARI design flood as any impacts are minor and localised around the embankments.

- There is a minor increase in flood velocities (less than 0.2m/s) for both the 20 year and 100 year ARI design floods on the eastern floodplain of the Namoi River immediately upstream of the proposed rail bridge crossing. It is possible that the adopted blockage rate of the rail bridge crossing piers located within the Namoi River channel is causing some of the channel flows to distribute onto the eastern floodplain. The 20 year and 100 year ARI velocities in this area are approximately 0.5m/s and 1m/s respectively.
- The change in the distribution of flow that may occur if flood debris built up on the bridge piers within the waterway would be minor and likely to cause no additional erosion or flood impacts. Notwithstanding, scour protection on the banks of the Namoi River under the bridge is recommended in case a significant blockage occurs. Any debris blocking the bridge would be removed as soon as practicable.
- The model predicts localised velocity increases around the bridge piers of only about 0.05m/s. However higher localised velocity increases would be expected. It is recommended to provide scour protection at the base of each pier to minimise the potential scour and to improve the integrity of each pier.
- There is a minor increase in flood velocities adjacent to the Kamilaroi Highway abutment. However, even the 100 year ARI velocities for proposed conditions are about 0.45m/s and erosion is not expected to occur.

6 REFERENCES

ARR (1998)	'*Australian Rainfall and Runoff, A Guide to Flood Estimation'*, Revised Edition, Institution of Engineers, Australia, 1998.
ARR (1999)	*'Australian Rainfall and Runoff. A Guide to Flood Estimation'. Book VI, Estimation of Large and Extreme Floods, Nathan, R.J. and Weinmann, P.E. (Ed.s), Revised Edition, Institution of Engineers Australia, 1999*
PB (2008)	*'Boggabri Coal – Rail Pre-feasibility Study: Hydrologic and Hydraulic Assessment'* Technical Memorandum prepared by Parsons Brinckerhoff, October 2008
WBM (2008)	'*TUFLOW User Manual, GIS Based 2D/1D Hydrodynamic Modelling'* Build 2008-08-AA BMT WBM 2008

APPENDIX A

EXISTING HAUL ROAD BRIDGE ARRANGEMENT

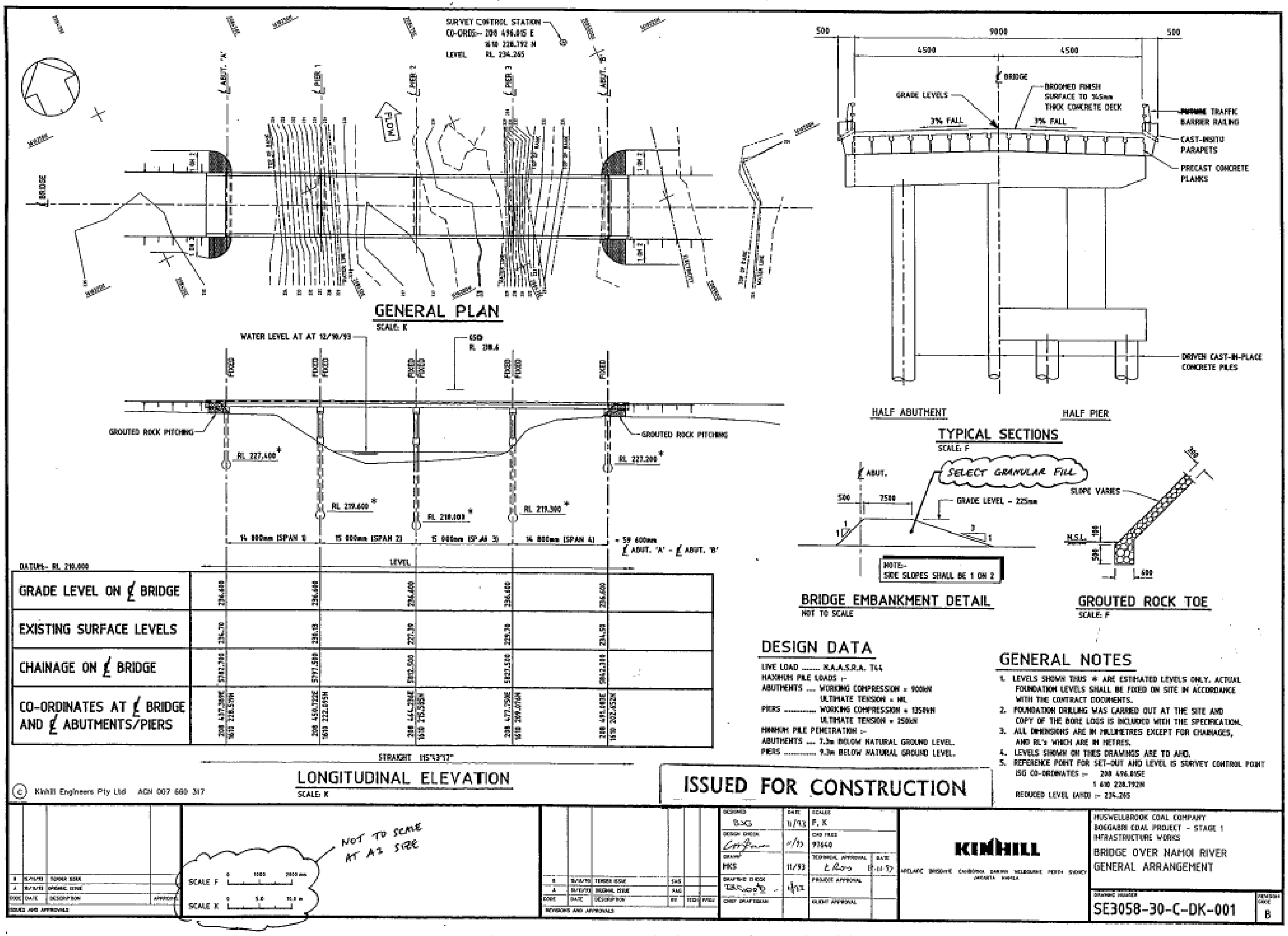


Figure A1 Existing Haul Road Bridge

APPENDIX B

PROPOSED RAIL BRIDGE ARRANGEMENT

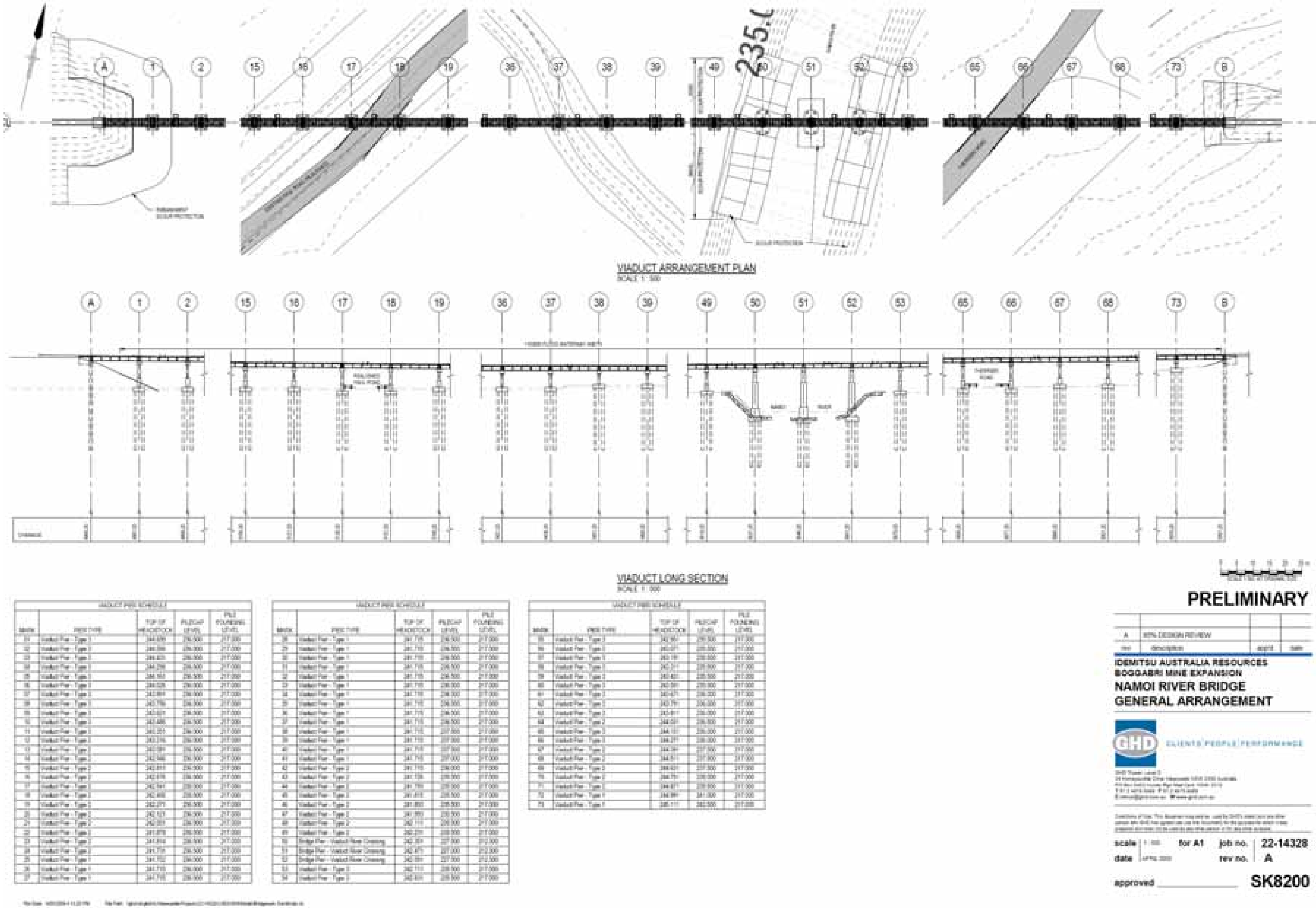
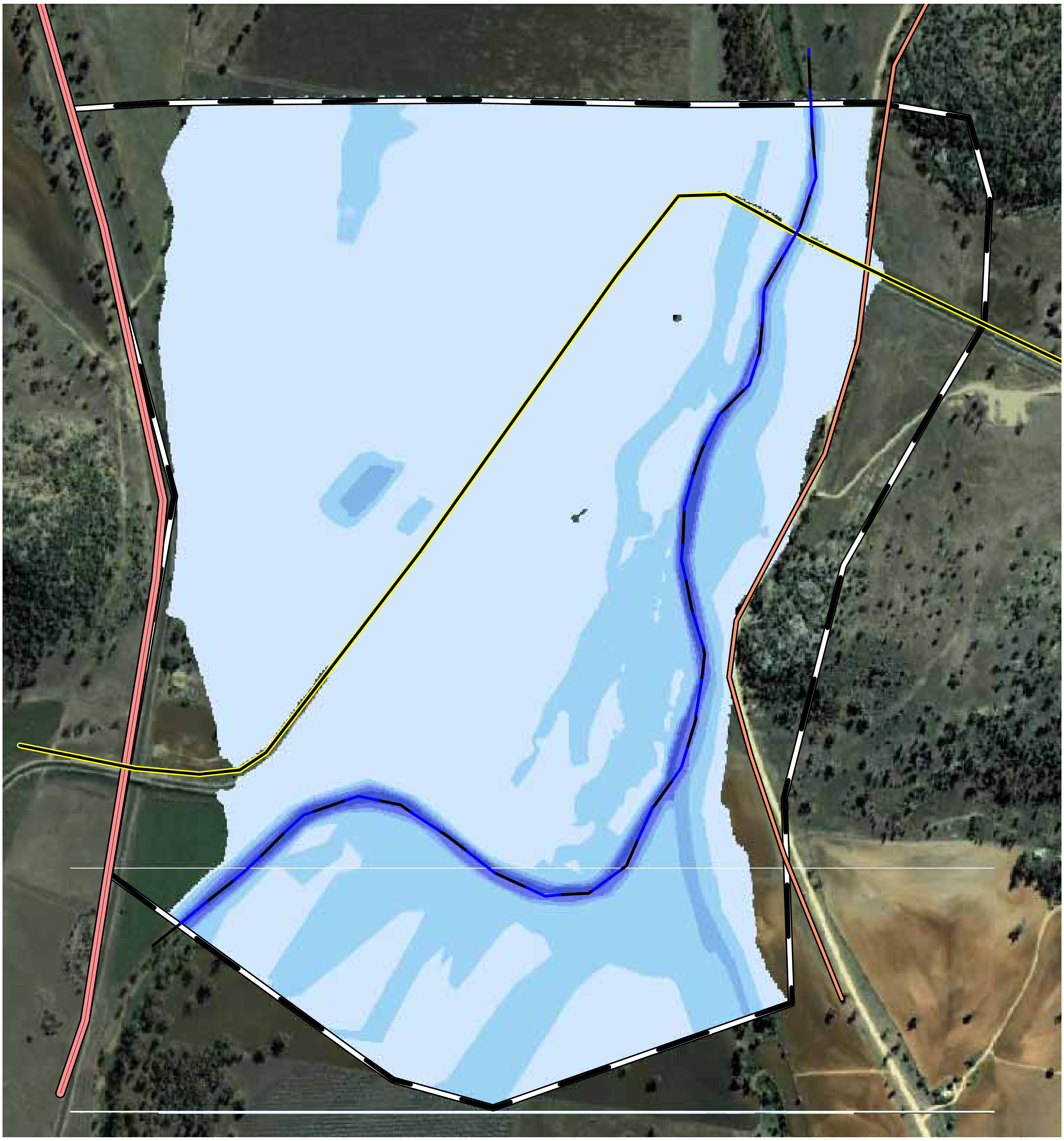


Figure B1 Proposed Rail Bridge

APPENDIX C

FLOOD DEPTHS



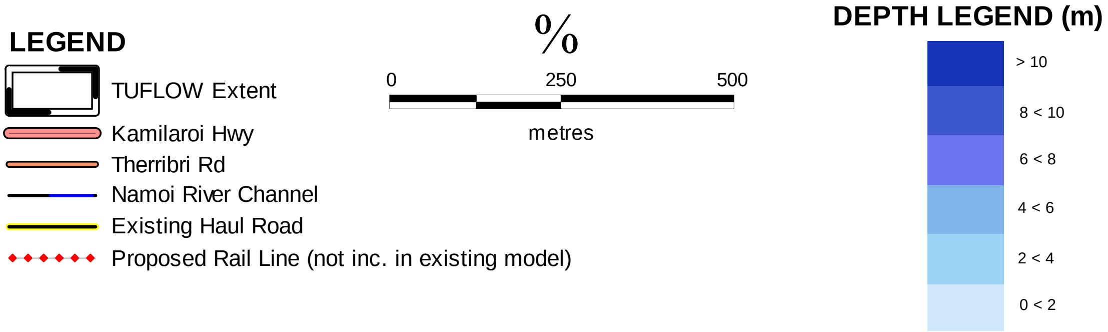


Figure C1 Existing Conditions Flood Depth, 5 year ARI Event

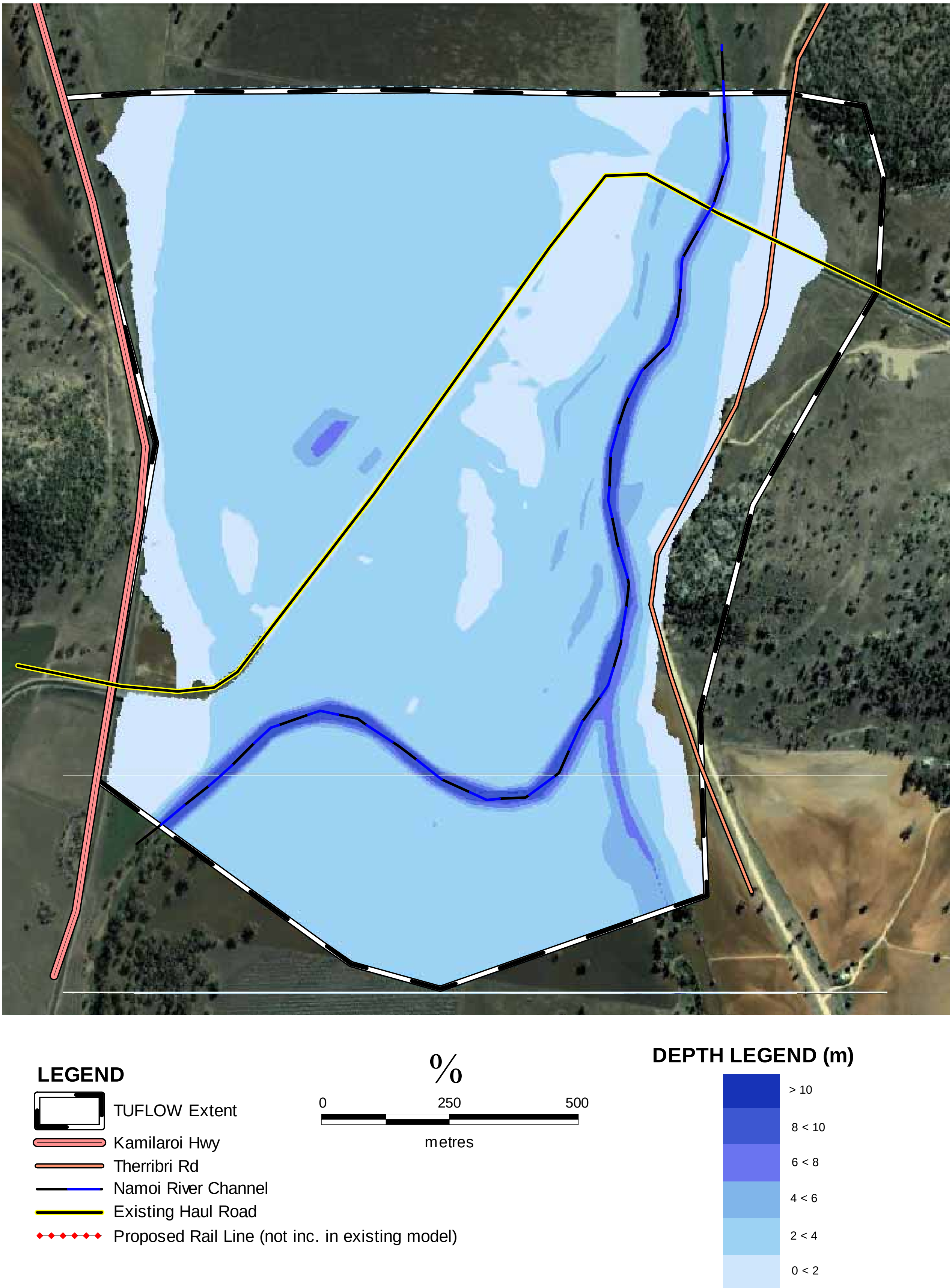


Figure C2 Existing Conditions Flood Depth, 20 year ARI Event

wrm water+environment

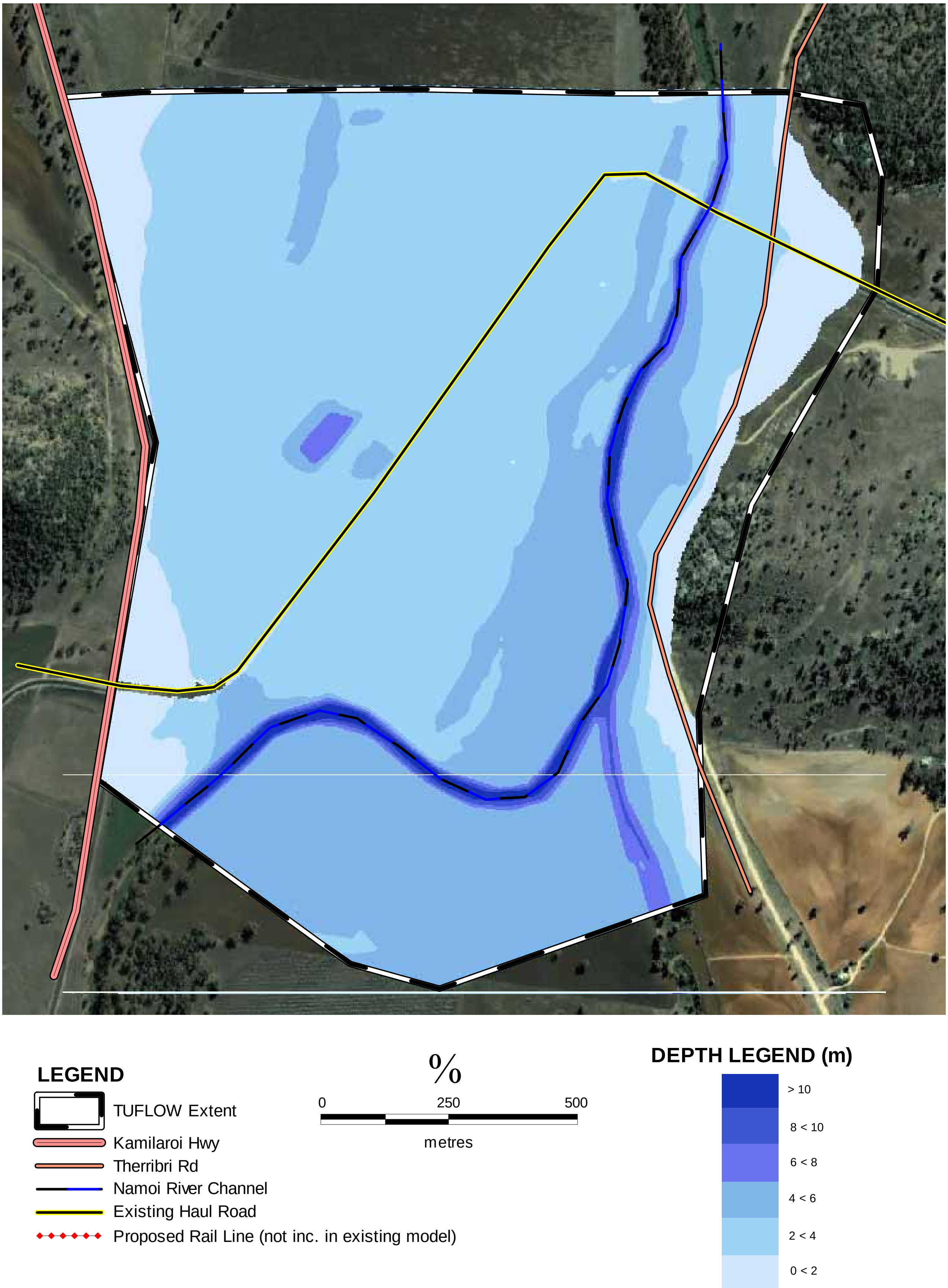


Figure C3 Existing Conditions Flood Depth, 100 year ARI Event

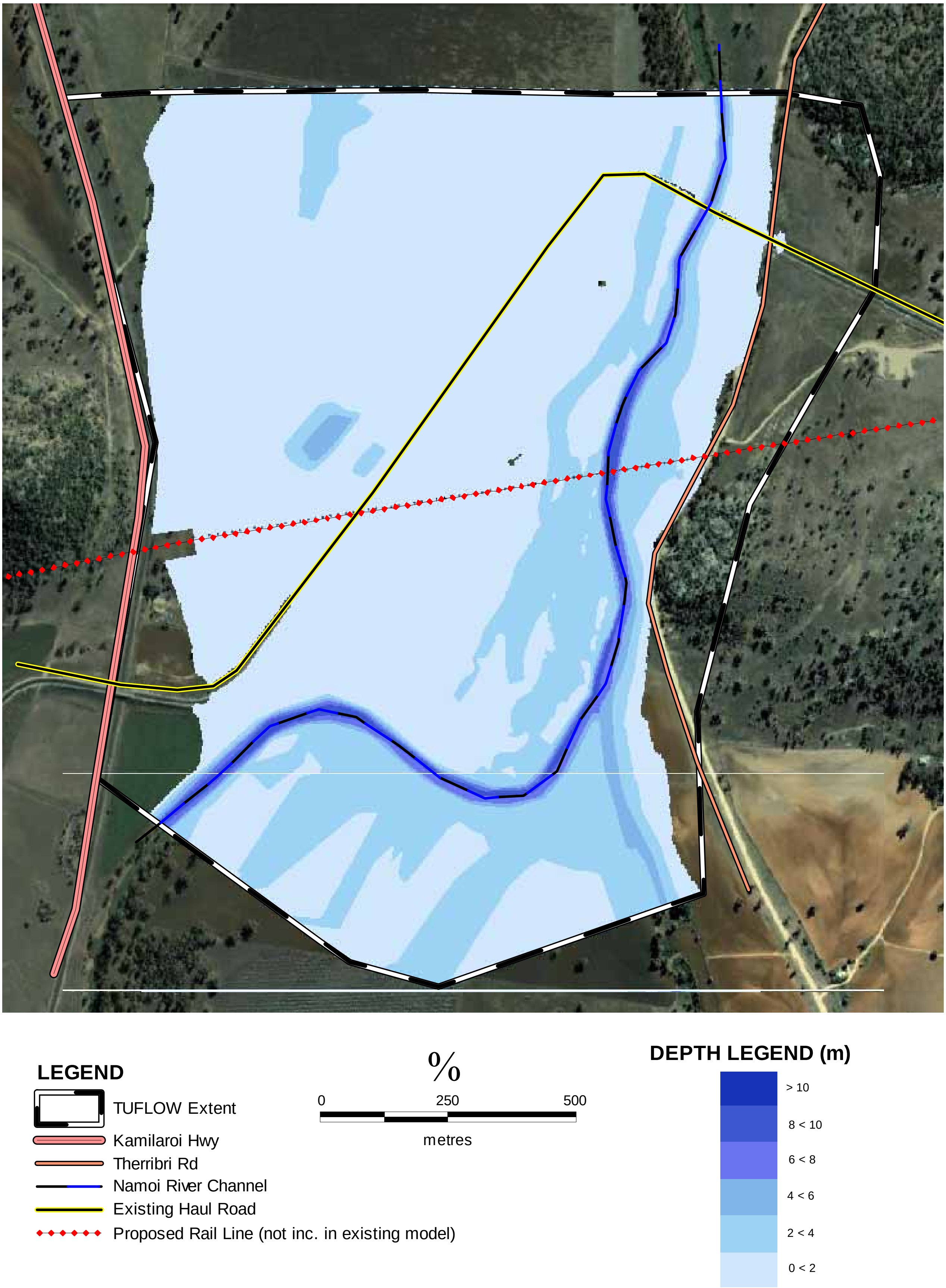
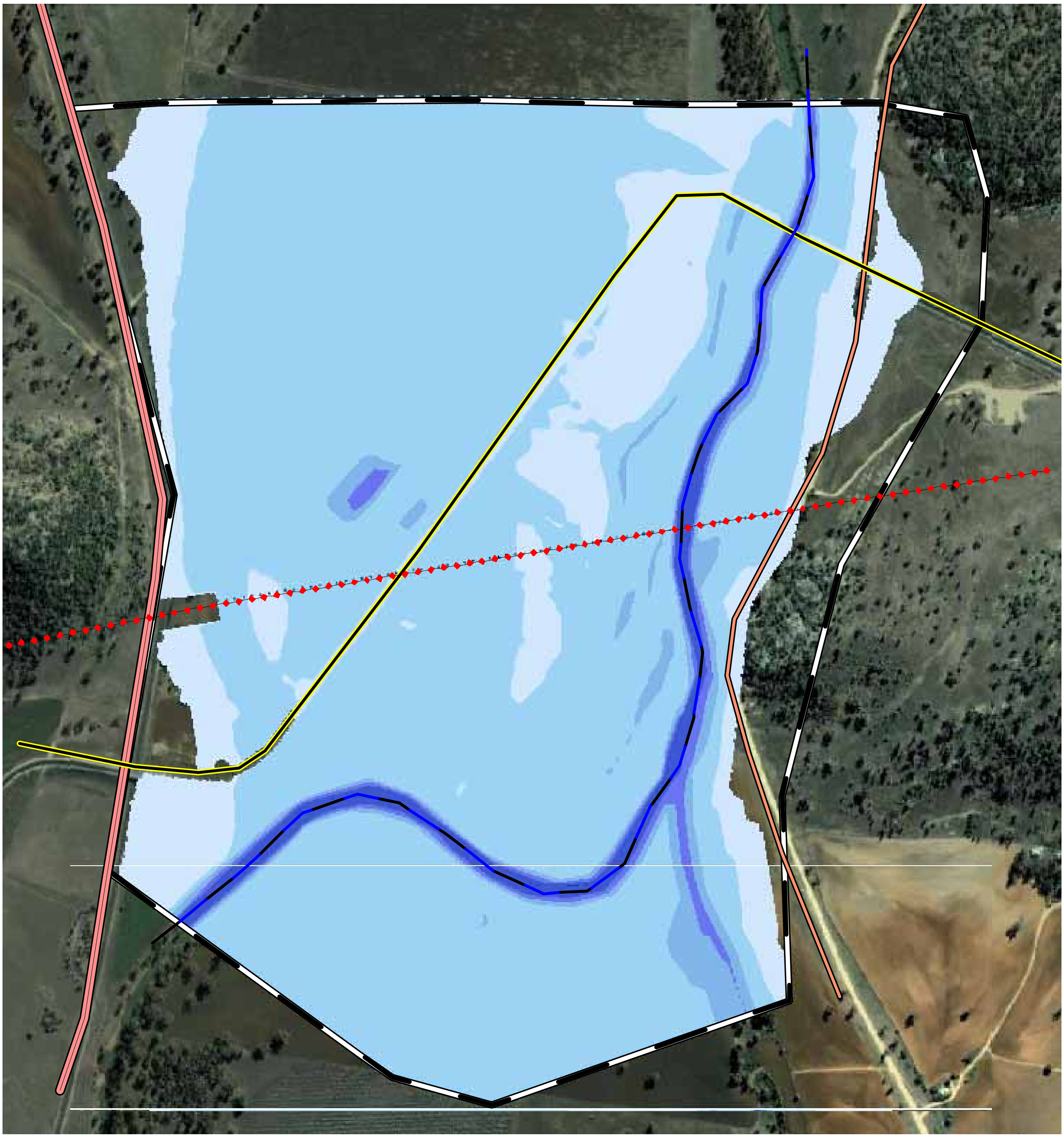


Figure C4 Proposed Conditions Flood Depth, 5 year ARI Event



LEGEND

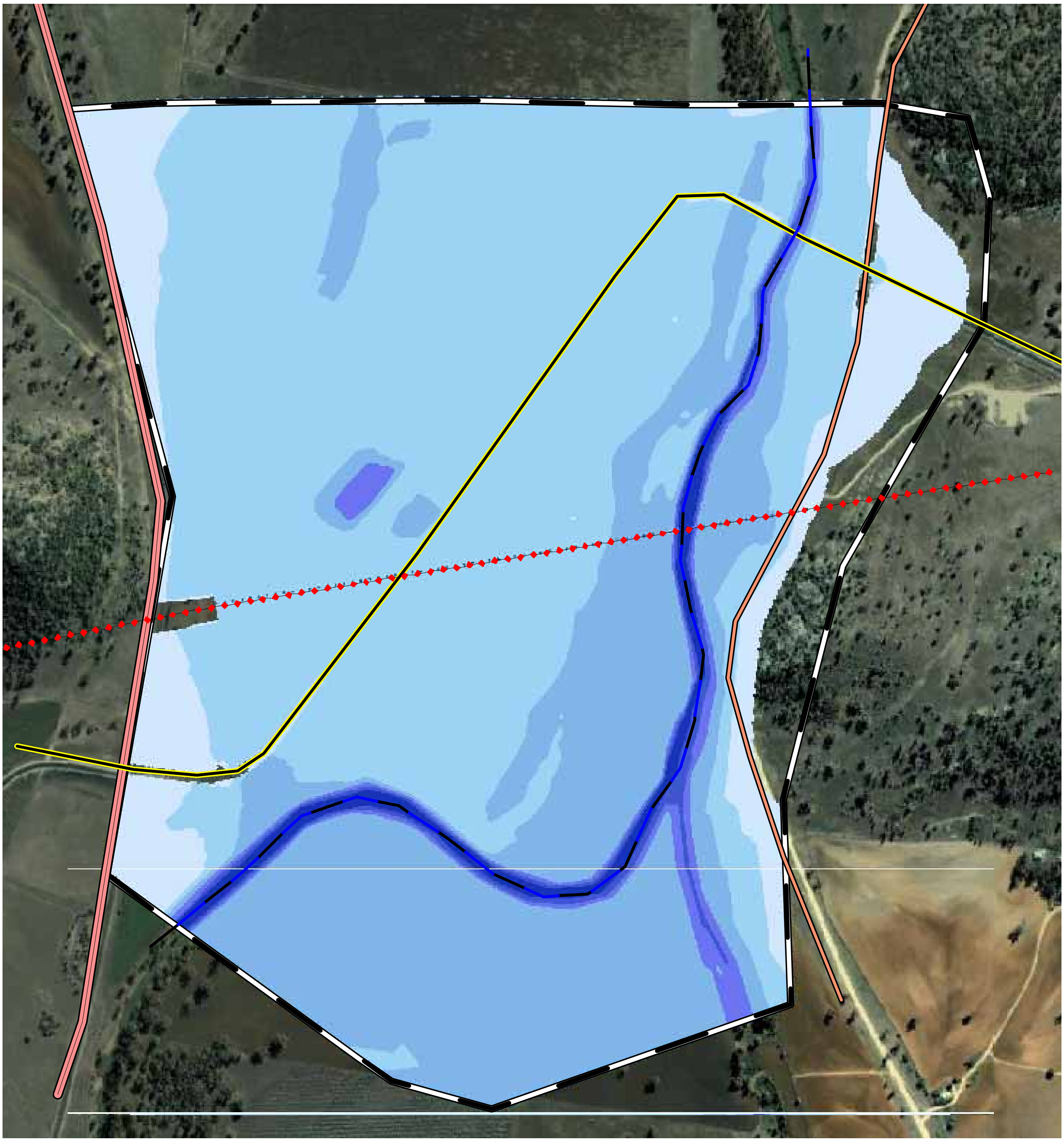
- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

DEPTH LEGEND (m)

- > 10
- 8 < 10
- 6 < 8
- 4 < 6
- 2 < 4
- 0 < 2

Figure C5 Proposed Conditions Flood Depth, 20 year ARI Event



LEGEND

- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

DEPTH LEGEND (m)

- > 10
- 8 < 10
- 6 < 8
- 4 < 6
- 2 < 4
- 0 < 2

Figure C6 Proposed Conditions Flood Depth, 100 year ARI Event

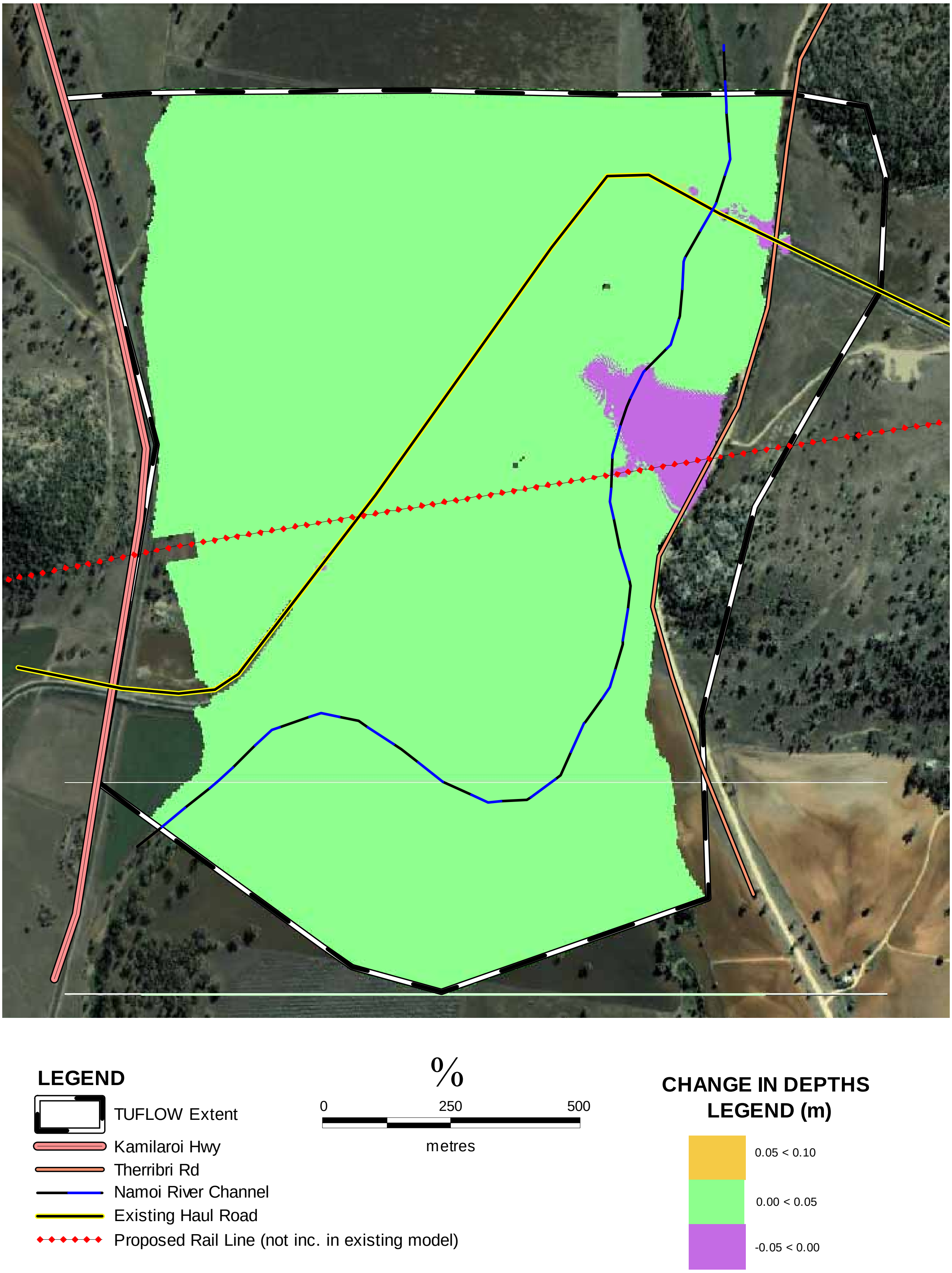


Figure C7 Change in Flood Depths, 5 year ARI Event

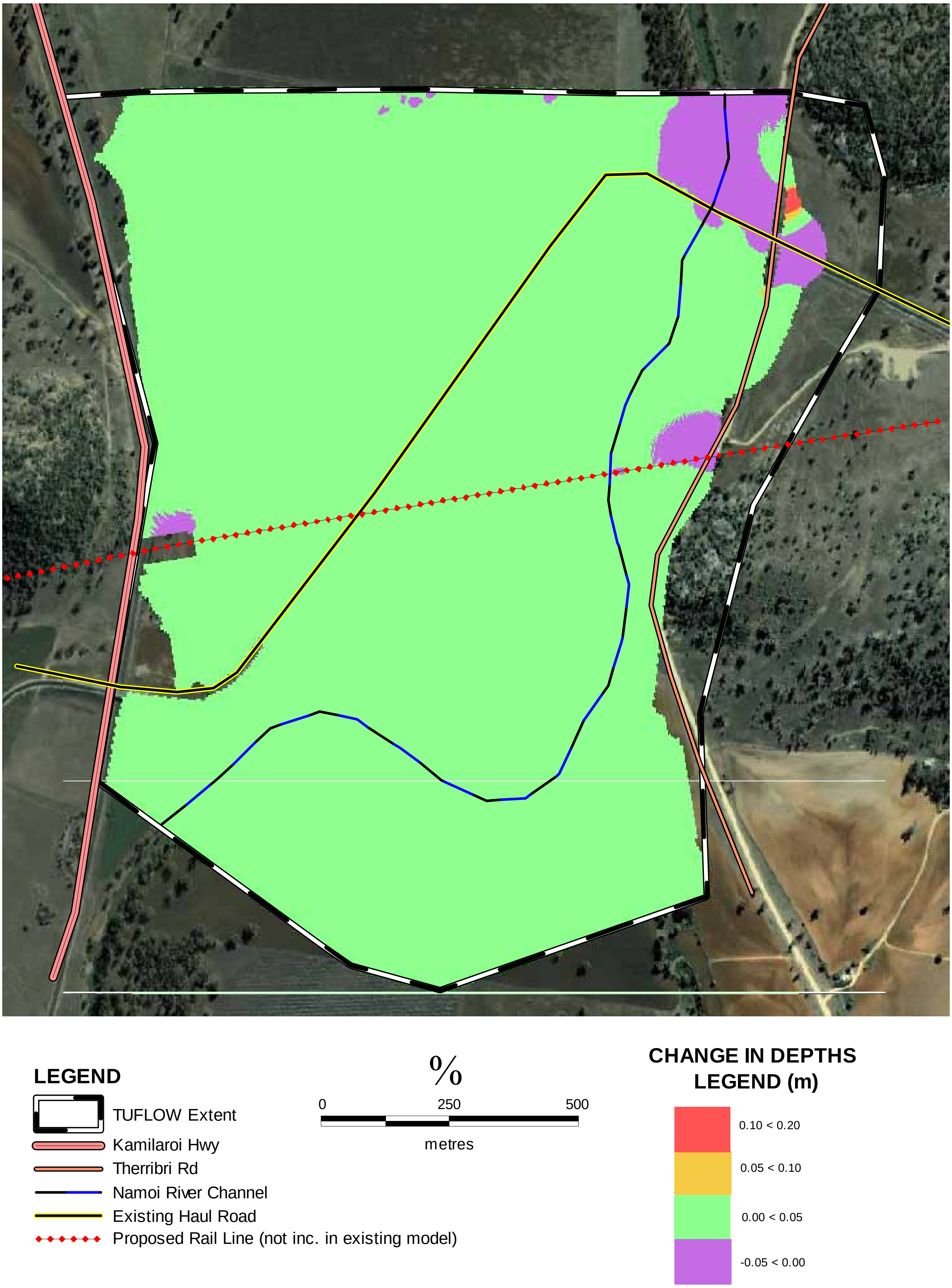


Figure C8 Change in Flood Depths, 20 year ARI Event

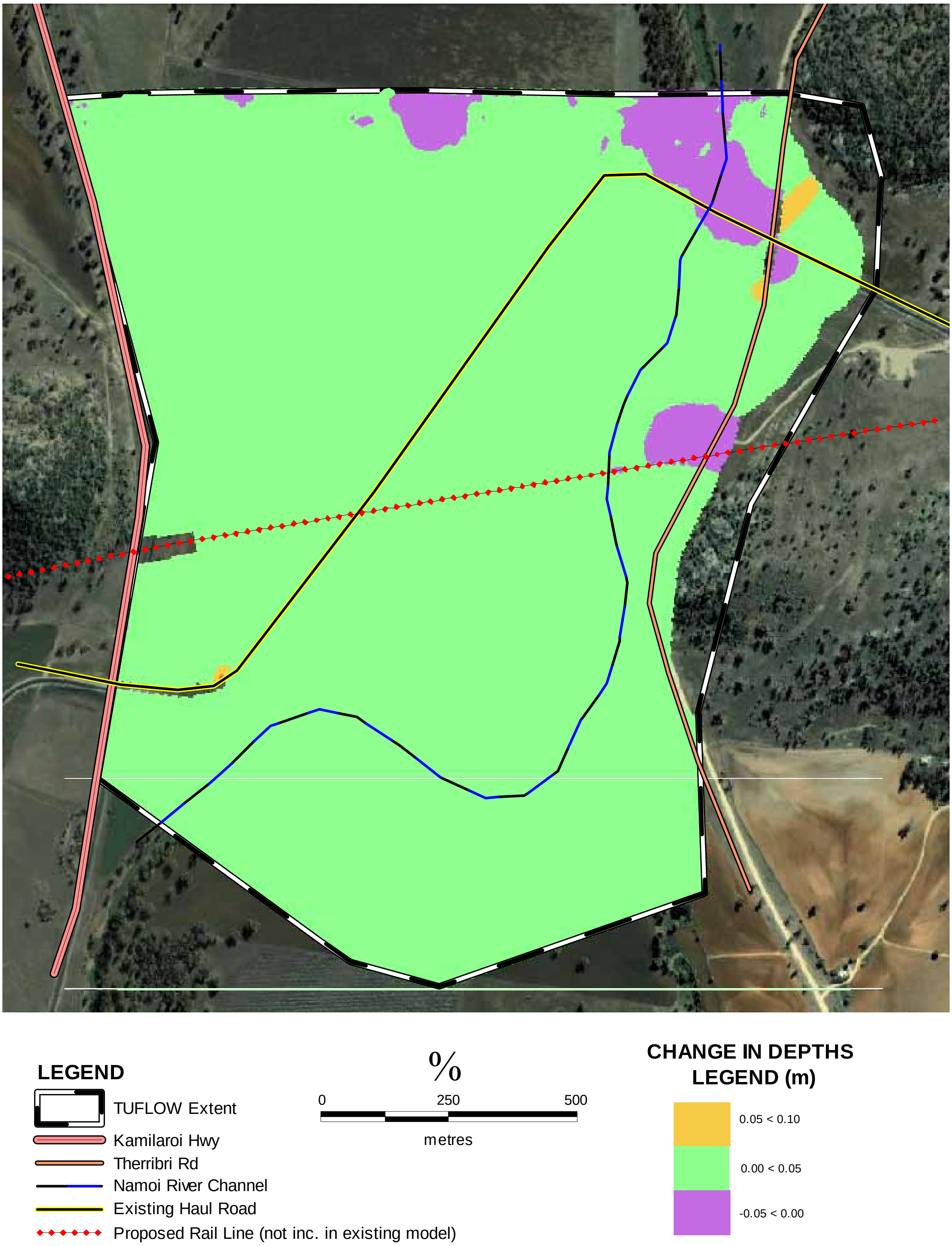


Figure C9 Change in Flood Depths, 100 year ARI Event

APPENDIX D

VELOCITIES

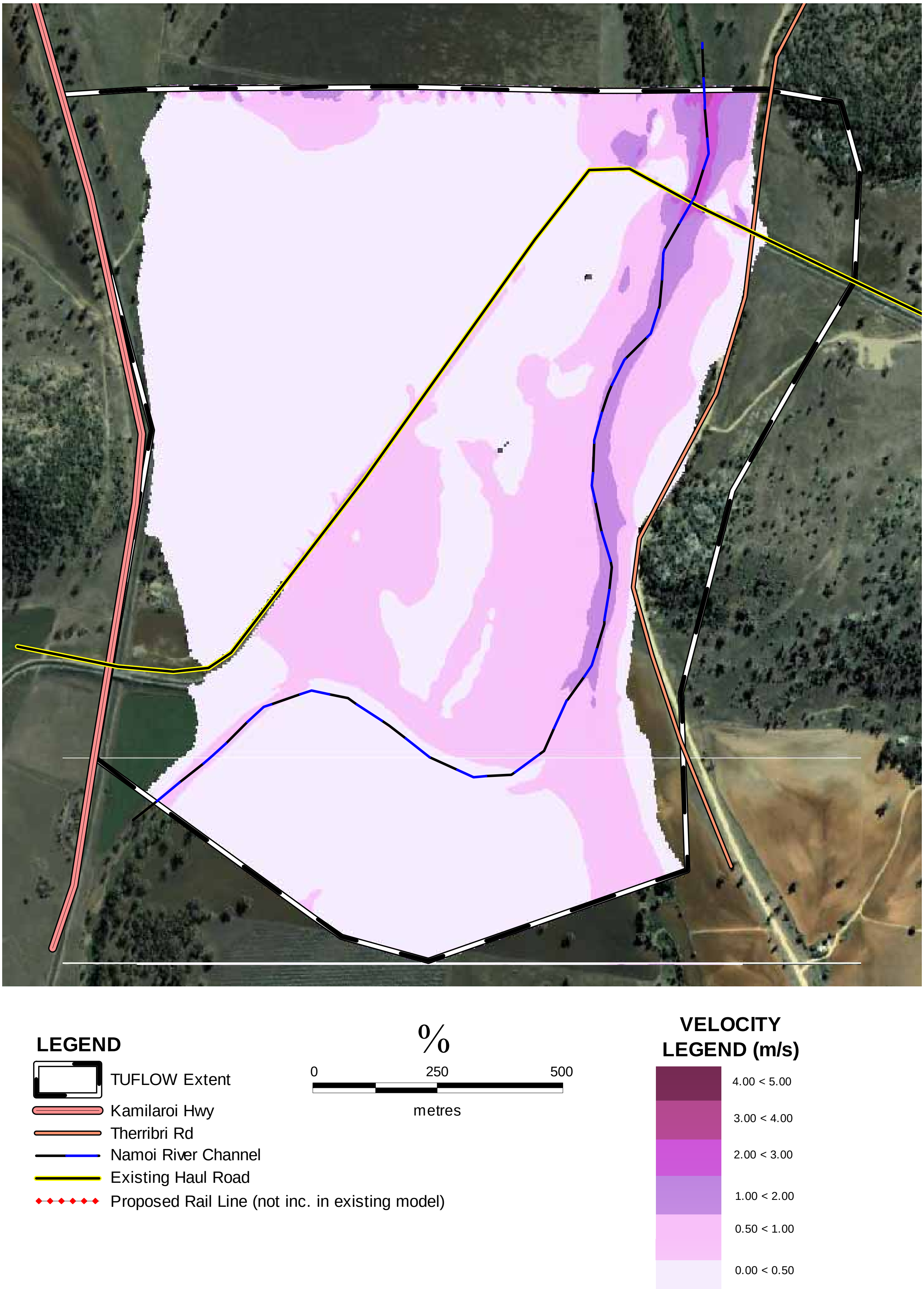
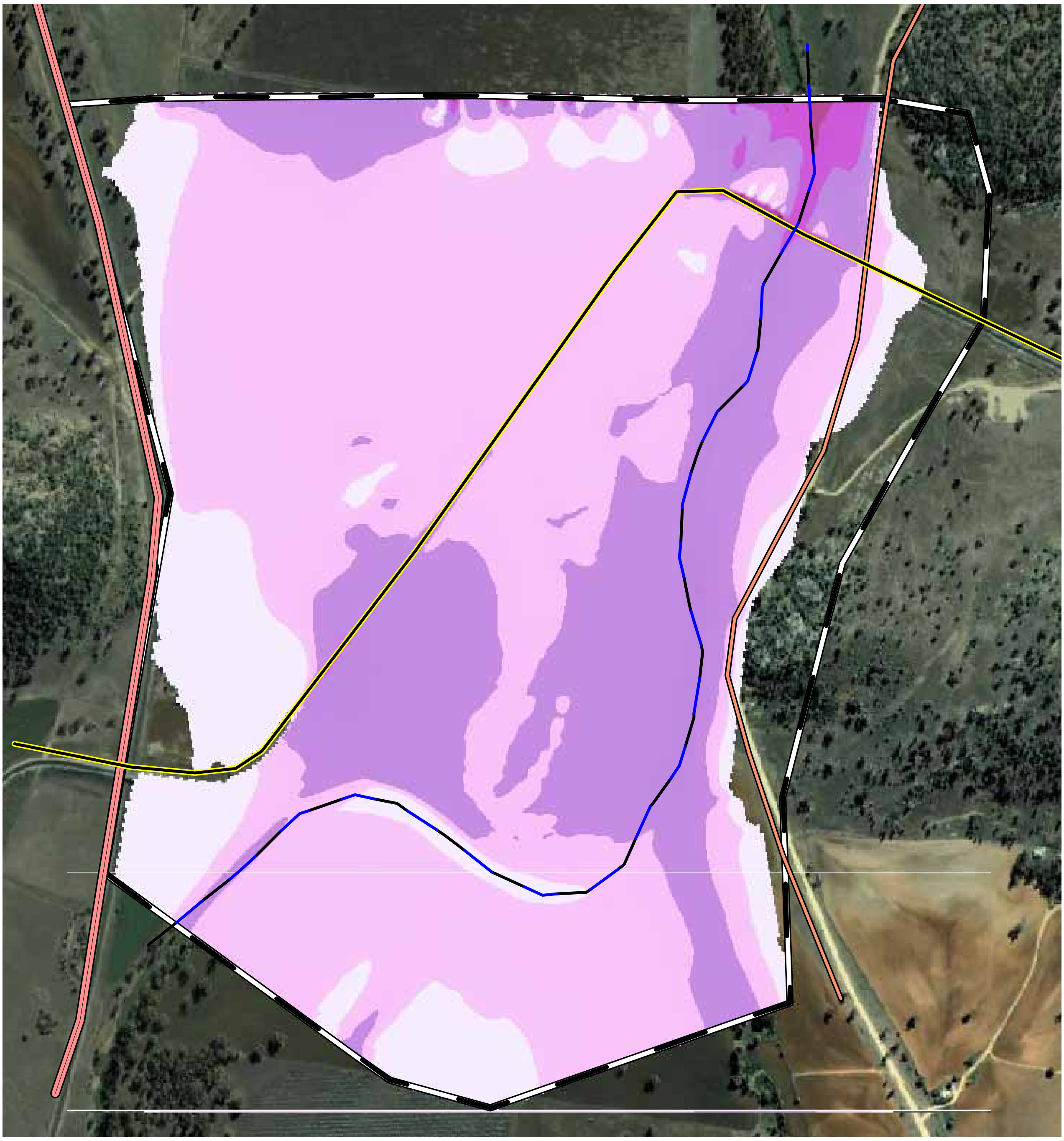


Figure D1 Existing Conditions Velocities, 5 year ARI Event



LEGEND

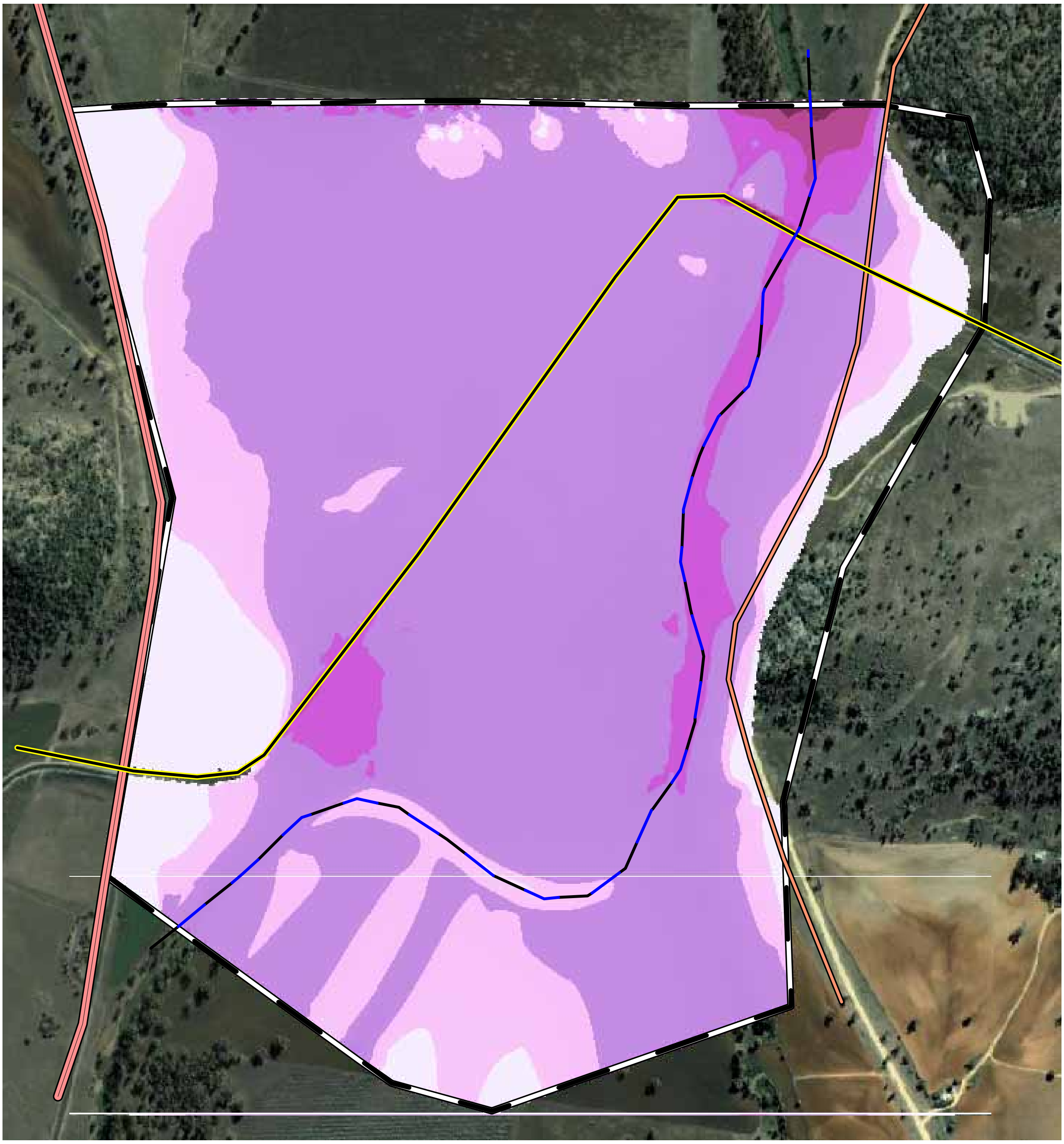
- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

VELOCITY LEGEND (m/s)

- 4.00 < 5.00
- 3.00 < 4.00
- 2.00 < 3.00
- 1.00 < 2.00
- 0.50 < 1.00
- 0.00 < 0.50

Figure D2 Existing Conditions Velocities, 20 year ARI Event



LEGEND

- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

VELOCITY LEGEND (m/s)

- 4.00 < 5.00
- 3.00 < 4.00
- 2.00 < 3.00
- 1.00 < 2.00
- 0.50 < 1.00
- 0.00 < 0.50

Figure D3 Existing Conditions Velocities, 100 year ARI Event

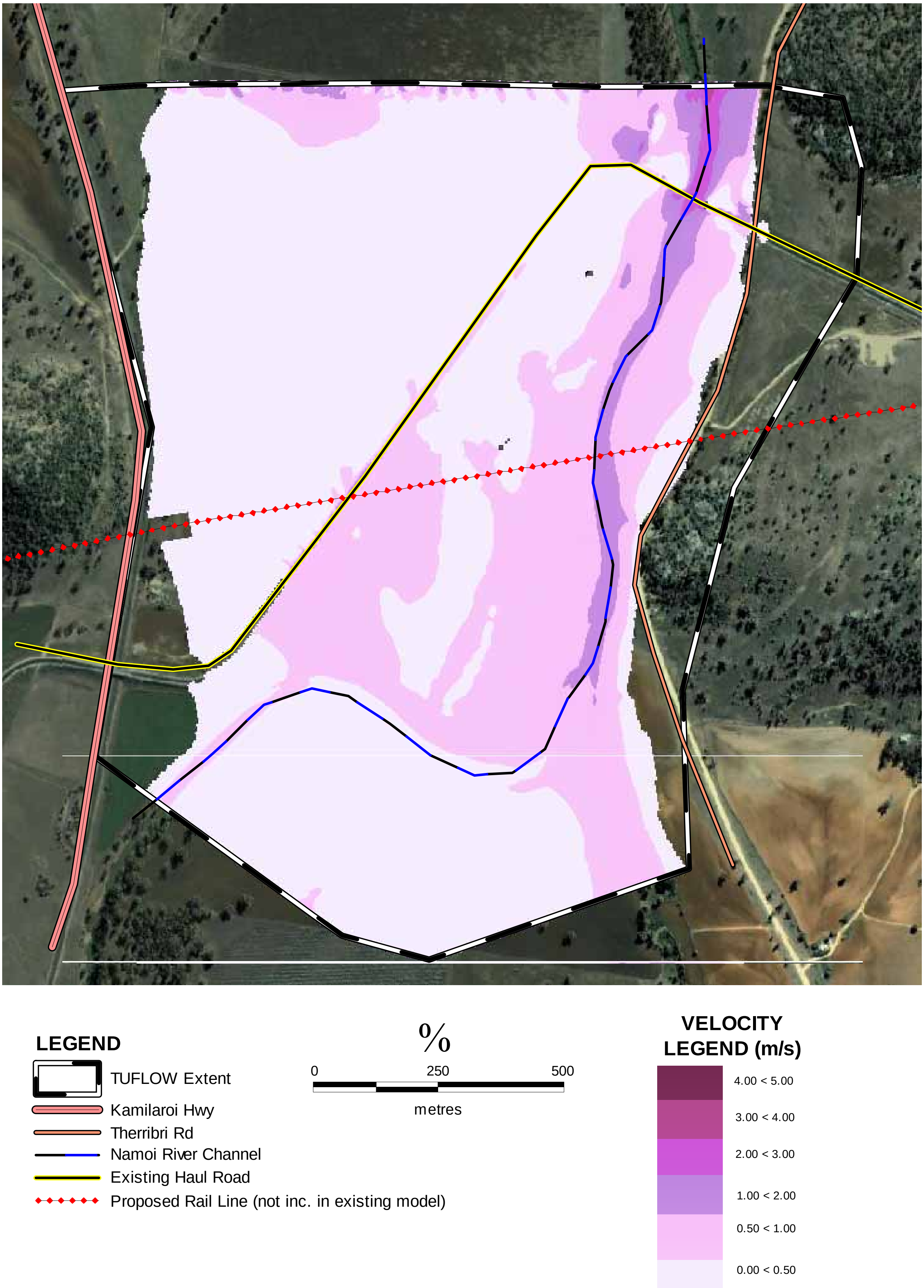


Figure D4 Proposed Conditions Velocities, 5 year ARI Event

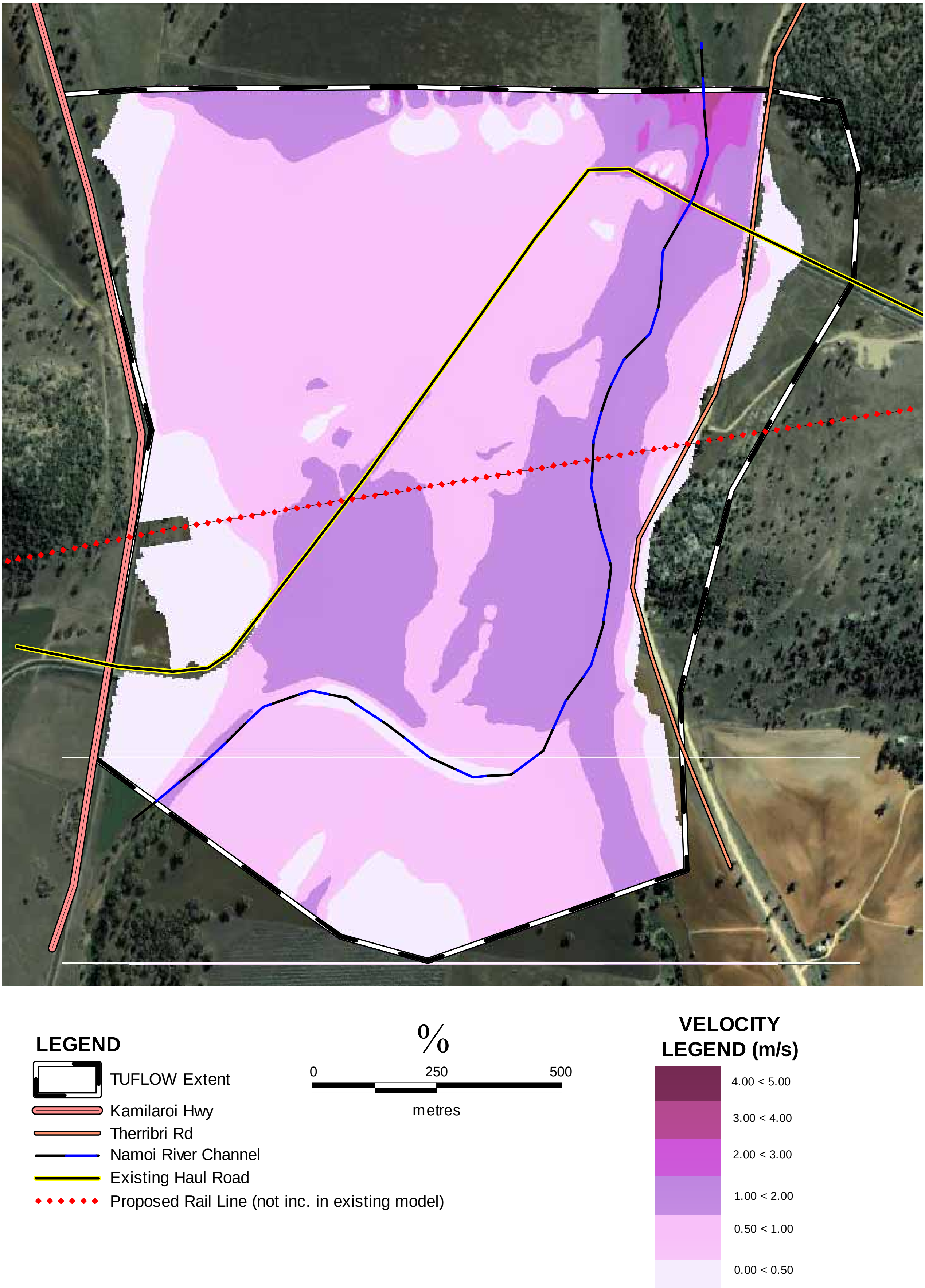
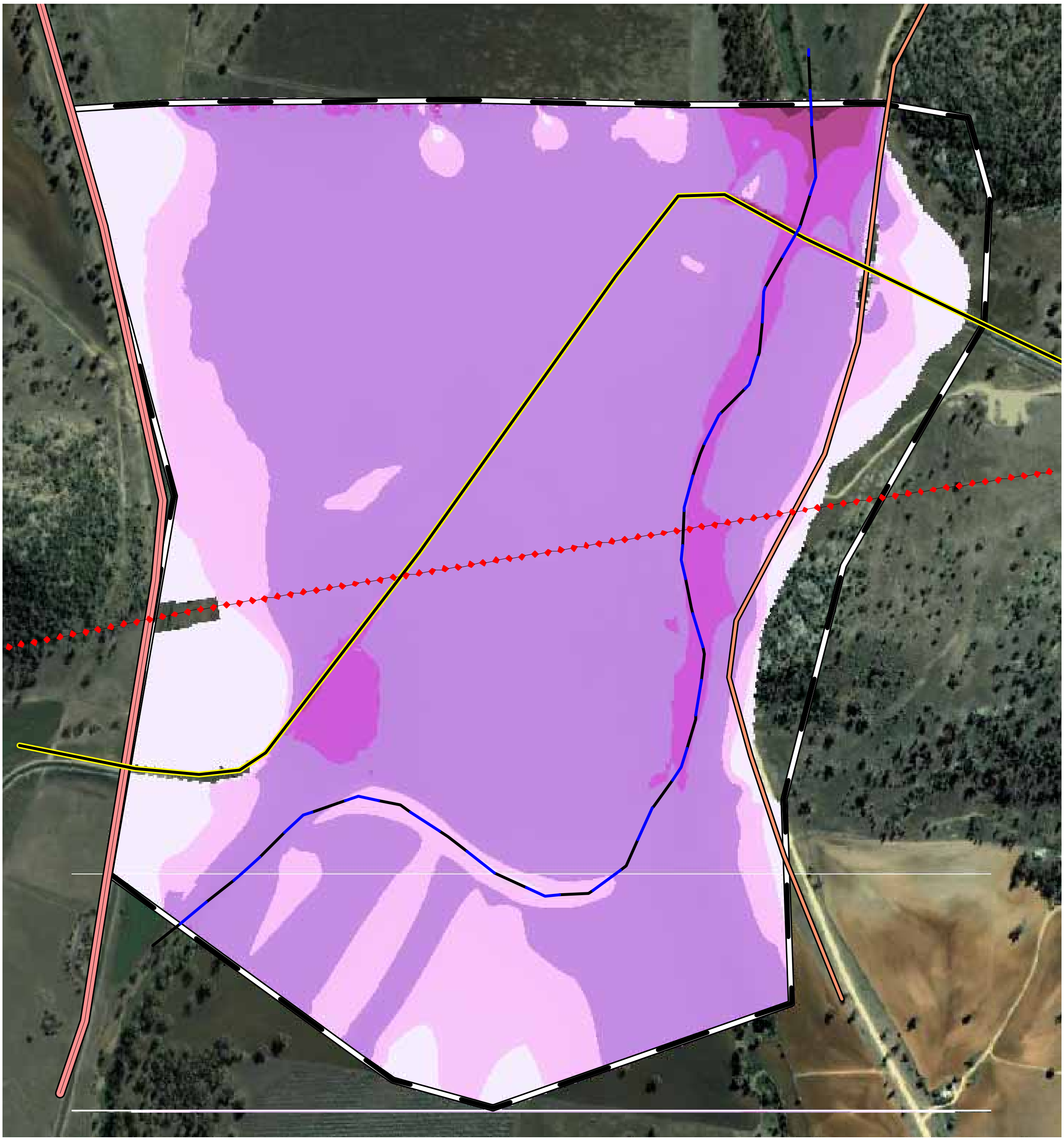


Figure D5 Proposed Conditions Velocities, 20 year ARI Event



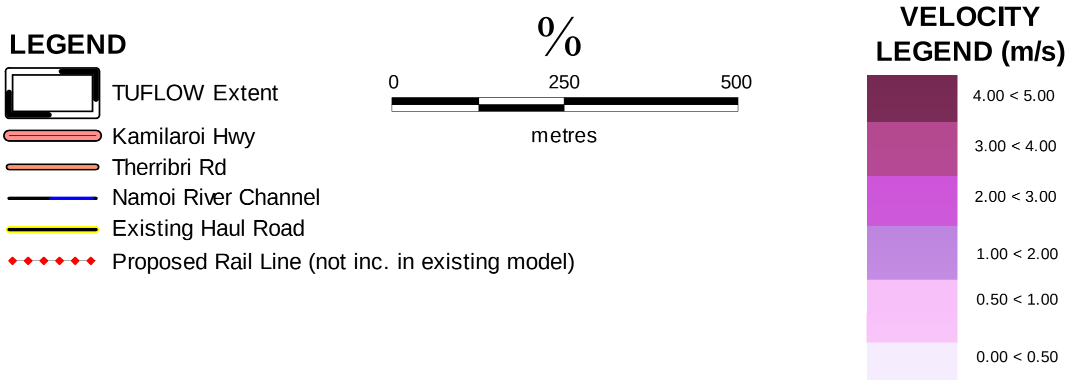


Figure D6 Proposed Conditions Velocities, 100 year ARI Event

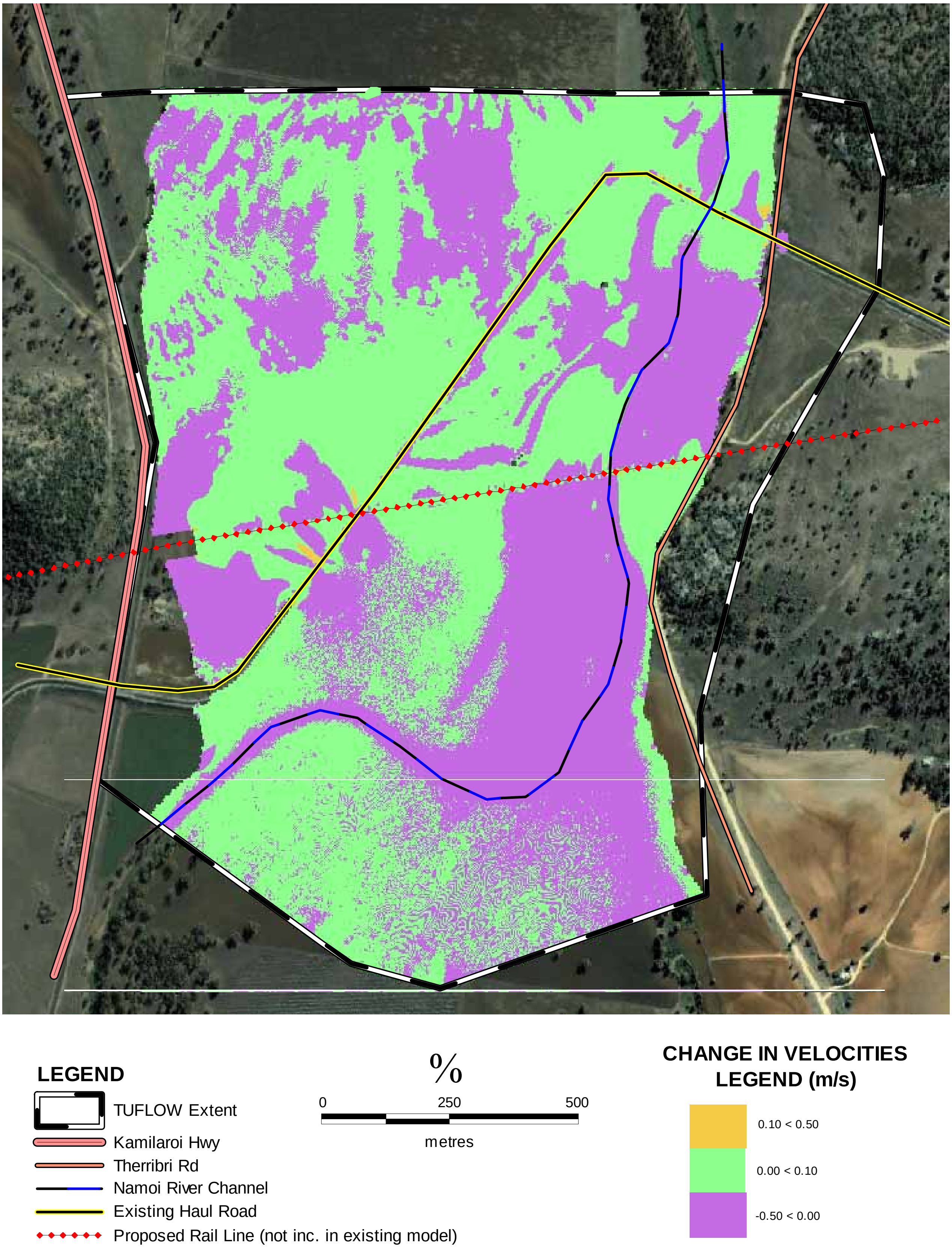
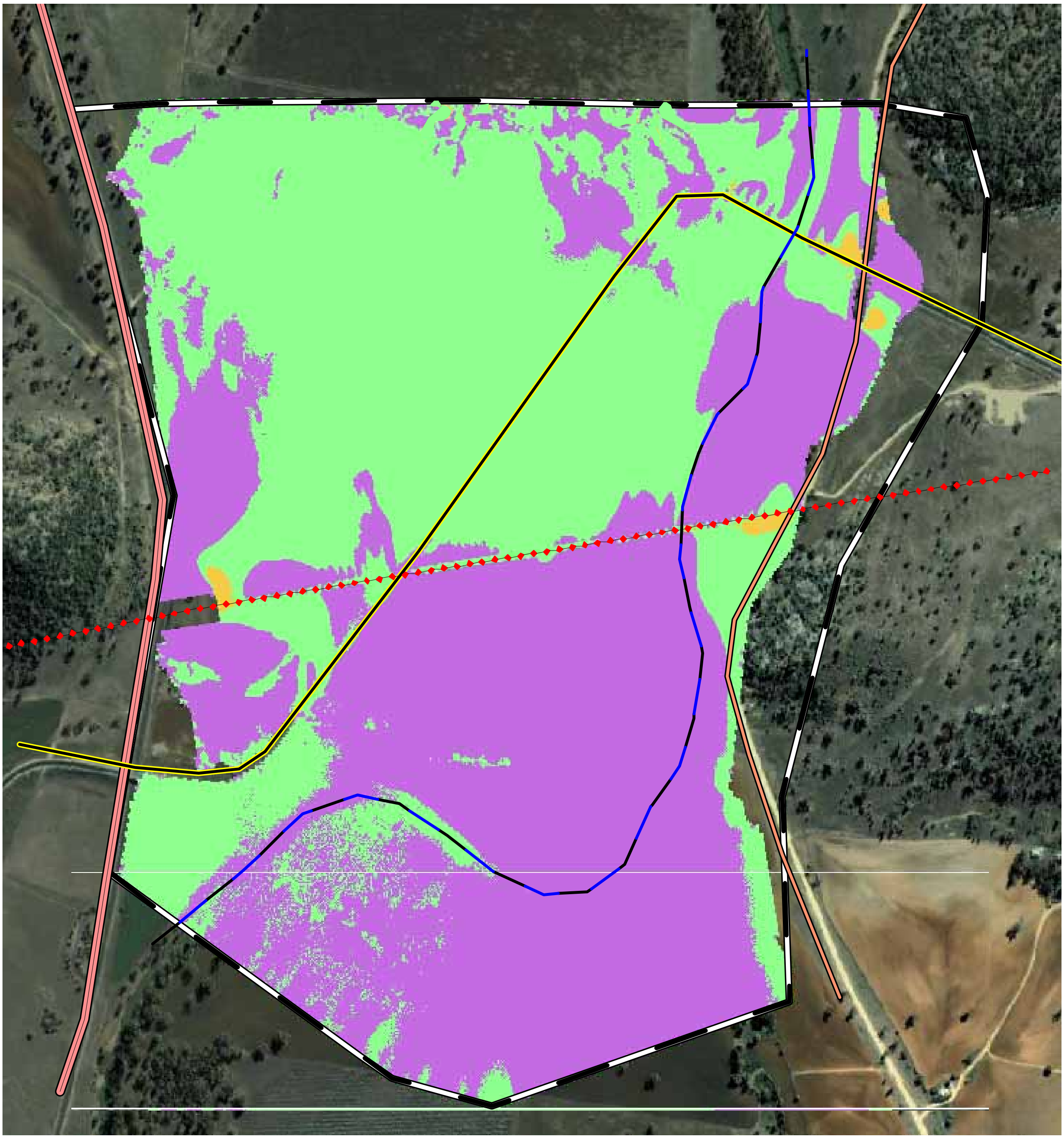


Figure D7 Change in Velocities, 5 year ARI Event



LEGEND

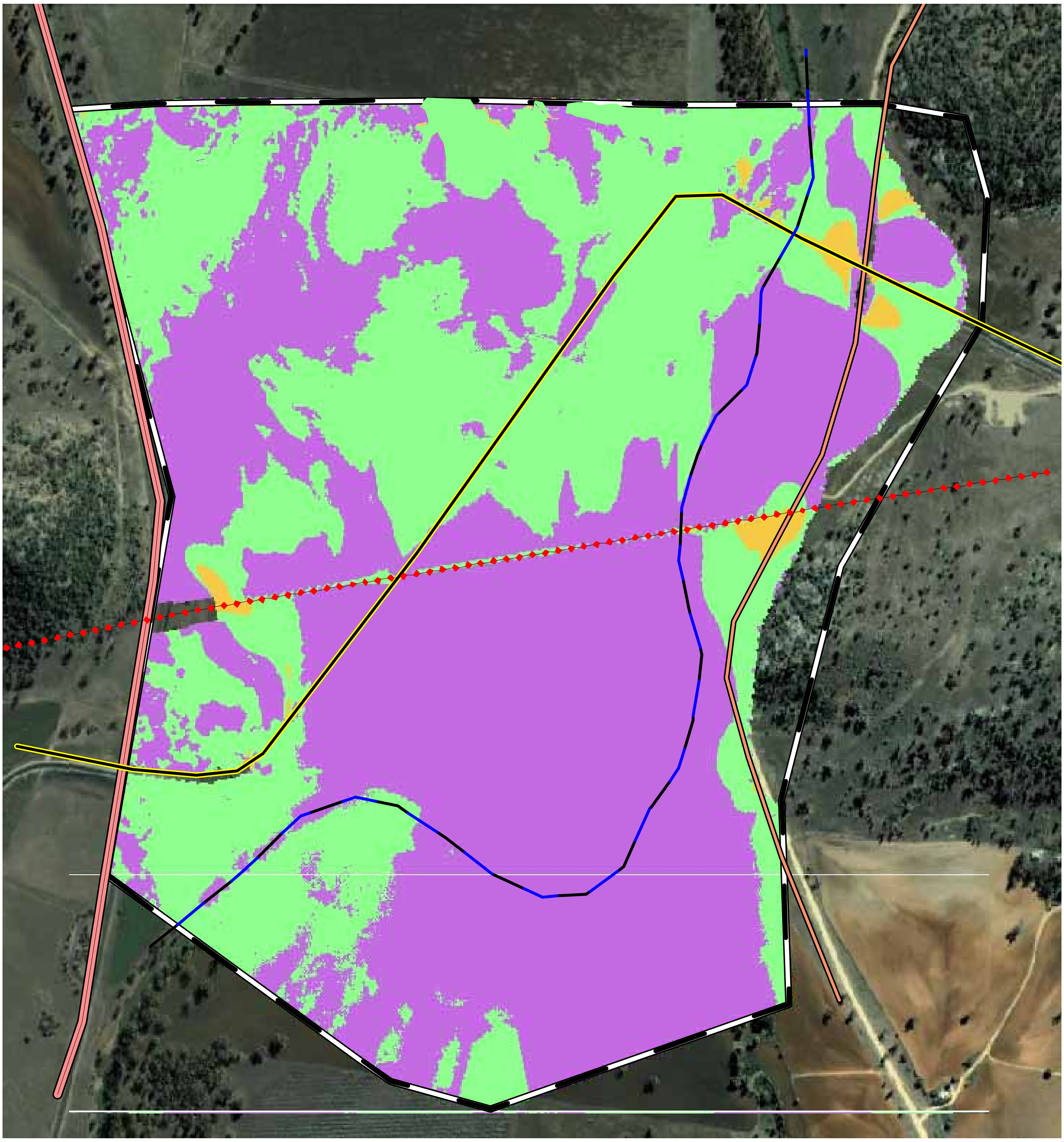
- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

CHANGE IN VELOCITIES LEGEND (m/s)

- 0.10 < 0.50
- 0.00 < 0.10
- -0.50 < 0.00

Figure D8 Change in Velocities, 20 year ARI Event



LEGEND

- TUFLOW Extent
- Kamilaroi Hwy
- Therribri Rd
- Namoi River Channel
- Existing Haul Road
- Proposed Rail Line (not inc. in existing model)

0 250 500
metres

CHANGE IN VELOCITIES LEGEND (m/s)

- 0.10 < 0.50
- 0.00 < 0.10
- -0.50 < 0.00

Figure D9 Change in Velocities, 100 year ARI Event