HYDROLOGICAL REPORT

MOUNT PIPER POWER STATION

PIPERS FLAT

Preliminary Flood Study

June 2018

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EXECUTIVE SUMMARY

Lycopodium Infrastructure Pty Ltd (Lycopodium (LIPL)) has conducted a flood study on the Proposed Pipers Flat Rail Loop and associated waterway crossing structures for the 20yr,100yr and 500yr design Annual Return Interval (ARI) flood events.

Conclusions drawn from this study are approximate and could be improved with the availability of detailed survey levels and measurements for the existing crossing structures, however, the following key points are to be highlighted from the study results:

- The adopted crossing structures are of sufficient capacity to prevent significant impact on flood levels (or hazard) outside of the site boundary for the 100 yr ARI.
- The results indicate that the adopted crossing structures and embankment exert localised, relatively low impacts on flood levels and hazard outside of the site boundary for the 500 yr ARI, with the greatest impacts concentrated upstream of the existing Irondale Creek Crossings.
- Earthworks are required at the Irondale Creek Proposed Loop Culvert location to ensure the flowpath from the Existing Rail Embankment Culvert is free draining and suitably protected from scour (rock pitching channel between the 2 crossings is recommended).
- Scour analysis is recommended at the proposed bridge and crossing structures at detailed design to determine if energy dissipators as required at crossing outlets and determine appropriate dimensions (if required).
- Some minor earthworks and/or a 900mm culvert may be required to alleviate trapped flow that bypasses the Proposed Thompsons Creek Rail Loop Bridge at the south-eastern section of the Rail Loop.
- Although the current model results should give a reasonable approximation of flood depths/levels, it would be prudent to rerun the model with detailed survey measurements for the existing crossing structures.

1.0 BACKGROUND

1.1 Introduction

Lycopodium Infrastructure Pty Ltd was requested to undertake a preliminary hydrological assessment, on behalf of the Mount Piper Power Station, to assess the impacts of a proposed Rail Loop and Coal Unloader design on the underlying floodplain. The proposed Rail Loop and Coal Unloader Design represents an alternative to a design that was previously investigated by SKM in 2007 (Figure 2). This study uses the hydrological data from the previous assessment.

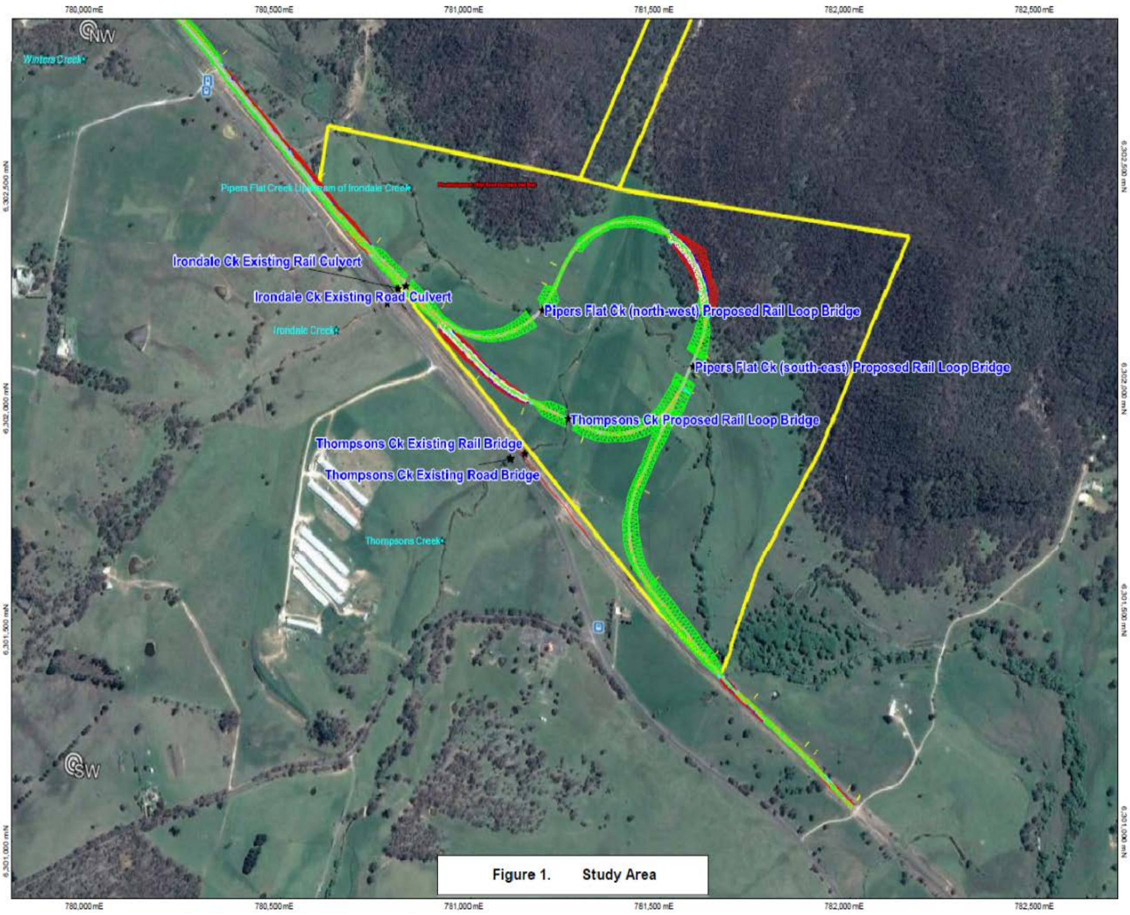


Figure 1: Plan view of project area (Site boundary shown in yellow).

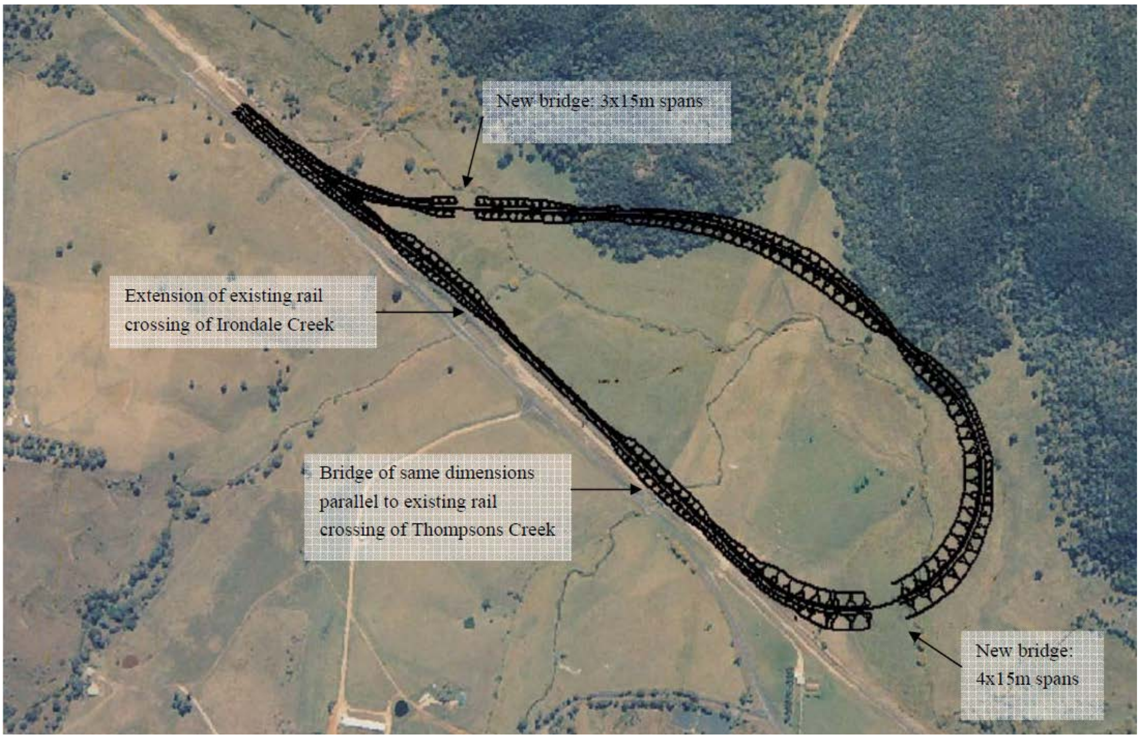


Figure 2: Previous Proposed Rail Loop (Source: SKM, 2007).

1.2 Study Area

The proposed rail loop is located on the floodplain of Pipers Flat Creek (Figure 1). The rail loop will connect to and be constructed adjacent to the existing Western Rail Line, which runs parallel to the Portland to Wallerawang access road (Pipers Flat road). Pipers Flat Creek runs in a south easterly direction adjacent to the road and rail line. The rail loop will cross Pipers Flat Creek at two locations. Two tributaries of Pipers Flat Creek (Thompsons Creek and Irondale Creek) cross the existing road and rail line and will be crossed by the rail loop. Private agricultural land lies to the west of the road and rail line.

The rail loop crosses Pipers Flat Creek at 2 locations in addition to crossing 2 western tributaries, Thompsons Creek and Irondale Creek. The main potential flood impacts of the proposed rail loop are from increased flood levels and flood extents to adjoining properties (west and north of the site) due to inadequate waterway openings. This is particularly important for the waterway crossing locations at Thompsons Creek and Irondale Creek, as afflux on these crossings has the potential to impact directly on private property. This is in contrast to afflux at the 2 Pipers Creek crossings, which will (under most likely circumstances) only affect flooding on land within the site boundary.

The existing road and rail line crossings consist of bridges and culverts across Thompsons Creek and Irondale Creek. Providing an equal or larger waterway opening for the rail loop bridges should ensure that the afflux is not increased at these locations and therefore the adjoining properties will not be impacted, at least for events less than the magnitude of flood that overtops the existing road/rail embankment. If the existing embankments are relatively low and are overtopped in relatively frequent flood events, then it is possible that the new rail loop could cause a significant flood impact for larger events. It will therefore be necessary to check flood impacts for a range of recurrence intervals.

Construction of a high embankment on the floodplain could introduce a new hazard in the event that the embankment fails, generating a dam-break flood wave. To protect downstream residents from this hazard and to protect the rail/mine infrastructure it is necessary to ensure sufficient scour protection at each bridge to avoid undermining and failure of the bridge. The embankment design and construction should also be designed to withstand the hydraulic loadings and head differences between the upstream and downstream sides of proposed earthworks. It is noted that according to information published by the Soil Conservation Service, the majority of the soils in the Lithgow City Council area have moderate to high erodibility.

2.0 OBJECTIVES

- To undertake a preliminary hydrological assessment of the proposed Pipers Flat Rail Coal Unloader in relation to the Pipers Flat floodplain.
- To estimate flood levels of relevance to the design of the rail loop and associated infrastructure.
- To provide a quantitative assessment of the potential impact of the proposed Rail Loop Design on flood levels external to the project property boundary.

3.0 RECOMMENDED STANDARDS

The following standards from the Country Regional Network and Lithgow Council were reviewed to determine appropriate design standards for the proposed Mt Piper rail loop:

1. CRN CS 420 Track Drainage, Version 1.1 June 2016
2. CRN CS 410 Formation and Earthworks, Version 1.1 June 2016
3. CRN CM 421 Track Drainage, Version 1.1 July 2016
4. Lithgow Council Guidelines for Civil Engineering Design and Construction for Development, February 2012

The CRN standards primarily target drainage design and were not specifically prepared to address broader flooding issues. The Lithgow standards primarily address the design of subdivisions and roads, but the principles can be equally applied to rail lines.

3.1 CRN Standards

Flood Design Standard

Drainage components should be designed for the following storm events:

Track Class	Average Recurrence Interval – ARI (Years)
1	50
2	25
3/3g	10
5	5

Matters to be addressed in design of Earth Embankments

Embankment designs should consider the following items:

- Drainage issues and impacts for adjoining properties
- Surface and subsoils drainage
- Prevention and mitigation of erosion and siltation

Design Flood Levels

Where the track is on a flood plain, the formation level shall be designed so that it is not overtopped in a 1 in 100 year flood, subject to environmental impact assessment in accordance with legislation and assessment of the impact of potential flooding on earthworks and other structures.

3.2 Lithgow Council Standards

General Design Principle

The function of drainage is to capture surface runoff from the design storm event, and safely convey it to an approved reserve or receiving waters with minimal damage, danger and nuisance to life, property and the environment.

Flood Design Standard

- Arterial Road – cross drainage (culverts): 50 year ARI
- Bridges – major structures 100 year ARI with 500 mm freeboard

Adjacent Properties

Major system drainage designs shall aim at controlling flood flows so that the severity of flooding downstream, and afflux upstream, is not increased.

Consideration must be given to the effect of floods greater than the design flood, and in no circumstances should the design create conditions where the capacity of the downstream drainage system is exceeded.

Where stormwater discharge is concentrated onto other property, and/or works are necessary on the other property, it is the responsibility of the developer to make appropriate arrangements and provide Council with a copy of the owner's consent, prior to the release of a construction certificate for the works.

Energy Dissipaters

It may be necessary to provide energy dissipating devices on stormwater outlet structures, to minimise the effect of erosion.

4.0 FLOOD MODEL METHODOLOGY

A combined 1D/2D XP Storm hydraulic model (applying the TUFLOW 2D flow calculation engine) was established for the study area. A 1m x 1m grid cell resolution Digital Terrain Model (DTM) was derived from a combination of LiDAR, the proposed Rail Loop design earthworks TIN (Triangulated Irregular Network) and available field survey data points. This surface was, where necessary, adjusted with the field survey data points and used to define the 1D channel cross sections at the proposed Rail Loop bridge locations. A 5m x 5m grid cell resolution Digital Terrain Model (DTM) was similarly derived for 2D flow calculations across the broader floodplain area. Digital Terrain Model (DTM) grid was used for modelling of flow across the 2D domain. All identified crossing locations (bridges and culverts) were modelled in 1D for improved accuracy of results.

The hydrology modelling of the previous flood study (SKM, 2007) was reviewed and considered valid for reuse in the current hydraulic flood model (See Inflow Boundaries below). At the time of this study, detailed survey data for the existing rail and road crossings was not available. Culvert invert/obvert levels, bridge soffit levels, top of road, top of existing rail formation and other hydraulic parameters were estimated based on the site photos, LiDAR and field observations from SKM (2007). For this reason it should be noted that the reliability of the flood modelling results, particularly west of the existing road and rail, may be impacted by these assumptions and estimations.

The model was run for both pre and post development stages for storm events equivalent to the 20, 100 and 500yr Average Recurrence Intervals (ARI's). The requested scope of this report required only the100yr ARI scenario to be analysed in detail.

4.1 Model Boundary Conditions

Boundary conditions applied are as follows:

Downstream Boundary:

- A downstream constant-head hydraulic boundary condition of 904m was applied approximately 570m downstream of the Pipers Flat Creek Proposed Rail Bridge.
- This equates to a flow depth generally between 0.5-1m across the floodplain, which is typical of the range of predevelopment peak 100yr depth results upstream of the boundary for non-channelized areas the floodplain.
- The boundary condition was considered to be of sufficient distance downstream to have negligible impact on flow results within the study area.

Inflow Boundaries:

- Inflow hydrographs were taken from the RORB hydrological model developed during the previous flood study (SKM, 2007).

- Inflow hydrographs for the Thompsons Creek, Irondale Creek and Pipers Flat Upstream of Irondale Creek catchments (as described in SKM (2007)) were applied as model boundary inputs.

4.2 Model Parameters

Details of the key parameters applied in the hydraulic model are listed below:

Manning n

- A global Manning n of 0.05 was applied across the 2D model domain due to the study site being located in a predominantly tall grass pasture environment.
- An independent Manning n was not applied to the main creek channel due to its negligible size and conveyance capacity relative to the broader floodplain, and due to the focus of this study being on predominantly extreme events.
- A Manning n of 0.03 was applied to the channels at the bridge/culvert crossings.
- A Manning n of 0.013 and 0.016 was applied to concrete box and brick culvert conduits respectively.

Energy loss

- Entry and exit loss coefficients of 0.5 and 1 were applied to bridge and culvert crossings.
- A weir Discharge coefficient of 1.66 was considered suitable for sections of rail and road during overtopping.

4.3 Model Limitations

The limitations of the model are stipulated below:

- The model has been established to demonstrate the pre and post design flood impact from the broader regional catchment runoff. It has not been designed for the purpose of modelling minor drainage structures such as may be required on the north side of the rail loop.
- Detailed survey data for the existing crossings was not available at the time of this study and has been coarsely estimated as follows:
    - Top of rail/top of road crossing levels and channel inverts were estimated from raw LiDAR data provided.
    - Bridge/culvert soffit/obvert levels were estimated from the top of road and top of rail raw LiDAR data points, the dimensions/measurements of crossings provided in SKM (2007) and site photos and the provided post-design Rail TIN.
    - Flood model results presented in this report are sensitive to the accuracy of these estimations.
- The above estimations are expected to reduce the certainty of “absolute” modelled flood depths and extents, particularly west of the existing rail line, but the model should provide a reasonable indication of the risk (if any) of the proposed design to result in increased flood depth/extent at this location.

- The model is un-calibrated due to the absence of relevant stream gauging and flood level data. However, this is common for local scale flood models and does not nullify their value for assessing the potential impact of proposed works.

4.4 Model Calibration

The model is un-calibrated due to absence of suitable data, however, a comparison between the previous SKM and current Lycopodium models was undertaken for the pre-development 100yr flood extents and levels, and a close match was observed (Figure 3).

5.0 RESULTS AND DISCUSSION

Flood modelling results for 100yr ARI are presented in Figure 4 to Figure 10, Table 1 & Table 2.
Key results for the 20yr & 500yr ARI's are presented in the Appendices of this report.

The adopted crossing structures are of sufficient capacity to prevent significant impact on flood levels (or hazard) outside of the site boundary for the 100 yr ARI. Both road bridges are just overtopped in the 100 yr ARI event, but the rail embankments are all well above the 100 yr ARI flood. The flood level difference map of Figure 6 shows that flood level impacts are essentially confined to the site in the 100 yr ARI event. Flood levels immediately upstream of the Irondale Creek road bridge increase by 10 mm and flood levels immediately upstream of the Thompsons Creek road bridge increase by 20 mm in the 100 yr ARI event. In both cases the flood level increase reduces to zero a short distance upstream of the road. A significant elevation drop (~2m) in the Thompsons Creek channel between the Existing Road Crossing and the Proposed Rail Loop Bridge has helped contain flood extent increase within the site boundary
The flow capacity of the proposed crossing structures was also sufficient to maintain moderately low flood impacts outside of the site boundary in the 500 yr ARI. Flood map results for the 500yr ARI can be found in the Appendices of this report. Flood levels immediately upstream of the Irondale Creek road bridge were found to increase by 120 mm and flood levels immediately upstream of the Thompsons Creek road bridge increased by 20 mm in the 500 yr ARI event. Larger ARI events than the 1 in 500 year were not modelled as part of this study.

Local scour protection may be required to protect the bridge abutments and the downstream channel reaches. Scour assessment of the final design is recommended to determine rock pitching requirements and to determine requirement for and sizing of energy dissipators at crossing outlets.

A sill/mound of elevated ground was noted in the predesign DTM (and raw survey data) approximately 20m downstream of the existing Irondale Creek Rail Culvert outlet (Figure 11). This approximately 0.8m (height) channel obstruction is located just downstream of a scour hole at the outlet of the Irondale Creek Existing Rail Culvert. This mound is likely the result of deposition of suspended sediment caused by the sudden deceleration of flow exiting the rail crossing into the floodplain, including re-deposition of sediment from the scour hole. In this case the bridge has concentrated flow and increased velocities through the structure creating supercritical flows through the structure and the formation of a hydraulic jump downstream of the structure. Hydraulic jumps are very turbulent and this is what has generated the scour hole. It will be necessary to reshape this area, line the channel and it may be necessary to construct an energy dissipator downstream of the new rail loop culvert at this location.

Flow velocities for the crossing outlets are provided in Table 2.

The 100yr and 500yr flood maps indicate that, for these ARI's, some flow overtops the floodplain at the Proposed Thompsons Creek Rail Loop Bridge and becomes trapped between the 2 converging rail embankments to the east. This does not occur for the 20 year ARI. This overflow has the potential to cause some minor scour at the toe of the embankment directly east of the proposed bridge crossing and will result in significant ponding. It may be desirable to either fill the trapped area or, prevent the overflow with a ~25m length of flood levee of 1-2m height and accept some ponding from local runoff, or install a single 900mm culvert (with suitable outlet apron).

The reported 100yr flow level estimates presented should be checked against the final rail design top of formation and proposed bridge deck levels and other flood sensitive infrastructure to ensure suitable freeboard is achieved in final design. Geotechnical advice should be sought to verify the modelled flood levels to not result in head differentials that exceed the hydraulic loading capacity for the available embankment construction fill material and proposed compaction method.

2 parallel bands of deep water can be seen in the 100 year flood depth map approximately 70m and 100m north of the main Pipers Flat Creek channel at the Pipers Flat Creek (north-west) Proposed Rail Loop Bridge location. These represent secondary flow channels that may result in some ponding of water against the rail embankment at these locations. Some minor fill or a gully drain may be required at the embankment toe.

It should be noted that the currently adopted bridge design for the 2 Pipers Flat Creek Proposed Rail Loop Bridges provides roughly equivalent cross section flow width compared to the 3x15m and 4x 15m bridge spans recommended in the SKM (2007) flood study for the previous rail loop design.

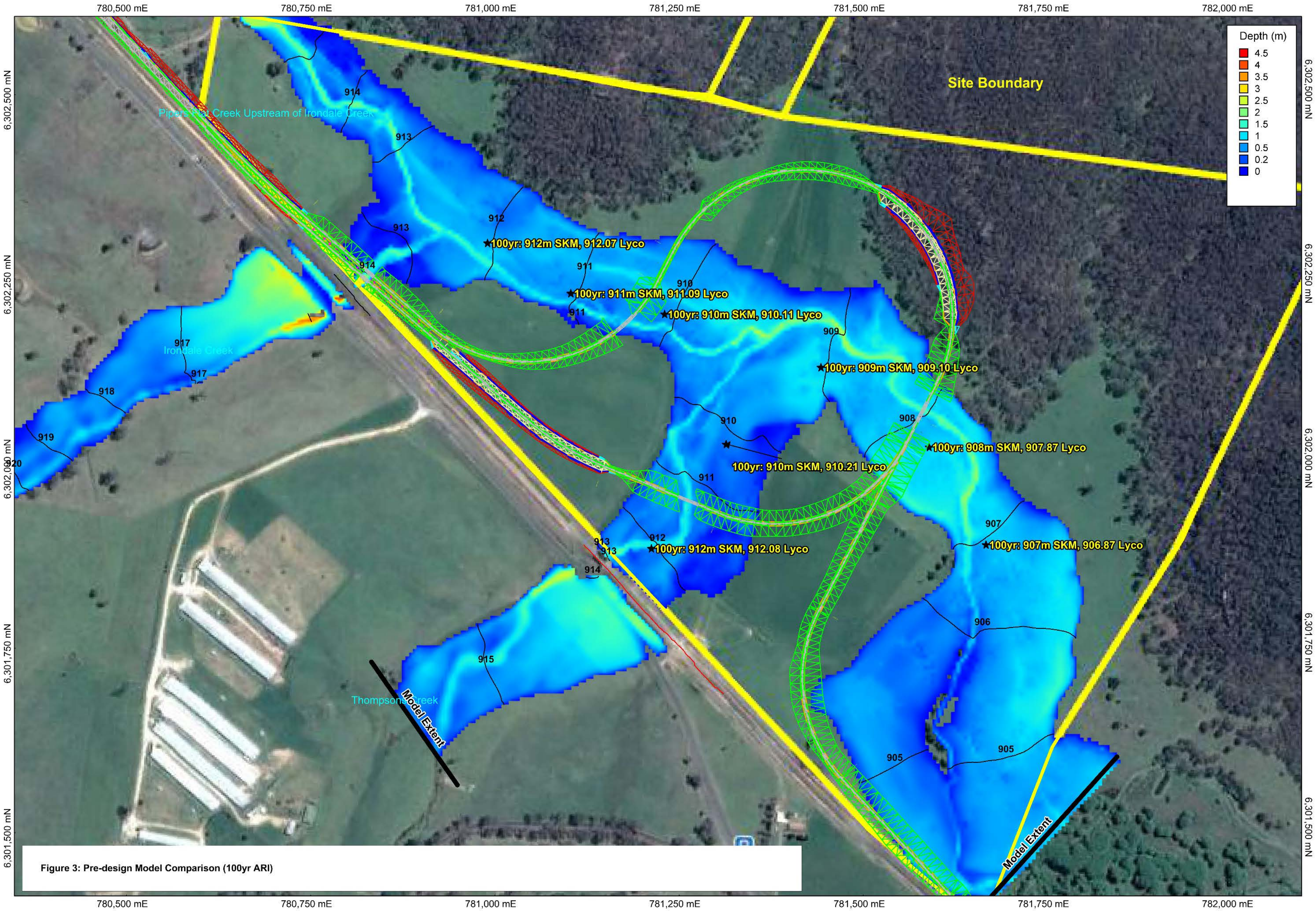


Figure 3: Pre-design model comparison

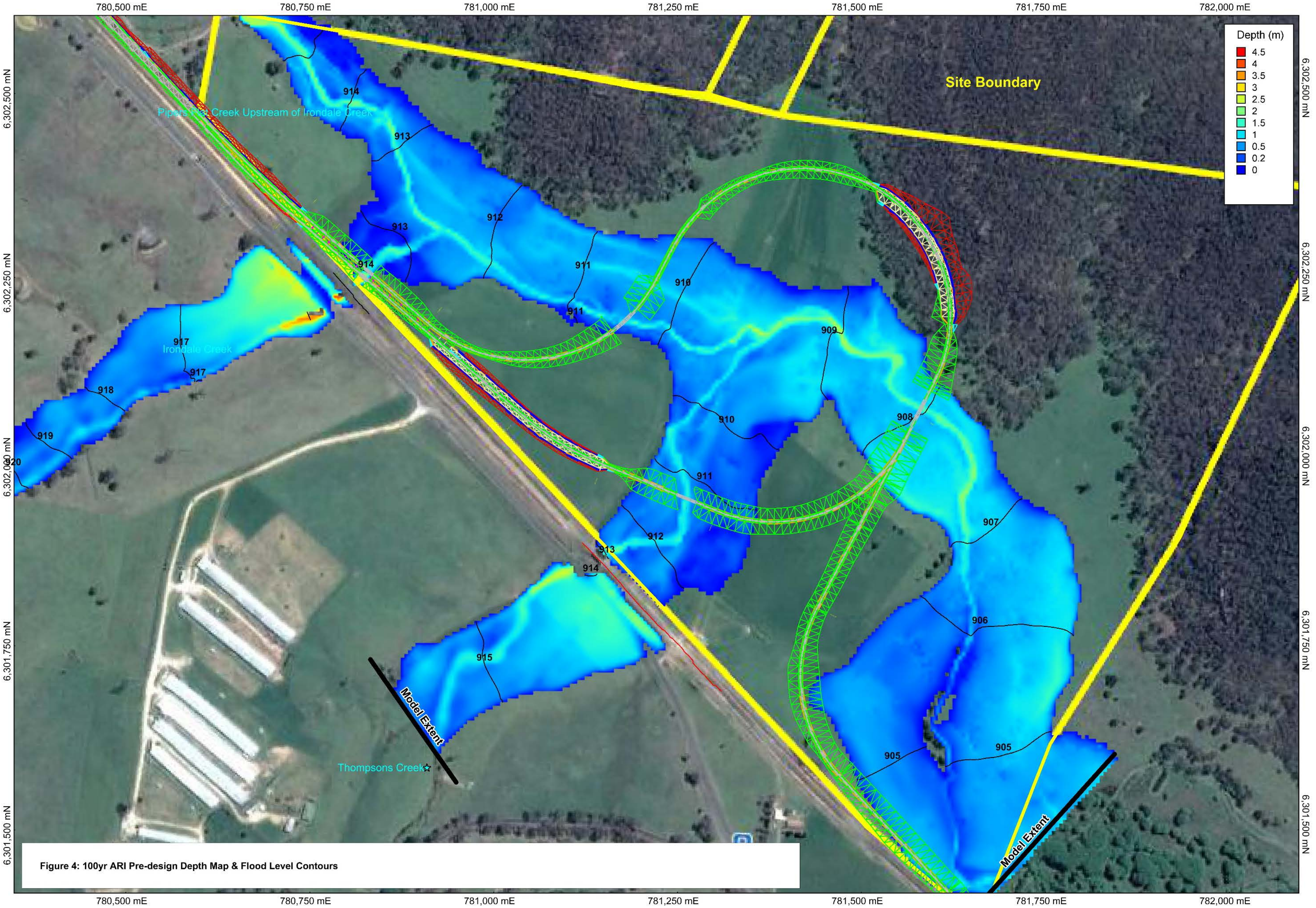


Figure 4: 100yr ARI Pre-design Depth Map & Flood Level Contours

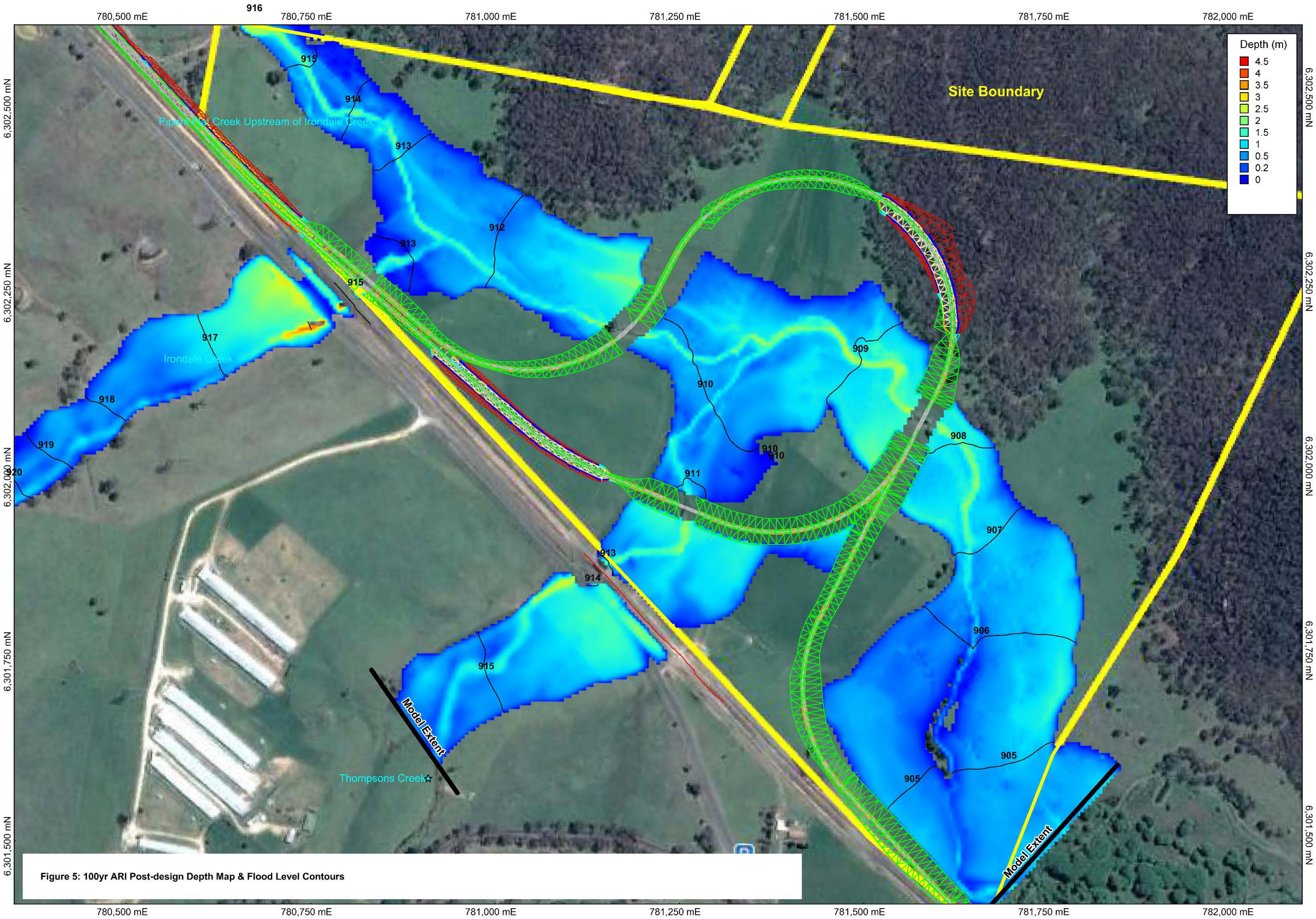


Figure 5: 100yr ARI Post-design Depth Map & Flood Level Contours

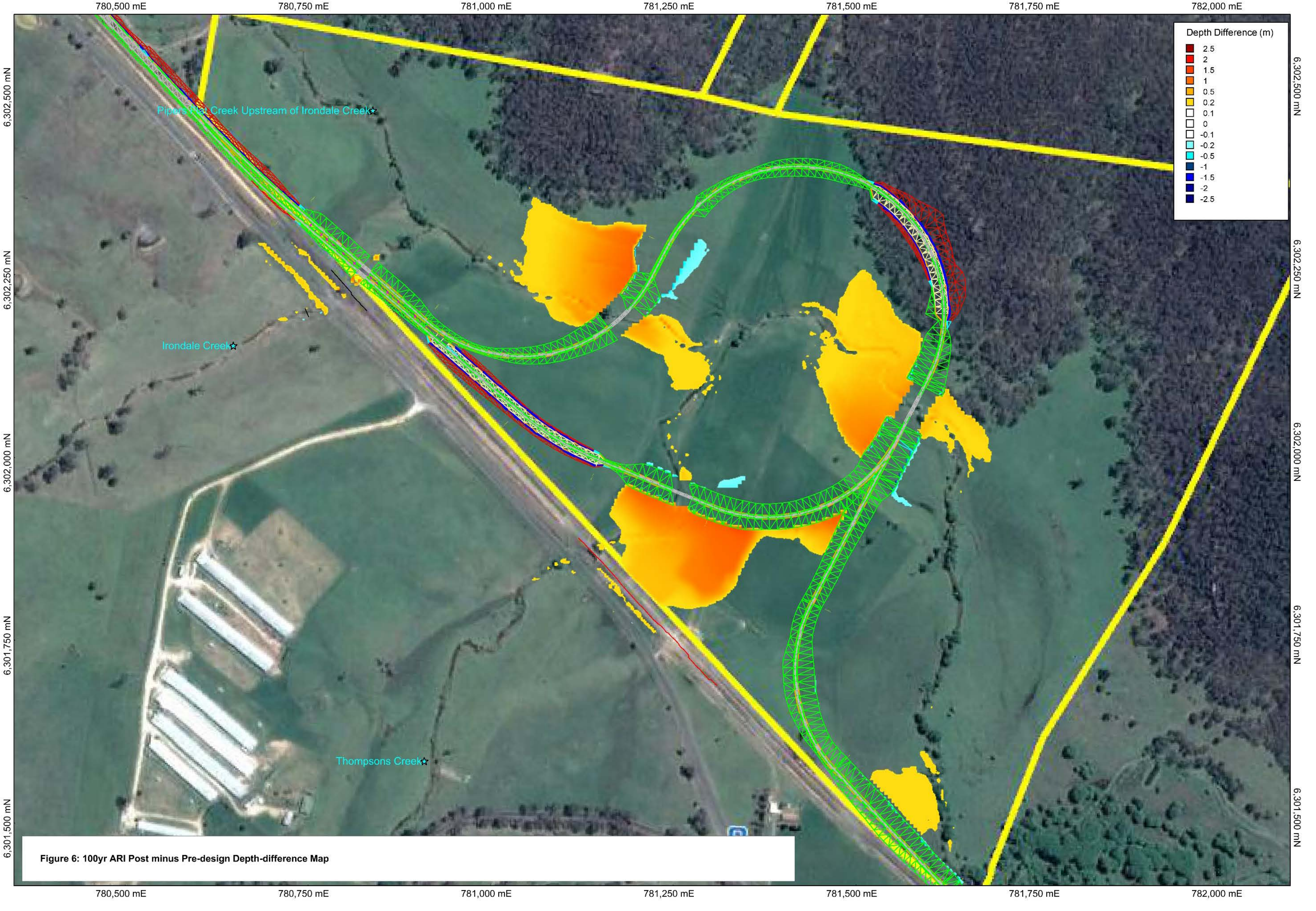


Figure 6: 100yr ARI Post minus Pre-design Depth-difference Map

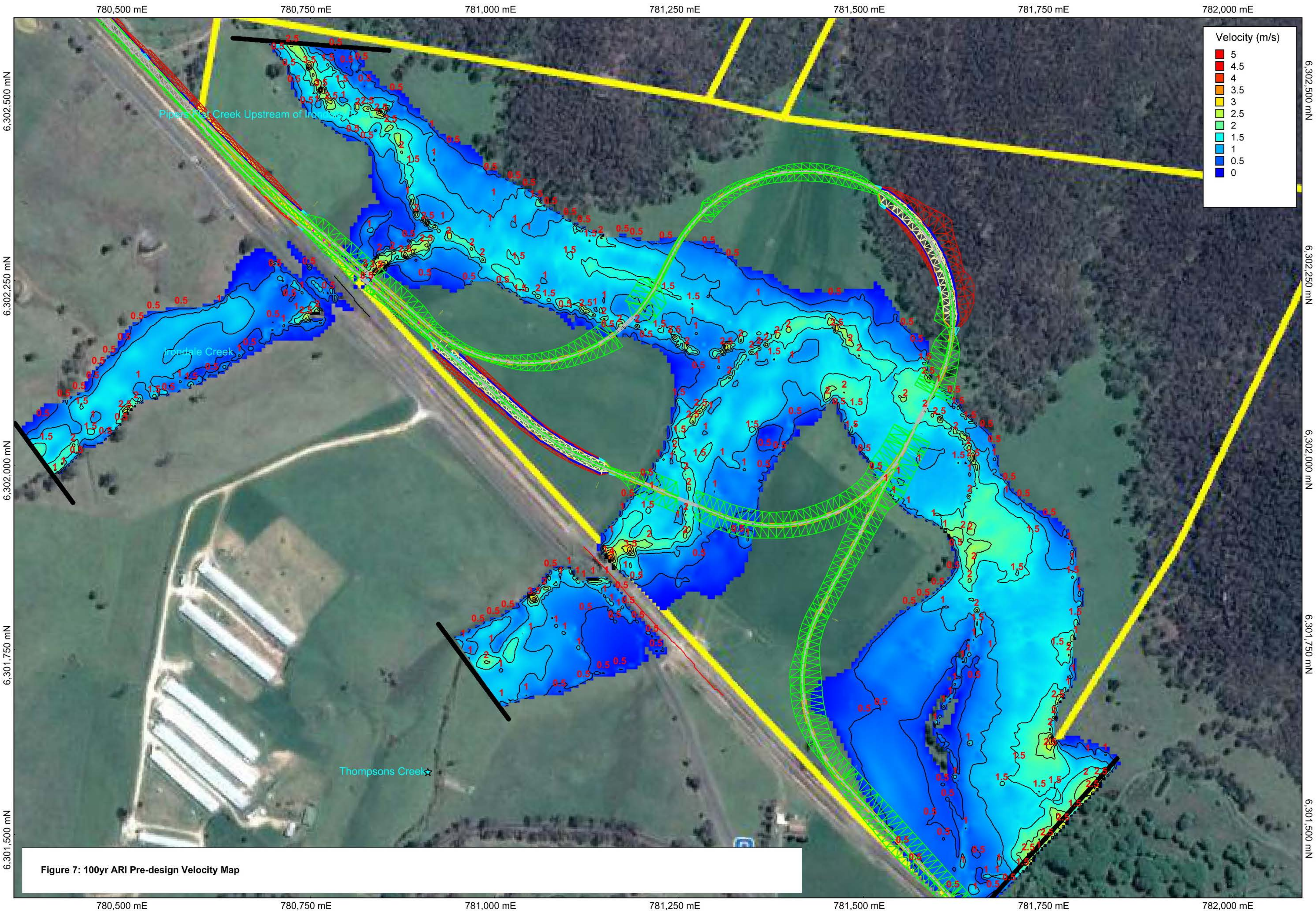


Figure 7: 100yr ARI Pre-design Velocity Map

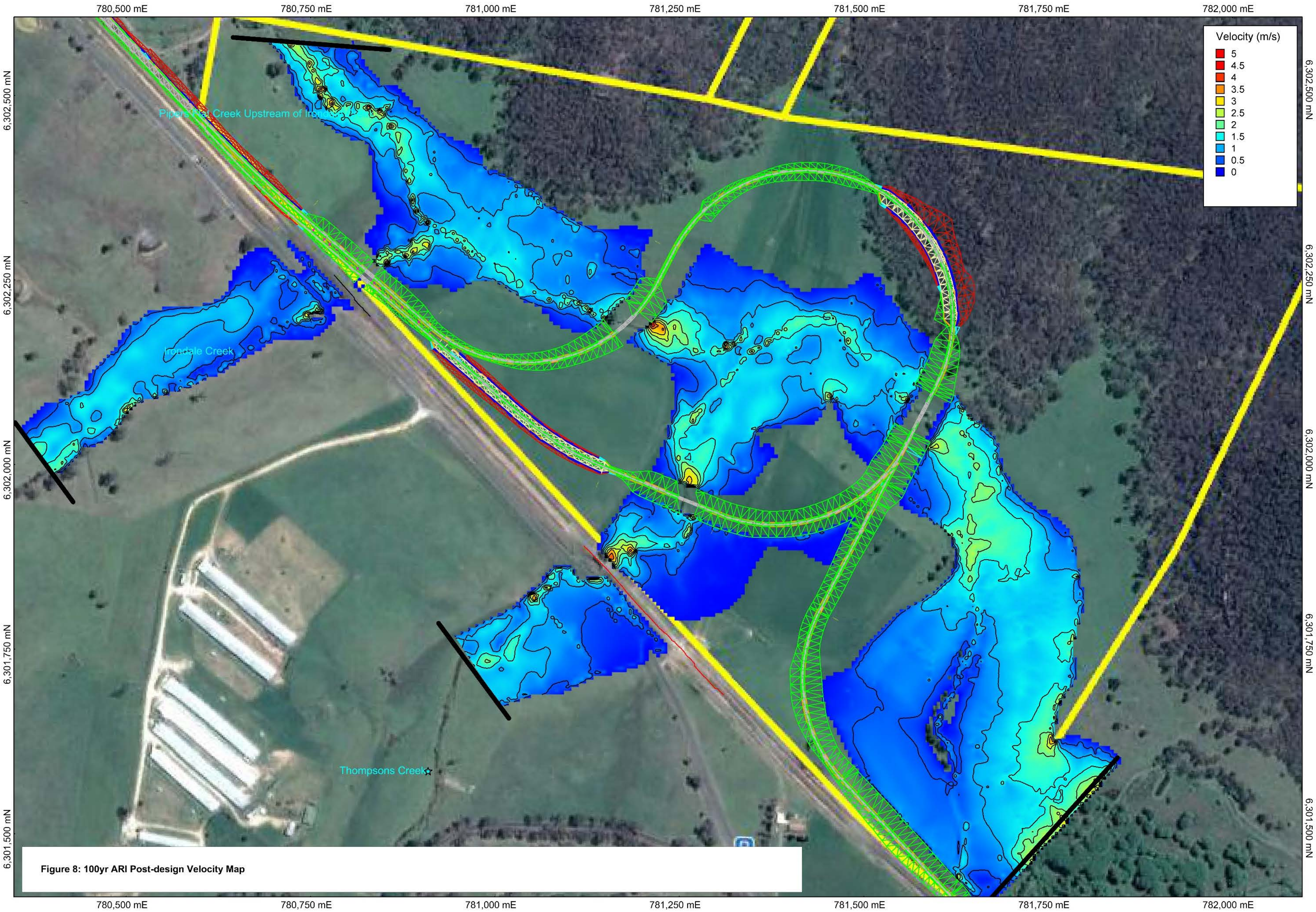


Figure 8: 100yr ARI Post-design Velocity Map

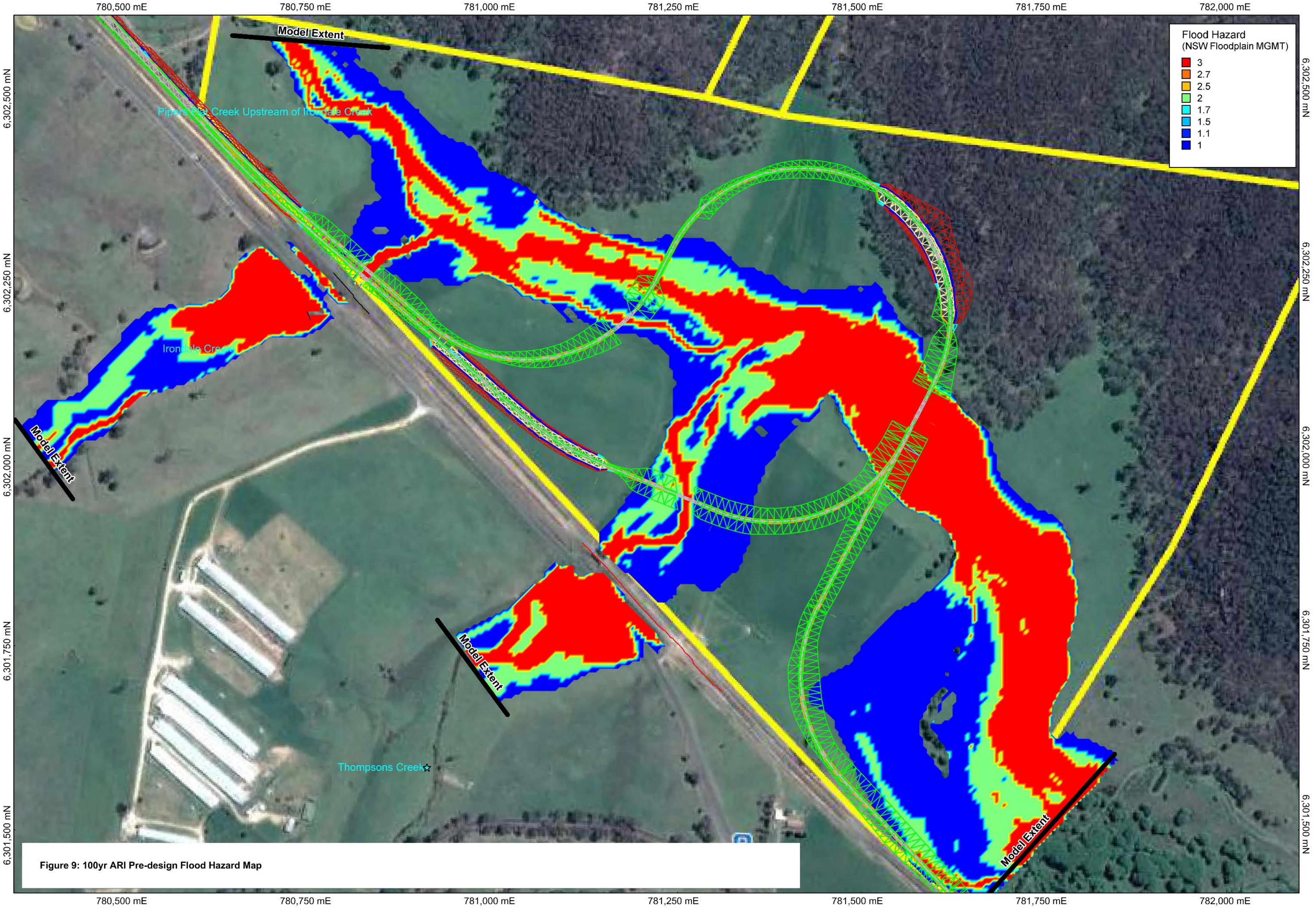


Figure 9: 100yr ARI Pre-design Flood Hazard Map (NSW Floodplain Management Method)

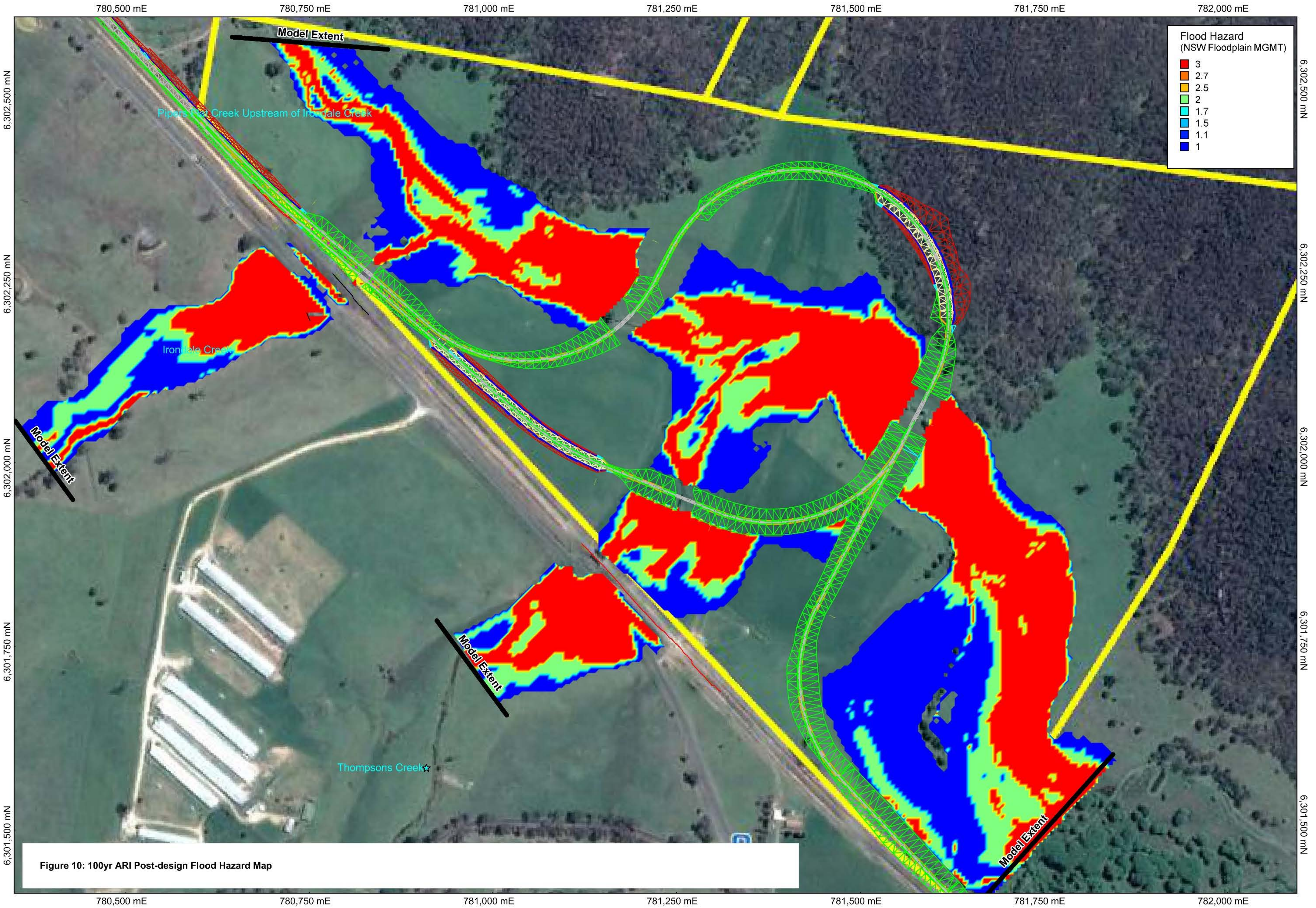


Figure 10: 100yr ARI Post-design Flood Hazard Map (NSW Floodplain Management Method)

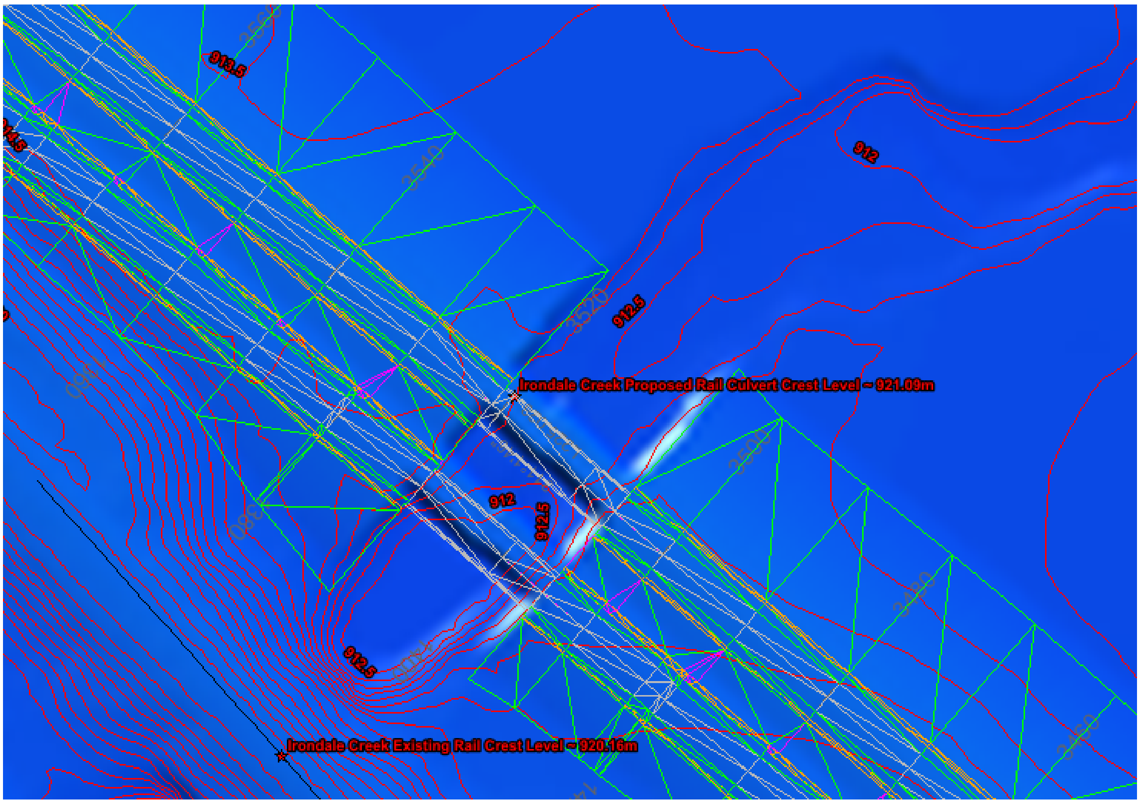


Figure 11: Irondale Creek proposed Rail Culvert (existing channel 0.5m contours in red).

Table 1: Crossing Flow Levels and freeboard (100yr ARI)

WATERWAY CROSSING LOCATION	CREST LEVEL (OVERFLOW) m AHD	LOCATION	PRE DESIGN		POST DESIGN	
			100 Yr level m AHD	Free-Board m	100 Yr level m AHD	Free-Board m
Irondale Creek: Existing Road Culvert	916.66 (Estimate)	**Upstream**	916.97	-0.31	916.98	-0.32
		Downstream	916.22	0.44	916.24	0.42
Irondale Creek: Existing Rail Culvert	920.16 (Estimate)	**Upstream**	916.22	3.94	916.25	3.91
		Downstream	914.08	6.08	915.05	5.11
Irondale Creek: Proposed Rail Loop Culvert	921.09	**Upstream**	914.07	NA	915.04	6.05
		Downstream	913.65	NA	913.71	7.38
Thompsons Creek: Existing Road Bridge	914.38 (Estimate)	**Upstream**	914.54	-0.16	914.56	-0.18
		Downstream	913.88	0.50	913.89	0.49
Thompsons Creek: Existing Rail Bridge	916.49 (Estimate)	**Upstream**	913.88	2.61	913.89	2.6
		Downstream	913.07	3.42	913.11	3.38
Thompsons Creek: Proposed Rail Loop Bridge	919.50	**Upstream**	911.42	NA	912.31	7.19
		Downstream	911.09	NA	911.40	8.10
Pipers Flat Creek: Proposed Rail Loop Bridge (north-west)	920.68	**Upstream**	910.69	NA	911.31	9.37
		Downstream	910.30	NA	910.90	9.78
Pipers Flat Creek: Proposed Rail Loop Bridge (south-east)	919.87	**Upstream**	908.20	NA	908.77	11.10
		Downstream	907.90	NA	908.28	11.59

Table 2: Post design crossing velocities (100yr ARI)

WATERWAY CROSSING LOCATION	APPROXIMATE INVERT LEVEL		100 YR VELOCITY m/s
	UP-STREAM m AHD	DOWN-STREAM m AHD	
Irondale Creek: Existing Road Culvert	913.26	912.37	2.7
Irondale Creek: Existing Rail Culvert	912.04	911.86	3.6
Irondale Creek: Proposed Rail Loop Culvert	911.85	911.64	2.9
Thompsons Creek: Existing Road Bridge	912.20	912.17	2.6
Thompsons Creek: Existing Rail Bridge	911.55	911.50	2.2
Thompsons Creek: Proposed Rail Loop Bridge	910.00	909.80	2.0
Pipers Flat Creek: Proposed Rail Loop Bridge (north-west)	909.16	908.41	1.4
Pipers Flat Creek: Proposed Rail Loop Bridge (south-east)	906.39	906.00	1.4

6.0 RECOMMENDATIONS

- Geotechnical advice should be sought to verify the modelled water levels do not result in pressure head differentials that exceed the hydraulic loading capability of the available embankment earthworks materials and compaction method.
- Scour analysis is recommended at the proposed bridge and crossing structures at detailed design to determine if energy dissipators as required at crossing outlets and determine appropriate dimensions (if required).
- 2000 year ARI and PMP flood analysis was not within the scope of this study and has not been analysed. It seems unlikely the rail embankments would sustain the head of water or scour at overflow locations from such an event. The value of further analysis should be assessed against the risk of potential upstream afflux for these events or risk of a flood wave from sudden embankment failure (dam break) scenario may be worth further investigation for extreme events in excess of the 500yr ARI.
- As the proposed Rail Loop embankment is of significantly higher elevation than the existing upstream road and rail levels, the impact of the rail design on flood levels increases with increasing ARI, especially once the capacity of the proposed crossing structures is exceeded. It may be prudent to evaluate the upstream impacts of the proposed rail loop for greater than the 500yr ARI if the consequences of such impact deem it necessary.
- Any future changes the design embankment levels for the proposed rail loop should be checked against the modelled flood levels to ensure suitable freeboard is maintained.
- It should be noted that there appears to be an old remnant river channel approximately 60m north-east of the Pipers Flat Creek (north-east) Proposed Rail Loop Bridge. This channel can best be observed in the predevelopment flood depth map (Figure 3) as a green linear band of relatively deep water. A minor culvert or drainage works may be required to alleviate the resulting ponding of flow against the rail embankment.

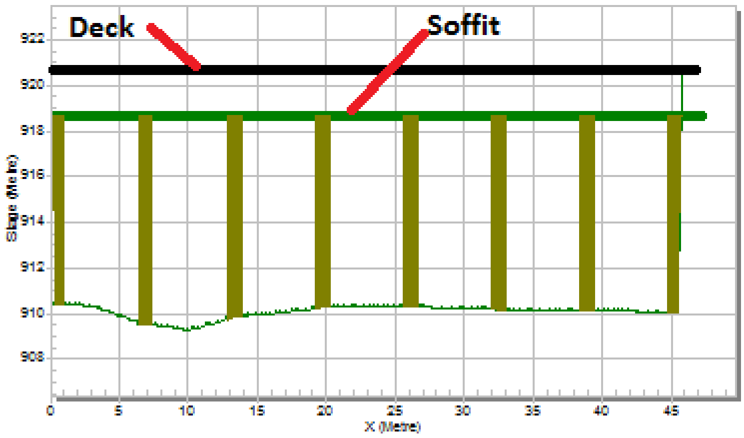
7.0 REFERENCES

Sinclair Knight Merz (SKM). 2007. Western Rail Coal Unloader – Mt Piper Power Station. Flood Study.

8.0 APPENDIX A

<u>Pipers Flat Ck (north-west) Proposed Rail Loop Bridge</u>

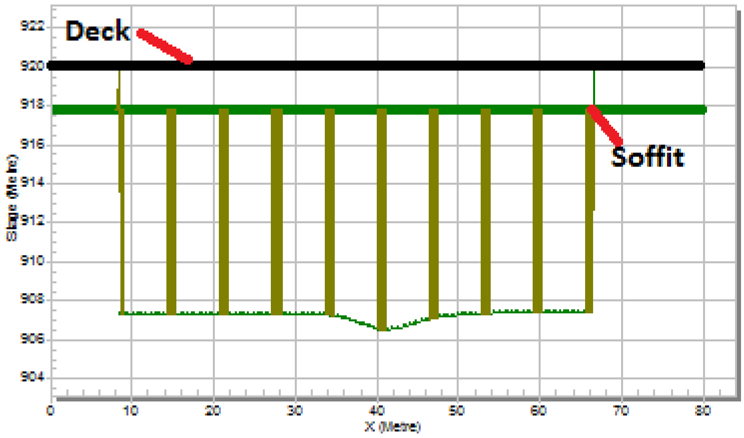
The top of bridge deck level of 920.68m was taken from the rail embankment design. A deck thickness of 2.05m was assumed, resulting in a soffit (under-deck) level of 918.63m. 7 bridge spans each of width 6.4m (5.4m flow width) were applied with 6 x 1m width vertical piers.



Cross-section profile of Pipers Flat Creek North-West Rail Bridge

Pipers Flat Ck (south-east) Proposed Rail Loop Bridge

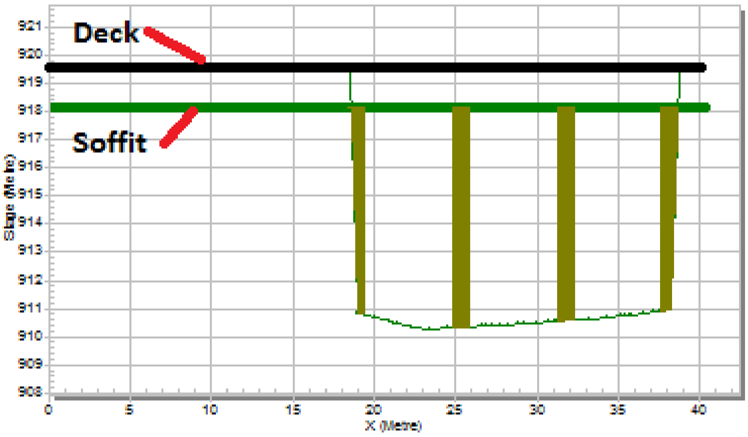
The top of bridge deck level of 919.87m was taken from the rail embankment design. A deck thickness of 2.05m was assumed, resulting in a soffit (under-deck) level of 917.82m. 8 bridge spans each of width 6.4m (5.4m flow width) were applied with 6 x 1m width vertical piers.



Cross-section profile of Pipers Flat Creek South-East Rail Bridge.

Thompsons Ck Proposed Rail Loop Bridge

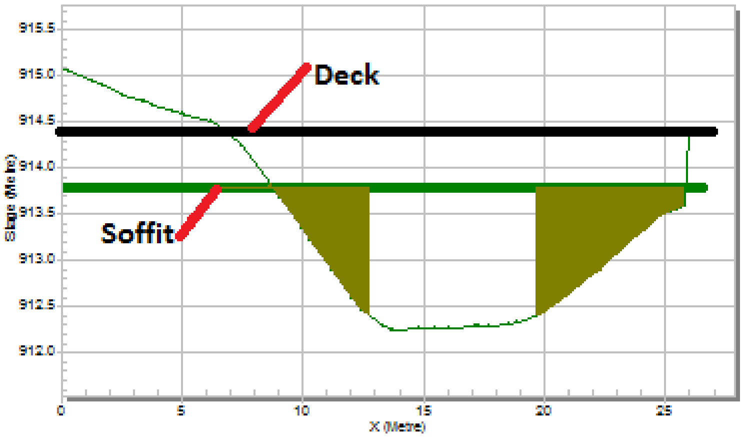
The top of bridge deck level of 919.50m was taken from the rail embankment design. A deck thickness of 1.35m was assumed, resulting in a soffit (under-deck) level of 918.15m. 3 bridge spans each of width 6.4m (5.4m flow width) were applied so as to mimic the existing Thompsons Ck Rail Crossing. 2 vertical piers were modelled (as shown in the site photographs for the Thompsons Ck Rail Crossing). The piers have been assumed to be 1m wide.



Cross-section profile of Thompsons Creek Rail Loop Bridge.

Thompsons Ck Existing Road Bridge (data/assumptions to be confirmed by design team):

Top of bridge deck level for the Thompsons Ck road crossing was interpolated from the raw lidar data as 914.38m. A deck thickness of 0.6m was assumed, resulting in a soffit (under-deck/soffit) level of 913.78m. A single bridge span width of 7m (as stated in the SKM report) has been used.

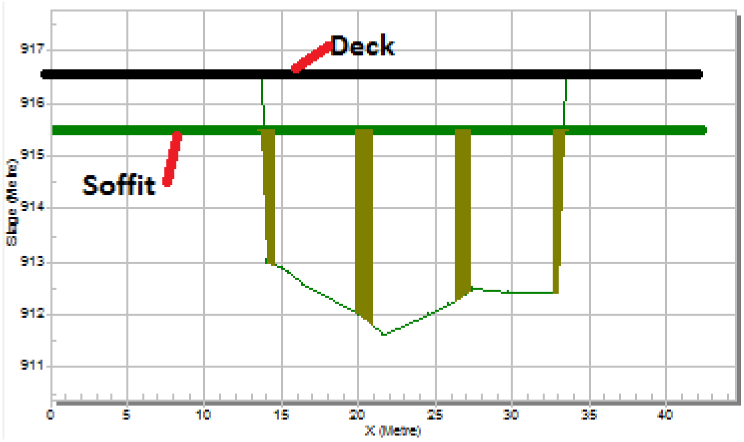


Cross-section profile of Thompsons Creek Existing Rail Loop Bridge.

Existing bridge.

Thompsons Ck Proposed Rail Bridge:

Top of bridge deck level was interpolated from the raw lidar data as 916.49m.A deck thickness of 1m was assumed, resulting in a soffit (under-deck) level of 915.49m. 3 bridge spans each of width 6.4m (5.4m flow width) were applied (based on information in the SKM report). 2 vertical piers were modelled (as shown in the site photographs). The piers have been assumed to be 1m wide.



Cross-section profile of Thompsons Creek Proposed Rail Loop Bridge.

Photo source: SKM (2007)

Irondale Ck Proposed Rail Loop Culvert

Top of deck/formation level (level at which rail overtops) of 921.09m was taken from the rail design TIN. A single 3.6mx3.6m concrete box culvert (upstream invert: 911.85m, downstream invert: 911.69m) was applied, providing a little extra flow capacity than the upstream brick culvert crossing for the existing rail, so as not to create significant tailwater impact upstream. It was assumed 3.6m is the internal flow width and height (not accounting for concrete thickness).

Irondale Ck Existing Road Culvert (data/assumptions to be confirmed by design team):

Road level for the semi-circular CSP Irondale Creek road crossing was interpolated from the raw LIDAR data as 916.656m.1m cover over the pipe was estimated from the site photographs such that an obvert level of 915.656m could be estimated for determining flow area. The 2.4m internal height from culvert obvert to channel invert, stated in the SKM Flood Study, is assumed to be still valid

Photo source: SKM (2007)

Irondale Ck Existing Rail Culvert (data/assumptions to be confirmed by design team):

The crossing structure has been identified as a brick vertical ellipse structure in the previous flood report. It has been approximated to a modified basket handle shape of similar dimensions to more closely match what the site photos indicate. Rail has been assumed to overtop when water depth reaches the top of rail formation level (this may need to be reviewed). Top of formation has been assumed to be the tallest elevation point located in the centre of the rail formation. This was estimated to be 920.16m from the combined raw LiDAR/survey data points provided.

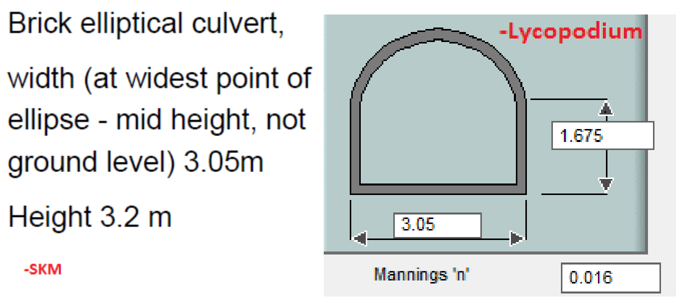



Photo source: SKM (2007)


Photo source: SKM (2007)

Winters Ck and Pipers Flat Rail and Road Crossings):

It has been considered not necessary to model these crossings as considerable constriction of flow will need to occur at the north-western rail loop crossing before they are likely to be hydraulically impacted. There will be significant flood impact to other areas (requiring a larger crossing design) prior to this occurring.

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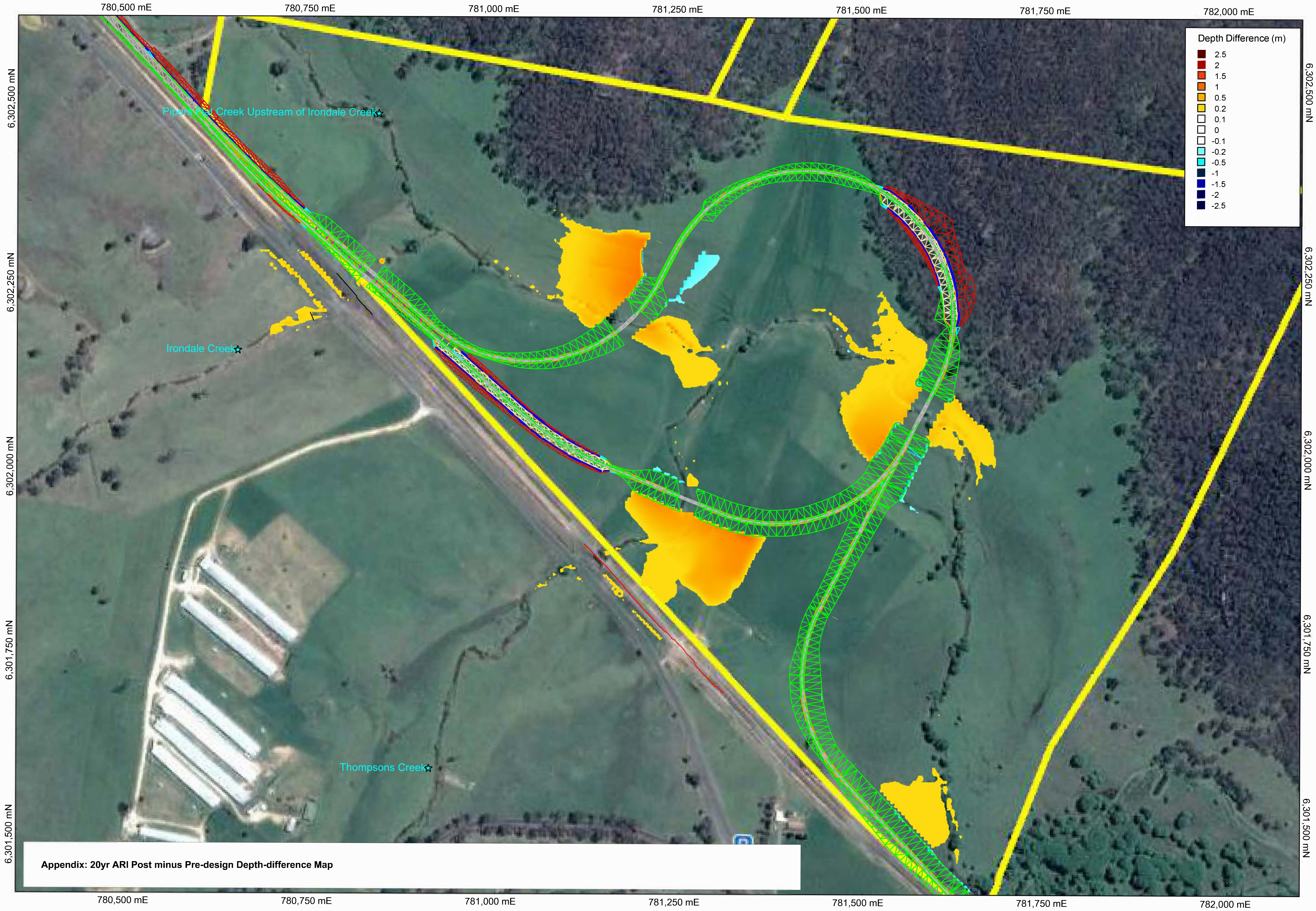
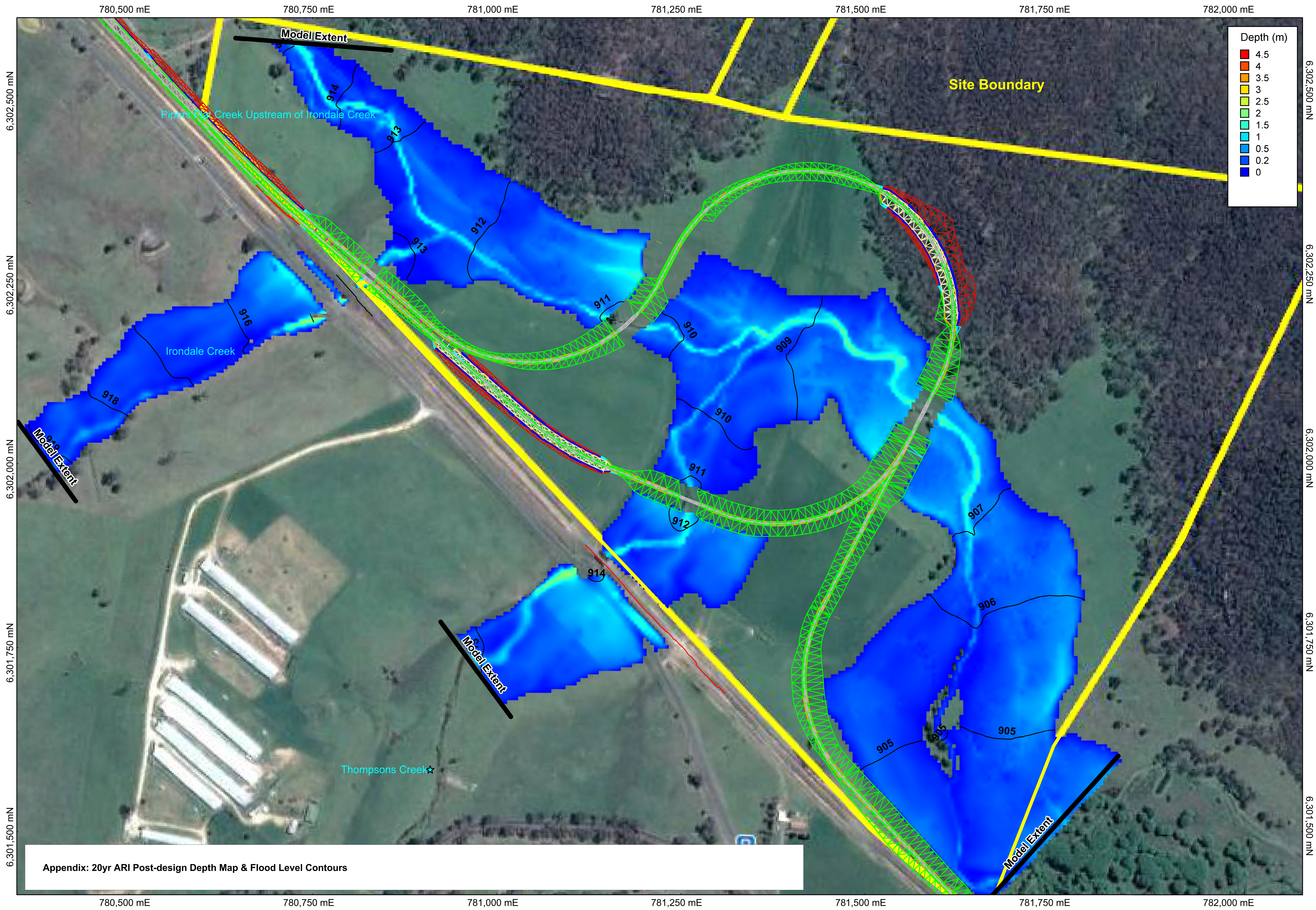
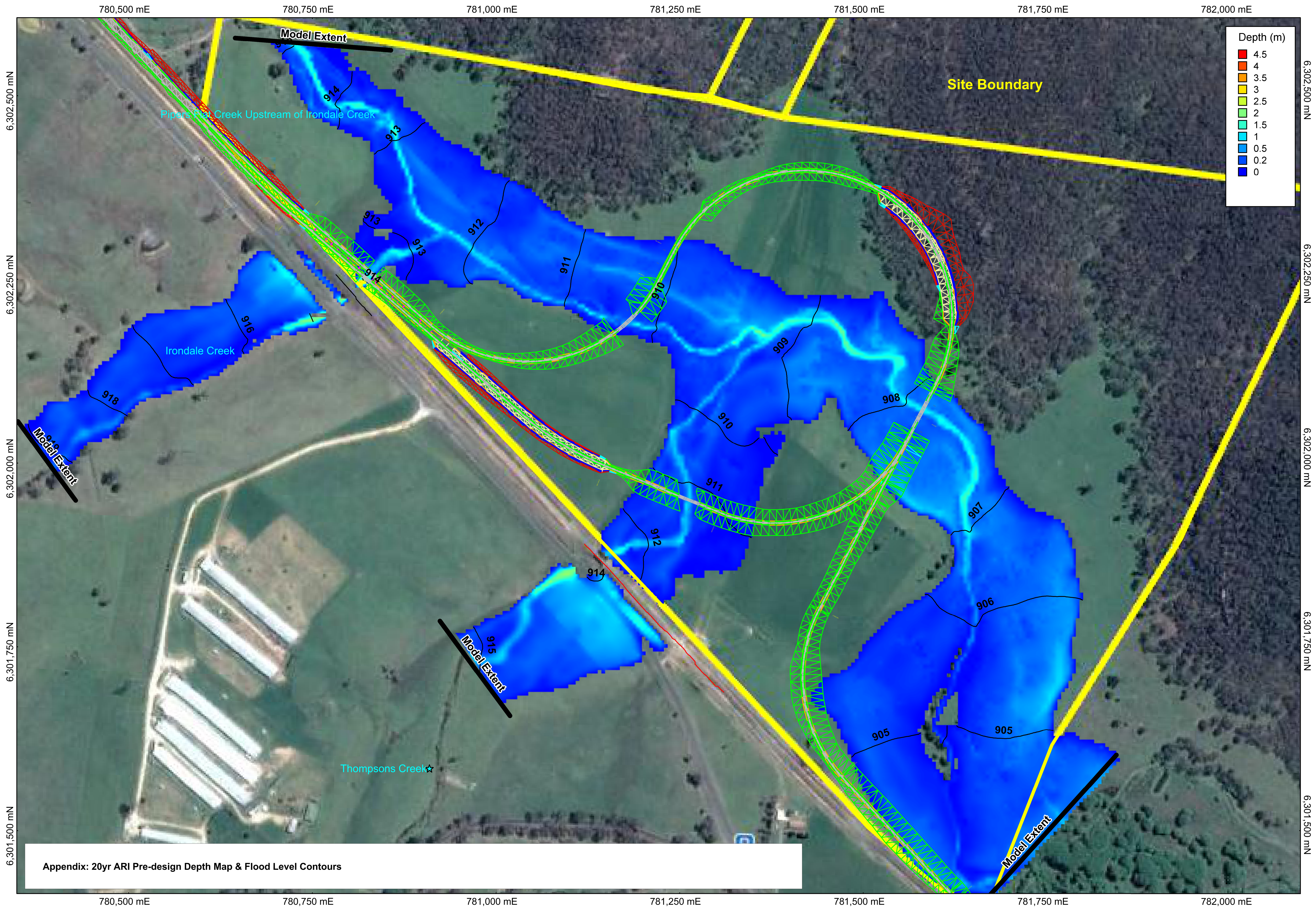


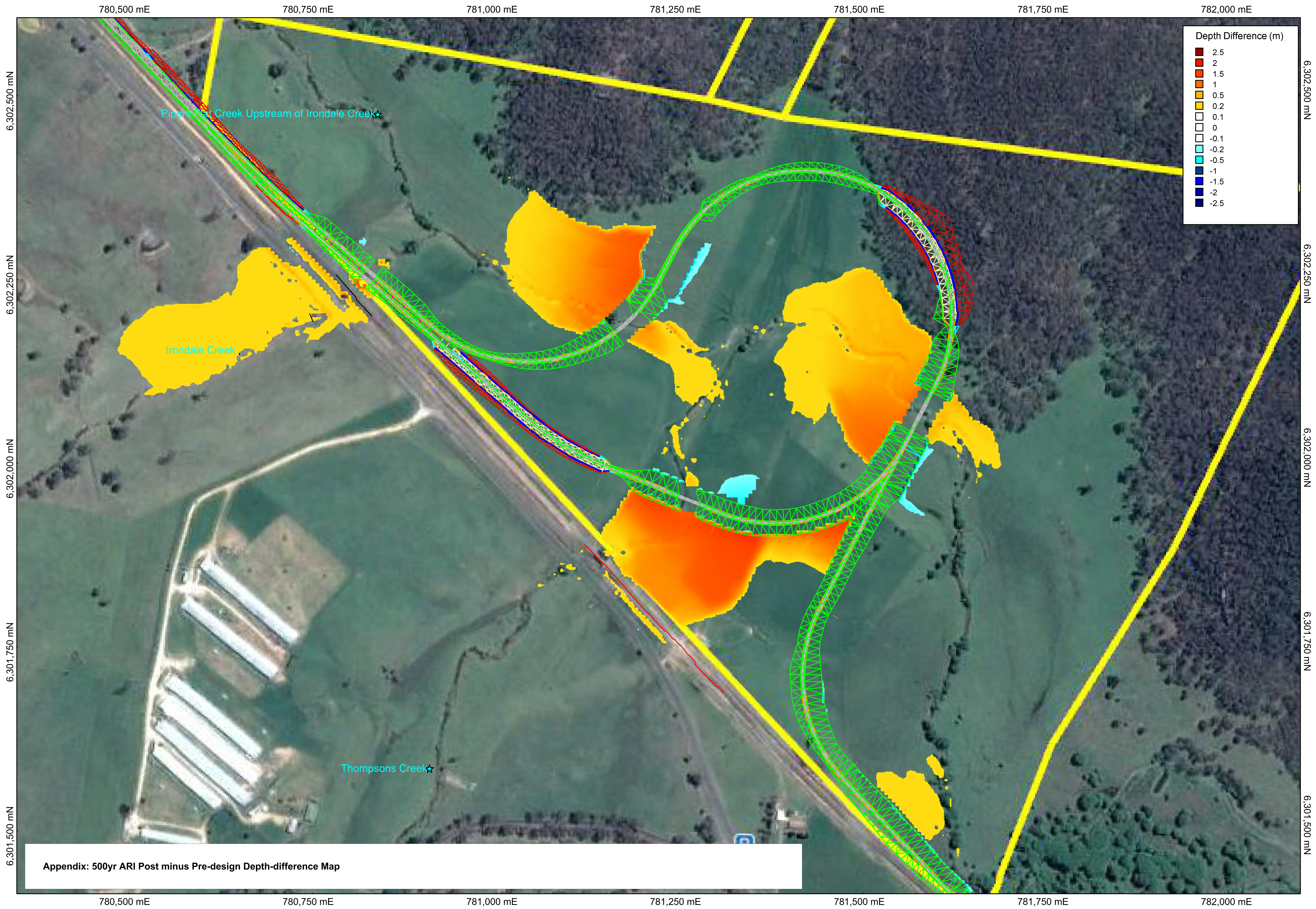
Appendix: 20yr ARI Post minus Pre-design Depth-difference Map



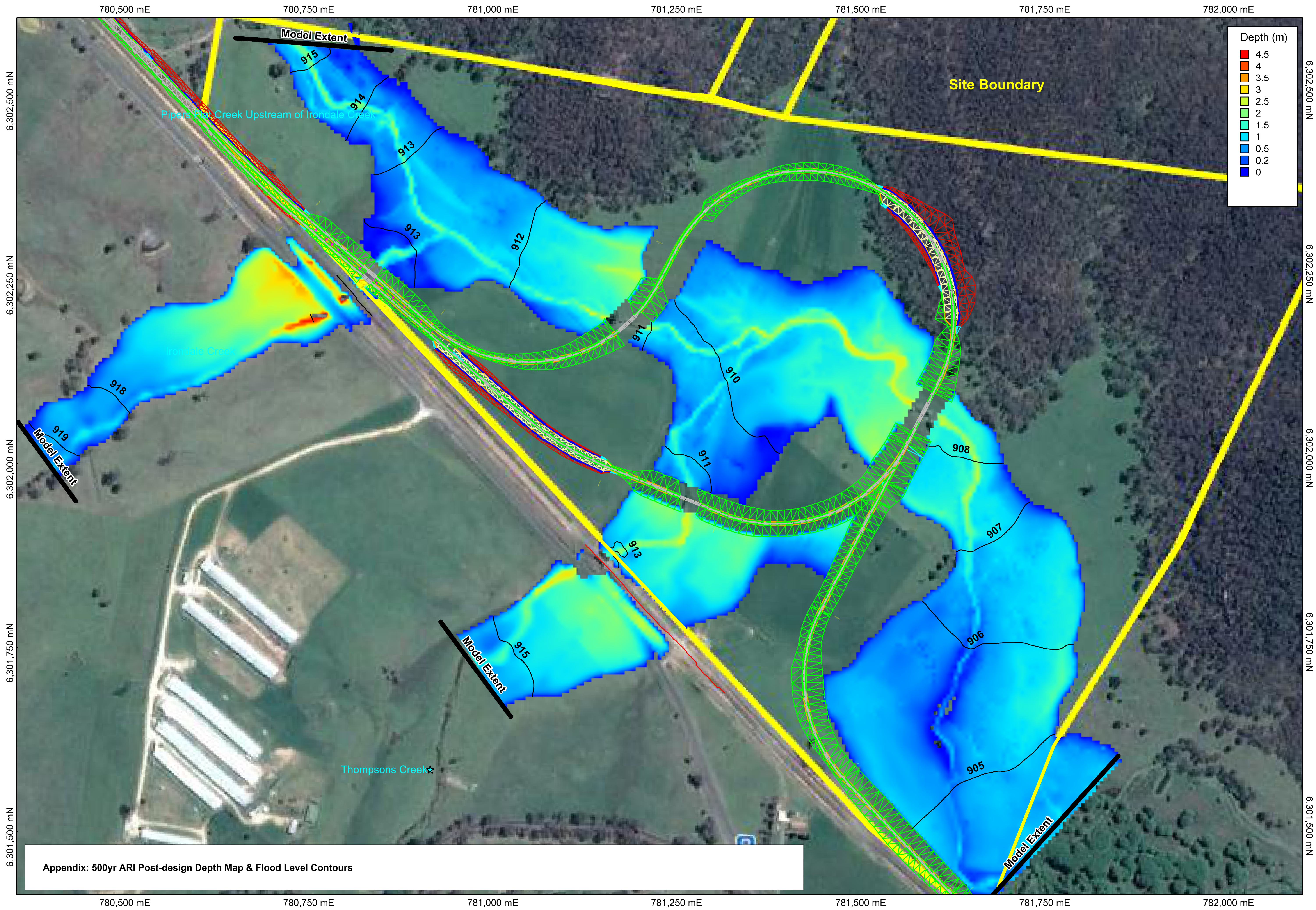
Appendix: 20yr ARI Post-design Depth Map & Flood Level Contours



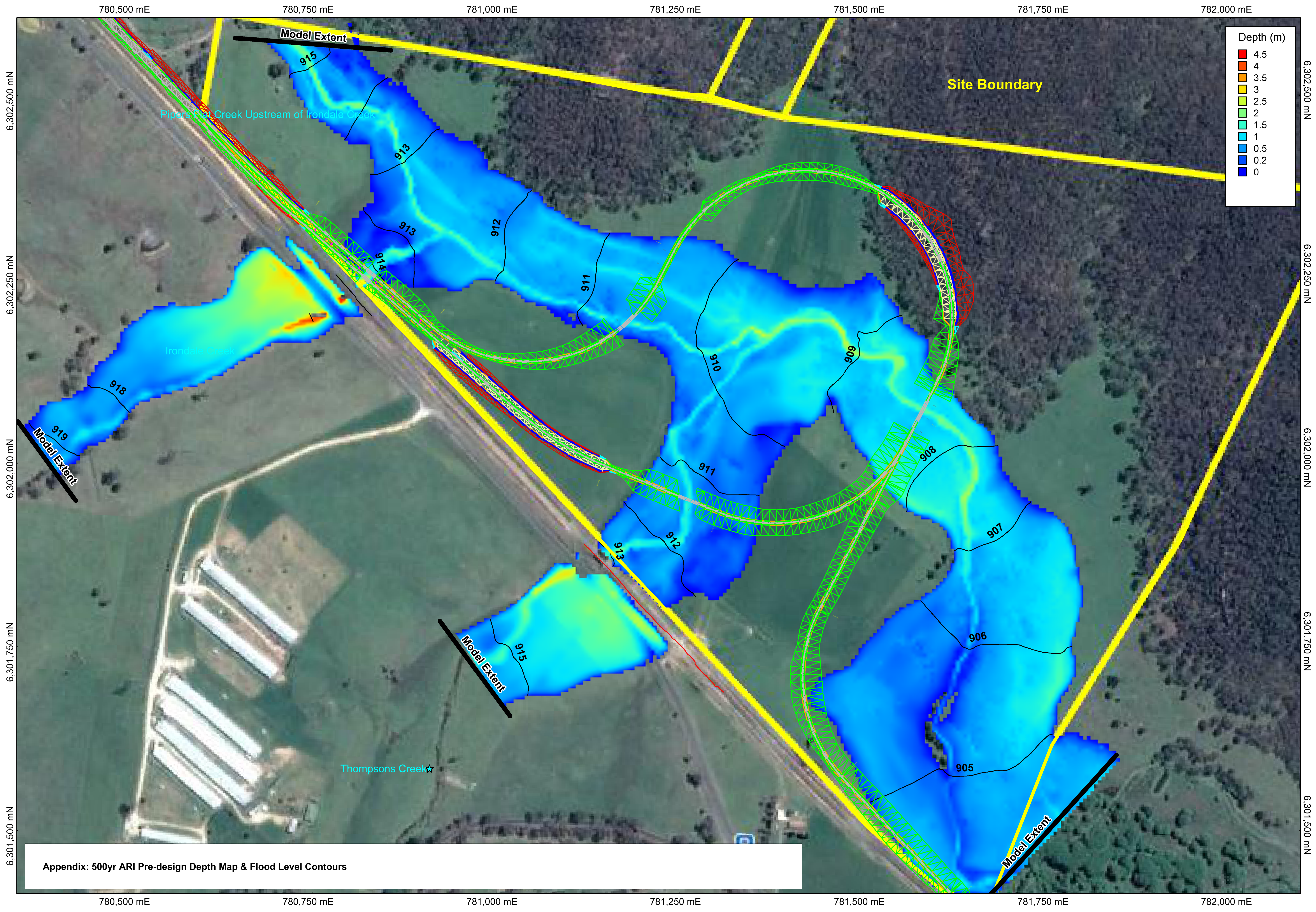
Appendix: 20yr ARI Pre-design Depth Map & Flood Level Contours



Appendix: 500yr ARI Post minus Pre-design Depth-difference Map



Appendix: 500yr ARI Post-design Depth Map & Flood Level Contours



Appendix: 500yr ARI Pre-design Depth Map & Flood Level Contours