



Independent Review of Flood Modelling

Narromine to Narrabri Inland Rail Project

Holding Redlich
1283-03-B [DRAFT], 19 February 2021

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1 Introduction

1.1 BACKGROUND

The Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Narromine to Narrabri (N2N) section of Inland Rail ('the proposal'). The proposal consists of about 306 kilometres of new single-track standard gauge railway with crossing loops. The proposal includes major river crossings of the Macquarie River (Narromine), Castlereagh River (near Curban) and the Namoi River (Narrabri) as well as over 100 creek crossings.

The proposal is State significant infrastructure and is subject to approval by the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also determined to be a controlled action under the Commonwealth *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act) and requires approval from the Australian Minister for the Environment.

JacobsGHD IR Joint Venture (JacobsGHD) have undertaken hydrological and hydraulic modelling of the various waterways that cross the proposed rail as part of the Environmental Impact Statement (EIS) prepared by ARTC to support the application. Design discharges were estimated for a wide range of flood events from the 20% Annual Exceedance Probability (AEP) event up to the Probable Maximum Flood (PMF) event using both calibrated and uncalibrated hydrological models. Fourteen hydraulic models were developed to estimate design flood levels, depths and velocities for existing conditions, construction conditions and proposed conditions as well as assess the impact of the proposed rail.

1.2 NSW FARMERS AND CWA CONCERNS

I have been advised that the NSW Farmers and CWA members have numerous concerns regarding the N2N Project and the explanations/justifications put forward in the EIS, including in relation to the flooding and hydrology impacts from the proposal. They have specific concerns with two flood prone areas:

1. To the east of Narromine near Webb's Siding and Backwater Cowal (**Webb's Siding**). NSW Farmers and CWA members suggest that this area is an important relief valve to reduce flooding in Narromine during large flow events. They have concern that the alignment will act as a semi-impermeable barrier and prevent the waters escaping to the north east;
2. To the west of the Warrumbungle Ranges (from the Castlereagh River Bridge north to the Baradine Crossing Loop (**Warrumbungles Watershed**)).

Landholders in Warrumbungles Watershed report that relatively short duration but intense rainfall events in the Warrumbungles give rise to what they describe as a sheet of water between 40-60cm deep moving over the land. This water has a tendency to only pool for a short duration before soaking away into the subsurface soil. Where there has been a prolonged wet period, the water pools to a much larger extent than indicated in the ARTC modelling.

The NSW Farmers and CWA members are concerned that the flooding and hydrology modelling for the N2N Project significantly underestimates the amount of water in these areas.

The underestimating of flows raises concerns that the number, extent and location of bridging and culverts will not be sufficient to accommodate the anticipated flows, leading to concerns that there will be consequential changes to flow patterns, as well as depth and velocity of flows.

Due to the nature of the farming operations in the area (principally dry land cropping and grazing), there is also a lot of stubble that moves across the water during flow events. The landowners are concerned that modelling does not sufficiently account for the frequency and extent of blockages where culverts, rather than bridges, are being proposed.

If this is the case, and the flooding and hydrology modelling is inaccurate or insufficient, then a question also arises as to whether alternative routes should have been selected to avoid the worst of the flood affected land.

Additionally, the landowners do not believe that the erosive nature of the 'black soils', which are highly erodible, have been adequately considered in the EIS documentation.

1.3 SCOPE OF SERVICES

I have been engaged by Holding Redlich, on behalf of NSW Farmers and the CWA, to provide an opinion on the adequacy and accuracy of the ARTC's flooding and hydrology modelling for the N2N Project in relation to the above matters. More specifically, I have been requested to:

- undertake a desktop review of the assumptions which underpin the analysis in the EIS and confirm whether these assumptions are appropriate; and
- consider whether the assumptions underpinning the EIS justify the conclusions reached in the EIS regarding the impacts and whether they are acceptable.

This report has been prepared on the basis of information provided in the EIS.

No independent hydrologic or hydraulic modelling has been undertaken by WRM as part of this review. Further, this review has been limited only to flood modelling undertaken in the two specific areas of concern (Webb's Siding and the Warrumbungle Watershed).

2 Design requirements, standards and guidelines

2.1 OVERVIEW

The Secretary’s Environmental Assessment Requirements (SEARs) for the NSN Project are detailed in Appendix A of the EIS. The SEARs key issues with respect to flooding are tabulated in Table A2 Section 9. Of relevance to this review, the SEARs require the proponent to “develop and justify quantitative design limits on potential adverse flooding, hydrological and geomorphological impacts resulting from the project. These are to consider land use and include afflux, velocity, extent, duration, hazard, scour potential, etc”.

2.2 QUANTITATIVE DESIGN OBJECTIVES

Table 2.1 shows the quantitative design objectives adopted by ARTC for the proposed rail. These quantitative design objectives apply outside the rail corridor for events up to and including the 1% AEP flood event. The following comments are made regarding the adopted design objectives.

- The afflux, flood hazard and flood duration design objectives would appear reasonable.
- The scour/erosion potential design objectives are vague. Further discussion on erosion/design objectives is given in Section 4.5.
- No design objectives have been provided to minimise the changes in the distribution of flow. Further discussion on changes in the distribution of flow is given in Section 4.4.
- No consideration has been given to uncertainty and model sensitivity.

Table 2.1 - Quantitative design objectives

Parameter	Location or land use	Quantitative design objective
Afflux	Habitable floor/Sensitive infrastructure	10 mm
	Other urban and recreational	200 mm
	Agriculture	200 mm
	Forest and unimproved grazing	400 mm
	Highways and sealed roads >80 km/hr	<10 mm at sensitive infrastructure
	Roads <80km/hr	<10% change in length of overtopping
Scour/erosion potential		Outlet velocities from the rail corridor to be in accordance with site-specific assessment conducted by an experienced geotechnical or scour/erosion specialist. The increase in velocity is to be in accordance with the requirements of the NSW Blue Book.
Flood hazard	Urban, commercial, industrial, highways and sealed roads	Minimise changes based on an assessment of risk with a focus on land use and flood sensitive receptors

Parameter	Location or land use	Quantitative design objective
Flood duration	Habitable floors	Less than 10% change in duration of inundation where there is above floor flooding
	Highways and sealed roads >80km	Minimise changes to accessibility during flood events.
	Elsewhere	Minimise changes based on an assessment of risk with a focus on land use and flood sensitive receptors.

3 Design discharge estimates

3.1 OVERVIEW

The EIS does not provide sufficient information to undertake an independent peer review of the methodology used to derive design discharges draining to each waterway crossing. The EIS provides a brief description of the methodology used but no details of the hydrological model configuration, model parameters, validation methodology or results have been provided.

Outlined below is a review of the design discharge estimates, which are provided in the EIS in Table C-1 of Appendix C of the Technical Report 3. The review is based on an interpretation of the brief descriptions of the methodologies given in Technical Report 3 (Flooding and hydrology assessment) and an independent analysis of selected waterways in the two areas of interest.

3.2 MACQUARIE RIVER / CASTLEREAGH RIVER

The EIS states that design discharges in the major watercourses were derived from at site flood frequency analysis (FFA) of the historical flows recorded at the available stream gauges. RORB rainfall runoff routing models were developed of these catchments to convert the peak discharges to a discharge hydrographs. The adopted methodology to estimate flows for the major catchments is reasonable. However, no information has been provided in the EIS to review or provide comment on the assumptions made in the FFA or RORB modelling.

The peer review, undertaken by BMT and provided in Appendix B of Technical Report 3, provides some commentary regarding the model parameters but insufficient to undertake an independent review.

There is considerable uncertainty surrounding the Macquarie River design discharges because it was derived from an FFA of only 32 years of recorded data at the Baroona gauge (GS421127) with design discharges extrapolated out for the larger floods. There is a high level of uncertainty when the FFA is extrapolated to estimate design discharge for larger events such as the 1% AEP event.

Notwithstanding this, the peer reviewer noted that the design discharges are similar to the design discharges determined by Lyall & Associates (2009) who prepared the Narromine Floodplain Risk Management Study and Plan for Narromine Shire Council. The rigour undertaken to derive these design discharges for this study is not known.

No data has been provided, or is publicly available, to determine the appropriateness of the adopted Castlereagh River design discharges.

3.3 CREEK CATCHMENT FLOWS

The EIS states that design discharges for the creek catchments crossing the rail line were determined by the development of RORB rainfall runoff routing models. No details on the configurations of the models were provided. The EIS states that RORB parameters were adopted from recommendations in Australian Rainfall and Runoff (ARR) (Ball et al, 2019). For ungauged catchments, such as all of the catchments within the two areas of interest (Webb's Siding and Warrumbungles Watershed), ARR provides regional recommendations for the RORB k_c parameter. Whilst this methodology is reasonable, the appropriateness of the k_c value is dependent upon the configuration of each model, which has not been provided. ARR also notes that there is a high level of uncertainty in the discharge estimates using the regional parameter even when a consistent and appropriate model configuration has been used.

ARR provides an alternative method to estimate flows for ungauged catchments using the Regional Flood Frequency Estimation (RFFE) technique (ARR, 2021). RFFE is based on data from 853 gauged catchments across Australia. Given the lack of good quality stream gauge data in this area, there would be a similar level of uncertainty surrounding RFFE flow estimates.

Notwithstanding the uncertainties, a comparison of the design discharge estimates at three locations along the rail is shown in Table 3.1. For reference, Wallaby Creek is a local catchment draining to the Backwater Cowal near Webb's Siding to the east of Narromine. Tenandra Creek and Gulargambone Creek are located within the Warrumbungles Watershed. The following is of note:

- The EIS design discharges are **higher** than RFFE design discharges for Wallaby Creek.
- The EIS design discharges are **lower** than RFFE design discharges for Tenandra Creek.
- The EIS design discharges are **substantially higher** than RFFE design discharges for Gulargambone Creek.

Table 3.1 - EIS design discharge estimate comparison to RFFE estimates, Wallaby Creek Tenandra Creek and Gulargambone Creek

AEP	Wallaby Creek (m ³ /s)		Tenandra Creek (m ³ /s)		Gulargambone Creek (m ³ /s)	
	EIS	RFFE	EIS	RFFE	EIS	RFFE
20%	224	88	58	58	184	82
5%	348	204	106	136	354	190
2%	420	314	133	209	490	294
1%	480	420	160	280	567	393

It is not possible to discern the reasons for the differences from the information provided in the EIS. However, with neither methodology predicting consistently higher or lower discharges even for catchments relatively close to each other, the inconsistency should be investigated as it may be related to poor model setup. At the very least, the higher of the two regional estimates should be adopted given the uncertainty surrounding the estimates.

3.4 SUMMARY OF FINDINGS

There is not sufficient information provided in the EIS to undertake an independent peer review of the methodology used to derive design discharges draining to each waterway crossing. From the information that has been provided:

- The general methodology adopted to undertake the design discharge estimates for both the gauged and ungauged waterways is appropriate. However, no information has been provided to determine whether the methodologies have been implemented appropriately.
- The design discharges adopted for the Macquarie River were reported to be consistent with the design discharges estimated for the Narromine Flood Study by Lyall & Associates (2009), which provides some confidence in the Macquarie River discharge estimates.
- No information has been provided or is publicly available to determine whether the Castlereagh River discharges have been determined correctly or are appropriate.
- For the ungauged creek catchments, which is most of the waterway crossings along the rail, RORB models using regional parameters were used in the EIS to derive peak discharges. This methodology is appropriate but has a high level of uncertainty.
- A comparison of the RORB design discharges to design discharges estimated using an alternative regional methodology (RFFE) at three selected waterways showed significant differences. One methodology did not consistently produce higher estimates than the other, which could suggest some issues with the adopted RORB model configurations. Given the uncertainty surrounding the estimates, both methods should be used and the higher of the two adopted.

4 Flooding assessment

4.1 OVERVIEW

Fourteen TUFLOW hydraulic models were developed for the EIS to define the flooding behaviour along the rail. The models were developed for existing conditions and for proposed rail conditions. The EIS provides details of the culvert and bridge crossings of the various waterways (Table A-1 of Appendix A of Technical Report 3) and provides flood mapping for events ranging from the 20% AEP (approximately the 5 year average recurrence interval (ARI) event), 5% AEP (20 year ARI), 2% AEP (50 year ARI), 1% AEP (100 year ARI) as well as for a number of very rare and extreme events. Mapping was provided for:

- Existing peak flood depths and flood level contours;
- Existing peak flood velocities (20% AEP event only);
- Existing flood hazard;
- Flood level impacts (construction and operational phases);
- Flood velocity impacts;
- Flood duration impacts; and
- Flood hazard impacts.

The models were not available for review and no detail was provided on the development and validation of the models. As a result, a detailed review of the methodology used to derive the flood model results and the impacts at each waterway cannot be undertaken.

Outlined below is an assessment of the flood model results from the information provided.

4.2 MODEL METHODOLOGY

The following comments are provided regarding the hydraulic modelling methodology:

- The hydraulic modelling package adopted for the EIS (TUFLOW) is used widely across Australia and is suitable to assess the impacts of the project.
- Although it is not documented, it would appear that the upper catchment inflows have been derived using the hydrology model results and a 'rain-on-grid' approach has been adopted for runoff within the modelling area. If this is the case, this methodology is appropriate.
- The EIS states that four sets of ground level survey data were used. However, only the Lidar data captured by AAM Pty Ltd would be appropriate to define flood levels and flood impacts. The extent of the AAM data was not provided. The publicly available Lidar data from the ELVIS database across the Warrumbungle Watershed has a vertical accuracy of $\pm 1\text{m}$. It would be completely inappropriate to assess flood impacts using the Elvis data.
- The hydraulic models in the Warrumbungles Reach are uncalibrated (as no data is available).
- Ground level roughness values (Manning's 'n') used in the modelling were not provided. The adopted roughness values will change both the peak flood levels and peak flood velocity across the floodplain and should have been provided in the EIS. At the very least, a sensitivity analysis to changes in ground level roughness should have been undertaken. No sensitivity analysis was documented.
- The documented methodology to model the culverts and bridges in the EIS appear appropriate. However, no details have been provided to determine whether appropriate

parameters have been applied other than the commentary in the peer review (Appendix B of Technical Report 3).

4.3 FLOOD LEVEL IMPACTS

Flood level impacts were provided along the rail via a series of 14 maps covering the 306 km of new rail. Overall, the flood mapping provided is grossly inadequate and unsuitable for an individual farmer to identify the extent and quantity of flood level impacts at their property because of the following:

- the mapping scale is too coarse to show the extent and location of impacts;
- the rail corridor GIS layer covers locations of the greatest flood impact;
- it is difficult to determine the locations and depths of flood level impacts in comparison the quantitative design objectives, given in Table 2.1, from the adopted afflux colour scheme;
- even if the difference in afflux colour for the over and above the 0.01 m impact could be determined from the mapping, the locations of sensitive receptors that fall within the impact zone have not been identified or shown;
- the locations where flood afflux exceeds the ‘agriculture’ quantitative design objective of 0.2 m cannot be determined as the locations of agriculture areas are not shown; and
- the locations where flood afflux exceeds the grazing area quantitative design objective of 0.4 m in the cannot be determined because there is not an afflux colour boundary that coincides with 0.4 m.

In the Webb’s Siding area, the mapping shows flood afflux exceeding 0.2 m for most creek crossings between the existing rail at Narromine to the Macquarie River. The afflux exceeds 0.5 m at several locations. This suggests that more culverts are required to satisfy their own quantitative design objective.

For the Castlereagh River, the afflux for the 1% AEP event exceed 0.2 m and this impacts 11 existing dwellings. The EIS provides no discussion as to how this impact would be mitigated but a larger bridge opening would appear necessary.

In the Warrumbungles Watershed reach, any exceedances of the afflux quantitative design criteria would appear to be confined to the proposed rail corridor study area corridor and therefore very localised.

4.4 CHANGES TO FLOW PATTERNS

4.4.1 Macquarie River / Webb’s Siding

The flood mapping shows that the Macquarie River overflows into the Backwater Cowal at Webb’s Siding for events greater than the 2% AEP event. The overflowing floodwater drains along the Backwater Cowal and away from the Narromine township. In effect, the overflows at Webb’s Siding are a natural flood mitigation measure for Narromine as they reduce flows draining along the Macquarie River for rare to extreme events.

The proposed rail is located directly across the overflow path from the Macquarie River to the Backwater Cowal. Approximately 1,650 m of viaduct is proposed across the river, existing rail, the Mitchell Highway and the Backwater Cowal channel at this location. The proposed rail configuration will convey the flows up to the 2% AEP event without significant changes in flow patterns. However, there is about 1,000 m of elevated embankment in between the viaducts and a further 1,000 m of elevated embankment to the south of the Backwater Cowal that would obstruct the overflows and divert flows back along the Macquarie river for the larger events. The EIS predicts that the change in flows due to the proposed rail would increase above floor flooding to 605 dwellings in Narromine for the 1% AEP plus climate change event and 2,520 dwellings for the 0.2% AEP event. This is a poor outcome for Narromine.

It would appear that there are two options to reduce the impacts:

- Realign the rail away from Webb's Siding; or
- Extend the viaduct to reduce the embankment sections by an additional 2 km.

Further to this, the existing rail between Dubbo and Narromine may also be preventing the Macquarie River from overflowing into the Backwater Cowl and diverting flows into Narromine for the more frequent events. The construction of the inland rail would appear to provide opportunity to increase the waterway opening of the existing rail to mitigate flooding in Narromine.

4.4.2 Creek catchments

The flood mapping shows changes to flow patterns along much of the rail alignment for all flood events investigated from the 20% AEP (frequent) event to the extreme events. The changes to the flow patterns occur in areas of very flat topography such as:

- to the south of Webb's Siding along Wallaby Creek and its tributaries (see Figure 4.1);
- to the south of the Castlereagh River to Nancarrow Road (N2N11N12 flood model);
- along the Gulargambone Creek tributaries (N2N10 flood model); and
- along Box Ridge Road to the north of Baronne Creek (N2N9 model).

The impact of these changes will vary at each individual property as it depends on the site infrastructure such as fences and whether the individual paddocks are cropped. Figure 4.1 shows a high resolution image of the changes in flow patterns that are predicted to the west of Wallaby Creek along Tomingley Road (to the south of Narromine). This figure was extracted from Appendix F of Technical Report 3. The figure shows that the changed flows would increase frequency and depth of flooding at a house and shed as well as along boundary fences. It is not possible to show the impacts at other locations because of the quality of the flood mapping, as described above.

Overall, it suggests that there are insufficient culvert locations to prevent changes in the distribution in flow at this location, and potentially at many other locations. It is suggested that ARTC engage with each landholder with higher resolution maps to explain the predicted impacts and attempt to address any concerns.

4.5 FLOOD VELOCITY IMPACTS

4.5.1 Erosion potential

The EIS includes a geomorphic characterisation of the various waterways that cross the proposed rail based on the River Styles framework. The characterisation has been used to assess the existing erosion potential of the waterways and assist in assessment the erosion risk of the project. The assessment found that most waterways that cross the proposed rail are in a moderate to poor geomorphic condition and all waterways have a moderate to high fragility. This means that the watercourses, particularly those within the Warrumbungles Watershed, are prone to erosion and sedimentation, have catchments that produce high sediment loads and there is little vegetation along the waterways to prevent accelerated rates of erosion.

The soils of the Warrumbungle Watershed soils were also identified as predominantly Vertosol soils to the north of Gulargambone Creek and Kandosol soils to the north. Vertosol soils are cracking clays that have a high erosion potential. Kandosol soils are generally sandy and susceptible to rill, sheet and stream bank erosion.

4.5.2 Creek erosion impacts

The geomorphic characterisation was used to define the expected bedform types of each waterway and a literature search was undertaken to define the maximum velocity prior to which the various bed forms would erode.

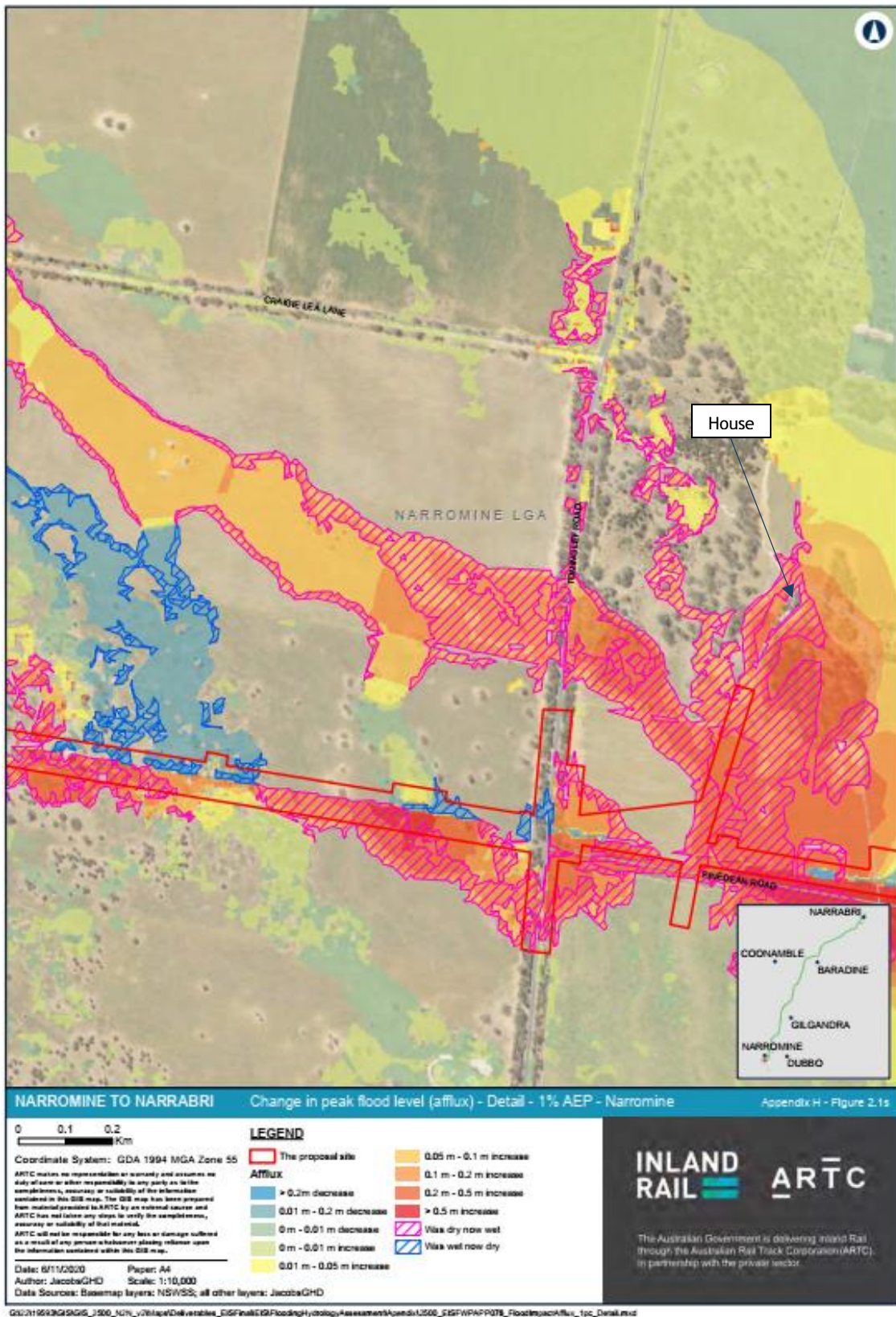


Figure 4.1 - Change in peak flood level at Tomingley Road crossing to the south of Narromine

Maximum velocity thresholds were defined for three typical bedform types:

- 0.5 m/s for sandy loam;
- 0.8 m/s for fine gravels; and
- 2 m/s for vegetated surfaces.

The hydraulic model was used to assess the changes in velocity due to the project and the potential impact this would have on the geomorphological condition of the waterway. That is, will the channels degrade as a result of the proposed rail. The results are presented as a series of figures (Figure 7.11 to Figure 7.14) in Technical Report 3 showing the change in maximum velocity at a single point in each waterway.

These figures are misleading and more than likely wrong. For instance, about 25 of the waterways show a reduction in 5% AEP velocity due to the rail, some are substantial reductions. More than a 50% reduction was predicted for the large waterways of the Macquarie River and Castlereagh River for the 5% AEP event, which is clearly wrong. If this was true, significant and unacceptable changes to the waterways would occur.

It would be expected that a minor increase in velocity would occur upstream of the rail (due to the afflux) and an increase in velocity downstream due to the confinement of the flows. The use of a single, undefined point at the rail with inconsistent results provides no confidence that an appropriate analysis has been undertaken.

4.5.3 Overbank erosion impacts

The EIS provides existing conditions velocity maps for the 20% AEP event only. For this event, the mapping colour scheme shows most overbank velocities below 1 m/s. This scale is too coarse to determine where existing condition scour would occur on the sandy loam soils and the vertosol soils (which would erode at 0.5 m/s). Much of the Warrumbungles Watershed contains vertosol soils.

Maximum velocity maps along the waterways and overbank areas for the other events were not provided and as such the existing erosion potential of the overbank areas is not known. Also, maximum velocities under the proposed conditions were not provided for any events and velocity impact maps showing impacts between 0.1 m/s and 0.5 m/s cannot be used to determine whether the increase has risen above the thresholds at which erosion would occur.

In other words, it is not possible to determine whether the proposed rail would cause increased soil erosion in the overbank areas.

4.6 IMPACT OF BLOCKAGE

The EIS states that a blockage assessment was undertaken in accordance with ARR (Ball et al, 2019) recommendations. However, no mapping or results were provided to demonstrate the impacts. Note that the EIS states that a blockage factor of 100% was recommended at Mt Tenandra, within the Warrumbungles Watershed, using the ARR risk assessment. Given that Tenandra Creek was identified as having a discontinuous river style (highly erosive) and has vertosol soils (also highly erosive), it could be concluded that significant erosion would occur if the waterway opening was blocked.

Blockage factors for the other waterways within the Warrumbungles Watershed was not provided. However, it could be expected that similar blockage factors and subsequent erosion would be encountered.

5 Summary of findings

Technical Report 3 of the EIS prepared by ARTC for the Narromine to Narrabri section of the inland rail has been reviewed to provide an opinion on the adequacy and accuracy of the flooding and hydrology modelling and whether the conclusions reached in the EIS are acceptable. The review is limited to the flood modelling undertaken in the two specific areas of concern (Webb's Siding and the Warrumbungle Watershed). My conclusions of the review are as follows:

- The quantitative design objectives adopted by ARTC are reasonable for afflux, flood hazard and flood duration. The scour/erosion potential design objectives are vague and no design objectives have been provided to minimise the changes in the flow patterns.
- With respect to the estimated design flows used for the assessment:
 - The adopted Macquarie River flows are consistent with those adopted by Narromine Shire and would therefore appear reasonable.
 - A review of the Castlereagh River flows cannot be undertaken because no information was provided.
 - The Warrumbungle Watershed creek flows have been derived using regional relationships because there is no historical data to base the flow estimates on. No information has been provided to determine whether the approach used to determine the flows is reasonable. However, a comparison to predicted discharges using another regional method showed significant differences and no bias high or low. Given the uncertainty surrounding the estimates, both methods should be used and the higher of the two adopted.
- The models and methodology used to estimate flood levels, velocities and flood impacts of the rail is appropriate.
- With respect to the flood level impacts (afflux):
 - The flood mapping provided is grossly inadequate and unsuitable for an individual farmer to identify the extent and quantity of flood level impacts at their property.
 - In the Webb's Siding area (where detailed mapping is available), the predicted flood afflux exceeds 0.2 m for most creek crossings and exceeds 0.5 m at several locations. This suggests that more culverts are required to satisfy the ARTC quantitative design objective.
 - For the Castlereagh River, the afflux would exceed 0.2m for the 1% AEP event and impact 11 existing dwellings. The EIS provides no discussion as to how this impact would be mitigated but it would appear a larger bridge is required.
 - In the Warrumbungles Watershed reach, any exceedances of the afflux quantitative design criteria would appear to be confined to the proposed rail corridor study area corridor and therefore very localised.
- The proposed rail is located directly across the overflow path from the Macquarie River that directs floodwater around Narromine during rare flood events. The change in the distribution in flow due to the proposed rail would increase above floor flooding to 605 dwellings in Narromine for the 1% AEP plus climate change event and 2,520 dwellings for the 0.2% AEP event. Additional viaduct or an alternative rail location would be required to mitigate the impacts at Narromine.
- Changes to flow patterns are predicted along much of the rail alignment for all flood events investigated. The changes to the flow patterns occur in areas of very flat topography both in the Webb's Siding area and the Warrumbungles Watershed. It is difficult to determine the impact of this change with the available flood mapping. It is

suggested that ARTC engage with each landholder with higher resolution maps to explain the predicted impacts and attempt to address any concerns.

- The assessment undertaken to predict the erosion impacts of the waterways appears misleading and likely wrong. For instance, more than a 50% **reduction** was predicted for the large waterways of the Macquarie River and Castlereagh River for the 5% AEP event, which is clearly wrong. If this was true, significant and unacceptable changes to the waterways would occur. The assessment provides no confidence that an appropriate analysis of the impact to the waterways has been undertaken.
- The flood mapping provided cannot be used to determine whether the changes in flow patterns would cause overbank erosion. Velocity maps were only provided for the 20% AEP event under existing conditions and the velocity colour scheme cannot be used to determine whether these velocities would cause erosion, particularly in the areas containing vertosol soils in the Warrumbungle Watershed.

6 References

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