Flood velocities

Flow velocities on the floodplain would generally be low during flood events that do not overtop the existing rail level. There would be a localised increase in velocity immediately upstream of culverts as the water approaches and enters the structure. The approach velocities are not expected to exceed about 1.5 metres per second. The velocity in defined watercourses would be greater than that on broad floodplain areas, and is predicted to be less than two metres per second except in very localised areas. These predicted velocities are not anticipated to result in watercourse instability.

During flood events that overtop the rail level, there would be a progressively larger proportion of the flow that would pass overland than through the culverts. As a result, there would not be a significant increase in the flow velocity over the floodplain areas.

Periods of flooding

The periods/duration of flooding are related to the area of the catchment. It generally takes about nine hours for flood levels to fall to less than 0.1 metres deep at culverts for smaller catchments, and up to 36 hours for larger catchments. Regional flood events, which are typically a result of flooding from major rivers and watercourses after rainfall over a significant portion of catchment, can extend for several days or more.

Flooding downstream of the existing rail corridor

Flood events

In most areas downstream of the existing rail corridor there is expected to be a reduction in flood levels up to the one per cent AEP flood event. There may be localised changes in flood levels immediately downstream of structures, but these are expected to be confined to the existing rail corridor.

Flood velocities

During flood events that do not overtop the existing rail level, the flow downstream of culverts would generally be confined within watercourses.

When floods overtop the rail level (assuming the ballast does not erode), there would be a localised relatively high velocity of flow down the downstream face of the rail track and formation. As the rail level is generally not very high, it is anticipated that the velocity on the face of the track and formation is unlikely to exceed about 2.5 metres per second. This could erode the downstream face of the track and formation.

Historical records show the rail ballast generally fails and washes out, at least for part of the overtopping length, prior to or about the same time as the rail is overtopped. This could result in a flow on the downstream formation of the rail line of up to about two metres per second.

Periods of flooding

Watercourses downstream of the existing rail corridor are likely to be inundated for similar periods to those upstream.

Building impacts

A review of aerial photography indicates that no buildings currently are likely to be impacted by the predicted one per cent AEP flood events.

15.3 Impact assessment

15.3.1 Risk assessment

Potential impacts

The environmental risk assessment for the proposal (summarised in Appendix B) included an assessment of the potential risks associated with hydrology and flooding. The assessed level for the majority of potential risks was medium to high. Risks with an assessed level of medium or above included:

- impact of flooding on unprotected areas during construction resulting in wash-outs or erosion
- temporary impact to the behaviour of local surface water systems during construction
- presence of or change to structures associated with the proposal could impact upstream and downstream local flood behaviour
- change to structures associated with the proposal and track height could impact upstream and downstream regional flood behaviour
- changes to flow patterns and altered hydrology due to construction in watercourses
- blockages of flow paths affecting low flows through construction within watercourses and through erosion and sedimentation control structures
- sedimentation and changes to geomorphology in watercourses
- impacts on upstream and downstream drainage due to the introduction of structures such as embankments and culverts
- direct and indirect impacts on waterfront land as defined by the *Water Management Act 2000.*

The proposal would impact on flooding in the study area, because it involves raising the height of tracks to provide flood immunity – for the proposal, this is defined as the one per cent AEP flood event. The proposal would form a raised rail level across the floodplain.

How potential impacts would be avoided/minimised

The proposal has been designed to avoid and minimise potential flooding impacts and modifications to surface and groundwater flows. The strategies that have been, and would continue to be, implemented include the following:

- key infrastructure would not be located within the one per cent AEP flood prone areas or where it is not practical to design for a flood immunity greater than one per cent AEP
- culverts would be upgraded to permit an appropriate flow and minimise the potential for adverse flooding impacts, as described in section 7.2.2
- swales would be constructed along the outside edges of the track and formation to minimise the potential for water infiltration into the formation
- culverts would be installed prior to, or concurrent with track works
- standardised culvert shapes have been adopted to facilitate the use of pre-cast structures. This would minimise the amount of works required on site, and therefore the potential impact on watercourses. This would also reduce water usage at the proposal site
- spoil mounds would be designed and located to minimise impacts on flows as they are directed toward culverts or where they discharge from culverts.

15.3.2 Construction impacts - hydrology

Impacts on natural processes within rivers and floodplains

The proposal would require works within and around ephemeral watercourses, including:

- installing erosion protection measures in accordance with the CEMP
- construction of culverts as described in chapter 8
- rehabilitating the disturbed area once works are complete.

If inadequately managed, work in watercourses has the potential to change the flow regime, impact aquatic ecology (considered in chapter 10), and contribute to erosion, sedimentation and water quality impacts (considered in chapter 16).

During construction there is also the potential for works to be impacted by flooding. As described in section 15.3.1, the proposal has been designed to minimise the duration of onsite work in watercourses, which would enable increased flexibility when scheduling works around forecast rain periods.

The potential for impacts would be minimised by implementing the mitigation measures provided in section 15.4 and 16.4.

Impacts on the form and stability of watercourses

Construction of the proposal would result in a small increase in impervious areas (such as construction compounds), which would have the potential to increase the volume of water flowing to watercourses. However, the change in impervious area would be negligible compared to the overall catchment area.

Construction would involve temporary diversions to transfer runoff around worksites. This may involve excavations and embankments that would alter localised flow patterns and impact the stability of surrounding surface watercourses. These changes would be temporary and limited to the construction phase. The landform would be restored as near as practicable to the pre-works condition following construction.

Increases in overland flow, and/or changes to surface water flow patterns, could result in increased erosion and siltation of watercourses in the proposal site, as considered in chapter 16. The majority of watercourses which cross the proposal site are ephemeral and in poor condition, therefore any impacts to surface water hydrology and flow regimes as a result of construction would be limited in extent.

Impacts on natural hydrological attributes and conveyance capacity

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures in accordance with *Managing Urban Stormwater: Soils and Construction* volumes 1 and 2.

Wastewater could result from the following activities/sources:

- use of site amenities at construction compounds
- dewatering of groundwater from excavations
- use of vehicle wash down areas.

Wastewater from site amenities would be removed via vacuum trucks on a regular basis, and would be disposed of in accordance with relevant regulatory requirements.

Wastewater from other construction activities would be initially contained on site to confirm it meets relevant water quality requirements (considered in chapter 16). Discharge of wastewater to surface water would consider the hydrological attributes of the receiving watercourse, including whether the receiving waterway has sufficient flow volume and velocity to incorporate and disperse the potential discharge.

The potential to encounter groundwater during construction is considered below.

Water take from all surface and groundwater sources

As described in chapter 8, water would be required during construction to control dust, compact soil, undertake site concrete works and establish vegetation. Estimated water demand would be in the order of 75 to 100 megalitres. The actual amount of water required at the time of construction would depend on final design details, weather, and the adopted construction methodology.

Likely water sources were identified, subject to the gaining of applicable approvals and access agreements, and there being sufficient water at each site. These water sources include:

- potable water from Parkes and Narromine councils' supplies – five megalitres from each
- groundwater from private bores near chainages 708, 716, 724, 738, 748 and 778 (each within five kilometres of the proposal site) – three megalitres per bore
- recycled/treated water from Parkes North and Peak Hill mines – 10 to 15 megalitres from each mine
- water from private dams near chainages 730, 782 and 798 – 10 megalitres from each dam
- water extracted from various locations along the Macquarie River – 10 megalitres.

Use of water from these sources would be subject to relevant approvals, access agreements, and the amount of water available at the time of construction.

Water extraction from bores could reduce the availability of water to landowners for irrigation and affect surface water and groundwater flow regimes. This impact would be short term, as a number of sources would be used along the length of the proposal site, and water sources would recharge following rainfall.

Groundwater extracted from bores during construction may have a short term impact on flows within the alluvial layer as a result of water used during construction. The lateral extent of impacts would be localised around individual extraction locations, and is unlikely to extend more than about 50 metres from the extraction point. Existing private bores would be used for the extraction of groundwater.

Measures are provided in section 15.4 to minimise the potential impacts of water usage during construction.

Water usage could also increase infiltration rates and surface water runoff in the proposal site. The impact of this additional discharge is expected to be minimal, as the additional flow and infiltration would be negligible compared to regional rainfall levels. Any impacts would be short term. Impacts to water quality are considered in chapter 16.

Excavation would generally not exceed one metre below ground surface and groundwater is unlikely to be encountered during the majority of works. However, there is the potential for shallow groundwater to be encountered during construction of bridges. As the groundwater is likely to be perched and recharged via rainfall, any impacts would be short term.

A residual redirection of alluvial flows may occur around the piers, although this is unlikely to extend more than five metres from individual piers. As a result, this would be a minor, localised impact.

15.3.3 Construction impacts – flooding

Any detrimental increases in the potential flood affectation of properties, assets, and infrastructure

The presence of construction compounds in floodplains has the potential to impact on surrounding properties. The layout of construction work sites and compounds would be prepared with consideration of overland flow paths, avoiding flood liable land where possible to avoid detrimental impacts.

During construction, there is also the potential for works to be impacted by flooding. As described in section 15.3.1, the proposal has been designed to minimise the duration of on-site work in watercourses, which would enable increased flexibility when scheduling works around forecast rain periods.

Soil and water management measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2C* (DECC, 2008), to minimise any potential impacts resulting from flooding during construction. Where possible, construction would be staged to minimise the duration of the works and exposure to wet weather periods.

Beyond the potential impacts described above, the impact of construction on flood behaviour is expected to be negligible compared to regional flood levels and behaviour.

15.3.4 Operation impacts - hydrology

The proposal would impact the hydrology and hydraulics of the study area during operation. This is because the existing rail corridor would be raised across the floodplain, and upgraded structures would be required to enable surface water to flow under the rail formation.

Impacts on natural processes within rivers and floodplains

The proposal would raise the height of the rail formation, which would impact the surface water flows across the floodplain. This would change the upstream flooding regime and result in more concentrated flows through culverts that discharge to downstream watercourses. Raising the formation also has the potential to change the frequency of flow interaction between adjacent catchments upstream of the proposal site.

The proposal could also modify flow paths across floodplains as a result of the installation of replacement of additional culverts and bridges. Changes to such structures could change the pattern of cross drainage from upslope to downslopes areas, which may change the patterns of erosion and scouring within existing watercourses and drainage lines, and within the broader floodplain area. These impacts are likely to be minimal, because the culverts and bridges have been designed to convey flows at rates similar to those for the existing rail corridor. This would minimise surface water redirections or restrictions.

The proposal would have minimal impact on groundwater during operation. Replacing the drainage structures in the proposal site would generally have a beneficial effect on water flow, including groundwater recharge potential. The change in ponding duration upstream of the proposal is not sufficiently long such that it would impact on the infiltration volume of water into groundwater.

Impacts on the form and stability of watercourses

The proposal could result in increases in erosion and siltation and an associated reduction in stability of riverbanks and watercourses, due to increased flood levels and velocities upstream and downstream of culverts and underbridges. The potential for these changes are considered below.

It is predicted that there would be a negligible change in upstream flood velocities with the proposal in place, because the same floodplain processes would apply. Velocities on the floodplain would continue to be low, and would be higher immediately upstream of a culvert. The approach velocities are not expected to exceed 1.5 metres per second.

The upstream velocity in defined watercourses would be larger than that on broad floodplain areas. For these locations, the velocity is predicted to be less than two metres per second, except in very localised areas.

The predicted low velocities are not anticipated to create watercourse instability. It is estimated that the average velocities of flows to the new structures would increase by less than 0.1 metres per second. As a result, the proposal is unlikely to impact on the geomorphology of watercourses upstream of the proposal site.

While upstream velocities are not expected to change appreciably, downstream of the culverts there is the potential for peak flow velocities to increase by between 0.5 and one metre per second, as a result of increased flood levels upstream at some structures.

The increase in water flowing through culverts has the potential to result in erosion and impacts to downstream stream stability. The results of the assessment predict that, without mitigation, these impacts could result in increased erosion and scour at a number of locations downstream of culverts. A rock energy dissipation layer (a rock blanket) is proposed across the full width of culverts to reduce the flow velocity of water exiting the culverts prior to discharging onto the ground. Further modelling would be undertaken during detailed design to confirm the locations and required erosion protection.

Impacts on natural hydrological attributes and conveyance capacity

Surface water during maintenance activities would be managed by implementing standard erosion and sediment control measures in accordance with *Managing Urban Stormwater: Soils and Construction* volumes 1 and 2C.

There are not expected to be any activities undertaken during operation that would generate wastewater requiring discharge.

Water take from all surface and groundwater sources

No water would be required from surface and groundwater sources during operation of the proposal. Any water required during maintenance activities would be trucked to site in accordance with ARTC's existing maintenance procedures.

Maintenance activities are not expected to require excavation to depths at which groundwater may be encountered.

15.3.5 Operational impacts – flooding

Any detrimental increases in the potential flood affectation of other properties, assets and infrastructure

Rail overtopping

Modelling of the potential impacts of the proposal indicates that the length of the rail corridor that would be overtopped in the one per cent AEP event would substantially reduce compared to the existing situation. The predicted length of overtopping would reduce by 94 per cent, from 7,175 metres to 406 metres.

Overtopping locations for the one per cent AEP event are shown in red in Figure 15.4. These locations coincide with the location of level crossings.

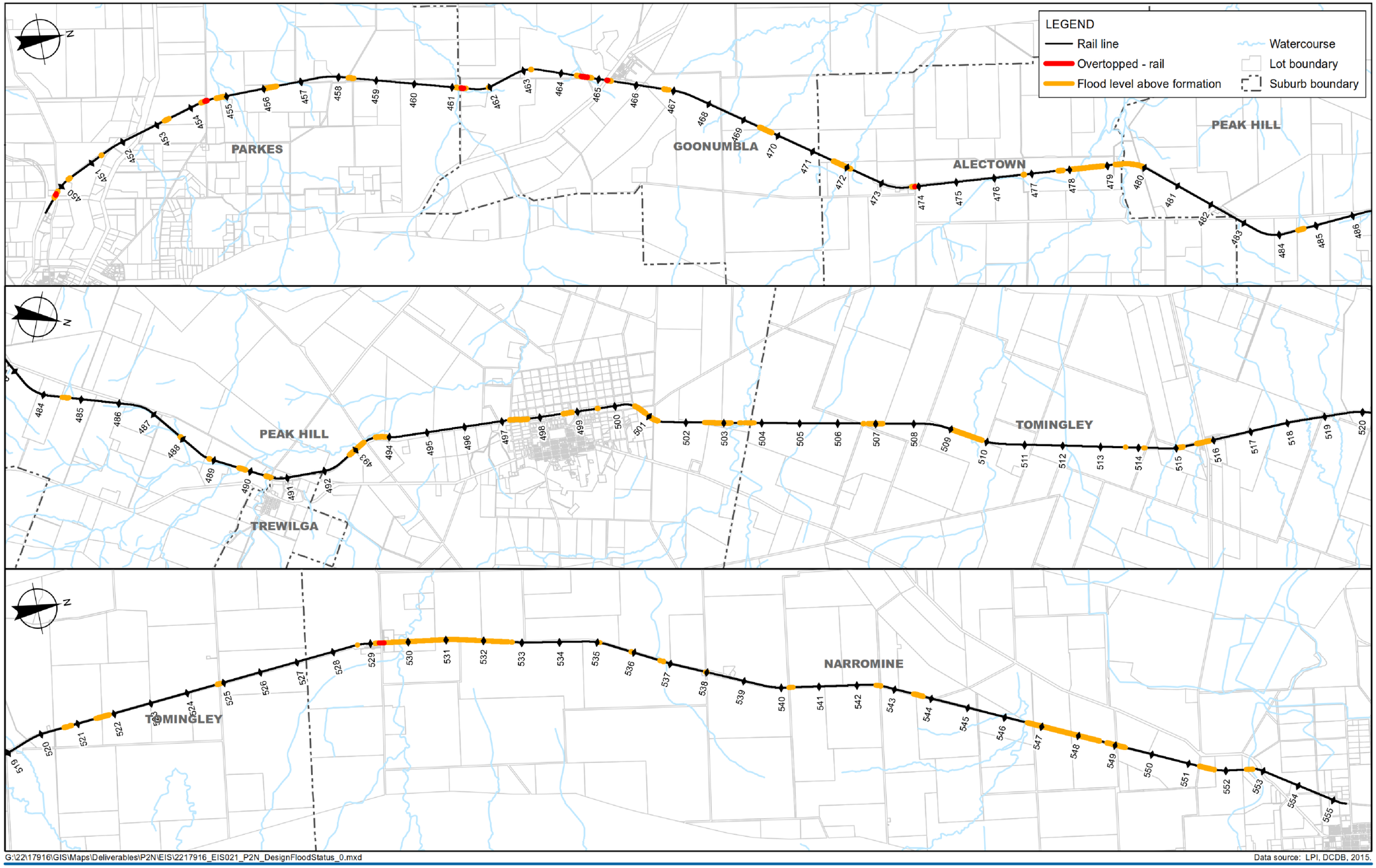


Figure 15.4
Rail overtopping during operation

Public road overtopping

Table 15.7 lists the predicted locations where public roads would be overtopped with the proposal in place. The results indicate that:

- no new roads would be inundated
- the depth of overtopping is similar to the existing situation for most roads
- overtopping of Wyanga Road and Peak Hill Railway Road is predicted to increase in both depth (an increase of 0.51 metres and 0.11 metres, respectively) and length (an increase of 141 metres and 30 metres, respectively), for the one per cent AEP event.

The total length of overtopping during the one per cent AEP flood event would increase by 76 metres. This is considered to be a minor additional impact, as the increase would be limited to only two of the roads that are currently impacted by flooding – Peak Hill Railway Road and Wyanga Road.

Figure 15.5 shows the locations and extent of the predicted locations where public roads would be overtopped for the proposal compared with the existing situation.

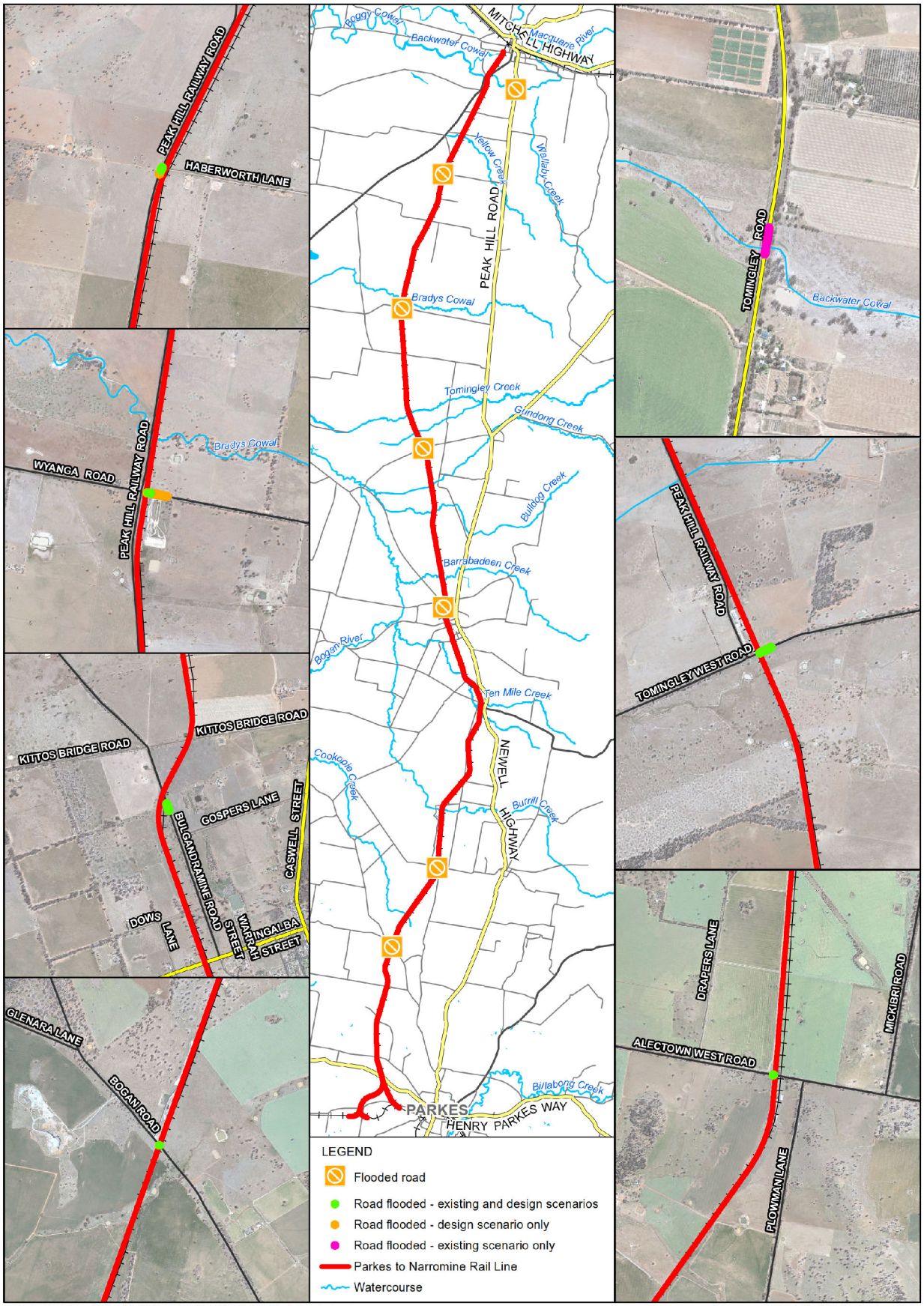
Table 15.7 Road overtopping

Road	Maximum depth of overtopping (m)						Maximum length overtopping (m)
	50% AEP	20 % AEP	10% AEP	5% AEP	2% AEP	1% AEP	
Alectown West Road	0	0.01	0.02	0.03	0.04	0.05	7
Bogan Road	0	0.05	0.11	0.12	0.13	0.14	2
Bulgandramine Road	0	0.03	0.08	0.09	0.10	0.11	61
Peak Hill Railway Road	0	0	0	0	0.11	0.20	70
Tomingley Road	0	0	0	0	0	0	0
Tomingley West Road	0	0	0.11	0.31	0.32	0.33	110
Wyanga Road	0	0	0	0.13	0.57	0.65	181
Total							431

Adjacent land impacts – flood extents

Figure 15.6 shows the change in the flooding extents during the one per cent AEP flood event, when compared to the existing situation. Table 15.8 lists the land area that would be impacted by a range of flooding for events compared to the existing situation. With the proposal in place, it is predicted that the area of upstream flooding would:

- reduce for events up to and including the two per cent AEP event
- increase for events exceeding the two per cent AEP event.



G:\22\17916\GIS\Maps\Deliverables\P2N\EIS\22217916_EIS023_P2N_FloodedRoads_0.mxd

Data source: DCDB, LGA, 2012. ARTC, railway, 2012.

Figure 15.5

Public roads impacted by floodwater during a one per cent AEP event

0 5 10 15 Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55
30 Nov 2016

N

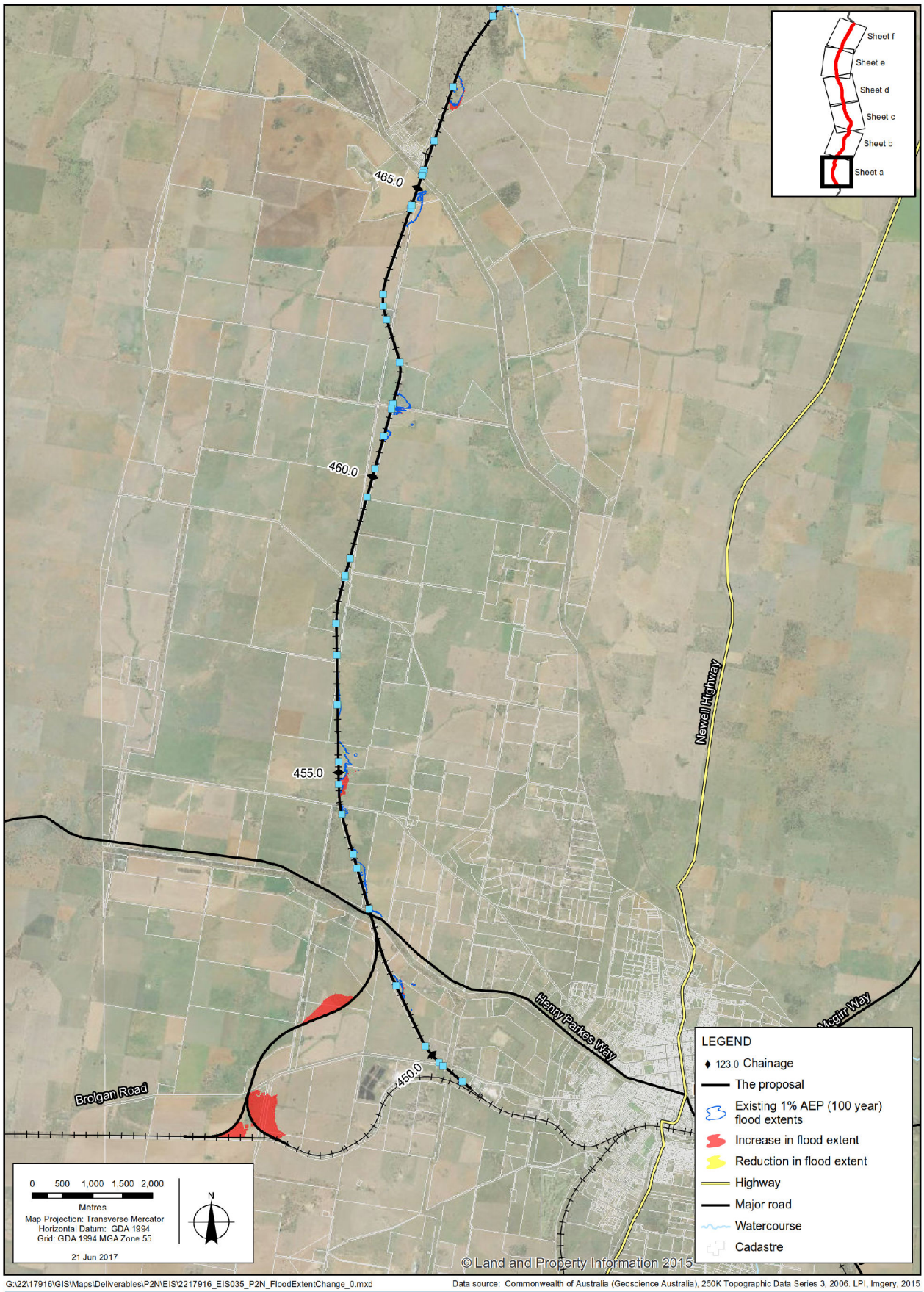


Figure 15.6a

Change in flood extents for the proposal

Figure 15.6b

Change in flood extents for the proposal

Figure 15.6c

Change in flood extents for the proposal

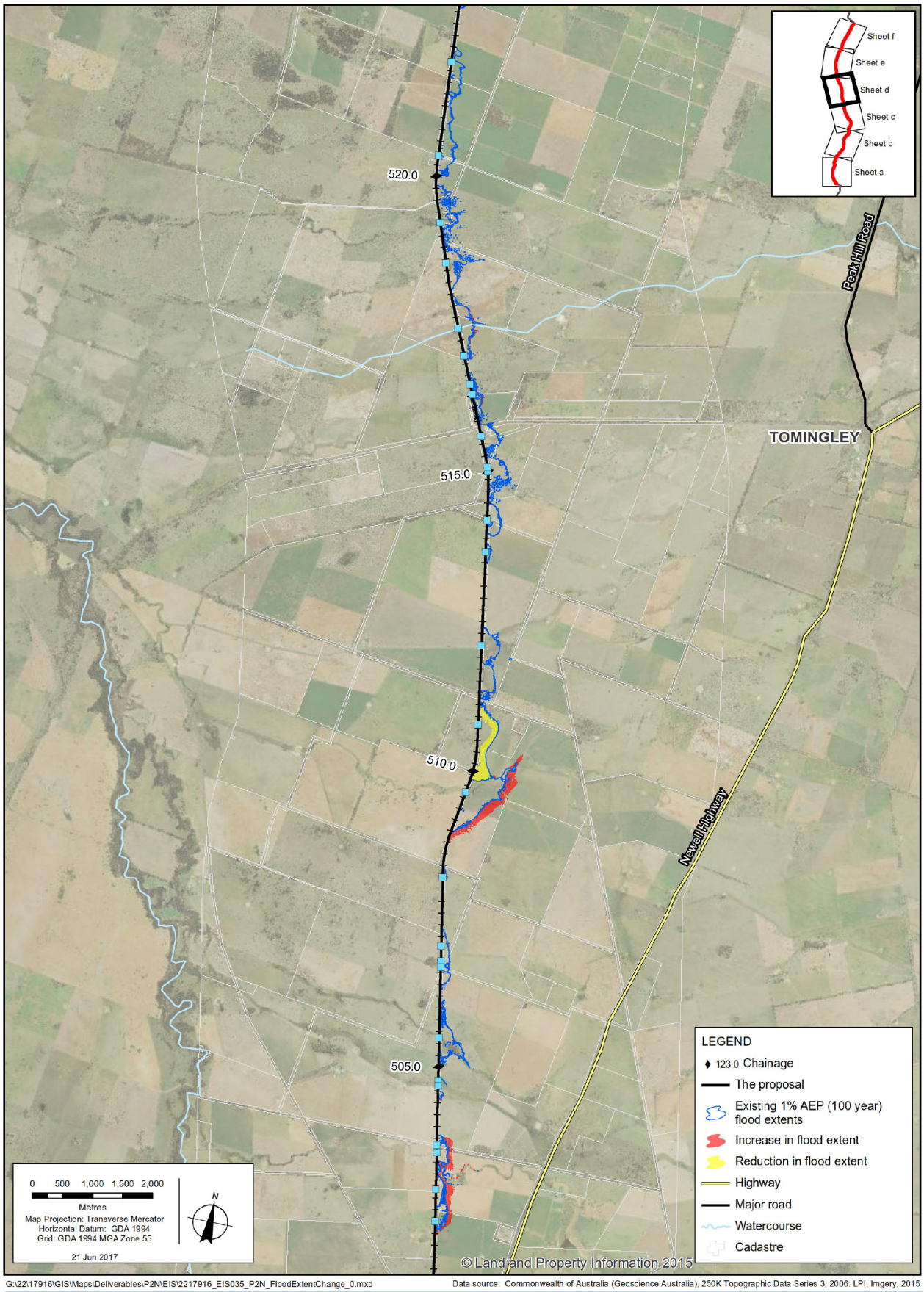


Figure 15.6d

Change in flood extents for the proposal

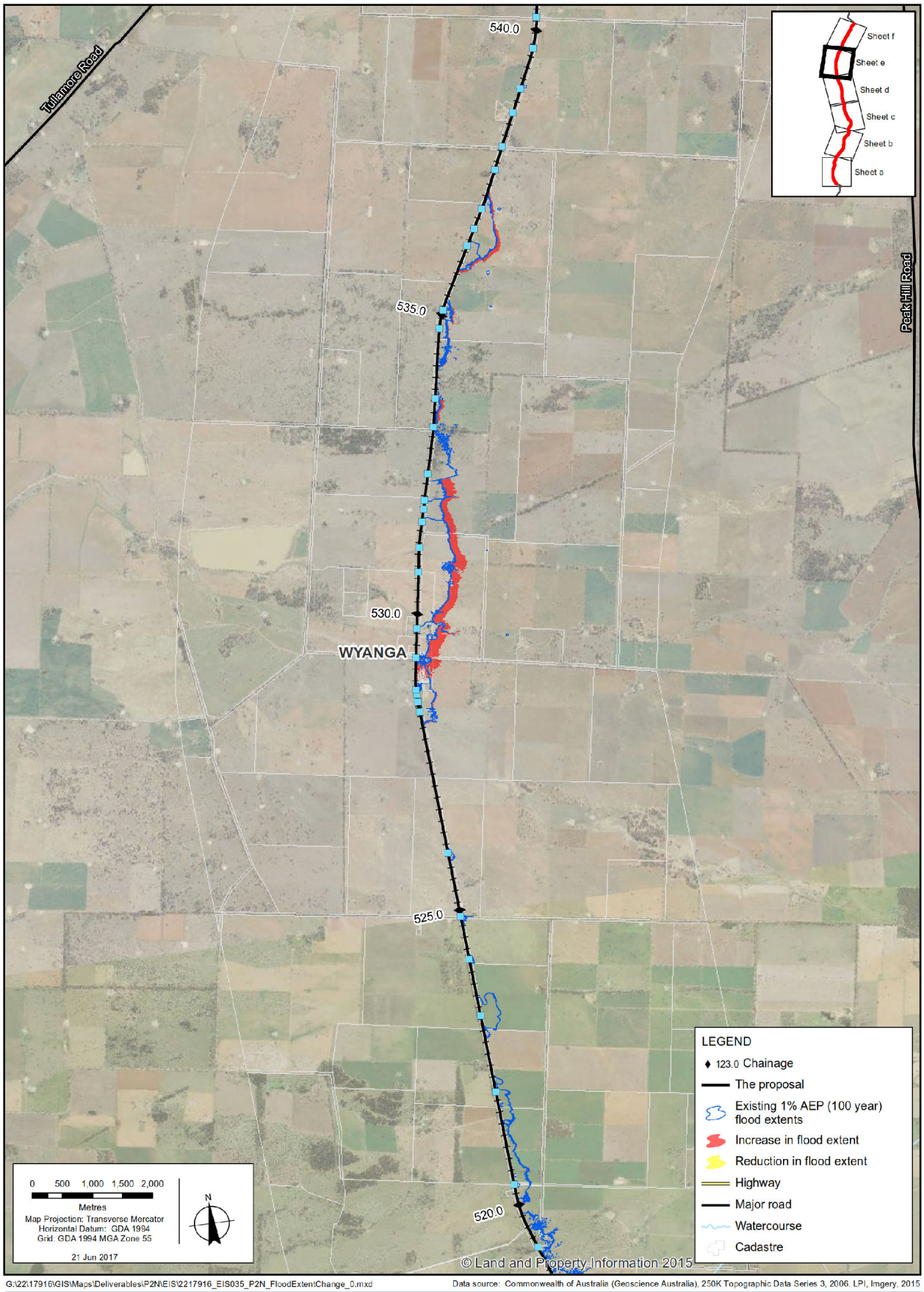


Figure 15.6e

Change in flood extents for the proposal

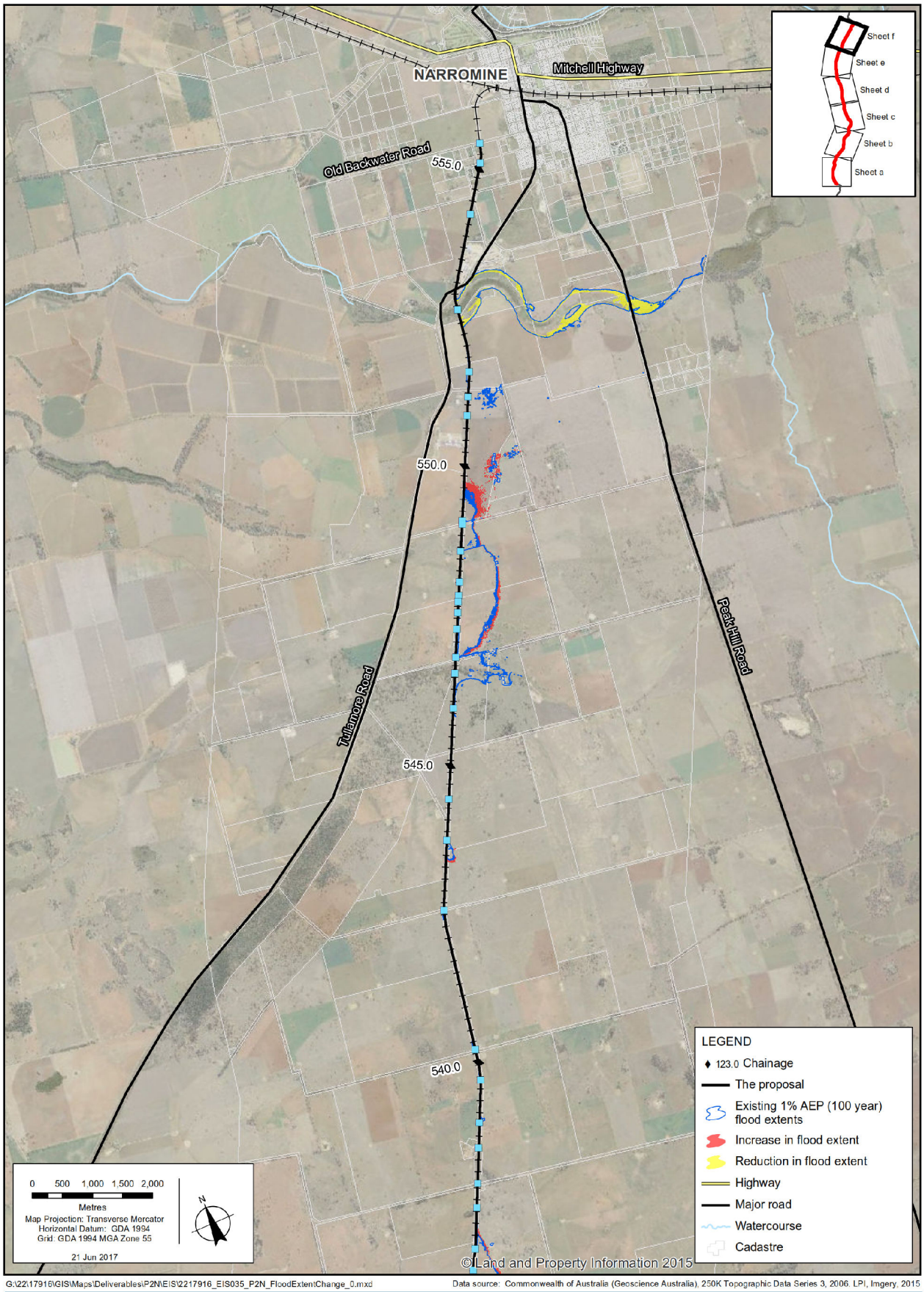


Figure 15.6f

Change in flood extents for the proposal

Table 15.8 Areas of upstream flooding

Design event (% AEP)	Area of inundation for the existing rail corridor (ha)	Area of inundation for the proposal (ha)	Change in area of inundation due to the proposal (ha)
50	355.9	242.0	-113.9
20	480.1	363.9	-116.2
10	553.3	454.8	-98.5
5	648.2	579.9	-68.3
2	840.0	821.9	-18.1
1	938.0	1,036.5	98.5
0.5	1,044.8	1,146.2	101.4
0.2	1,146.5	1,283.3	136.8
PMF	2,720.8	3,162.1	441.3

The proposal is predicted to reduce flood levels in most areas downstream of the proposal site for events up to the one per cent AEP event. There may be very localised changes in levels immediately downstream of structures, but these are expected to be confined to the existing rail corridor.

Potential impacts on land use due to the predicted changes in flood extents are described in chapter 20.

Adjacent land impacts - period of flooding

Periods of flooding for local catchment flood events are predicted to be slightly longer than the existing situation. This is because all water runoff for events up to the one per cent event would flow through culverts. However, the increase in size of the culverts relative to the existing structures would mitigate this potential impact. Typically, the increased duration of ponding is likely to be up to about nine hours.

Parkes north west connection

The rail level and culvert sizes for the Parkes north west connection would be consistent with the rest of the proposal site. However, given that this area does not currently contain any rail infrastructure, the resultant change in landform would have an impact on surface hydrology and flood levels. The extent of impact would be further assessed during detailed design and the proposal would be designed to minimise flooding impacts to the adjacent land, as well as changes to surface water flow regimes as the result of drainage structure installation.

Building and property impacts

No buildings are predicted to be inundated for the one per cent AEP flood event with the proposal in place.

Consistency with applicable Council floodplain risk management plans

As described in section 15.1.2 there is a floodplain risk management plan available for the Narromine LGA. However, it only covers the town of Narromine, which is outside the proposal site. No floodplain risk management plan is publically available for the Parkes LGA.

The flooding assessment identified those areas where the proposal is likely to affect the extent and depths of flooding. As generally required by a council's floodplain risk management plan, these changes to flooding responses were considered in terms of impacts to property (including buildings) and access (flooding of public roads). The impacts to property and access were considered by Technical Report 6, as summarised in this chapter.

Compatibility with the flood hazard of the land

Floods can create hazardous conditions, including fast flowing, shallow water, or slow-flowing deep water, in which humans are vulnerable. It is the human interaction with the floodplain and the associated exposure to flood hazards that creates flood risk. Without the human element there would be no risk to the community. Flood hazards can include direct impacts to people (fast currents sweeping them away) or impacts to the built environment, including community infrastructure such as roads and rail.

The proposal site generally passes through rural land, with land uses that are less sensitive to flood hazards. This is because there are less people and infrastructure likely to be impacted. Additionally, the modelling indicates that flood depths and velocities due to the proposal are not expected to appreciably change the existing flood hazard in rural areas, and changes in flood levels are not generally expected to adversely affect flooding of roads.

Compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land

The proposal would generally maintain the location of bridges and culverts, with the capacity of new structures generally exceeding that of the existing structures. Therefore, it is considered that the function of flow conveyance in floodways would be preserved or improved.

The proposal would also generally maintain the existing alignment of the rail line and the location of culverts, and works outside of the corridor would be limited (with the exception of the Parkes north west connection). As a result, the existing areas of flood storage would generally be maintained, albeit with some changes to flood levels and extents (both increases and decreases) at some locations including Parkes north west connection. Overall, the function of flood storage areas is expected to be maintained as a result of the proposal.

Downstream velocity and scour potential

There is predicted to be an increase in the extent of erosion downstream of culverts at around 20 locations, and erosion is likely to extend up to 100 metres downstream of a structure at these locations. Increased erosion could affect flow regimes and water quality. Watercourses located downstream of many culverts already exhibit signs of erosion. Rock protection is proposed immediately downstream of structures to reduce the flow velocity and distribute flow laterally. During detailed design, each location would be reviewed in detail to provide site specific erosion protection to mitigate this potential impact. Visual monitoring would also be undertaken during construction to assess the effectiveness of erosion protection devices, particularly following rainfall, and further measures would be installed if required.

Impacts of flooding on existing emergency management arrangements

Vehicles can become unstable when flood depths on roads exceed 0.3 metres (NSW Government, 2005) leading to road closure. Therefore, emergency management/evacuation arrangements may be impacted where flood depths on roads increase, or where the location of road flooding changes, coinciding with potential community evacuation and emergency management routes.

Comparing the results in Table 15.7 to those for the existing conditions in Table 15.5, it is evident that the proposal would have minimal impact on the closure of potential evacuation and management routes.

Modelling indicates that, during the one per cent AEP event, flood depths could exceed 0.3 metres at two locations – Tomingley West Road and Wyanga Road. For Tomingley West Road there would be no change compared to the existing situation. Tomingley Road is currently closed during existing conditions, so the proposal would improve conditions along this road by making it passable with care during the one per cent AEP event. For Wyanga Road, the proposal would have the potential to cause road closure during the one per cent AEP, which is passable with care during existing conditions.

Conditions at Alectown West Road, Bogan Road, Bulgandramine Road, and Peak Hill Railway Road would stay the same, with those roads remaining passable with care during the one per cent AEP flood event.

It is considered that the overall impact of the proposal on road closures would not impact existing emergency management arrangements.

Ongoing liaison with local councils, Roads and Maritime Services, and emergency services organisations would be undertaken as part of the detailed design phase to identify potential opportunities to improve the impacts of the proposal on road flooding.

Social and economic costs to the community as a consequence of flooding

Given that the increase in flood levels would only occur at areas already subject to flooding, the proposal would not require changes to existing infrastructure or community emergency management arrangements for flooding. As a result, there would not be increased social and/or economic costs to the community as consequence of flooding.

15.4 Mitigation and management

15.4.1 Approach to mitigation and management

As described in section 15.3.1, the proposal would incorporate a number of design features to avoid and/or minimise the potential impacts on flooding and watercourses.

Flood modelling has indicated that, despite the implementation of the design features described in section 15.3.1, there may still be some impacts to watercourses downstream of culverts and land upstream during flood events equal and larger to the one per cent AEP event. Further modelling would be undertaken during detailed design and the design refined such that the proposal would not worsen existing flooding characteristics, where feasible.

Mitigation measures are provided below to mitigate the impacts that are not avoided by the proposal design.

15.4.2 Summary of mitigation measures

To mitigate the potential hydrology and flooding impacts of the proposal, the following measures would be implemented.

Table 15.9 Hydrology and flooding mitigation measures

Stage	Impact/issue	Mitigation measures
Detailed design/ pre-construction	Flooding	The design features listed in section 15.3.1 would continue to be refined to not worsen existing flooding characteristics, where feasible and reasonable, up to and including the one per cent AEP event. Detailed flood modelling would consider potential changes to: ▸ upstream flood extents ▸ level crossing and road flood levels and extent ▸ overland flow paths and storage effects due to spoil mounds and other proposal infrastructure

Stage	Impact/issue	Mitigation measures
		▸ flood evacuation routes Flood modelling to support detailed design would be carried out in accordance with the guidelines listed in section 15.1.2.
		Flood modelling and mitigation would consider future floodplain risk management plans, and would be undertaken in consultation with the relevant local council, the Office of Environment and Heritage, and State Emergency Services.
	Downstream watercourse stability	Further modelling would be undertaken during detailed design to confirm the locations downstream of culverts that require erosion protection, and the extent and type of protection required.
	Emergency responses	Where feasible, facilities and routes identified as being critical to emergency response operations would be protected from the probable maximum flood level.
	Water usage (private bores and surface water)	Detailed design and construction planning would aim to minimise the use of potable water during construction. Appropriate sources for construction water would be determined prior to construction in consultation with relevant stakeholders, and appropriate approvals and agreements would be sought for the extraction of water.
Construction	Flooding	Construction planning and the layout of construction work sites and compounds would be carried out with consideration of overland flow paths and flood risk, avoiding flood liable land and flood events where possible.
	Water usage (private bores and surface water)	Monitoring would be undertaken during extraction to ensure volumes stipulated by license requirements and/or private landholder agreements are not exceeded.