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Our Ref: DXW: L.N21143.005.docx

27 May 2019

Aurizon Operations Limited
Ground floor, 121 Woodstock Street
Mayfield
NSW 2304

Attention: Harry Egan

Dear Harry

RE: HEXHAM TRAIN SUPPORT FACILITY TURNING ANGLE – FLOOD ASSESSMENT

Background

BMT was engaged by Aurizon to undertake a flood assessment for the proposed addition of turning angle at the Hexham Train Support Facility (TSF). Construction of the turning angle requires the modification to the existing State Significant Infrastructure (SSI) approval MP07_0171. This flood assessment forms part of the detailed environmental assessment submission and supports a modification application for MP07_0171.

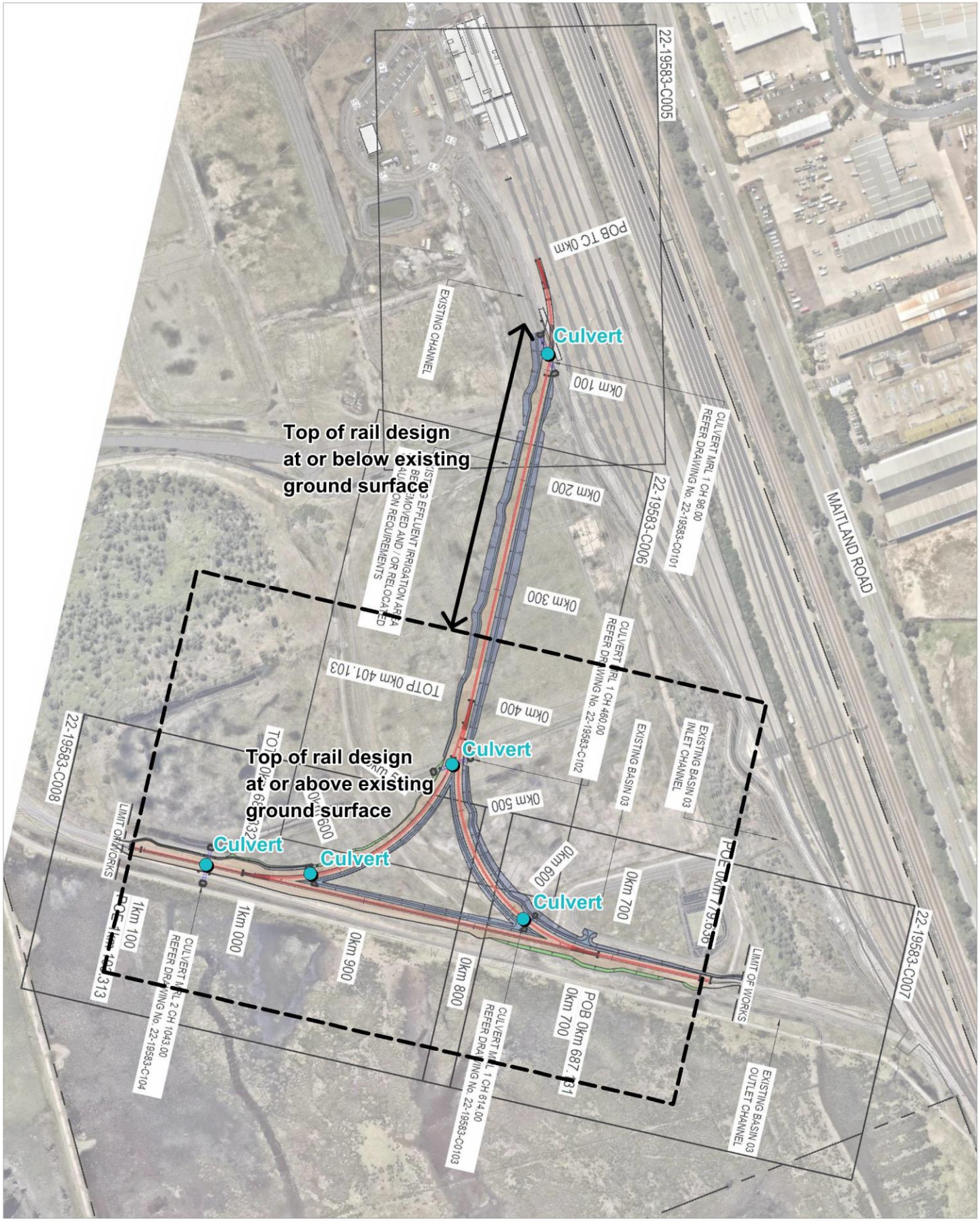
The proposed construction and operation of the turning angle consists of:

- Excavation works for railway track formation and ballast
- Approximately 1.5 km of rail track and associated signal and turnout infrastructure
- Construction of vehicular access tracks and associated lighting
- Installation of culverts within existing drainage channels, under the rail track and access tracks
- Associated civil and stormwater works.

The purpose of this assessment is to determine whether the existing flood impact assessment for the Train Support Facility (R.N2335.003.01) sufficiently addresses the potential flood impacts, or whether additional flood modelling is required to address potential flood impacts to satisfy the SEARs. The review of the proposed turning angle design and the context of potential flood impacts is documented within this report.

Proposed Works

The details of the proposed works were provided to BMT by Aurizon within the GHD design drawing set 22-19583. The design drawings include a general arrangement and detailed plans, longitudinal sections and cross sections. The design drawing set was reviewed in the context of the existing design flood conditions, as documented within the Hexham Relief Roads and NSW Long-term Train Support Facility: Joint Flood Impact Assessment, Final Report, R.N2335.003.01 (BMT WBM, March 2013). The general arrangement is presented in Figure 1, with key hydraulic controls identified.



Title:

Hexham TSF Turning Angle General Arrangement Plan

Figure: 1

Rev: B

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Existing Flood Conditions

The design flood conditions of the Hunter River are well documented, together with descriptions of flood behaviour in the Hexham Relief Roads and NSW Long-term Train Support Facility: Joint Flood Impact Assessment, Final Report, R.N2335.003.01. The flood mechanisms relevant to the proposed turning angle construction can be summarised as follows.

For design flood events of a 10% AEP or more frequent magnitude the flooding within Hexham Swamp is largely disconnected from the Hunter River. Exchange of flood waters between the Hunter River and Hexham Swamp is limited to the capacity of the Ironbark Creek floodgates and a few smaller hydraulic structures.

At floods in the order of a 5% AEP frequency the volume of floodwater in Hexham Swamp is significantly increased by contributions from the Hunter River spilling over the New England Highway and rail infrastructure between Hexham and Tarro. However, discharge back to the Hunter River south of Hexham is still confined to the Ironbark Creek floodgate structures.

Between flood events of a 5% AEP frequency and 1% AEP frequency there is a significant change in flood behaviour as the significance of overtopping flood volumes from the Hunter River increases. This sees a transition from Hexham Swamp acting as an offline storage to a fully-connected alternative flood flow path in parallel to that of the Hunter River, as flood waters in Hexham Swamp overtop the Pacific Highway to the south of Hexham. Flood levels within Hexham Swamp increase significantly from those of the 5% AEP and more frequent events.

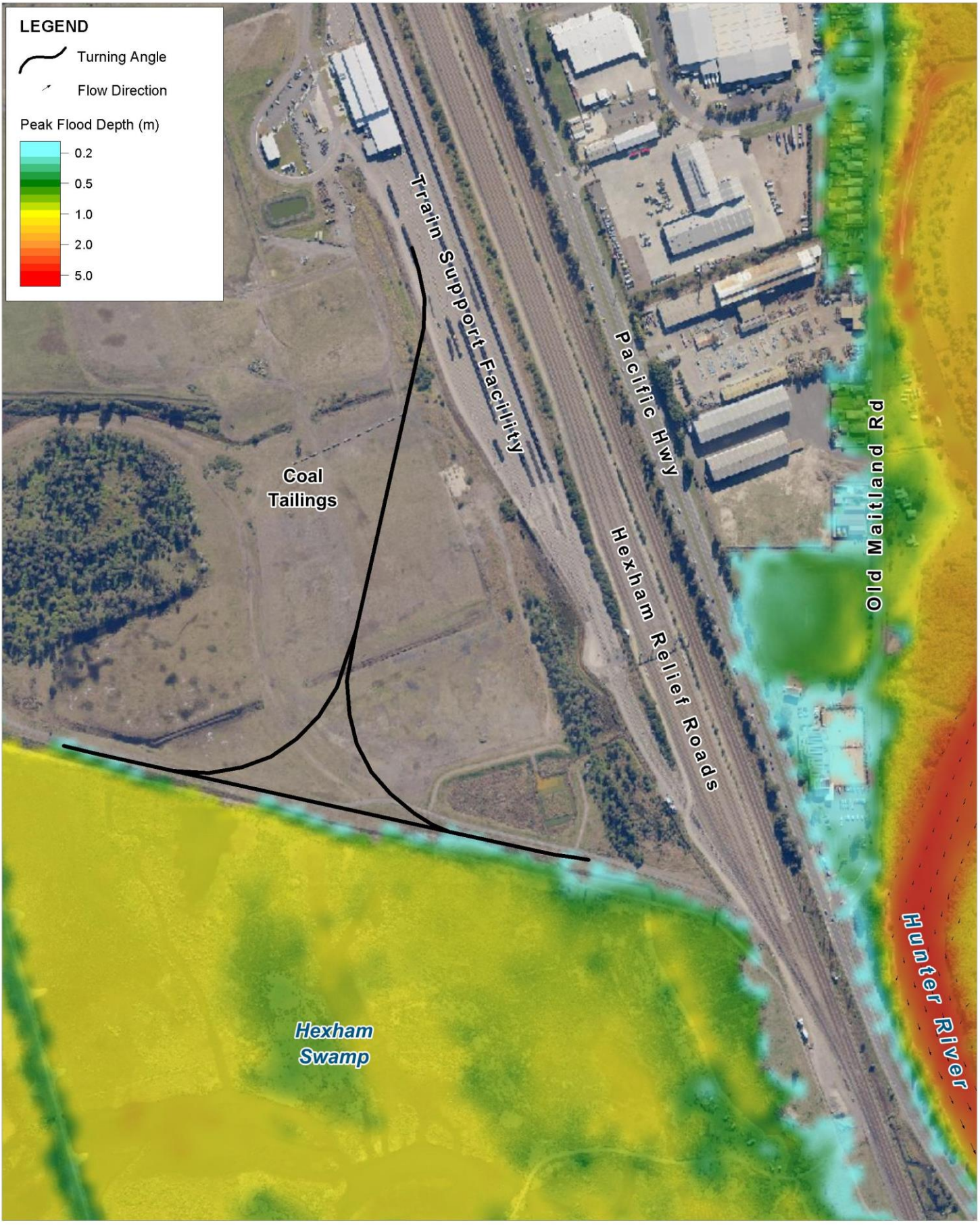
At floods of a 1% AEP magnitude the floodplain storage of Hexham Swamp is fully drowned, with a state of equilibrium being reached between flood levels in the Hunter River and Hexham Swamp. Although peak flood levels are increased for rarer flood events, the overall flood behaviour remains consistent with that of the 1% AEP.

The Williamtown – Salt Ash Floodplain Risk Management Study and Plan (BMT WBM, 2017) represents the most current and detailed modelling of Hunter River flood conditions in the estuary. Flood mapping from this study has been used to present representative flood conditions local to the turning angle site for the 5% AEP, 2% AEP and 1% AEP events in Figure 2 to Figure 4 respectively.

At the 5% AEP the turning angle site (which is situated atop the historic coal tailings fill) is effectively flood free. Convective flood waters are limited to the Hunter River channel, with surrounding areas of floodplain being non-convective flood storage.

At the 2% AEP the Hexham Swamp flood storage volume is substantially larger, although the flood waters are still largely non-convective. The southern extent of the proposed turning angle becomes flooded by backwater inundation.

At the 1% AEP the significant conveyance of flood waters through Hexham Swamp is evident, where the overtopping of the Pacific Highway and rail infrastructure acts as the principal local hydraulic control, as evidenced by the higher velocities. A minor flood flow path is also initiated over the coal tailings, within the footprint of the proposed turning angle works.



Title:

Hunter River 5% AEP Flood Conditions

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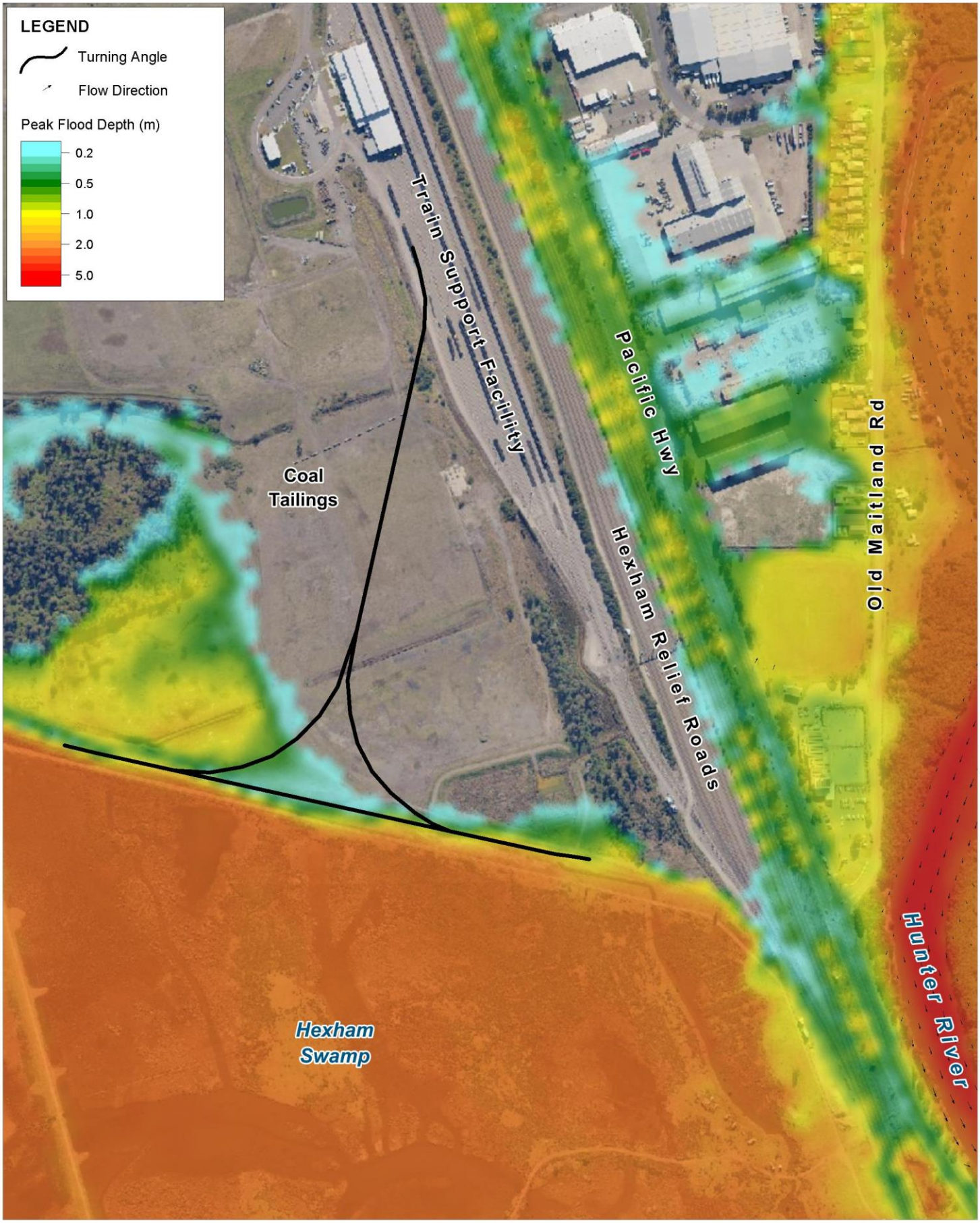

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Hunter River 2% AEP Flood Conditions

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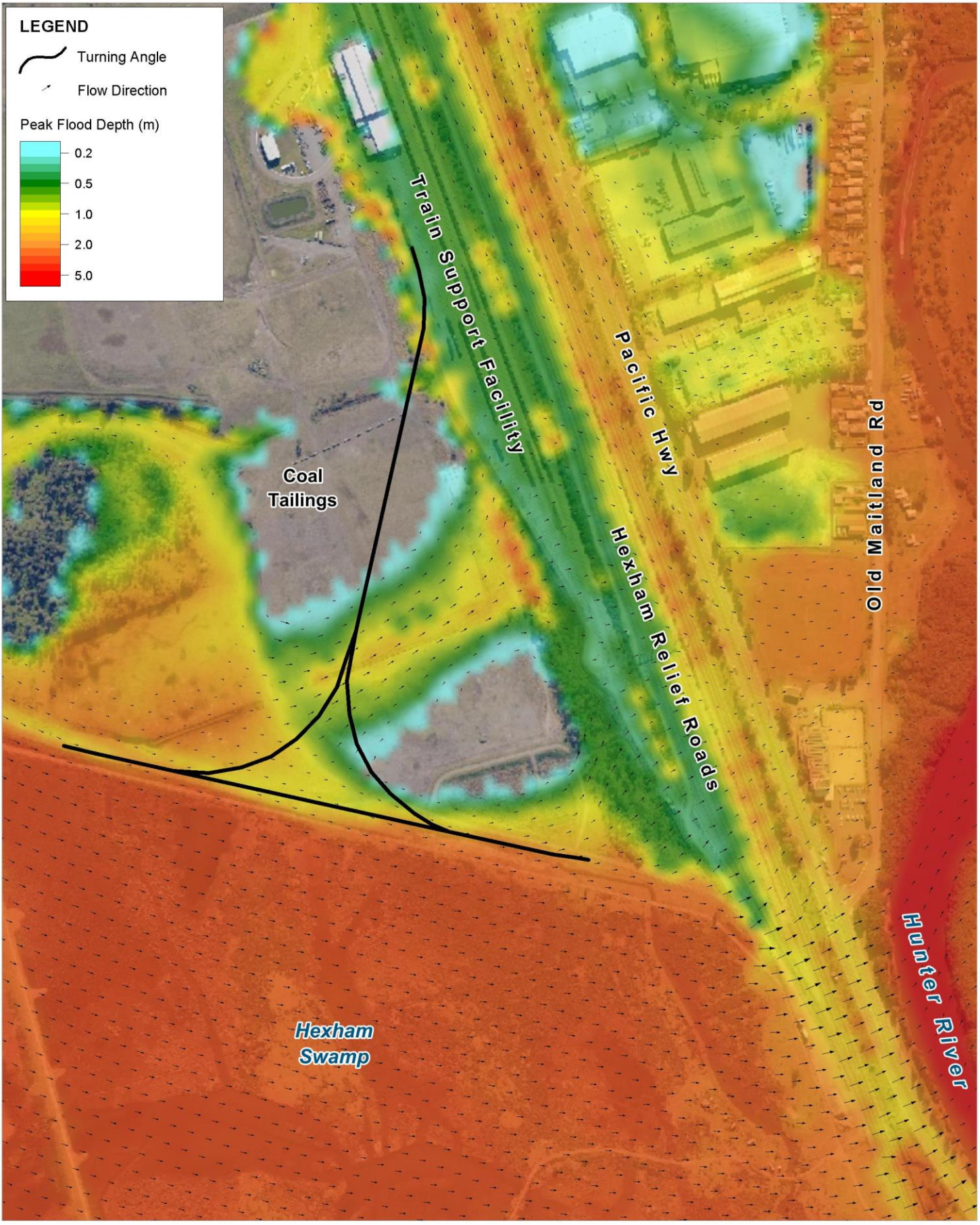

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Hunter River 1% AEP Flood Conditions

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Flood Impact Assessment

At the 5% AEP and more frequent flood events the turning angle site is effectively flood free. Therefore, potential flood impacts only need to be considered for rarer events.

At the 2% AEP event the southern end of the proposed turning angle becomes flooded by backwater inundation. However, due to the nature of flooding, which is relatively shallow (< 1 m) non-convective backwater inundation, potential flood impacts associated with the proposed works would be negligible. The peak flood level of the 2% AEP is around 2.9 m AHD in Hexham Swamp and so the proposed turning angle works would be largely elevated above this. The overall loss of potential flood storage volume associated with the proposed works is negligible compared to the vast flood storage volume afforded by Hexham Swamp.

At the 1% AEP and rarer flood events a minor flood flow path is also initiated over the coal tailings, within the footprint of the proposed turning angle works. The peak flood level of the 1% AEP is around 3.7 m AHD in Hexham Swamp and so the proposed turning angle works would obstruct this flow path, with the top of rail control being above the water surface.

Conveyance of flood waters along the coal tailings flow path will instead become limited to the capacity of the proposed 2.4 m by 0.6 m (MRL1 ch.460) and 0.6 m by 0.45 m (MRL3 ch.624) box culverts. This would result in a minor reduction in flooding along the flow path downstream (east) of the turning angle (due to a reduction of flood flows being limited to the conveyance capacity of the culverts), with an associated redistribution of those flows into the principal flow path through Hexham Swamp to the south. Flood waters flowing east across the coal tailings in the current flooding scenario would instead be confined to Hexham Swamp south of the turning angle, resulting in a minor increase in flow being conveyed within that principal flow path.

It is expected that the localised flow redistribution would have a negligible impact on the broader flooding regime, due to the substantial flood flows (over 2700 m^3/s at the 1% AEP event) being conveyed through the swamp relative to those along the flow path across the coal tailings (~35 m^3/s at the 1% AEP event). Figure 5 has been produced to demonstrate the relative conveyance of the flow paths, mapping the modelled peak flood flow distribution, i.e. velocity x depth product. The flow path across the Pacific Highway has around a 2 km width of VxD > 1.0, whilst the flow path over the coal tailings is around a 150 m width of VxD < 0.5.

The coal tailings flow path of around 35 m^3/s would be redistributed to the south of the turning angle, combining with the existing flow of over 2700 m^3/s being conveyed within the principal flood flow path through Hexham Swamp, which represents only around a 1% increase in flow along that alignment. As such, any associated increase in flood levels along the principal flood flow path in Hexham Swamp, and hence the broader existing flooding regime, would be negligible.

At the PMF event the entire area including the site is inundated by several metres of flood water and any impacts associated with the proposed works would be negligible due to having no influence on the broader hydraulic controls governing the flood behaviour of such an extreme event.

In summary, there is no expected change to flood levels and velocities at other properties, assets and infrastructure at the 2% AEP and rarer events associated with the proposed works from those previously presented in the Hexham Relief Roads and NSW Long-term Train Support Facility: Joint Flood Impact Assessment, Final Report, R.N2335.003.01 (BMT WBM, March 2013), as summarised in Table 1.

Table 1 Summary of Expected Flood Impacts

Design Flood Event	Expected Change to Approved SSI Flood Impacts
10% AEP	Nil change
5% AEP	Nil change
2% AEP	Nil change
1% AEP	Nil change
PMF	Nil change

The nature and magnitude of the expected localised flood flow redistribution does not have implications for downstream velocity and scour potential. Additional scour protection measures are not required, beyond the standard local scour protection measures associated with the proposed culverts.

The proposed modification does not affect the original SSI approval's consistency with applicable Council floodplain risk management plans. Also, the proposed works are consistent with the broader flood hazard compatibility of the original approval and do not impact the existing emergency management arrangements.

Climate Change Considerations

There are a range of sources that predict various future increases in global and regional sea levels. However, the typically accepted predictions for NSW are those of the *NSW Sea Level Rise Policy Statement* (DECCW, 2009), which provides projected increases in mean sea level for NSW of 0.4m and 0.9m, by the years 2050 and 2100 respectively (as considered within the Hexham Relief Roads and NSW Long-term Train Support Facility: Joint Flood Impact Assessment).

With regards to potential future changes to rainfall intensities the current research has identified that short duration rainfall intensities are showing signs of significant increases (from sub-daily rainfall records). However, research undertaken using daily rainfall records has not identified any long-term climatic change. The impacts of increased rainfall intensity on flood risk are therefore more applicable to smaller local catchments with a shorter critical duration, rather than larger river systems such as the Hunter River.

In summary, the likely impacts of potential future climate change would be principally related to increased sea levels and the implication for flood levels at the site. Climate change flood modelling undertaken for the Williamtown – Salt Ash Floodplain Risk Management Study and Plan has found that for a future sea level rise of 0.9 m, the peak flood level of the 1% AEP design event in Hexham Swamp increases by around 0.15 m. Therefore, although sea level rise associated with potential future climate change does have some level of impact at the site it is minor in comparison to the overall variance in design event magnitude and associated uncertainties. The potential for flood impacts associated with the proposed works would not change in relation to future climate change, but there would be some level of reduction in the overall flood immunity of the proposed works.

Conclusions

BMT has reviewed the proposed addition of turning angle at the Hexham TSF in the context of the existing Hunter River flood conditions and SSI approval MP07_0171. It is the opinion of BMT that the proposed turning angle does not have significant implications for potential impacts to the existing flood behaviour. As such the existing flood impact assessment for the Train Support Facility (R.N2335.003.01) sufficiently

addresses the potential flood impacts relating to the addition of the turning angle at the Hexham TSF and hence the required modification to the existing MP07_0171 approval.

The expected flood impacts relating to the proposed addition of the turning angle are minor in nature and limited to a reduction in peak flood conditions downstream of the works within Aurizon's land. No off-site flood impacts are anticipated. There is no expected change to flood levels and velocities at other properties, assets and infrastructure at the 2% AEP and rarer events associated with the proposed works from those previously presented in R.N2335.003.01.

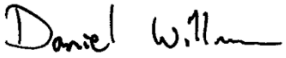
The nature and magnitude of the expected localised flood flow redistribution does not have implications for downstream velocity and scour potential. Additional scour protection measures are not required, beyond the standard local scour protection measures associated with the proposed culverts.

As the assessment has determined a negligible impact on flooding, the proposed modification does not affect the original SSI approval's consistency with applicable Council floodplain risk management plans. Also, the proposed works are consistent with the broader flood hazard compatibility of the original approval and do not impact the existing emergency management arrangements.

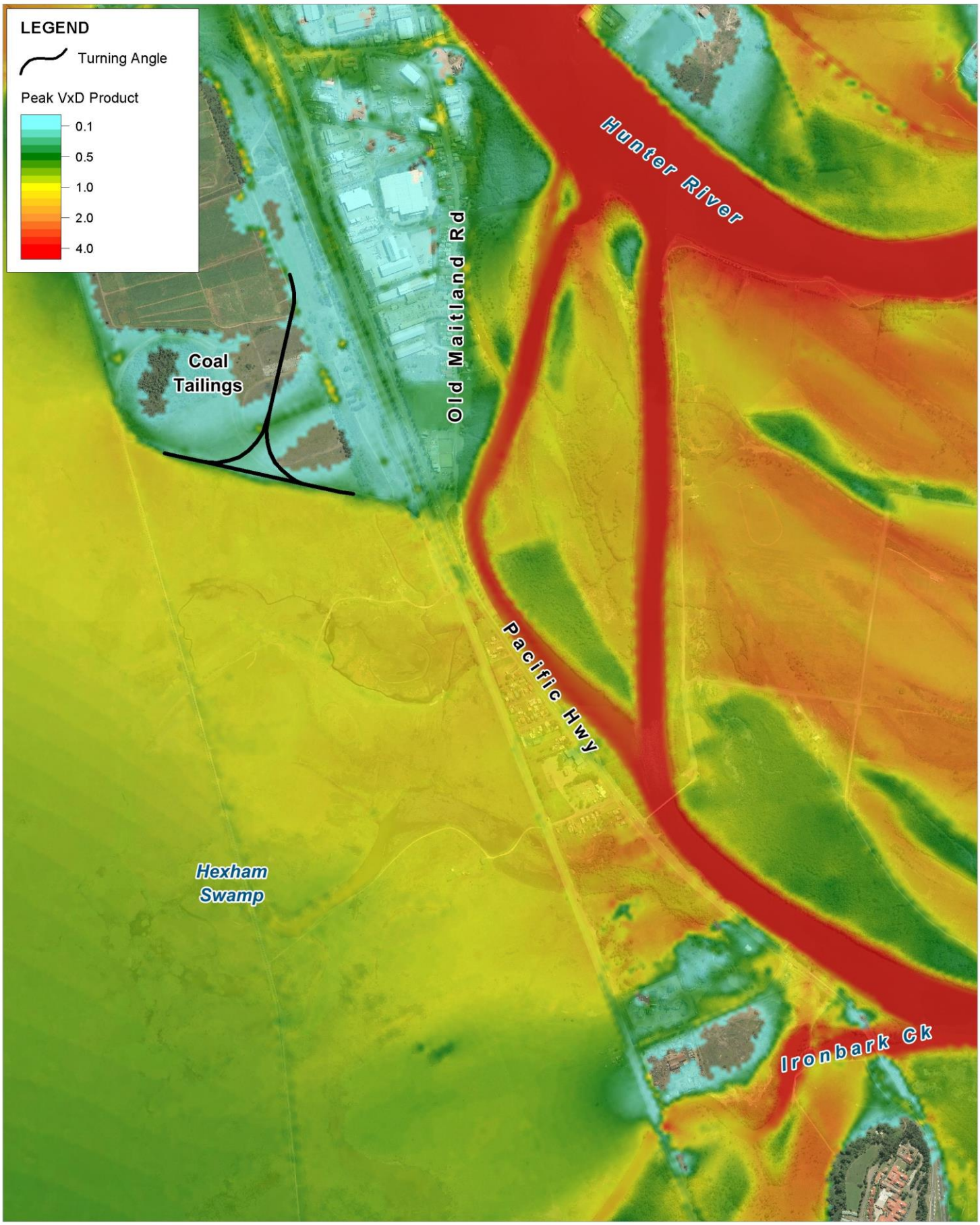
Whilst sea level rise associated with potential future climate change does have some level of impact at the site it is minor in comparison to the overall variance in design event magnitude and associated uncertainties. The potential for flood impacts associated with the proposed works would not change in relation to future climate change, but there would be some level of reduction in the overall flood immunity of the proposed works.

We trust the above provides a suitable of the existing flood behaviour at the site and the potential for flood impacts associated with the proposed turning angle works at the Hexham TSF. Please feel free to contact the undersigned to discuss further as required.

Yours Faithfully
BMT



Daniel Williams
NSW Flood Lead



Title:

Hunter River 1% AEP Flood Flow Distribution

Figure: 5

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