

# APPENDIX

# E

## Flood Study Report

### **Attachment F** Flood Impact Assessment for Extreme Events

PART 1 OF 3

NARRABRI TO NORTH STAR SUBMISSIONS PREFERRED INFRASTRUCTURE REPORT

# Memo

<b>Project Name</b>	Technical and Approvals Consultancy Services: Narrabri to North Star
<b>To</b>	Rob Walker, ARTC Project Manager Zisis Plakas, ARTC Design Manager Jack O'Donoghue, ARTC Project Delivery Engineer
<b>From</b>	Rob Leslie, IRDJV Hydrology & Drainage Lead
<b>Subject</b>	Flood Impact Assessment for Extreme Events
<b>Our Ref</b>	3-0001-260-IHY-00-ME-0004_A
<b>Date</b>	Tuesday, 6 August 2019

## 1. Introduction

This memo reports on the results of the flood impact assessment undertaken for extreme events that exceed the 1% Annual Exceedance Probability (AEP) event, which is the highest event considered in the design for compliance with flood impact criteria and rail flood immunity. The purpose of the assessment is to develop an understanding of the risks to adjacent land, assets and the rail infrastructure for flood events that exceed the design limits.

The assessment has been undertaken in response to ARTC's request (mail ref. 3-0001-260-PCM-00-LT-0084) for IRDJV to provide an assessment of worst case flooding impacts.

## 2. Background

The Flood Study Report Volumes 1 and 2 (3-0001-260-IHY-00-RP-0002 and 3-0001-260-IHY-00-RP-0003) have been delivered and include an assessment of flood risk to the rail line and impacts on adjacent land and assets for the following events:

**Table 2.1** Event modelled by the N2NS Flood Study

Design event	Approximate equivalent Average Recurrence Interval (ARI)	Purpose of event analysis
39% AEP	2.5 year ARI	Flood impact assessment
18% AEP	5 year ARI	Flood impact assessment
10% AEP	10 year ARI	Flood impact assessment and potential lower standard adopted for Top Of Formation (TOF) flood immunity as part of ARTC's Flooding Multi-Criteria Analysis (MCA) procedure
5% AEP	20 year ARI	Flood impact assessment and potential lower standard adopted for TOF flood immunity as part of Flooding MCA procedure

Design event	Approximate equivalent Average Recurrence Interval (ARI)	Purpose of event analysis
2% AEP	50 year ARI	Flood impact assessment and potential lower standard adopted for TOF flood immunity as part of Flooding MCA procedure
1% AEP	100 year ARI	Flood impact assessment and typical standard adopted for TOF flood immunity as part of Flooding MCA procedure
1% AEP with climate change allowance (approx 12% increase in flow over 1% AEP)	100 year ARI	Sensitivity test to assess impact of climate change on flood impacts and TOF flood immunity
0.05% AEP	2000 year ARI	Flood impact assessment and to inform loading for structural stability assessments for bridges

For each of these events the following set of maps has been produced:

- Existing conditions:
  - Flood extent and depth;
  - Flood velocity;
  - Flood duration (time of inundation);
- Design case:
  - Change in flood level (afflux) and extent as compared to existing conditions;
  - Change in flood velocity as compared to existing conditions; and
  - Change in flood duration as compared to existing conditions.

The project has been designed to meet impact limits for flood level (afflux), velocity and duration up to and including the 1% AEP event. The impact limits are referred to as 'Flood Management Objectives' (FMOs). Generally, the design has met the FMOs, with a small number of exceedances that have been classified as 'low risk' on the basis that they do not increase flood risk on sensitive land uses or restrict the ongoing use of the land under its current use.

The project has also been designed to deliver a 1% AEP flood immunity to the TOF level in most areas (approximately 90% of the corridor), with lower immunity provided in the remaining areas (approximately 10% of the corridor) where flood risk to the rail is low (i.e. where 1% AEP event depth above TOF, velocity and duration are low) in accordance with the ARTC Flooding MCA Procedure. In areas where less than 1% AEP flood immunity is provided to the TOF, the design still ensures that the Top of Rail (TOR) level is not overtopped at the 1% AEP event, which is another key requirement of the Flooding MCA Procedure.

The project has not been designed to meet the FMOs for events above the 1% AEP event, nor has it been designed to provide TOF or TOR flood immunity to events above the 1% AEP event. For events above the 1% AEP event the Flood Study Report provides the following key findings:

- For the 1% AEP with climate change scenario, the flood immunity of the TOF is reduced but depths above TOF remain below 200mm in most areas and the TOR is not overtopped at any location. This indicates that the design is resilient to climate change in terms of rail flood immunity;

- The impacts on adjacent land are increased across most of the project area for the 1% AEP with climate change scenario with numerous instances of non-compliant impacts against the FMOs introduced under this scenario. The non-compliances are generally confined to agricultural land with no significant increase in impacts to sensitive areas such as settlements or dwellings;
- The impacts on adjacent land for the 0.05% AEP event are considerably higher than the 1% AEP and 1% AEP event with climate change. Significant areas of non-compliant impacts against the FMOs occur under this event, however, they are generally confined to agricultural land with no significant increase in impacts to sensitive areas such as settlements or dwellings. The following limitations should be noted with regard to the impact assessment for the 0.05% AEP event:
  - No analysis was undertaken to determine where the TOR would be overtopped under this event;
  - The assessment assumed that the rail embankment, ballast and track remain intact and impervious to flow under this event. In reality, the track, ballast and possibly the entire embankment would wash away in numerous areas during such an event, particularly in areas where the TOR is overtopped, and therefore the predicted flood level impact is likely to be overestimated in these areas as washout of the track, ballast and embankment would reduce the flood level difference across the rail line and the flood level impact on the upstream side; and
  - No analysis of the risk of sudden embankment failure under this event has been undertaken. In areas where this could occur it may pose an increased risk to land downstream of the rail when compared to the existing conditions where the TOR would be overtopped and/or breached at a significantly lower flood level.

ARTC has requested further assessment of worst-case flooding impacts to land, dwellings, commercial and local government infrastructure over and above the 1% AEP event and up to the height of rail structure overtopping. The available results for the 1% AEP event with climate change (equivalent to approximately a 12% increase in 1% AEP event flows and likely to be similar to the 0.5% AEP event under present day climate) and the 0.05% AEP event have been used as the basis for this assessment.

### 3. Scope

The detailed scope of this assessment is as follows:

- Task 1: Rail structure failure risk assessment:
  - For the two extreme events (1% AEP with climate change and 0.05% AEP) assess the hotspots along the rail corridor where overtopping and breaching of the rail structure could occur;
  - Downstream of each hotspot, list sensitive assets that could be affected by a sudden failure of the rail structure, such as:
    - Towns and smaller settlements;
    - Isolated dwellings and access roads / tracks to the dwellings;
    - Isolated commercial, agricultural or other buildings and access roads / tracks to the buildings;
    - Highways and public roads;
    - Other public infrastructure (such as sewage treatment plants, pumping stations, etc);
- Task 2: Identification of non-compliant flood impacts:
  - For each event assess the extent of non-compliance against the current FMOs, including:



- Areas of non-compliant afflux impact;
- Areas of non-compliant velocity impact;
- Areas of non-compliant duration impact;
- Areas where flood hazard rating on the Newell Highway is increased;
- Based on the above mapping, produce a schedule of impacted areas / assets, including:
  - List of buildings experiencing non-compliance against the current FMOs;
  - List of public roads experiencing non-compliance against the current FMOs;
  - Total areal extent of non-compliance against the current FMOs within agricultural land; and
  - List of locations (in terms of rail chainages) and linear extents of increased flood hazard on the Newell Highway.

## 4. Methodology

For Task 1: Rail structure failure risk assessment the following methodology was used:

- Where the flood level is above the TOR, the failure risk is classified as high;
- Where the flood level is below the TOR but over 300mm above the TOF, the failure risk is classified as medium;
- Where the flood level is less than 300mm above the TOF, the failure risk is classified as low; and
- A set of maps was produced to indicate areas of high (red) and medium (orange) risk. The maps were used to identify assets at risk downstream of the high and medium failure areas.

For Task 2: Identification of non-compliant flood impacts the following methodology was used:

- Flood impact maps for the extreme events were extracted from the Flood Study Report; and
- The GIS layers for these maps were interrogated to develop schedules of impacts that do not comply with the FMOs.

## 5. Results

### 5.1 Rail Structure Failure Risk

The rail structure failure risk maps are provided in Appendices A1 and A2. Tables 5.1 and 5.2 provide locations of sensitive assets located downstream of the rail structure failure risk areas.

### 5.2 Non-Compliant Flood Impacts

The non-compliant flood impacts for the events are scheduled in Tables 5.3 and 5.4. Tables 5.5 and 5.6 provide the changes to flood hazard on the Newell Highway for both events.

**Table 5.1 Assets downstream of failure areas for 1% AEP with climate change event**

Assets Downstream of Rail Structure Failure Area	Rail Structure Failure Risk	
	Medium	High
Towns and settlements	636km – Gurley	-
Isolated dwellings and accesses	716km – 1 property	-
Isolated commercial / agricultural / other buildings and accesses*	-	-
Highways and public roads	636 to 640km – Newell Highway 645km – Newell Highway 659km – Newell Highway 660km – Newell Highway	-
Other public infrastructure*	-	-

\*Note: No GIS layers are available for these asset types. Information is obtained from inspection of the mapping.

**Table 5.2 Assets downstream of failure areas for 0.05% AEP event**

Assets Downstream of Rail Structure Failure Area	Rail Structure Failure Risk	
	Medium	High
Towns and settlements	633 to 638km – Gurley 733km – 10 properties	-
Isolated dwellings and accesses	584km – 1 property 661km – 2 properties 705km – 1 property 708km – 1 property 737km – 2 properties 755km – 2 properties	594km – 1 property 597km – 1 property 647 to 649km – 4 properties 716km – 1 property 734km – 1 property
Isolated commercial / agricultural / other buildings and accesses	-	-
Highways and public roads	625km – Newell Highway 633 to 638km – Newell Highway 643 to 646km – Newell Highway	627.5km – Newell Highway 638 to 640km – Newell Highway
Other public infrastructure	-	-

\*Note: No GIS layers are available for these asset types. Information is obtained from inspection of the mapping.

Table 5.3 Non-compliant impacts for 1% AEP event with climate change

Asset Type	Non-Compliant Impacts		
	Afflux	Velocity Change	Duration Change
Buildings and accesses	575km – 1 building and access road 582.85 – access road 614.4km – access road 615km – access road 627.85km – access road 634.4km – 1 building 634.5km – access road 636.25km – access road 641km – access road 643.1km – 1 residence 643.3km – 1 building and access road 643.75km – access road 643.8km – access road 644km – access road 644.1km – 1 residence 648.1km – access road 648.2km – access road 649.4km – multiple access roads 654.5km – access road 658.6 to 660km – several commercial buildings 657.8km – 1 residence 660.25km – access road 660.9km – access road 664.6 to 665km – commercial / residential land and access roads 691km – access road 706.55km – access road 707.4km – commercial building 711.75km – access road 716.25km – access road 721.1km – access road 723.6km – access road 723.75km – access road 724.75km – access road 733.5km – access road 733.75km – access road 733.9km – 1 residence 734km – Croppa Creek Public School 734.15km – sports buildings 735.25km – 1 residence 745km – access road	614.75km – access road 627.85km – access road 634.5km – access road 635.5km – several buildings in Gurley 636.25km – access road 638km – access road 639.3km – access road 643.25km – 1 residence, 1 building and multiple access roads 648.25km – access road 649km – access road 661.5km – access road 711.75km – access road 716.3km – access road 724.85km – access road 726.1km – access road 734km – 1 residence 734.25km – 1 residence 745km – access road 752.7km – access road 755.5km – access road	584.6km – access road 616km – access road 627.9km – access road 634.5km – 1 building and access road 641.15km – access road 634.5km – 1 residence 660.25km – access road 711.5km – access road
Highways and public roads	582.15km – Newell Highway 625.5km – Pennys Road 635.75km – Gurley Creek Road 643.6km – Gurley Settlers Road 659.1km – unnamed road 657.8km – Burrington Road 660.6km – Bulluss Road 665km – Tycannah Street 665.2km – Dingwall Place 706.5km – County Boundary Road 717km – Gil Gil Creek Road 730.25km – Croppa Moree Road 733.9km – Buckie Road 755.5km – Croppa Creek Road	590.25km – Smithfield Lane 593.75km – Homestead Road 635.7km – Gurley Creek Road and Moloney Road 658.4km – Tapscott Road 657.8km – Burrington Road 685km – Roydon Road 734km – Buckie Road	643.5km – Gurley Settlers Road
Agricultural land	271ha	315ha	528ha

Table 5.4 Non-compliant impacts for 0.05% AEP event

Asset Type	Non-Compliant Impacts		
	Afflux	Velocity Change	Duration Change
Residences, buildings and accesses	575km – 1 building 580.25km – access road 589.1km – access road 589.7km – access road 590.25km – access road 590.4km – 1 residence 615km – access road 615.25km – 6 residences 616.05km – access road 627.25 – 1 residence 629.25 – access road 634.35km – 1 building and access road 636.25km – access road 641km – access road 643.1km – 1 residence 643.3km – 1 building and access road 643.75km – access road 643.8km – access road 644km – access road 644.1km – 1 residence 648.1km – access road 648.2km – access road 648.25km – 2 residences 649.4km – multiple access roads 654.5km – access road 658.6 to 660km – several commercial buildings 657.8km – 5 residences 660.25km – access road 660.9km – access road 664.6 to 665km – commercial / residential land and access roads 691km – access road 704.65km – access road 706.55km – access road 707.4km – 1 commercial building 711.75km – access road 716.25km – access road 721.1km – access road 723.75km – access road 724.75km – access road 726.5km – access road 730.25km – access road 730.65km – access road 732.55km – access road 733.2km – 1 residence 733.5km – access road 733.75km – access road 733.9km – 1 residence 734km – Croppa Creek Public School 734.15km – sports buildings 735.25km – 1 residence 736.4km – access road 745km – access road 732.75km – access road	575km – building and access road 589.25km – access road 614.75km – access road 627.25km – access road 634.5km – access road 635.5km – several buildings in Gurley 636.25km – access road 638km – access road 639.3km – access road 643.25km – 1 residence, building and access road 648.25km – access road 649km – access road 659.8km – 4 residences 660.15km – access road 711.75km – access road 724.85km – access road 732.5km – access road 734km – 1 residence 734.15km – 2 residences 734.25km – 1 residence 745km – access road 752.7km – access road	584.6km – access road 614.75km – access road 616km – access road 627.9km – access road 634.5km – 1 building and access road 636km – several buildings in Gurley 641.15km – access road 660.25km – access road 711.5km – access road 732.25km – access road
Highways and public roads	579.75km – Newell Highway 580.7 to 585.75km – Newell Highway 580.9km – Newell Highway 581.25km – Murumbilla Lane 581.6km – Newell Highway 582.25km – Newell Highway 583.25km – Newell Highway 584.75km – Newell Highway 585.75km – Newell Highway 587.5km – Newell Highway 588.25 to 592.25km – Newell Highway 590.25km – Smithfield Lane 594.25km – Newell Highway 596.5km – Newell Highway 607.25km – Newell Highway 609km – Newell Highway 609.25km – Ten Mile Lane 614.5km – Newell Highway 625.5km – Pennys Road 635.75km – Gurley Creek Road 643.6km – Gurley Settlers Road 659.1km – unnamed road 657.8km – Burrington Road 660.6km – Bulluss Drive 665km – Tycannah Street and Gosport Street 665.2km – Dingwall Place 706.5km – County Boundary Road 717km – Gil Gil Creek Road 730.25km – Croppa Moree Road 733.9km – Buckie Road 755km – Croppa Creek Road	590.25km – Smithfield Lane 635.7km – Gurley Creek Road and Moloney Road 658.4km – Tapscott Road 659.8km – Burrington Road 665km – Dingwall Place 707.km – Gil Gil Creek Road 730.25km – Croppa Moree Road 734km – Buckie Road	625.5km – Pennys Road 643.5km – Gurley Settlers Road 734km – Buckie Road
Agricultural land	1,703ha	1,013ha	955ha

**Table 5.5**      **Locations of increased flood hazard on Newell Highway for 1% AEP with climate change event**

Location (km)	Existing Conditions				Design Case			
	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category
582115	0.2	0.9	0.2	H1	0.3	1.0	0.3	H2
584535	0.3	1.1	0.3	H1	0.3	1.1	0.3	H2
584650	0.5	0.9	0.5	H2	0.5	1.1	0.6	H4
588560	0.3	0.6	0.2	H1	0.3	0.8	0.3	H2
588690	0.3	0.5	0.1	H1	0.3	0.7	0.2	H2
588920	0.3	0.8	0.2	H1	0.3	0.8	0.3	H2
589940	0.1	0.9	0.1	H1	0.3	0.9	0.3	H2
641455	0.6	1.0	0.6	H3	0.6	1.2	0.7	H4
641505	0.8	1.0	0.8	H4	0.8	1.3	1.0	H5
641515	0.2	1.3	0.3	H1	0.2	1.5	0.4	H2
641550	0.2	1.5	0.3	H1	0.2	1.6	0.3	H2
641560	0.2	0.9	0.2	H1	0.2	1.3	0.3	H2
641735	0.2	2.0	0.4	H2	0.2	2.0	0.4	H5
641815	0.0	2.0	0.0	H1	0.0	2.0	0.1	H5
641825	0.1	2.0	0.2	H1	0.1	2.0	0.2	H5

**Table 5.6**      **Locations of increased flood hazard on Newell Highway for 0.05% AEP event**

Location (km)	Existing Conditions				Design Case			
	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category
580970	0.3	0.9	0.2	H1	0.4	0.9	0.4	H2
581035	0.2	1.2	0.2	H1	0.3	1.2	0.4	H2
581130	0.2	0.9	0.2	H1	0.3	1.1	0.3	H2
581305	0.2	0.8	0.2	H1	0.3	1.0	0.3	H2
581495	0.3	1.3	0.4	H2	0.5	1.4	0.7	H4
581650	0.3	1.2	0.3	H2	0.5	1.2	0.6	H4
581800	0.2	1.4	0.3	H1	0.3	1.9	0.6	H4
581895	0.2	1.3	0.3	H1	0.5	1.3	0.7	H4
581985	0.2	1.0	0.2	H1	0.5	1.3	0.7	H4
582115	0.3	1.1	0.3	H2	0.7	1.5	1.0	H4
582190	0.4	1.2	0.5	H2	0.8	1.5	1.1	H5
582320	0.4	1.1	0.5	H2	0.8	1.2	0.9	H4
582435	0.5	1.0	0.4	H2	0.8	1.0	0.8	H4
582485	0.4	1.0	0.5	H2	0.8	0.9	0.7	H4
582730	0.4	1.4	0.6	H2	0.7	1.4	1.0	H4
582785	0.3	1.3	0.4	H2	0.6	1.2	0.7	H4

Location (km)	Existing Conditions				Design Case			
	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category
582855	0.2	1.1	0.2	H1	0.4	1.1	0.5	H2
582915	0.1	0.7	0.1	H1	0.4	1.0	0.4	H2
583275	0.0	0.9	0.0	H1	0.3	0.9	0.3	H2
583455	0.0	0.7	0.0	H1	0.3	0.8	0.3	H2
583535	0.1	0.9	0.1	H1	0.4	0.9	0.4	H2
583645	0.2	1.2	0.2	H1	0.5	1.1	0.5	H2
583710	0.2	1.0	0.2	H1	0.4	0.9	0.4	H2
583840	0.2	1.3	0.3	H1	0.5	1.0	0.6	H3
583965	0.2	1.1	0.2	H1	0.5	0.9	0.5	H3
584020	0.2	0.8	0.1	H1	0.4	0.8	0.3	H2
584425	0.2	0.8	0.2	H1	0.3	1.0	0.3	H2
584650	0.5	1.0	0.5	H3	0.7	1.1	0.8	H4
584955	0.2	1.0	0.2	H1	0.3	1.1	0.4	H2
585040	0.3	1.1	0.3	H1	0.4	1.2	0.4	H2
585370	0.3	1.4	0.5	H2	0.5	1.4	0.6	H4
585490	0.3	1.8	0.6	H2	0.4	1.7	0.7	H4
588290	0.2	0.9	0.2	H1	0.4	0.9	0.4	H2
588360	0.2	0.9	0.2	H1	0.6	0.9	0.5	H3
588470	0.3	0.9	0.2	H1	0.6	1.0	0.6	H4
588560	0.4	0.9	0.3	H2	0.7	1.0	0.8	H4
588690	0.4	0.8	0.3	H2	0.7	0.8	0.6	H3
588805	0.5	1.0	0.5	H2	0.8	1.1	0.9	H4
588920	0.4	0.9	0.3	H2	0.7	0.9	0.6	H4
589035	0.1	1.0	0.1	H1	0.5	1.4	0.7	H4
589130	0.1	0.5	0.0	H1	0.4	0.9	0.4	H2
589225	0.0	0.4	0.0	H1	0.4	0.7	0.3	H2
589335	Not flooded	Not flooded	Not flooded	Not flooded	0.4	0.9	0.3	H2
589470	0.0	0.4	0.0	H1	0.3	0.7	0.2	H2
589665	Not flooded	Not flooded	Not flooded	Not flooded	0.3	1.1	0.3	H2
589745	Not flooded	Not flooded	Not flooded	Not flooded	0.5	0.5	0.2	H2
589785	0.0	0.7	0.0	H1	0.6	0.8	0.5	H3
589850	0.0	0.6	0.0	H1	0.6	0.6	0.4	H3
589940	0.2	1.0	0.2	H1	0.8	1.0	0.9	H4
590040	0.2	0.6	0.1	H1	0.7	0.7	0.5	H3
590130	0.1	0.7	0.1	H1	0.7	0.8	0.6	H3
590225	0.1	0.8	0.1	H1	0.7	0.9	0.6	H4

Location (km)	Existing Conditions				Design Case			
	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category
590280	0.2	0.9	0.2	H1	0.8	1.0	0.7	H4
590390	0.2	0.9	0.2	H1	0.7	1.0	0.7	H4
590495	Not flooded	Not flooded	Not flooded	Not flooded	0.4	1.2	0.4	H2
591440	Not flooded	Not flooded	Not flooded	Not flooded	0.3	0.4	0.1	H2
591565	0.5	0.7	0.3	H2	1.0	0.8	0.7	H4
591605	0.6	1.0	0.6	H4	1.1	1.0	1.2	H5
591750	0.6	1.2	0.7	H4	1.1	1.2	1.3	H5
591855	0.4	1.1	0.4	H2	0.9	1.2	1.0	H5
591915	0.4	1.0	0.4	H2	0.9	1.0	0.9	H4
592020	0.2	0.9	0.2	H1	0.7	0.9	0.6	H4
592090	0.0	0.7	0.0	H1	0.5	0.7	0.3	H2
592165	Not flooded	Not flooded	Not flooded	Not flooded	0.3	0.1	0.0	H2
602285	0.2	1.3	0.3	H1	0.3	1.2	0.4	H2
602490	0.4	1.4	0.5	H2	0.4	1.4	0.6	H4
609250	0.2	1.4	0.2	H1	0.3	1.2	0.4	H2
614310	0.6	0.8	0.5	H3	0.6	1.0	0.7	H4
614475	0.6	1.5	1.0	H4	0.7	1.5	1.0	H5
623075	0.1	2.0	0.2	H1	0.1	2.1	0.2	H5
623100	0.3	0.8	0.2	H1	0.3	0.9	0.3	H2
627175	0.3	0.5	0.1	H1	0.3	0.6	0.2	H2
633720	0.2	1.5	0.3	H1	0.2	1.6	0.3	H2
641485	0.2	1.8	0.4	H2	0.2	2.0	0.5	H5
641505	0.8	1.1	0.9	H4	0.8	1.4	1.2	H5
641530	0.4	1.3	0.5	H2	0.4	1.6	0.7	H4
641560	0.2	1.3	0.3	H1	0.3	1.5	0.5	H2
641690	0.2	1.1	0.3	H1	0.3	1.2	0.3	H2
641700	0.2	1.5	0.3	H1	0.2	1.5	0.4	H2
643335	0.3	0.8	0.2	H1	0.3	0.8	0.3	H2
643785	0.2	1.0	0.2	H1	0.2	1.3	0.3	H2
643815	0.2	1.5	0.2	H1	0.2	1.8	0.3	H2
643835	0.1	1.5	0.2	H1	0.2	1.8	0.3	H2
643845	0.1	1.5	0.2	H1	0.2	1.8	0.3	H2
643865	0.1	1.3	0.2	H1	0.2	1.6	0.3	H2
643915	0.2	1.0	0.2	H1	0.3	1.4	0.4	H2
643925	0.2	1.2	0.2	H1	0.2	1.5	0.4	H2
643935	0.1	1.3	0.2	H1	0.2	1.6	0.3	H2



Location (km)	Existing Conditions				Design Case			
	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category	Depth (m)	Velocity (m/s)	Hazard (m <sup>2</sup> /s)	Hazard Category
643945	0.2	1.0	0.2	H1	0.3	1.4	0.4	H2
643955	0.1	1.2	0.2	H1	0.2	1.6	0.3	H2
643965	0.3	1.0	0.3	H1	0.4	1.2	0.5	H2
643975	0.3	1.6	0.6	H2	0.4	1.7	0.6	H4
643995	0.2	1.2	0.3	H1	0.3	1.4	0.5	H2
644005	0.1	1.2	0.2	H1	0.2	1.5	0.3	H2
644025	0.2	1.0	0.2	H1	0.3	1.2	0.3	H2
644045	0.2	0.9	0.2	H1	0.3	1.1	0.4	H2
644075	0.2	1.2	0.2	H1	0.3	1.4	0.4	H2
644085	0.1	1.3	0.2	H1	0.2	1.5	0.3	H2
644105	0.2	1.2	0.2	H1	0.3	1.4	0.4	H2
644115	0.2	1.4	0.3	H1	0.2	1.6	0.4	H2
644135	0.2	1.4	0.3	H1	0.3	1.6	0.4	H2
644145	0.2	1.5	0.2	H1	0.2	1.8	0.4	H2
644155	0.2	1.1	0.2	H1	0.3	1.3	0.4	H2
644205	0.3	0.9	0.3	H1	0.4	1.0	0.4	H2
644235	0.2	0.7	0.2	H1	0.3	0.8	0.3	H2
644255	0.2	0.6	0.1	H1	0.3	0.8	0.2	H2
644825	0.3	0.2	0.1	H1	0.3	0.6	0.2	H2
644855	0.3	0.1	0.0	H1	0.3	0.6	0.2	H2
644935	0.2	0.3	0.1	H1	0.3	0.6	0.2	H2
645185	0.3	0.5	0.1	H1	0.3	0.8	0.2	H2

## 6. Conclusions

The results indicate the following:

- Two settlements and a number of isolated buildings are located immediately downstream of sections of the rail that are at medium risk of failure / breaching during extreme flood events;
- A small number of isolated buildings are located immediately downstream of sections of the rail that are at high risk of failure / breaching during extreme flood events;
- For both events, there are significant areas of agricultural land that experience non-compliant flood impacts;
- For both events, afflux is the main non-complying parameter, with significant areas of agricultural land, residences and roads affected. The areas of non-compliance are less significant for velocity and duration;
- For the 1% AEP with climate change event, flood hazard is increased on the Newell Highway at 15 locations. This occurs either at the inlets of culverts where the project causes afflux where the highway is upstream of the rail corridor, or at the outlets of culverts where concentrated flow is directed towards the highway where it is downstream of the rail corridor. For the 0.05% AEP event this impact is

increased, with widespread increases in flood hazard on the highway where it is located close to the rail corridor;

- Impacts for the 0.05% AEP event are likely to be overestimated due to the assumption of the rail structure remaining intact under this event. In reality, the track, ballast and possibly the entire embankment would wash away in numerous areas during such an event, reducing the flood level difference across the rail line and the flood level impact on the upstream side; and
- While the analysis shows that a number of residences and buildings are impacted, these assets would experience significant flood depth under existing conditions and therefore the actual impact in terms of flood damage may be low. Further investigation of existing conditions and design case flood depths at these buildings would be required to further clarify the impact.

Kind regards,

**Rob Leslie**

IRDJV Hydrology and Drainage Lead

CC: Richard Bromilow, IRDJV Project Manager, Rebecca Mackay, IRDJV Design Manager

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## **LIST OF APPENDICES**

**APPENDIX A1: 1% AEP WITH CLIMATE CHANGE EVENT RAIL STRUCTURE FAILURE RISK MAPS**

**APPENDIX A2: 0.05% AEP EVENT RAIL STRUCTURE FAILURE RISK MAPS**

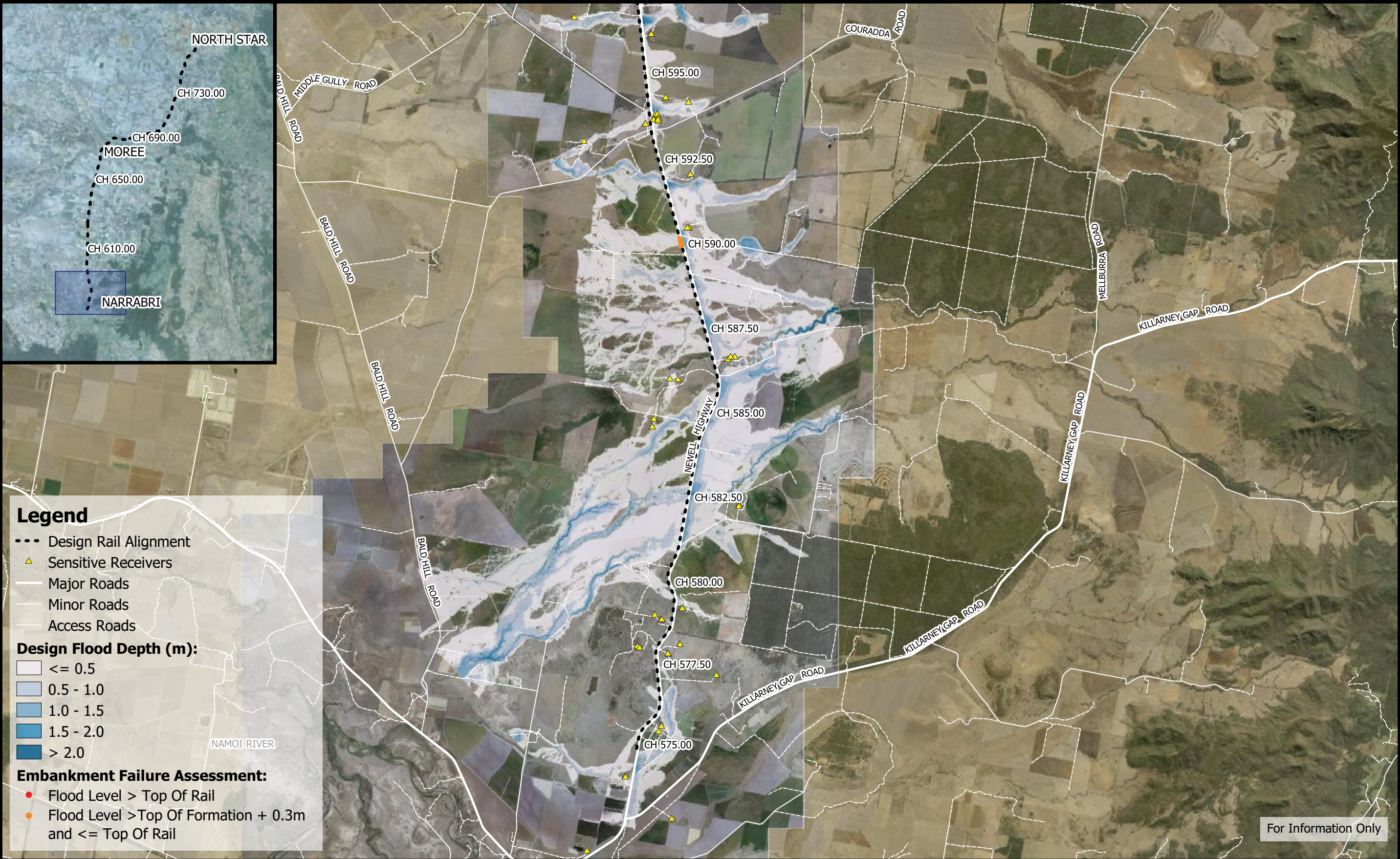
**APPENDIX B1: 1% AEP WITH CLIMATE CHANGE EVENT FLOOD IMPACT MAPS**





**APPENDIX B2: 0.05% AEP EVENT FLOOD IMPACT MAPS**



## APPENDIX A1: 1% AEP WITH CLIMATE CHANGE EVENT RAIL STRUCTURE FAILURE RISK MAPS




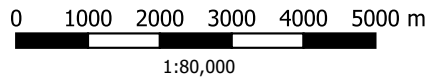



	 1:80,000 Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3	 	Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>FIGURE A1.1</b> <i>1% AEP Climate Change Design Case Embankment Failure Assessment - NAM01</i>

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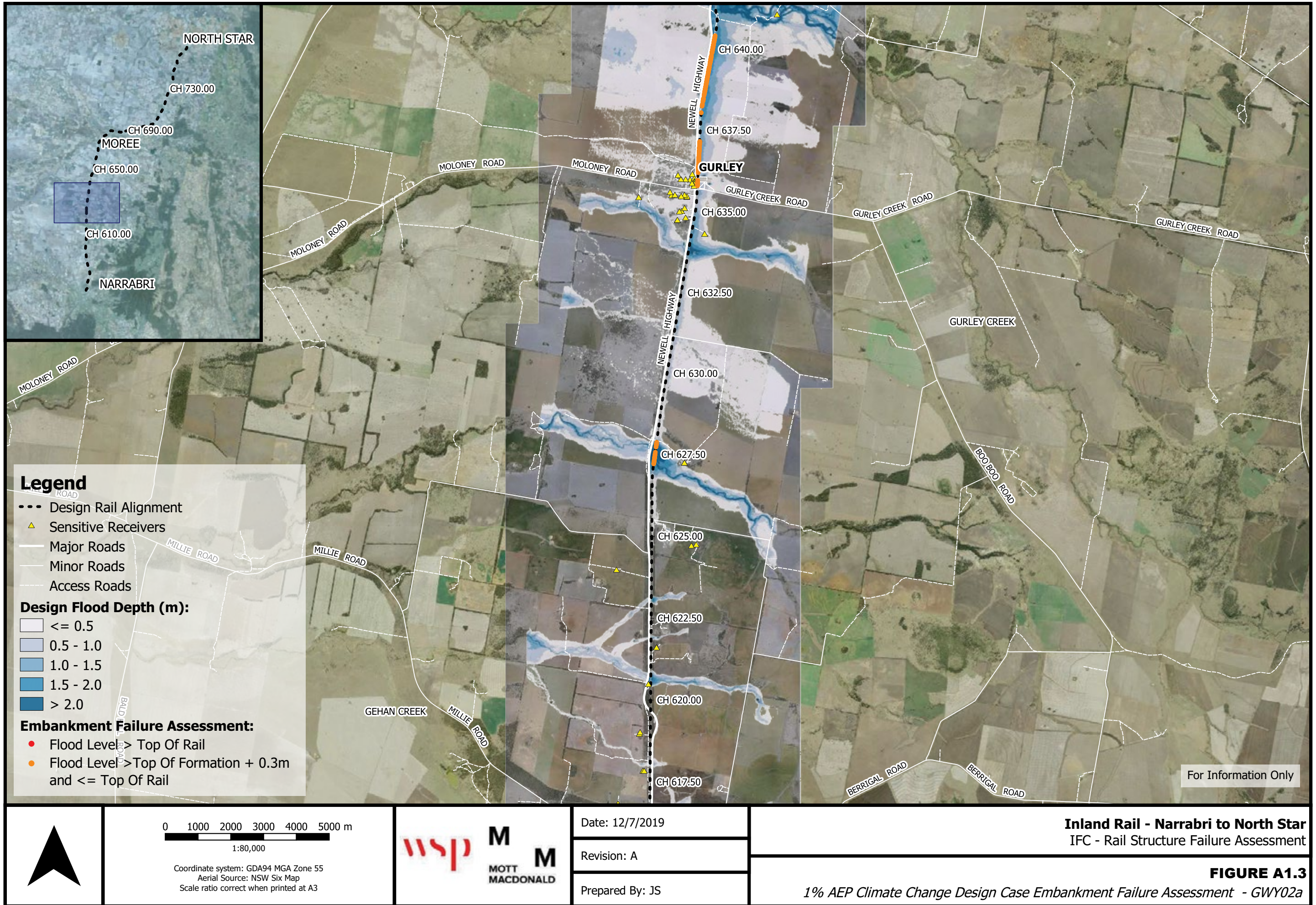




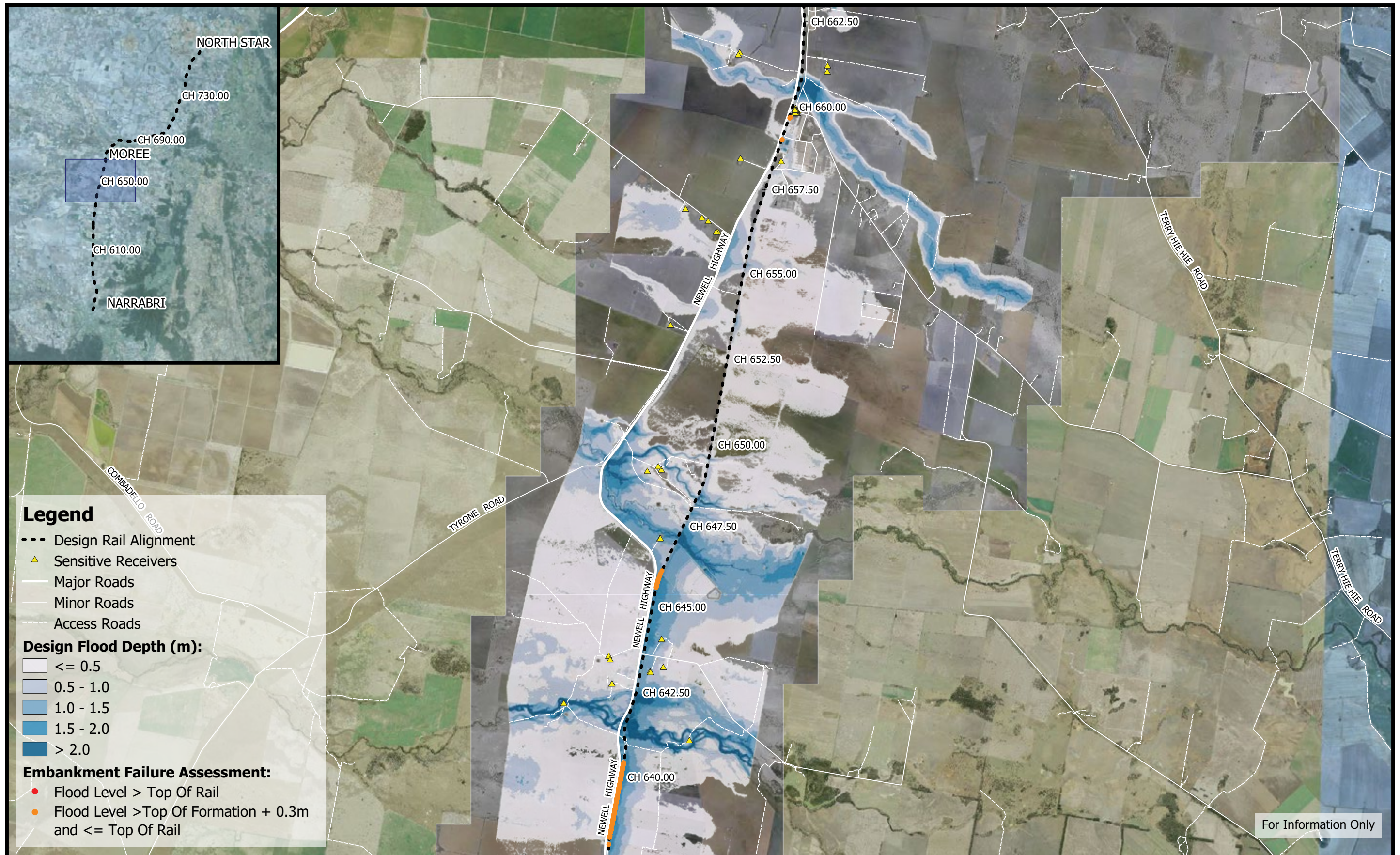
	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>FIGURE A1.2</b> <i>1% AEP Climate Change Design Case Embankment Failure Assessment - GWY01</i>


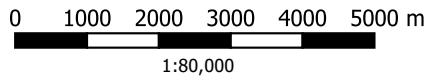

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	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>FIGURE A1.4</b> <i>1% AEP Climate Change Design Case Embankment Failure Assessment - GWY02b</i>




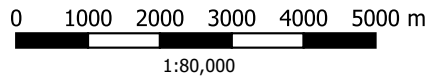



	 Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>FIGURE A1.5</b> 1% AEP Climate Change Design Case Embankment Failure Assessment - GWY03

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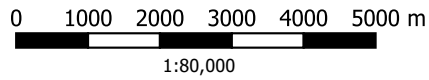





	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>FIGURE A1.6</b> <i>1% AEP Climate Change Design Case Embankment Failure Assessment - MACI01</i>





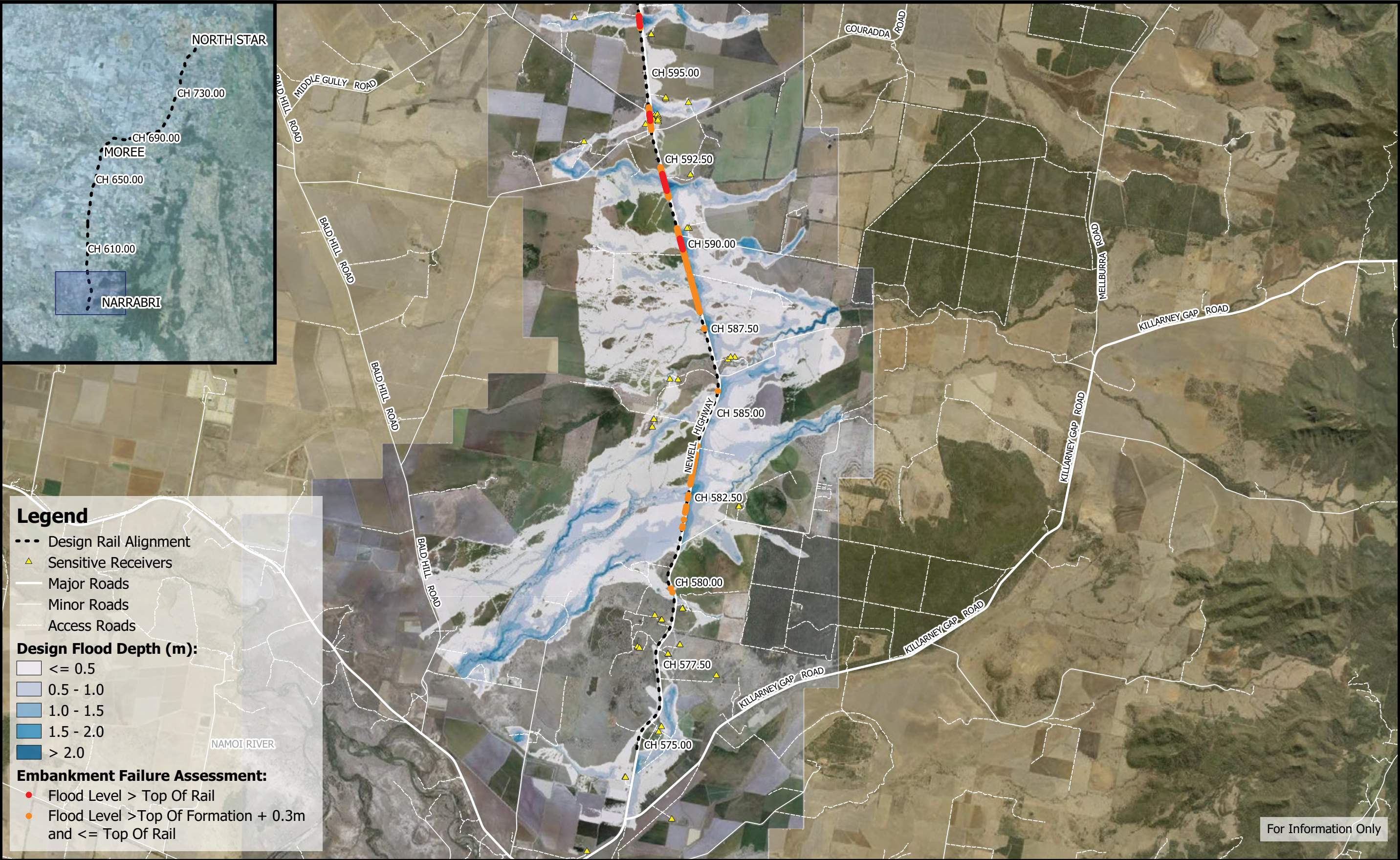
	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
<b>FIGURE A1.7</b> 1% AEP Climate Change Design Case Embankment Failure Assessment - MACI02				





## APPENDIX A2: 0.05% AEP EVENT RAIL STRUCTURE FAILURE RISK MAPS






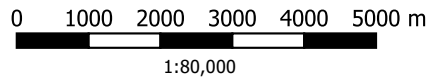





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			Revision: A	
			Prepared By: JS	
				<b>Figure A2.2</b> <i>0.05% AEP Design Case Embankment Failure Assessment - GWY01</i>

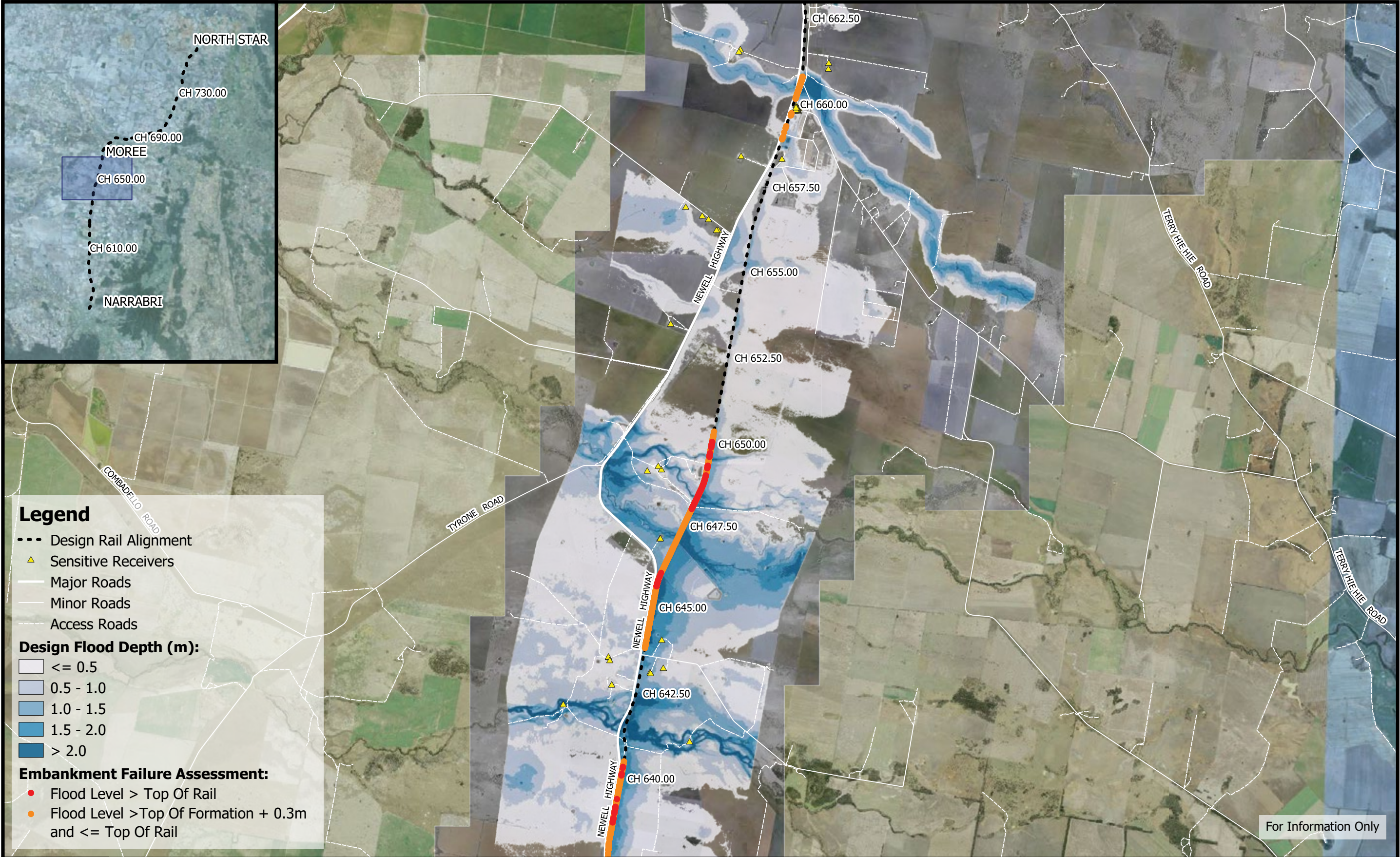



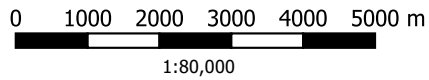



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			Revision: A	
			Prepared By: JS	
				<b>Figure A2.3</b> <i>0.05% AEP Design Case Embankment Failure Assessment - GWY02a</i>

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	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>Figure A2.4</b> <i>0.05% AEP Design Case Embankment Failure Assessment - GWY02b</i>

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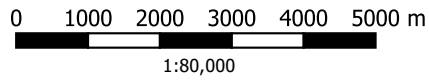



	 Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>Figure A2.5</b> <i>0.05% AEP Design Case Embankment Failure Assessment - GWY03</i>

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	 <p>Coordinate system: GDA94 MGA Zone 55 Aerial Source: NSW Six Map Scale ratio correct when printed at A3</p>		Date: 12/7/2019	<b>Inland Rail - Narrabri to North Star</b> IFC - Rail Structure Failure Assessment
			Revision: A	
			Prepared By: JS	
				<b>Figure A2.6</b> <i>0.05% AEP Design Case Embankment Failure Assessment - MACI01</i>





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			Revision: A	
			Prepared By: JS	
<b>Figure A2.7</b> <i>0.05% AEP Design Case Embankment Failure Assessment - MACI02</i>				