New England Highway bypass of Muswellbrook

Chapter 6.2 Surface water, hydrology and flooding

Transport for NSW | October 2021

6.2 Surface water, hydrology and flooding

A Surface and Groundwater Assessment was prepared by AECOM (2021) for the proposal (refer to Appendix I). A Flood Risk Assessment was also undertaken by BMT Commercial Australia Pty Ltd (2021) (refer to Appendix E). Surface water, hydrology and flooding aspects are outlined in this chapter and groundwater aspects covered in Section 6.2.

6.2.1 Methodology

Surface water quality

The surface water assessment adopted the following methodology:

- Review available water quality, flooding data and existing conditions to obtain background information on catchment history and land use and define the existing environment
- Review the legislative context within which the proposal sits and relevant guidelines
- Define the area that influences the surface water environment
- Review existing flood conditions and design flood simulations
- Identify potential impacts of construction and operational activities and potential cumulative impacts on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines for protection of relevant environmental values
- Nominate water quality treatment measures to mitigate the impact of construction on water quality, following the principles of the Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECC 2008)
- Identify water quality treatment measures to mitigate the impact of the operation of the proposal on water quality following the principles set out in Procedure for Selecting Treatment Strategies to Control Road Runoff (RTA 2003) and Transport's Water Policy (RTA 1997)
- Nominate additional measures to manage potential cumulative impacts resulting from the proposal
- Provide a consolidated list of measures to be applied during the construction and operational phase to mitigate potential impacts to surface water.

An accidental spills assessment was undertaken to identify potential spills that may result in impacts to water quality within the receiving environment as a result of the proposal and assess if an incident could be managed appropriately with standard emergency response procedures, or if additional control measures are required.

The potential for accidental spills exists for both construction and operation phases. Potential spills during construction would be managed by the CEMP, and therefore are not discussed further.

To determine baseline water quality impacts associated with the proposal, a water quality monitoring plan (WQMP) was developed and initiated in July 2020. The objective of the WQMP was to establish the baseline water quality conditions of watercourses that could potentially be impacted by the proposal. Monthly sampling was carried out at 15 sampling points located along the Hunter River and its associated tributaries.

The initial water quality information gathered prior to construction would be used as baseline conditions when applying for an EPL.

Flooding

A flood risk assessment was undertaken to establish pre- and post- bypass flood conditions for the proposal and identify associated potential flood impacts.

Potential flood impacts that were considered included:

- Changes in peak flood level
- Changes in peak flood velocity
- Scour potential associated with proposed infrastructure.

Hydrologic and hydraulic models were developed for the proposal to determine design floods for annual exceedance probabilities (AEPs) for the 20 per cent (one in five AEP), five per cent (one in 20 AEP), two per cent (one in 50 AEP), one per cent (one in 100 AEP), 0.5 per cent (one in 200 AEP), 0.2 per cent (one in 500 AEP) and the 0.05 per cent AEP (one in 2000 AEP). The hydraulic models were developed for the Sandy Creek and Muscle Creek catchments but also allowed for backwater flooding from the Hunter River. The Probable Maximum Flood (PMF) was also modelled to represent an estimated upper limit of flood magnitude.

Study area

The study area for the surface water assessment is broadly defined by the area depicted in Figure 6-6, comprising the contributing catchments associated with Sandy Creek and Muscle Creek as well as the proposed road corridor.

The study area for the flooding assessment includes the township of Muswellbrook and the floodplain of the Hunter River including its tributaries Sandy Creek and Muscle Creek.

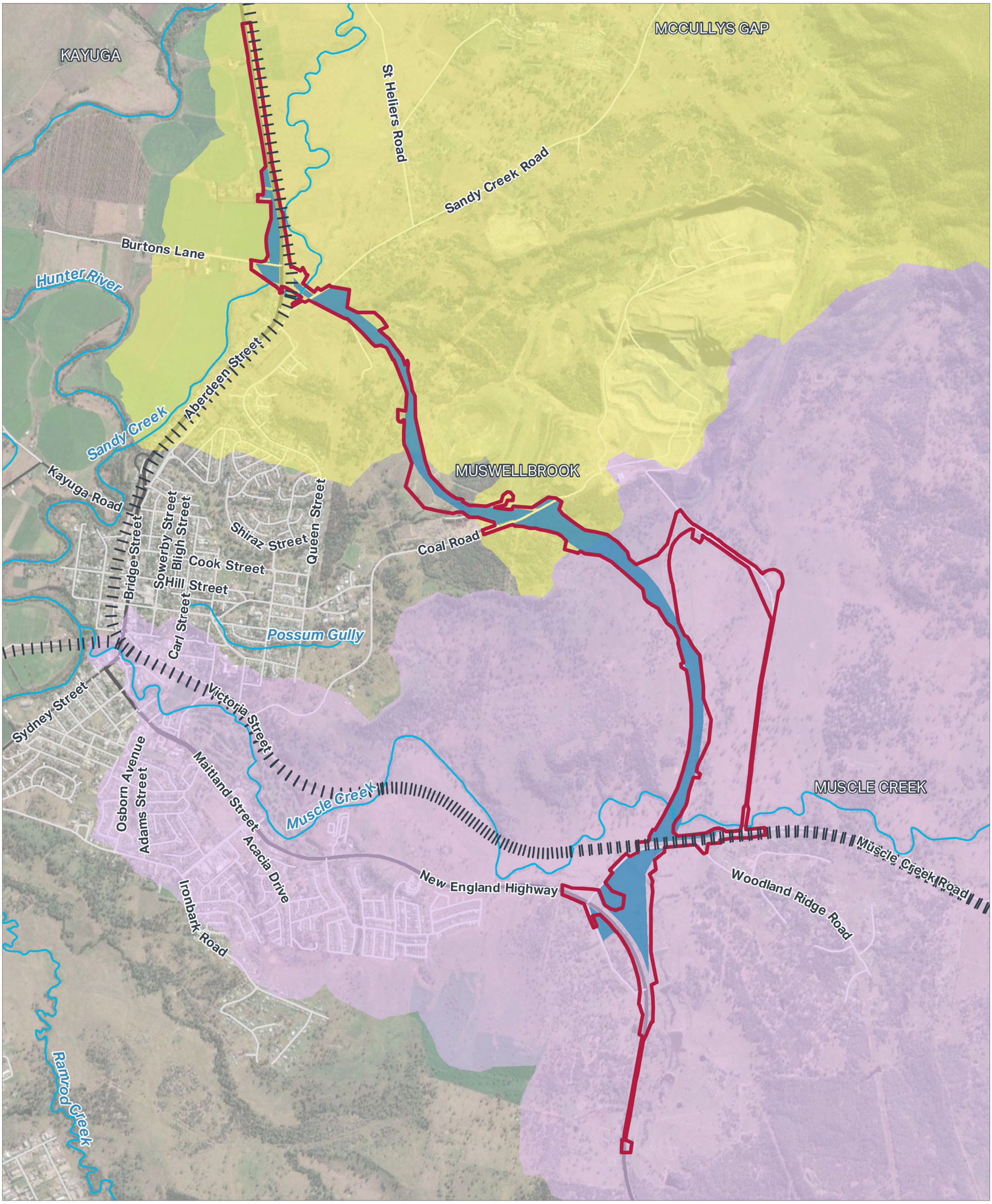

FIGURE 6-6: WATERCOURSES AND THEIR CATCHMENTS AROUND THE PROPOSAL

AECOM

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Sandy Creek catchment
- Muscle Creek catchment

0 0.5 1 km

6.2.2 Existing environment

Hydrology

The Hunter River rises on the western slopes of the Mount Royal Range, part of the Great Dividing Range, east of Murrurundi, and flows generally south-west and then south-east before flowing into the Pacific Ocean at Newcastle. The contributing catchment of the Hunter River upstream of the proposal, referred to as the Upper Hunter catchment, covers about 4,220 square kilometres. Lake Glenbawn is located about 37 kilometres upstream of the town of Muswellbrook. The Upper Hunter Catchment can be split into three broad catchments:

- Dart Brook (incorporating Middle Brook)
- Isis River (incorporating Pages River)
- Hunter River.

The Hunter River is located to the west of Muswellbrook. The western bank of the Hunter River comprises predominantly agricultural land use. Along the reach adjacent to Muswellbrook, the Hunter River flows in a southerly/south westerly direction.

The proposed road corridor traverses a number of watercourses associated with Sandy Creek and Muscle Creek which confluence with the Hunter River shown on Figure 6-6. The proposal is located to the east of the Hunter River and, at its closest point, is about 650 metres away. The Sandy Creek catchment drains an area of about 162 square kilometres whilst the Muscle Creek catchment covers an area of about 93 square kilometres. Land use within both the Sandy Creek and Muscle Creek catchments is typically grazing or farmland, with a small portion of urbanised land in the lower reaches associated with the town of Muswellbrook.

Surface water quality

Upstream of the proposal, land use that could potentially impact water quality within the Hunter River predominantly comprises agriculture and localised mining activities.

The report card for the Muswellbrook water source (NSW Department of Water and Energy, August 2009) states that:

- There is low economic dependence of the local community on water extracted for irrigation
- Instream values are at medium risk of being impacted by extractions within the water source
- There is low relative instream value (within catchment) given:
    - The presence of one threatened bird species and one endangered ecological community
    - Platypus have been identified
    - Moderate fish community integrity
- The ecology value for invertebrates is deemed to be moderate.

In order to determine the most appropriate level of protection[1] and guideline values for physical and chemical stressors (including toxicants), the ecosystem condition category of the surface water receiving environment has been assessed according to the categories outlined in the *Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality* (ANZG 2018) and using information from the Biodiversity Assessment Report (WSP Australia 2021) (refer to Appendix A).

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[1] Defined in ANZG (2018) as "*the degree of protection afforded to a water body based on its ecosystem condition (current or desired health status of an ecosystem relative to the degree of human disturbance).*"

Whilst the surface water environment sits within some highly modified landscapes with relatively low value in terms of supporting aquatic ecosystems, some higher value areas exist. For this reason, a precautionary approach has been adopted and the ecosystem condition category is assumed to fall into the 'slightly to moderately disturbed' category. Refer to Table 3-4 in Appendix I which outlines the ecosystem condition categories and associated attributes.

The baseline water quality results obtained from the July to December 2020 monthly sampling events carried out by Transport are summarised as follows:

Hunter River

- Surface water quality conditions indicate that water within the Hunter River are slightly to moderately turbid
- Geochemical conditions of the Hunter River suggest slightly alkaline freshwater conditions with an average electrical conductivity of 542 µS/cm and pH ranging from 7.80 to 8.07
- Analysis of heavy metals reported concentrations for arsenic, chromium lead (total only) nickel and zinc to be present within the Hunter River with concentrations of copper, lead (total) and zinc reported slightly above the adopted screening criteria. Where concentrations of heavy metals were reported, there was little, or no variance observed between the upstream and downstream concentrations along the associated river reach. As such sampling of heavy metals within Sandy and Muscle Creek was not considered critical (i.e. tributaries not significantly contributing to heavy metal concentrations within the Hunter River).

Muscle Creek

- Surface water quality conditions within Muscle Creek suggest that these contributing catchment waters are slightly turbid
- Geochemical conditions observed upstream of the confluence with the Hunter River suggest fairly pH neutral, slightly saline water conditions with an average electrical conductivity of 1,293 µS/cm and pH of 7.48
- No inorganic sampling was undertaken at this location as the metal concentrations between the upstream and downstream sampling points within the Hunter River remain largely unchanged.

Sandy Creek

- Surface water quality conditions within Sandy Creek suggest that these contributing catchment waters are slightly turbid
- Geochemical conditions observed upstream of the confluence with the Hunter River suggest fairly pH neutral, slightly saline water conditions with an average electrical conductivity of 1,135 µS/cm and pH of 7.58.

Flooding

Sandy Creek and the Hunter River

Flood events under existing conditions at the northern connection may be affected by flooding from Sandy Creek and/or the Hunter River. Both local (Sandy Creek dominated) and regional (Hunter River dominated) events have been considered in the Flood Risk Assessment (BMT 2021) (refer to Appendix E).

Sandy Creek passes below the Main North railway line and New England Highway bridges before entering the Hunter River to the southwest. During flood events up to the five per cent AEP, the local roads, highway and railway at the northern connection are not impacted by flood waters, apart from Burtons Lane. Elsewhere, properties in the Sandy Creek and Hunter River floodplains are impacted largely due to Hunter River backwater effects.

However, flood events larger than five per cent AEP result in the intersection of Sandy Creek and the New England Highway being submerged, along with the New England Highway north of Burtons Lane, Burtons Lane and Koolbury Flats Row. Extensive flooding of properties also occurs within the Sandy Creek and Hunter River catchments. The Flood Risk Assessment (BMT 2021) in Appendix E provides more information regarding existing flood conditions at the northern connection.

Muscle Creek

At Muscle Creek, near the southern connection, flood waters are largely contained within the existing channel up to a 0.05 per cent AEP event. During this event, the roads, highway and Main North railway line are not directly impacted by floodwater, however minor impacts to grass paddocks are experienced at properties adjacent to Muscle Creek and tributaries of Muscle Creek. Refer to the Flood Risk Assessment (BMT 2021) (refer to Appendix E) for more information regarding existing flood conditions near the southern connection.

6.2.3 Potential impacts

Construction

Surface water quality

Construction activities represent a risk to surface water quality within the Hunter River, Sandy Creek and Muscle Creek. During runoff events or flood conditions, sediment laden waters, chemicals stored on site, and construction waste have the potential to mobilise and enter waterways.

Generation of sediment laden waters and offsite discharge can occur during construction activities such as:

- Clearing and grubbing
- Stockpiling of materials
- General earthworks
- Temporary works (i.e. access roads, compounds, laydown areas and pads)
- Construction of bridge piers and abutments in and adjacent to the Hunter River
- Instream drainage works
- Placement of fill for embankments.

Sediment laden waters pose a potential risk to downstream surface water quality. Water quality impacts include (but are not limited to) increased turbidity and elevated concentrations of nutrients and other pollutants, such as heavy metals and organic chemicals.

Other potential sources that may impact surface water quality during construction include:

- Fuel or oils used by construction plant and equipment
- Concrete batching plant and associated concrete wastes
- Waste and litter from building activities and personnel
- Release of nutrients from fertilisers, herbicides and pesticides (e.g. used in site landscaping)
- Paint and paint wastes
- Acids from acid-based washes
- Disturbance of contaminated soils and/or acid sulfate soils, which may adversely affect water chemistry including pH and dissolved solids.

The potential impacts to water quality during construction of the bypass were qualified according to the water quality indicators provided in Section 3.5.2 of Appendix I. A description of the potential impact associated with the proposed construction phase activities and expected likelihood of the impact is provided in Table 6-11.

Table 6-11: Assessment of the impact on key water quality indicators

Key indicator	Likelihood of impact
Chlorophyll a	Chlorophyll-a is not expected to be present in site runoff as a result of construction activities. **Negligible** impact
Total Phosphorus (TP) and Total Nitrogen (TN)	Mobilisation of topsoil in runoff during construction has potential to cause an increase of both TP and TN in receiving waters. Whilst elevated TP and TN has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
Dissolved Oxygen (DO)	No substantial change is expected in DO concentrations from construction site runoff or sediment basin discharges. Direct impacts are therefore considered **low** Indirectly, a reduction in DO concentrations downstream could occur if site runoff presents elevated levels of nutrients (TN and TP) or total suspended sediments (TSS). However, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
pH	Based on the geological properties and soil landscape of the study area, preliminary sampling and available monitoring data which indicates generally more alkaline pH levels in water, there is a low probability of encountering potential acid sulfate soils which can release acid if disturbed. Therefore, the construction activities have a **low** likelihood of impacting pH of receiving waters
Electrical Conductivity (EC)	The EC of surface water from construction activities is likely to be consistent with the range of salinity historically observed in the Hunter River. Therefore, the construction activities have a **low** likelihood of impacting EC of receiving waters
Turbidity	Construction activities have the potential to increase turbidity and TSS in local waterways through the exposure of topsoils and subsoils. Whilst elevated turbidity and TSS has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
Temperature	Temperature of stormwater runoff or discharge from sediment basins would be similar to that in nearby waterways. Hence, potential impact of temperature changes from site runoff or releases of sediment basin discharges is considered to be **negligible**
Chemical contaminants	There is potential for chemical contamination from spills or other sources associated with construction activities. Whilst contamination in surface waters has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk associated is considered **low**
Faecal coliforms	There is a **low** likelihood of environmental impact due to faecal coliforms in surface water from construction activities
Algae and blue green algae	Elevated temperature and nutrients (TN and TP) have the potential to contribute to algal blooms in the receiving waters downstream. This increased likelihood is considered small when comparing the contributing catchment size with the size of the Upper Hunter River catchment, as well as taking into consideration contributing land uses (i.e. agriculture, urban development)

Key indicator	Likelihood of impact
	Given the proposed management measures and safeguards, the risk of this potential impact is considered **low**
Visual clarity and colour	This indicator is largely assessed above in relation to turbidity and TSS. There is limited baseline information on the natural visual clarity, hue and reflectivity of the receiving environments to determine whether there is likely to be a predicted change in the nominated indicator Given the proposed management measures and safeguards, there is a **low** likelihood of adverse impact on this environmental value
Enterococci	There is a very **low** likelihood of environmental impact due to enterococci in surface water from construction activities
Protozoans	There is a very **low** likelihood of environmental impact due to protozoans in surface water from construction activities

The potential for accidental spills (e.g. chemicals or fuels) during construction would be managed within the CEMP developed for the construction phase of the proposal. For spill management during construction activities, the CEMP should consider the following, amongst others:

- Principal sources that may result in chemical spills during construction activities
- Location of sources in relation to environmentally sensitive areas (e.g. watercourses)
- The probability of potential spills
- Construction stormwater management measures and associated drainage
- Bunding requirements and temporary drainage basins at points of discharge associated with the proposal.

Flooding

The construction of a road embankment across a floodplain and the bridging of watercourses can potentially increase flood levels, redistribute flows, increase inundation times and increase velocities. Potential impacts associated with flooding could occur where construction activities are located within the flood affected zones. If inundated during a flood, material, fuel, chemicals and equipment stored in stockpile and compound sites could wash away. This could impact the surrounding environment, particularly adjacent waterbodies. Compounds and stockpiles could also affect flood flow paths, if inappropriately located.

Flood behaviour of the study area is well understood, with adequate advance flood warning likely to be available to enable the removal of staff and equipment and protection of the works prior to inundation.

Ancillary facilities such as construction compounds, laydown areas and stockpiles would be located outside of areas where they would have the potential to impact on major natural flow paths or exacerbate flood conditions.

Mitigation measures would be included in the CEMP as outlined in Section 6.2.4.

Operation

Surface water quality

A potential impact to surface water quality during the operation of the proposal would be from pollutants and contaminants from the surface of the road being conveyed during runoff events to receiving waters.

Contaminants could include litter, sediment and suspended solids, nutrients, heavy metals, toxic organics, oils and surfactants. Potential sources include:

- Exhaust particles from vehicle engines
- Wear products from brakes, tyres and other mechanical parts
- Minor discharges from vehicle engines, including fluids, lubricants and other similar materials
- Minor discharges from leaking or damaged loads
- Litter or other waste
- Loss of goods and other materials due to vehicle incidents and accidents.

The principal source of accidental spills during operation would be from the transport of chemicals and could occur following a crash. However, the probability of potential spills is considered low because:

- The bypass provides a higher standard of road design when compared to the existing road
- The proposal is considered to reduce the potential risk of traffic incidents occurring and therefore associated spill incidents
- Legislative controls on the transport of dangerous goods require that safeguards are installed on vehicles transporting hazardous liquids to avoid spillage.

Whilst the likelihood of a chemical spill is low, if an incident occurred there would be potential for environmental harm.

Should a spill occur away from Muscle Creek and Sandy Creek, there would be sufficient time and storage for the spill to be contained and treated through standard emergency response procedures. Therefore, the spill would be unlikely to reach Muscle Creek and Sandy Creek and subsequently the Hunter River. However, if a spill occurred in the sections spanning Muscle Creek and Sandy Creek or their respective flood plains, there is a risk that the spill could make its way into the Hunter River.

To manage spills that occur on the bridge over Muscle Creek and Sandy Creek, a pit and piped drainage system is required to transport the runoff, and therefore any spill, to the spill containment measures where it would be appropriately removed and treated. Spill containment basins have been provided near Muscle Creek and Sandy Creek where the road drainage discharges.

The management of spills, minor discharges and litter or other waste would be addressed using standard operational mitigation measures. Spills would be managed by a combination of grass-lined swales and spill containment basins. Stormwater from the bridge over Muscle Creek and Sandy Creek would be captured and piped to provide drainage of surface water.

Flooding

Sandy Creek and Hunter River

The proposal would have the potential to impact flood levels where it crosses the Sandy Creek and Hunter River floodplains at the northern connection. The potential for impacts has been minimised through the inclusion of a 375 metre long bridge which extends across Sandy Creek and its floodplain. Piers located within the flow path would be aligned so as to minimise disruption to the flow, with scour protection provided to minimise bed and bank scour.

Drainage culverts would be provided through the bypass embankment at various locations to maintain natural flow paths. At the northern connection, the Sandy Creek and Hunter River flood waters may change the characteristics of flow through the culverts, including the direction of flow due to backwater effects.

Whilst the potential for flood impacts has been minimised through the design of the proposal, relatively minor impacts remain. These are primarily due to the embankments associated with the bypass resulting in localised redistributions of flow. The obstruction of a secondary flow path to the north of Sandy Creek causes water to back up to slightly higher levels than occur under existing conditions. This increase in flood levels extends into the floodplain on the eastern side of the proposed bypass.

The embankments also cause a minor constriction to flow across the broad floodplain of the Hunter River this creates minor increases in flood levels on the western side of the proposed bypass.

Refer to the Flood Risk Assessment (BMT 2021) (Appendix E) for more information regarding potential flood impacts at the northern connection during operation of the bypass.

An extreme (probable maximum) flood (PMF) has been modelled as part of the assessment. Flood impacts due to the bypass in this event are noted, however the Sandy Creek and Hunter River floodplains would already be inundated across a wide area and to significant depths. The small additional increase in flood level is considered to make minimal material difference.

Muscle Creek

The design of the bypass would minimise the potential for flood impacts by providing a bridge structure over Muscle Creek. Piers located within the flow path would be aligned to minimise disruption to the flow, with scour protection provided to minimise bed and bank scour. Modelling shows no significant peak flood level or velocity impacts on the main channel of Muscle Creek for all events up to and including the 0.5 per cent AEP with only minor impacts (up to a 0.05 metre increase in peak level) for the 0.2 per cent and 0.05 per cent AEP.

The proposal would have the potential to impact a tributary of Muscle Creek near the southern connection where natural flows are restricted by the bypass embankment. A large box culvert structure would be provided at this location to minimise impacts, however there would be a slight redistribution in flows which would cause localised increases and decreases to peak flood levels and velocities.

The changes in peak flood levels and velocities for Sandy Creek and Muscle Creek are summarised in Table 6-12: and Table 6-13: respectively. Further detail is provided in the Flood Risk Assessment (2021) (refer to Appendix E).

Flood levels and velocities

An overview of changes to flood levels and velocities for assessed flood events ranging from the 20 per cent AEP to the PMF event on Sandy Creek is provided in Table 6-12.

Table 6-12: Changes in peak flood levels and velocities for Sandy Creek

AEP event	Aspect	Changes
20%	Flood level	• No notable changes to modelled peak flood levels or velocities due to the minimal extent of out-of-bank flooding
	Flood velocity	• Some highly localised increases immediately upstream of the bypass on the southern tributary of Sandy Creek, immediately upstream of the bypass where flow backs up behind a culvert under the bypass
5%	Flood level	• Increase of up to 0.5 m between the Main North railway line and the New England Highway associated with the effective removal of the alternative flow path • Increase of up to 0.7 m on the southern tributary of Sandy Creek.
	Flood velocity	• No notable velocity changes other than localised increases and decreases adjacent to and within 100 m of the bypass.

AEP event	Aspect	Changes
2% and 1%	Flood level	• Increase of up to 0.22 m on the floodplain up to one kilometre upstream (east) of the bypass (1% AEP) • Increase of up to 0.06 m on the floodplain downstream (west) of the bypass at Burtons Lane (1% AEP) • Highly localised increases of up to 0.5 m to the north of Sandy Creek between the Main North railway line and the New England Highway
	Flood velocity	• Increases on the western side of the bypass due to changes in the distribution of Hunter River floodplain flow • Increases of up to 0.5 m/s along a 100 m length of Burtons Lane where existing velocities are about 1.5 to 2.0 m/s • Decreases in peak velocity on Burtons Lane of up to 0.5 m/s are also apparent
0.5%, 0.2% and 0.05%	Flood level	• Increases ranging from about 0.4 m adjacent to the bypass to 0.06 m along Burtons Lane • Increase of about 0.1 m on the eastern side of the bypass, increasing to 0.2 m immediately upstream of the Sandy Creek crossing • Highly localised increases of up to 1.5 m immediately upstream of the bypass on the southern tributary of Sandy Creek
	Flood velocity	• Similar changes to those of the 1% AEP event, except flood velocity reduces slightly as the size of the flood event increases
PMF	Flood level and velocity	• Shows the most extensive impacts although the magnitude of impact is similar to that of smaller events • Increase of up to 0.2 m with a flood depth typically between 3.5 and 4.0 m on the eastern side of the bypass • Peak flood level impacts near Koolbury Flats Row with increases of up to 0.35 m with a flood depth typically between 3.5 and 4.0 m on the western side of the bypass

An overview of changes to flood levels and velocities for assessed flood events ranging from the 20 per cent AEP to the PMF event on Muscle Creek is provided in Table 6-13:.

Table 6-13: Changes in peak flood levels and velocities for Muscle Creek

AEP event	Aspect	Changes
AEP events up to 0.5%	Flood level	• Flow contained within creek channel • Increase of up to 0.5 m where the southern tributary of Muscle Creek passes through the bypass (localised within about 150 m)
	Flood velocity	• No notable changes
AEP events beyond 0.5%	Flood level	• Increase of up to 0.05 m where the bypass crosses Muscle Creek • Increase of up to 0.15 m on the northern tributary of Muscle Creek immediately adjacent to the bypass, diminishes with distance upstream along approximately 150 m of channel

AEP event	Aspect	Changes
	Flood velocity	• Similar to flood level changes outlined above with increases associated with a southern tributary of Muscle Creek as it passes through the bypass. Water would back up behind a bypass culvert with a slight redistribution of flow downstream of this culvert
PMF	Flood level	• Increase of up to 2.0 m immediately upstream of the bypass • Increases within a one km radius of the crossing of Muscle Creek • Decreases up to 0.5 m on the northern side of the Main North railway line • Increases up to 0.8 m on the southern side of the Main North railway line, downstream of Muscle Creek
	Flood velocity	• Similar to flood level changes outlined above with large increases and decreases due to a redistribution of flow

Impact to property and infrastructure

Sandy Creek

The proposal with its large bridge crossing of Sandy Creek would have limited potential to affect flood levels for Sandy Creek. Flood impacts to property and local roads in the surrounding area, and to the Main North railway line, are considered minor except for the PMF event where impacts would be more pronounced. It should be noted that, in this extreme event, impacted roads and properties would already be inundated to significant depths.

Flood modelling for a one per cent event showed that for 28 out of 33 properties located near the Sandy Creek impact zone, the proposal would result in either no increase or very minor increases in peak flood level (less than 0.03 metres). Of the remaining five properties, only two showed an increase above 0.1 m (one of which is an agricultural lot containing a groundwater bore well).

Muscle Creek

For Muscle Creek, the potential flood impacts resulting from the proposal would be minimal as the flow in the main creek would remain largely ‘in bank’ for events up to and including the 0.05 per cent AEP.

In the PMF event, two properties would be impacted:

- One previously flooded to a depth of 0.8 metres would have a peak water level increase of 1.48 metres.
- One property previously dry in the PMF would be inundated to a depth of 0.7 metres.

Scour

The scour assessment concluded that the greatest local pier scour depth for Sandy Creek in the 1 per cent AEP event would occur at Pier 3, with a scour depth estimate of 2.14 metres. In the 0.05 per cent AEP event, the greatest scour depth occurs for Pier 8 with a scour depth estimate of 2.36 metres.

For Muscle Creek, the deepest point at Pier 2 provided a scour depth estimate of 1.91 metres for the one per cent AEP event and 2.30 metres for the 0.05 per cent AEP event.

There would also be a potential for increased scour and erosion due to increased flow velocities at partially blocked culverts or bridge openings. This could affect ecosystems, impact on flood levels and could ultimately affect the structural integrity of the road infrastructure.

Detailed design of the proposal would consider scour protection to ensure impacts to the road and other infrastructure would be minimised. Transport would also carry out a detailed survey of floor levels for dwellings to validate the flood study where required.

6.2.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
General	A Soil and Water Management Plan (SWMP) will be prepared in accordance with QA Specification G38 and implemented as part of the CEMP. The Plan will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with undertaking the activity and describe how these risks will be managed and minimised during construction. The SWMP will include arrangements for managing pollution risks associated with spillage or contamination within the construction footprint and adjoining areas, and monitoring during and post-construction. The SWMP will address the following: • Code of Practice for Water Management, the Roads and Maritime Erosion and Sedimentation Procedure • The NSW Soils and Construction – Managing Urban Stormwater Volume 1 “the Blue Book” (Landcom, 2004) and Volume 2 (DECC, 2008) • Technical Guideline: Temporary Stormwater Drainage for Road Construction, 2011 • Technical Guideline: Environmental Management of Construction Site Dewatering, 2011	Construction contractor	Pre-construction and construction	Core standard safeguard GEN1
Erosion and sediment control mitigation	A site-specific Erosion and Sediment Control Plan (ESCP) will be prepared and implemented and included in the SWMP. The ESCP will identify detailed measures and controls to be applied to minimise erosion and sediment control risks including, but not necessarily limited to: • Runoff, diversion and drainage points • Sediment management devices, such as fencing, hay bales or sandbags	Construction contractor	Construction	Core standard safeguard E1

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• Scour protection and energy dissipaters at locations of high erosion risk • Stabilising disturbed areas as soon as possible, check dams, fencing and swales • Staged implementation arrangements The ESCP will also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather			
Contamination of surface water quality	Sediment control basins will be provided at flow discharge points associated with the bypass and bridges over Muscle Creek and Sandy Creek. The requirements for erosion control measures and sediment basins (i.e. number, location and size) will be determined during the proposal detailed design phase	Construction contractor	Detailed design and construction	Additional safeguard
Contamination of surface water quality	A Spill Management Plan (SMP) will be prepared and implemented as part of the CEMP to minimise the risk of pollution arising from spillage or contamination on the site and adjoining areas. The SMP will address, but not necessarily be limited to: • Management of chemicals and potentially polluting materials • Appropriate location and storage of construction materials, fuels and chemicals, including bunding where appropriate • Maintenance of plant and equipment • Emergency management, including notification, response and clean-up procedures	Construction contractor	Pre-construction and construction	Additional safeguard
Surface water quality	Water quality requirements will form part of the conditions stipulated in the environment protection licence (EPL) for the proposal. The current water quality monitoring program results will be used for baseline purposes	Construction contractor	Construction	Core standard safeguard W2

Impact	Environmental safeguards	Responsibility	Timing	Reference
Flood mitigation	A Flood Risk Management Plan (FRMP) will be prepared as part of the CEMP. The FRMP will address, but not necessarily be limited to: • Processes for monitoring and mitigation flood risk • Steps to be taken in the event of a flood warning including removal or securing of loose material, equipment, fuels and chemicals	Construction contractor	Construction	Additional safeguard