7. Assessment of key issues

7.9 Surface water quality and hydrology

This section describes the potential surface water quality and hydrology impacts that may be generated by construction and operation of the project and presents a proposed approach to the management of these impacts. **Table 7-131** outlines the SEARs that relate to surface water quality and hydrology and identifies where they were addressed in this EIS. The full assessment of surface water quality and hydrology impacts is provided in **Appendix M**.

Table 7-131 SEARs (surface water quality and hydrology)

Secretary's requirement	Where addressed in this EIS
14. Water - Hydrology	
1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	The existing surface water hydrological regime is presented in **Section 7.9.3** The existing groundwater hydrological regime is presented in **Section 7.10.3**
2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration	A surface water balance is presented in **Section 7.9.4** A groundwater balance is presented in **Section 7.10.4**
3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including: a. natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Impacts on surface water natural processes and access to habitat are assessed in **Section 7.9.4** Impacts on groundwater natural processes and access to habitat are assessed in **Section 7.10.4**
c. changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	Changes to environmental surface water availability and flows are assessed in **Section 7.9.4** Changes to environmental groundwater availability and flows are assessed in **Section 7.10.4**
d. direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Erosion and related impacts are assessed in **Section 7.9.4**
e. minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Stormwater and wastewater management impacts are presented in **Section 7.9.4**

Secretary's requirement	Where addressed in this EIS
f. water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Water take from surface water sources is assessed in **Section 7.9.4** Water take from groundwater sources is assessed in **Section 7.10.4**
4. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Requirements for baseline surface water monitoring are discussed in **Section 7.9.6** and **Appendix M** Requirements for baseline groundwater monitoring are discussed in **Section 7.10.6**
15. Water - Quality	
1. The Proponent must: a. state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	Criteria relating to surface water are discussed in **Section 7.9.1** Criteria relating to groundwater are discussed in **Section 7.10.2** and **Section 7.10.4**
b. identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	The potential introduction of pollutants relating to surface water are discussed in **Section 7.9.4** The potential introduction of pollutants relating to groundwater are discussed in **Section 7.10.2** to **Section 7.10.4**
c. identify the rainfall event that the water quality protection measures would be designed to cope with;	The maximum rainfall event is identified in **Section 7.9.4**
d. assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	The significance of identified impacts relating to surface water is discussed in **Section 7.9.4** The significance of identified impacts relating to groundwater are discussed in **Section 7.10.4**
e. demonstrate how construction and operation of the project would, to the extent that the project can influence, ensure that: where the NSW WQOs for receiving waters are currently being met they would continue to be protected; and where the NSW WQOs are not currently being met, activities would work toward their achievement over time;	The protection of receiving waters relating to surface water is discussed in **Section 7.9.4** The protection of receiving waters relating to groundwater is discussed in **Section 7.10.4**
f. justify, if required, why the WQOs cannot be maintained or achieved over time;	Water quality objectives are discussed in **Section 7.9.4**
g. demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	Measures to avoid or minimise surface water pollution and protect health and the environment are discussed in **Section 7.9.4** and **Section 7.9.6** Measures to avoid or minimise groundwater pollution and protect health and the environment are discussed in **Section 7.10.6**
h. identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	Sensitive receiving environment relating to surface water are discussed in **Section 7.9.3** and **Section 7.9.6** Sensitive receiving environment relating to groundwater are discussed in **Sections 7.10.3** and **Section 7.10.6** The strategy to avoid or minimise impacts is disciussed in **Section 5.13.2**

Secretary's requirement	Where addressed in this EIS
i. identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Surface water monitoring is discussed in **Section 7.9.6** Groundwater monitoring is discussed in **Section 7.10.6**
16. Protected and sensitive lands	
1. The Proponent must assess the impacts of the project on environmentally sensitive land and processes (and the impact of processes on the project) including, but not limited to: a. Key Fish Habitat as mapped and defined in accordance with the *Fisheries Management Act 1994* (FM Act);	Temporary and permanent impacts on key fish habitat and fish passage are discussed and assessed in **Section 7.1.4** Key fish habitat has also been considered in the identification of sensitive receiving environments (SREs) as detailed in **Section 7.9.2**
b. waterfront land as defined in the *Water Management Act 2000*;	Impacts on waterfront land are discussed in **Sections 7.9.4** and **7.9.6** Impacts on riparian corridors are discussed further in **Section 7.1.4**

7.9.1 Policy and planning setting

The surface water quality and hydrology assessment was prepared in consideration of the following legislation and policy:

- *Protection of the Environment Operations Act 1997* (POEO Act)
- *Water Act 1912*
- *Water Management Act 2000* and *Water Management (General) Regulation 2011* (NSW)
- *Fisheries Management Act 1994*
- *Threatened Species Conservation Act 1995* (TSC Act)
- Sydney Regional Environmental Plan No. 20 – Hawkesbury-Nepean River (No 2-1997).

Further detail on the above legislation and policies and how they apply to project is provided in Chapter 2 of **Appendix M**.

Relevant guidelines

National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) was formulated with the objective of achieving sustainable use of the nation's water resources by protecting and enhancing their quality whilst maintaining economic and social development.

The NWQMS contains guidelines for setting water quality objectives to sustain current or likely future environmental values for water resources. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a) (referred to herein as the ANZECC Water Quality Guidelines) are part of the NWQMS and are relevant to the project as discussed below.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The ANZECC Water Quality Guidelines provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters and list a range of environmental values assigned to that waterbody. The ANZECC Water Quality Guidelines have been applied with guidance from the *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DECC, 2006) booklet to understand the current health of the waterways in the vicinity of the project and the ability to support nominated environmental values, particularly the protection of aquatic ecosystems. The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection which have been considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly to moderately disturbed ecosystems.

It should be noted that as per Section 2.2.1.9 of the ANZECC (2000) guidelines; "the guidelines have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environmental values they support."

NSW Water Quality Objectives

The NSW Water Quality Objectives (WQOs) are the agreed environmental values and long-term goals for NSW's surface water (DECCW, 2006). They set out:

- The community's values and uses (ie healthy aquatic ecosystem, water suitable for recreation or drinking water etc) for our waterways (rivers, creeks, lakes and estuaries)
- A range of water quality indicators to assess whether the current condition of the waterway supports these values and uses.

The water quality objectives consist of three parts: environmental values, water quality indicators and recommended guideline levels.

At the time that WQOs were approved by the government (September 1999) for catchments across NSW, the Hawkesbury- Nepean was subject to an independent inquiry by the Healthy Rivers Commission (HRC).

The HRC has determined water quality guidelines (referred to herein as 'HRC guidelines') for the protection of water quality in the Hawkesbury-Nepean River (HRC, 1998). The water quality objectives consist of three parts: environmental values, water quality indicators and recommended guideline levels. The HRC water quality objectives (discussed further below) have been adopted as the relevant water quality objectives for the project, along with the environmental values from the ANZECC Water Quality Guidelines (as discussed above). As the water quality criteria provided in the HRC guidelines were established in the 1990s, the ANZECC water quality guidelines developed in 2000 have superseded these. The ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment presented it his report.

Healthy Rivers Commission Inquiry

The HRC inquiry into the Hawkesbury-Nepean system in the late 1990s determined water quality objectives that recognise the communities 'environmental values' and uses of the waterways (DECCW, 2006). These water quality objectives were agreed to by the NSW Government through a statement of Joint Intent in 2001.

The HRC Inquiry is relevant to the project as it established environmental values for different regions of the Hawkesbury-Nepean River, into which the project drains (referred to herein as the HRC guidelines). As stated above, the ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment. The HRC guidelines, however, have been adopted to identify the environmental values to be protected.

Environmental values and water quality criteria

As discussed above, the ANZECC Water Quality Guidelines have been used as the basis for the surface water quality and hydrology assessment. In addition, the HRC has been used to determine water quality guidelines for the protection of water quality in the Hawkesbury-Nepean River (HRC, 1998).

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit or health. They are values that require protection from the effects of pollution and waste discharges and provide goals that help in the selection of the most appropriate management options (ANZECC/ARMCANZ, 2000a).

The project lies largely within the lower Hawkesbury-Nepean Catchment and Georges River Catchment within the regions classified as ‘mixed-use rural’ and ‘predominantly urban’. The nominated environmental values applying to waterways within the study area are:

- **Protection of aquatic ecosystems:** Aquatic ecosystems comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have historically been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality.
- **Visual amenity**: The aesthetic appearance of a waterbody is an important aspect with respect to recreation. As such the water should be free from noticeable pollution, floating debris, oil, scum and other matter. Substances that produce objectionable colour, odour, taste or turbidity and substances and conditions that produce undesirable aquatic life should not be apparent. The key aesthetic indicators are transparency, odour and colour.
- **Primary contact recreation —** Primary contact refers to where the body can be fully immersed and there is the potential to swallow water. You are in direct contact with the water. This includes water skiing, diving and swimming.
- **Secondary contact recreation —** This refers to activities such as paddling, wading, boating and fishing in which there is direct contact but the chance of swallowing water is unlikely.
- **Irrigation water supply —** This refers to the suitability of water supply for irrigation, for example irrigation of crops, pastures, parks, gardens and recreational areas.
- **Homestead water supply —** The objective applies to all homesteads that draw water from surface water for domestic needs, including drinking water. Suitability of domestic farm water supply, other than drinking water. For example water used for laundry and produce preparation.

Key water quality indicators and related numerical criteria nominated for each environmental value using the ANZECC Water Quality Guidelines are provided in **Table 7-132.** These environmental values were considered in the assessment of existing water quality and potential impacts as a result of the project.

Construction phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures that would be implemented during the construction phase of the project:

- NSW Department of Environment and Climate Change (DECC) (2008a) Approved Methods for the Sampling and Analysis of Water Pollutants in NSW
- NSW DECC (2008b) Managing Urban Stormwater – Volume 2D Main Road Construction, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2): Sydney
- NSW DPI (2012a) Guidelines for controlled activities on waterfront land
- Landcom (2004) Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (known as the Blue Book Volume 1): Sydney
- RTA (2003a) Road Design Guideline: Section 8 Erosion and Sediment, Roads and Traffic Authority of NSW: Sydney
- RTA (2003b) Guideline for Construction Water Quality Monitoring, Roads and Traffic Authority of NSW: Sydney
- RTA (2009) Erosion and Sediment Management Procedure, Oct 2009, Roads and Traffic Authority of NSW: Sydney
- RTA (1999) Code of Practice for Water Management - Road Development and Management, Roads and Traffic Authority of NSW: Sydney
- Roads and Maritime (2012c) Environmental Direction: Management of Tannins from Vegetation Mulch, Roads and Maritime Services: Sydney

- RTA (2005b) Guidelines for the Management of Acid Sulphate Materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulfidic Black Ooze, Roads and Traffic Authority of NSW: Sydney
- RTA (2001b) Stockpile Site Management Procedures, Roads and Traffic Authority of NSW: Sydney
- Roads and Maritime (2011c), Technical Guideline: Temporary Stormwater Drainage for Road Construction, Roads and Maritime Services: Sydney
- Roads and Maritime, (2011e) Technical Guideline – Environmental Management of Construction Site De-watering, Roads and Maritime Services: Sydney
- TfNSW, (2013a) NSW Sustainable Design Guidelines Version 3.0, Transport for NSW.
- DPI (2012a) Guidelines for controlled activities on waterfront land, Department of Primary Industries.

Table 7-132 Environmental values for waterways in the project area and associated indicators and guideline values

Environmental value	Indicator	Guideline value
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and their riparian zones over the long-term	Total phosphorus	25µg/L
	TN	350µg/L
	Chlorophyll-a	3µg/L
	Turbidity	6-50 Nephelometric Turbidity Unit (NTU)
	Salinity (electrical conductivity)	125-2200µS/cm
	Dissolved oxygen	85-110% saturation
	pH	6.5-8.5
	Toxicants	As per table 3.4.1 ANZECC/ARMCANZ (2000a) (95% level of protection for slightly to moderately disturbed ecosystems and 99% level of protection for toxicants that bioaccumulate)
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter. 250 µg/L
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts n/a (no quantitative value specified)

Environmental value	Indicator	Guideline value
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic works are undesirable.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values in Table 9.3 of NHMRC (2008) guidelines.
	Visual clarity and colour	As per the visual amenity guidelines.
	Surface films	As per the visual amenity guidelines.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation Toxic substances should not exceed values in table 9.3 of the NHMRC (2008) guidelines
	Visual clarity and colour	As per the visual amenity guidelines
	Temperature	15°-35°C for prolonged exposure.
Irrigation water supply – protecting the quality of waters applied to crops and pastures	Algae and blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.
	Salinity (electrical conductivity)	To assess the salinity and sodicity of water for irrigation use, a number of interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscapes and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC 2000 Guidelines.
	Thermotolerant coliforms (faecal coliforms)	Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in table 4.2.2 of the ANZECC Guidelines.
	Heavy metals and metalloids	Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in table 4.2.10 of the ANZECC 2000 guidelines.

Environmental value	Indicator	Guideline value
Homestead water supply – protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Blue-green algae	Recommended twice weekly inspections during danger period for storages with history of algal blooms. No guideline values are set for cyanobacteria in drinking water. In water storages, counts of: • <1000 algal cells/mL – of no concern • >500 algal cells/mL – increase monitoring • >2000 algal cells/mL – immediate action indicated; seek expert advice • >6500 cells/mL – seek advice from health authority
	Turbidity	5 NTU; <1NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection
	Total dissolved solids	• <500mg/L is regarded as good quality drinking water based on taste • 500-1000mg/L is acceptable based on taste • >1000mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste
	Faecal coliforms	0 faecal coliforms per 100mL (0/100mL). If micro-organisms are detected in water, advice should be sought from the relevant health authority. See also the guidelines for Microbiological Quality in relation to Monitoring, Monitoring Frequency and Assessing Performance in the Australian Drinking Water Guidelines (NHMRC & ARMCANZ 2004).
	pH	6.5-8.5
	Chemical contaminants	See Guidelines for Inorganic Chemicals in the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 2004).

Operational phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the operational phase of the project:

- NSW DPI (2013) Policy and guidelines for fish habitat conservation and management
- NSW DPI (2012b) Guidelines for instream works on waterfront land
- RTA (2003c) Procedures for Selecting Treatment Strategies to Control Road Runoff, Roads and Traffic Authority of NSW: Sydney
- RTA (1999) RTA Code of Practice for Water Management, Roads and Traffic Authority of NSW: Sydney
- RTA (1997) RTA Water Policy, Roads and Traffic Authority of NSW, Sydney
- NSW EPA (1997) Managing Urban Stormwater: Council Handbook, NSW EPA: Sydney
- Austroads (2001) Road Runoff and Drainage: Environmental Impacts and Management Options, Austroads AP-R180
- Austroads (2003) Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure, Austroads AP-R232

- Austroads (2010) Guide to Road Design, Part 5: Drainage Design, Austroads: Sydney
- DECCW (2007) Managing Urban Stormwater, Environmental Targets Consultation Draft, Department of Environment, Climate Change and Water: Sydney
- Penrith City Council, Water Sensitive Urban Design Policy December 2013, updated in December 2017
- Fairfield City Council, Stormwater Management Policy, September 2017
- Liverpool City Council, Liverpool Development Control Plan 2008. General controls for all development, Updated in April 2019.

The guidelines on water quality design criteria for the operational phase of development projects were obtained from the NSW EPA Managing Urban Stormwater – Council Handbook (NSW EPA, 1997) and recommend pollutant load reductions.

Penrith, Fairfield and Liverpool City Councils have their own guidelines and policies on stormwater quality management and Water Sensitive Urban Design. Their requirements are for pollutant load reductions for total suspended solids and nutrients as shown in **Table 7-133**. These are per centage reductions requirements for the developed conditions.

Table 7-133 Councils pollutant load reductions requirements (as a per centage)

Indicator	Penrith City Council	Liverpool City Council	Fairfield City Council
Total Suspended Solids	85%	85%	80%
Total Phosphorus	60%	45%	55%
Total Nitrogen	45%	45%	40%

7.9.2 Assessment methodology

The methodology for the assessment of surface water quality and hydrology is outlined in the following sections and has included:

- A desktop review and analysis of existing surface water quality and hydrology information including available literature, relevant guidelines and procedures, water quality data, hydrological data and background information on catchment history and land used to characterise the existing conditions and determine potential receptors
- A site visit and water quality monitoring event to support and enhance the findings of the desktop analysis and refine the understanding of potential issues
- Assessment of the impact of construction and operation activities on water quality and hydrology with reference to the ANZECC Water Quality Guidelines with regard to the relevant environmental values
- Identification of appropriate measures to mitigate the potential impacts on water quality and hydrology resulting from construction and operation of the project.

Further detail on the methodology is provided in the following sections and in Chapter 3 of **Appendix M**.

Study area

The study area for the surface water quality and hydrology assessment focussed on the area directly affected by the project and any additional areas likely to be affected, directly or indirectly. The study area comprised the construction and operational footprint and a 500-metre buffer.

Identification of sensitive receiving environments

Sensitive receiving environments (SREs) are environments that have a high conservation or community value or support ecosystems/human uses of water that are particularly sensitive to pollution or degradation of water quality. SREs were identified within 500 metres of the M12 Motorway alignment based on the following considerations:

- Key fish habitat field assessment in accordance with (DPI, 2013)
- Waterway classification (Fairfull and Witheridge, 2003)
- Key fish habitat mapping (DPI, 2018)
- Threatened aquatic species under FM Act, TSC Act and EPBC Act
- Groundwater and surface water dependent vegetation and fauna communities listed under the BC Act and EPBC Act
- Proximity to a drinking water catchment
- Areas that contribute to aquaculture and commercial fishing.

In addition, areas mapped as Coastal Wetlands within the vicinity of the project under the State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP) are also considered within this assessment to be SREs due to their environmental significance and sensitivity. Under the Coastal Management SEPP, an activity cannot impact on the biophysical, hydrological and ecological integrity of the wetland and its catchment. While the SEPP does not apply to the project because of its declared status as State Significant Infrastructure, the sensitivity of areas mapped under the SEPP was taken into account in this assessment.

The strategy to minimise impacts on the water quality of the SRE's is discussed in **Section 5.13.2** and **Section 7.9.6**.

Site investigations

A site visit was carried out on 18 June 2018, 19 June 2018 and 11 March 2019 to conduct water quality monitoring and to visually assess the condition of waterways within the construction and operational footprint. An additional monitoring event was carried out on 11 March 2019 at four locations within the Hinchinbrook Creek and Doujon Lake catchment.

A total of 14 locations within the study area were visited as shown in **Figure 7-125**. It also shows a number of existing water quality monitoring locations where sampling was carried out by others (including by Liverpool Council, Sydney Water, Western Sydney Airport and the Georges River Keepers). This sampling data was also used to characterise the surface water quality of waterways within the study area.

Project monitoring sites were generally located where the project is proposed to cross the waterway, with the exception of the unnamed tributary of Badgerys Creek due to access issues. At this location, the site was visited slightly upstream of the proposed crossing.

During 2018, a number of extended dry periods resulted in insufficient water being present at several of the monitoring sites to collect water quality samples. Further water quality monitoring is currently ongoing and the results would be considered during the detailed design stage of the project.

Water quality sampling included in-situ monitoring and the collection of grab samples. In-situ water quality parameters included temperature, conductivity, salinity, pH and dissolved oxygen and turbidity. A single grab samples were collected at each site and sent to the laboratory for analysis. The laboratory analysis included as assessment of:

- Total suspended solids (TSS)
- TN
- TP.

Water quality sampling results are presented in **Appendix M**.

The site visit also included a geomorphological assessment which involved a visual assessment of all waterways traversed by the project and an assessment of the existing watercourse geomorphology.

Impact assessment

Water quality data, both existing and collected for this project, were used to provide a qualitative assessment of impacts from the construction phase of the project and from the operation of the project to waterways not considered sensitive. A quantitative assessment of operational impacts on SREs was carried out using modelled data. Additional monitoring is recommended before construction to confirm if the project would maintain or improve water quality.

Further details regarding the impact assessment are provided in the following sections.

Assessment of construction impacts

The assessment of potential impacts during construction involved:

- Identifying potential risks to surface water quality, hydrology and geomorphology from construction activities
- Identifying potential impacts on downstream waterways, SREs and the Western Sydney Regional Park
- Assessment of potential impacts to the relevant environmental values of aquatic ecosystems, visual amenity, primary and secondary contact recreation, homestead water supply and irrigation water supplies with consideration to the ANZECC Water Quality Guidelines
- Identification of water quality treatment measures to mitigate the impacts of construction in line with the Blue Book
- A geographic assessment of the construction phase catchment and the selected sediment basin locations was carried out to confirm sediment basin locations. The locations of the sediment basins were selected to provide for the maximum runoff captured from catchments throughout the construction process using gravity driven diversion drains to divert runoff to the sediment basins.

Assessment of operational impacts

The assessment of potential impacts during operation involved:

- Identifying potential risks to surface water quality, hydrology and geomorphology from the operation of the project
- Identifying potential impacts on downstream waterways, SREs and the Western Sydney Regional Park
- Assessment of the flow and velocities within creeks using information from the TUFLOW flood modelling carried out for the project (see **Appendix M**). This modelling focussed on the four main floodplain creeks and the proposed bridge over Luddenham Road and considered flood conditions under the existing (pre-development) and proposed conditions (post-development). Operational modelling accounted for creek adjustments, and other design elements related to cross drainage and longitudinal drainage. Operational impacts on hydrology for the remainder of the project with the exception of the abovementioned sites was assessed qualitatively.
- Operational impacts on hydrology for minor drainage lines (overland flow paths, intermittent creek channels) downstream of the project were assessed quantitatively using DRAINS software. Modelling of catchments of the minor drainage lines under the existing (pre-development) and proposed conditions (post-development) were implemented for 2, 10 and 100 year storm events. Where the flow rate increased by more than 10 per cent (being a threshold value giving a reasonable representation of the change in catchment hydrology that would have a noticeable impact) at the operational boundary, further analysis was applied to the catchment to determine the point downstream where the measured increase in flow rate dropped below 10 per cent.
- The assessment of minor drainage lines also assessed impacts where the changes in hydrology were shown to result in reduced flows to farm dams

- Assessment of the potential impacts of the quality and volume of proposed discharges from stormwater runoff by modelling using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC model). The MUSIC model was used to determine surface water pollutant loading from project surface roads, with a focus on three key indicators; TSS, TP and TN. Further information on MUSIC modelling and results is provided in **Appendix M**.
- Assessment of increased runoff volumes at each of the SREs by considering the increase in impervious surface within each of their catchments. Operational water quality impacts across the remainder of the project were assessed qualitatively.
- Identification of appropriate treatment measures to mitigate the impact of the operational phase.

While the hydrology of Ropes Creek was assessed, flooding impacts were not modelled at Ropes Creek as the design of the bridge at this location was developed to match the existing bridge. As part of the design process, the existing M7 Motorway bridges were investigated to understand their form and function, including their hydraulic and hydrologic performance. The existing bridges while spanning Ropes Creek, are not primarily waterway bridges. Their span width and vertical clearance are governed by road design requirements (clearance above Villiers Road and the adjacent property access road). Hence the bridge decks are above the 2000 year ARI flood level, and the total opening and flood conveyance beneath the bridges provides capacity in excess of the 100 year ARI flood immunity requirement. Further, the flooding conditions and hydraulics in this area are controlled by the Wallgrove Road embankment and the existing culvert crossing under Wallgrove Road. The proposed bridge widening would maintain the same span widths and therefore total opening for flood conveyance would be the same. Based on this investigation, flooding impacts at this location are not expected.

The assessment did not examine in detail the project’s potential impacts on farm dam yields. Precise impact on farm dam yields is dependent on the final road design including alignment, geometry and drainage design and would be further investigated at the detailed design phase.

This assessment also did not examine the project’s potential impacts on the existing detention basins that were built as part of original M7 Motorway works, due to the lack of survey data or as-built information in regard to these existing basins. The existing basins would be assessed as part of detailed design and potential adverse impacts would be addressed through design solutions.

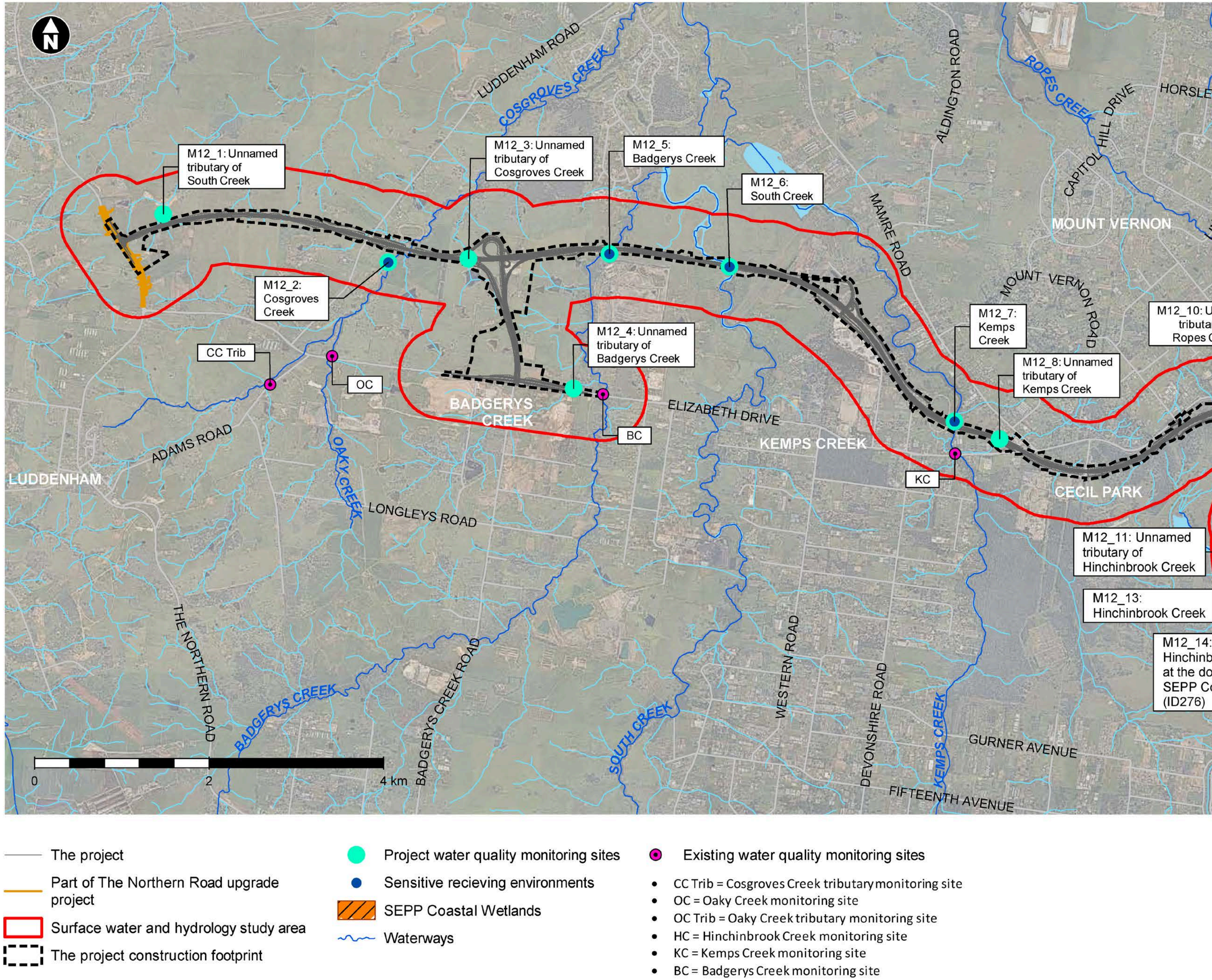

Figure 7-125 Water quality monitoring sites and sensitive receiving environments

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7.9.3Existing environment

This section includes a description of the existing environment and was informed by the desktop investigations and field inspections carried out for the project.

Rainfall and climate

Review of the Bureau of Meteorology (BOM) rainfall and temperature data for the Badgerys Creek observation station indicated that the average yearly rainfall for the general study area ranges from 22.6 millimetres in July to 98.5 millimetres in February, with an average annual rainfall of about 681 millimetres. Average maximum temperatures range from 17.5 degrees Celsius in July to 30.1 degrees Celsius in January, and average minimum temperatures range from 4.1 degrees Celsius in July to 17.1 degrees Celsius in January and February. This information was used to help inform sediment basin design.

Topography

The topography of the study area may be characterised into three general terrain types: Rolling Hills Terrain; Flat to Gently Undulating Terrain; and Creek Channels/Alluvial Floodplain Terrain, with slopes ranging from 0 to 20 degrees. Further information on the topography is provided in **Chapter 8.1**.

Catchment description

The project would be located primarily within the Hawkesbury-Nepean surface water catchment, with a small portion of the project located within the Georges River catchment.

The Hawkesbury-Nepean Catchment covers more than 22,000 square kilometres and is of national significance, being the longest coastal catchment in NSW flowing 470 kilometres from Goulburn to Broken Bay. The catchment provides drinking water, recreation opportunities, agricultural and fisheries produce, and tourism resources for the Sydney Metropolitan area.

The south eastern end of the project drains to Hinchinbrook Creek which is located in the Georges River catchment. The Georges River catchment covers an area of 960 square kilometres and is one of the most highly urbanised catchments in Australia (GRCCC, 2019).

The project lies within the South Creek subcatchment in the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. The South Creek subcatchment covers about 490 square kilometres and is one of the most degraded subcatchments of the Hawkesbury-Nepean. Catchment vegetation clearance and increasing urbanisation has dramatically altered the hydrological and sediment regimes.

The hydrology of the catchment was significantly altered due to increasing impervious surfaces which has in turn altered the geomorphology and ecology of the watercourses. Additional flow is also derived from a number of major Sewerage Treatment Plants which discharge into the catchment (HNCMA, 2007).

Key watercourses and geomorphology

The project intersects Cosgroves Creek, Badgerys Creek, Kemps Creek, South Creek, Ropes Creek and drains to Hinchinbrook Creek as shown in **Figure 7-125**. These creeks drain into South Creek which then flow north to join the Hawkesbury River at Windsor. There are also numerous farm dams in the area.

A description of the key watercourses and their geomorphological features at the point where the project intersects is provided in **Table 7-134**. All channels within the study area are situated in a broad valley on low relief floodplain.

Streams were classified using the Strahler stream classification system which denotes streams as either first, second, third or fourth order streams based on the number of streams flowing into them.

Existing surface water quality

This section discusses the existing surface water quality at the five main creeks where water quality data was available: Badgerys Creek, Cosgroves Creek, South Creek, Kemps Creek and Hinchinbrook Creek. Ropes Creek was dry at the time of monitoring and no other water quality data is currently available at this location. The existing water quality is discussed in relation to the ANZECC Water Quality Guidelines recommended trigger values for the protection of aquatic ecosystems for slightly to moderately disturbed ecosystems. The protection of this value provides the most conservative water quality criteria of all nominated environmental values (for indicators relevant to the proposed works). Therefore by meeting the protection of aquatic ecosystems, all other environmental values will be protected.

Cosgroves Creek

Water quality data for Cosgroves Creek downstream of a water quality basin near Adams Road was collected by Western Sydney Airport between November 2015 and September 2018.

The Cosgroves Creek tributary demonstrated poor water quality failing to meet relevant guidelines. Key indicators of concern were dissolved oxygen, nutrients and some metals. Dissolved oxygen concentrations were very low which can place stress on aquatic organisms. Nutrient concentrations, (ammonia, TN and TP) were elevated with concentrations exceeding recommended guidelines. Concentrations of total metals, chromium, copper and zinc were all greater than the recommended guidelines.

A single water quality sample was collected at Cosgroves Creek during project specific site inspections in June 2018. The creek itself was mostly dry and the sample was collected from a shallow residual pool. Algae was present along the edges of the waterbody and there was a slight film on the surface. Electrical conductivity, dissolved oxygen and TN all failed to comply on that sampling event. Electrical conductivity was elevated most likely due to groundwater intrusion and low flow.

Badgerys Creek

Water quality data for Badgerys Creek was collected downstream of a water quality basin bear Elizabeth Drive by Western Sydney Airport between November 2015 and September 2018. Overall the data revealed the water quality in Badgerys Creek to be poor and did not meet the relevant ANZECC Water Quality Guidelines for protection of slightly to moderately disturbed aquatic ecosystems.

Electrical conductivity was slightly above the trigger value and dissolved oxygen concentrations were very low suggesting that groundwater intrusions may contribute a large proportion of baseflow within the creek. Nutrient concentrations and chlorophyll-*a* concentrations were elevated which could suggest that the creek may suffer from algal blooms. Total metal concentrations for chromium, copper, cadmium and zinc were also above the recommended guidelines.

Badgerys Creek and a tributary of Badgerys Creek were both visited in June 2018. At the time of sampling the creek and tributary was dry and no water quality sample was available to be taken for the project.

South Creek

A single water quality sample was collected at South Creek during project specific site inspections in June 2018. The water level was low consisting of a series of large disconnected pools. Algae was present on the substrate at the creek edge and the water appearance was cloudy. Conductivity, dissolved oxygen and TN indicators exceeded the adopted guidelines. High conductivity levels are likely due to the prevailing dry weather conditions which may have resulted in groundwater intrusion.

Table 7-134 Summary of watercourse geomorphology

Watercourse	Watercourse description	Geomorphological description
Cosgroves Creek	Cosgroves Creek is an ephemeral fourth order stream (Strahler, 1952) with a series of disconnected pools and named and unnamed tributaries including Oaky Creek. Cosgroves Creek originates in Luddenham and flows for about 8.5 kilometres until it drains into South Creek. The catchment is largely rural with some residential estates. The hydrological subcatchment of Cosgroves Creek is about 2165 hectares, of which 15 per cent (325 hectares) is classified as impervious surfaces (GHD, 2016b).	Cosgroves Creek is a discontinuous channel with steep channel gradient, a depth of about two metres and an average channel width of about five metres. The substrate consists of silty clay. Significant undercutting occurs at meander bends, suggesting a high potential for erosion at this site.
Unnamed tributary of Cosgroves Creek		This tributary is a minor infilled drainage line between farm dams. The channel is shallow with no bank definition along most of its length. The channel was completely dry at the time of inspection. The substrate is sandy clay with no areas of active erosion and is unlikely to have received recent flows.
Badgerys Creek	Badgerys Creek is the largest tributary of South Creek in the study area. Badgerys Creek is a fourth order stream of about 16 kilometres in length, originating near Bringelly. Land use within the Badgerys Creek catchment consists of agricultural and rural residential. Ecologically sensitive riparian vegetation also exists within the catchment (GHD, 2016b) as do small areas of landfill and native forest. The hydrological sub-catchment of Badgerys Creek is about 2800 hectares of which 12 per cent (335 hectares) is classified as impervious surfaces (GHD, 2016b).	Badgerys Creek is an incised meandering channel with irregular bank morphology due to abundant riparian vegetation and woody debris. Significant undercutting occurs along the length of the channel. The channel has a steep gradient with a channel depth greater than three metres and average channel width of about five metres.
Unnamed tributary of Badgerys Creek		The tributary contains irregular bank morphology. Undercutting has occurred at meanders. The channel was completely dry at the time of inspection. The channel gradient is shallow transitioning to steep due to sediment accumulation. The substrate consists of silty clays.
South Creek	South Creek is a major fifth order tributary of the Hawkesbury-Nepean River. The South Creek catchment is a shale based catchment that encompasses most of the Cumberland Plain of western Sydney. South Creek is tidal in its lower reaches. South Creek drains a catchment of 414 square kilometres and is joined by 17 tributaries including Badgerys, Cosgroves, Kemps, Ropes and Eastern Creek. The South Creek Catchment is currently regarded as one of the most seriously degraded sub-catchments in the Sydney region, largely due to long-term clearing of vegetation and increased impervious areas due to urbanisation.	South Creek has a moderate gradient and a discontinuous channel which lies within a largely un-vegetated floodplain. Some bank undercutting occurs along the exposed right bank. The depth of the channel appears shallow and channel width is about seven metres.
Unnamed tributary of South Creek		This tributary consists of a single meandering channel which is modified and narrow, averaging one metre wide, with a shallow channel gradient. The substrate is a silty clay. Bank undercutting has occurred in sections of the channel. The channel was completely dry upon inspection.

<table>
<tr><th>Watercourse</th><th>Watercourse description</th><th>Geomorphological description</th></tr>
<tr><td>Kemps Creek</td><td rowspan="2">Kemps Creek is a tributary of South Creek and is a fourth order stream which flows into the Hawkesbury-Nepean River. The creek flows through a predominately semi-rural setting, although urbanisation has increased in recent years (Liverpool City Council (LCC), 2003).

Kemps Creek catchment is known to suffer from flooding and associated drainage problems (eg overtopping of creeks), due to limited hydraulic capacity in the creek channels, filling activities on the floodplain and inadequate hydraulic capacity at culverts and bridges (LCC, 2003). As a result of drainage problems there were considerable earthworks to control water including construction of dams to store water, construction of channels or banks to divert flow of water and enlarging the creek channel to reduce flood levels (LCC, 2003). Land use within the Kemps Creek sub-catchment largely includes agriculture, residential, commercial and extractive industry.</td><td>Kemps Creek has a moderate gradient and a discontinuous channel with irregular bank morphology. The creek is laterally unconfined and significant undercutting occurs at creek bends. The channel depth appears shallow with a silty clay substrate. The channel width averages about three metres.</td></tr>
<tr><td>Unnamed tributary of Kemps Creek</td><td>This tributary is a shallow gradient channel and was completely dry upon inspection. The channel width is about one metre and channel depth less than one metre. No undercutting or erosion is apparent due to vegetation overgrowth.</td></tr>
<tr><td>Ropes Creek</td><td rowspan="2">Ropes Creek is an ephemeral first order tributary of South Creek that originates in south-western Sydney near Fairfield and confluences with South Creek. Ropes Creek catchment was extensively cleared of vegetation, other than around the waterways, for agricultural activities to take place. The catchment has a long history of flooding (BMT WBM, 2013). The Ropes Creek catchment also contains two well defined open channel tributaries.

Ropes Creek is already traversed by several major roads including the M7 Motorway at Cecil Park, the M4 Western Motorway between Erskine Park and Colyton and the Great Western Highway and Main Western Railway Line east of Oxley Park.</td><td>Ropes Creek is a highly modified drainage line transitioning to a laterally confined low gradient channel. The channel was completely dry upon inspection with minimal bank definition. No undercutting is apparent due to vegetation overgrowth and shallow depth.</td></tr>
<tr><td>Unnamed tributary of Ropes Creek</td><td>This tributary is a minor drainage line, laterally unconfined with a shallow gradient. No apparent bank definition as there is no evidence of recent flows and the channel is overgrown with terrestrial vegetation.</td></tr>
</table>

Watercourse	Watercourse description	Geomorphological description
Hinchinbrook Creek	Hinchinbrook Creek would not be crossed by the project however the project would drain to this creek. At its closest point to the project, Hinchinbrook Creek is a fourth order stream. It drains to the sub-catchment of Cabramatta Creek which lies within the Georges River catchment. The health of Hinchinbrook Creek was measured using the ecological indicators of water quality, vegetation and macroinvertebrates by the Georges River Combined Councils Committee (GRCCC). The overall health rating (2014-15) for Hinchinbrook Creek was poor due to the poor condition or lack of riparian vegetation and the low diversity of macroinvertebrates which were dominated by pollutant tolerant animals. Water quality however was as good.	Hinchinbrook Creek is a highly modified drainage line consisting of a series of large disconnected pools. This section of the creek contains an artificial rock wall barrier downstream. The natural substrate consists of silty clays, with isolated sections of channel erosion and bank undercutting occurring at the channel meanders. The channel depth is greater than two metres.
Unnamed tributary of Hinchinbrook Creek		This tributary is a shallow gradient, meandering channel which was completely dry and densely vegetated. The channel was widest at the confluence with the Hinchinbrook Creek pool, reducing to less than one metre upstream. Isolated sections of undercut bank occurred on the channel meanders. The substrate consists of silty clays.

Kemps Creek

Water quality data for Kemps Creek was collected near Elizabeth Drive by Liverpool City Council between October 2017 and August 2018.

Over this time period the quality of the water in Kemps creek was poor when compared to the ANZECC Water Quality Guidelines for aquatic ecosystems. Dissolved oxygen concentrations were low and nutrients did not comply with the recommended guidelines, with some nutrients reaching up to thirty times greater than the recommended maximum levels.

A single water quality sample was collected at Kemps Creek during project specific site inspections in June 2018. Water levels were low at the time of inspection, but not stagnant. Dissolved oxygen levels were very low and nutrients were elevated exceeding relevant guidelines. TN concentrations were the highest recorded in the study area and were almost 18 times the recommended ANZECC Water Quality Guidelines. TP was also highest in Kemps Creek, 24 times the recommended ANZECC Water Quality Guidelines.

Ropes Creek

Ropes Creek was dry at the time that water quality monitoring was carried out for the project and currently is not monitored by Council or other stakeholders. Additional water quality monitoring would be carried out at this location as part of the water quality monitoring program for the project.

Hinchinbrook Creek

Hinchinbrook Creek was monitored downstream of the existing M7 Motorway by the Georges River Keeper for the past 10 years in autumn and spring. Water quality data from the past five years shows that the creek to have an average water quality with most of the indicators complying with relevant guidelines. However, similar to other waterways in the project area, dissolved oxygen levels were very low, failing to meet the guidelines. Ammonia, total nitrogen and total phosphorus concentrations were elevated and exceeded the ANZECC Water Quality Guidelines. Unlike other catchment streams, TN and oxidised nitrogen concentrations and total reactive phosphorus complied with relevant guideline limits.

Four sites were also visited in the Hinchinbrook Creek catchment as part of the water quality monitoring carried out for the project. These sites are shows as M12_12, M12_13 and M12_14, however only three had sufficient water for sampling. Hinchinbrook Creek site M12_13 was sampled within a large pool immediately downstream of the M7 Motorway. Additionally, a SEPP Coastal wetland on Hinchinbrook Creek (ID276) downstream of the alignment (M12_14) and Doujon Lake (M12_12) were monitored. Doujon Lake (M12_12) is immediately upstream of SEPP Coastal Wetland ID113 and ID114. The water quality of Hinchinbrook Creek itself was poor and generally did not comply with the ANZECC Water Quality Guidelines due to elevated pH and total nitrogen and phosphorus. Dissolved oxygen concentrations also failed to comply falling below the lower limit of 85 per cent saturation. The water quality of Doujon Lake and Hinchinbrook Creek at the wetland was also poor due to elevated nutrients, total suspended solids and low dissolved oxygen. Doujon Lake exhibited the poorest water quality with very high turbidity and total suspended solids and nutrient concentrations more than 35 times the recommended limit for protection of aquatic ecosystems. At the time sampling, the Lake was highly turbid which with thick films and scums present at the lakes edge.

Sensitive receiving environments

Waterways and other surface water features within the vicinity of the project were considered to be potential SREs and therefore were assessed against the SRE considerations outlined in **Section 7.9.2**.

This assessment is documented in **Appendix M** and the locations which were identified as SREs are mapped on **Figure 7-125** and include:

- Cosgroves Creek
- Badgerys Creek
- Kemps Creek
- Hinchinbrook Creek
- Unnamed tributary of Hinchinbrook Creek
- Doujon Lake
- SEPP Coastal Wetlands (ID113 and ID114)
- Hinchinbrook Creek at the downstream SEPP coastal wetland ID276
- SEPP Coastal Wetland ID117.

Soil landscapes

Based on a review of the 1:100,000 scale Soil Landscape Map for Penrith, the study area includes four soil landscapes; South Creek, Blacktown, Luddenham and Picton. High soil erodibility is listed as a limitation of all four soil landscape groups within the study area. A small area is also mapped as Disturbed Terrain.

Further information relating to geology and soil landscapes within the study area is discussed in **Section 8.1.3**. The location and extent of each soil landscape is provided in **Figure 8-3**.

Salinity

The Salinity Potential in Western Sydney 2002 Map (DLWC, 2002b) shows the soils along the project construction footprint generally have a moderate salinity potential with some areas of high salinity around Cosgroves Creek and Kemps Creek where there is potential for the ground to become waterlogged.

Further information relating to salinity within the study area is discussed in **Section 8.1.3**. A soil salinity risk map is provided in **Figure 8-6**.

Acid Sulfate Soils

The Australian Soil Resource Information System's (ASRIS, 2018) online ASS risk map indicates the project is mapped within an area considered to have an extremely low probability of ASS occurrence, indicating that there is no known or expected occurrence of ASS within the construction footprint.

Contamination

Historical and current potentially contaminating activities within the construction footprint include agricultural and rural land use, service stations, landfilling and waste recycling, quarries, potential areas of fill material and industrial land use.

Areas of potential contamination along the motorway alignment are discussed in **Section 8.1**.

7.9.4 Assessment of potential impacts

Construction impacts

During construction, the project has the potential to impact surface water quality and hydrology within the study area and affect environmental values of the downstream environment. Surface water quality impacts during construction are generally associated with:

- Water take to enable construction (eg dust suppression, earthworks)
- Impacts on geomorphology and hydrology of waterways
- Construction discharges, including
  - Construction de-watering of temporary sediment basins and farm dams
  - Construction surface water runoff.

With the application of standard mitigation measures and treatment of runoff, potential impacts on surface water quality, hydrology and geomorphology provided in **Section 7.9.6**, potential surface water quality and hydrology impacts are considered minor and manageable.

Surface water quality

A summary of the construction activities and potential impacts on surface water quality is presented in **Table 7-135** and identifies potential receiving waterways which may be impacted (see **Figure 7-125**).

Water balance

Water would be used for a range of purposes during construction including dust suppression, earthworks compaction, concrete batching for roads and bridges, wheel washing, machinery and for amenities (toilets, sinks, showers, drinking). This section provides a preliminary assessment of the water balance for the project. The water balance is limited to the construction phase of the project as there would be no ongoing water supply requirement during the operational phase. The water balance excludes consideration of groundwater as groundwater would not be used during construction of the project.

The water balance for each construction activities is summarised in **Table 7-136**. Overall about 676 megalitres of water is required for construction over the life of the project.

The project's core potable water demand (ie at the main ancillary facility and the outpost sties) is about 7.43 megalitres per year. Where possible, the remaining water demand would be sourced from the temporary sediment basins (about 82 in total) and/or farms dams within the construction footprint in order to minimise potable water use. However, sediment basins are not considered a secure water supply since they are typically required to be emptied within five days of a rain event. While not currently proposed, sediment basins could be enlarged to provide additional capacity to further avoid potable water use where possible.

Table 7-135 Potential construction impacts on surface water quality

Construction activity	Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Earthworks, cuttings, stockpiling	Erosion and exposure of sediments and contaminated soils from exposed areas, open cuts and stockpiles due to wind and stormwater runoff leading to sedimentation and contamination of downstream waterways	Sediment, nutrients, hydrocarbons, metal Contaminants and gross pollutants.	Increased sedimentation can alter the geomorphology of waterways and smother and reduce biological productivity of aquatic systems through reduced light penetration decreasing available plant material for fish to feed on. Increased sediments result in increased nutrients in waterways which can lead to algal blooms. This reduces the environmental value of water by limiting its potential uses.	All waterways within the study area have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Demolition	Dust, litter and other pollutants from building materials associated with demolition which can enter downstream waterways due to wind and stormwater runoff.	Sediments, gross pollutants.	Increased turbidity and rubbish reducing visual amenity of waterway.	• Ropes Creek • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Pollution – leakage or spills	Leakage or spills of petroleum, oils and other toxicants from construction machinery, plant equipment, refuelling and vehicles traveling to and from site. Spills and leakages could potentially be transported to downstream waterways.	Hydrocarbons, oil and grease, hydraulic fluids, high pH, zinc and other hazardous chemicals.	Oily films on surface water reducing the visual amenity. Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants	All waterways within the study area have the potential to be impacted. Waterways at high risk (within 50 metres of ancillary facilities) include: • Unnamed tributary of South Creek (and the South Creek downstream receiving environment), • Unnamed tributary of Kemps Creek (and the Kemps Creek downstream receiving environment).

Construction activity	Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Concreting	Concrete dust, concrete slurries or washout water discharged to downstream waterways or where the existing bridge crossing South Creek is proposed to be demolished.	High pH, chromium, solids.	Increased alkalinity and pH of downstream waterways which can be harmful to aquatic life. Water contaminated with chromium can accumulate in the gills of fish affecting the health of aquatic animals. Solids that are improperly disposed of can clog stormwater pipes and cause flooding.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Vegetation clearing and mulching	Soil and bank erosion and mobilisation of sediments to waterways via direct disturbance of waterway (due to installation of culverts, clearing of riparian vegetation etc) or via stormwater runoff and wind. Tannin leachate from clearing and mulching entering downstream waterways.	Sediment, nutrients, heavy metals (bound to sediments or resuspended in instream works), high Biological Oxygen Demand (BOD) and tannins.	Increased BOD resulting in decreased available dissolved oxygen which can impact on aquatic ecosystems and lead to fish kills. Tannins can also result in dark coloured water being discharged from construction sites into downstream waterways. This affects the visual amenity of the waterway, can alter the pH, reduce visibility and light penetration.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.
Cut and Fill	Sediment runoff from excavation and excess spoil storage to downstream waterways. Water pollution from dust generated from stockpiles or inappropriate storage, handling and disposal of spoils. Contaminants associated with previously land uses could be exposed and transported downstream	Sediment, hydrocarbons, metals, and nutrients.	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Increased metal and toxicant concentrations which can impact the health of aquatic organisms and result in fish kills. Reduced visual amenity.	Filling at: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek. Cuttings at: • Badgerys Creek • Kemps Creek.

Construction activity	Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Drainage and surface roadworks	Soil and bank erosion and mobilisation of sediments into receiving waterway during the direct disturbance of waterway bed and/or banks as a result of the construction of instream structures and associated earthworks.	Sediments, nutrients and heavy metals stored in bed sediments.	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Permanent in-stream structures and new culverts may change the characteristics of waterways by altering flow rates and flow paths, leading to scour and deposition of sediment. Disturbance and exposure of contaminated soils which could result in release of heavy metals and toxicants to surface water. Changes to geomorphology from installation of culverts and changes to flow.	All waterways within the project areas have the potential to be impacted.
Bridges	Elevated concentrations of sediments entering and polluting the waters from disturbance and erosion of bed and banks. Pollutants from construction machinery or concrete spills entering waterways.	Sediments and nutrients, high pH, fuels, chemicals, oils, grease and petroleum hydrocarbons.	Increased turbidity levels from suspension of solids smothering aquatic ecosystems and reducing visual amenity. Increased alkalinity and pH impacting aquatic organisms. Permanent in-stream structures could change the characteristics of these waterways due to changes in flow rates and flow paths leading to scour and deposition of sediments.	• Cosgroves Creek (BR02) • Badgerys Creek (BR05) • South Creek (BR06 and BR20) • Kemps Creek (BR08)
Adjustment of waterways	Bed and bank disturbance causing soil and streambank erosion which in turn can result in sediments being transported to downstream waterways	Sediments, nutrients, metals.	Elevated turbidity, nutrients and other contaminants and low dissolved oxygen levels could result in algal blooms and aquatic weed growth. Changes to geomorphology and flow velocities within waterways due to increased sedimentation and alteration to channel morphology. Decline in aquatic life, vegetation and ecosystem function downstream due to habitat removal and alteration/fill materials into existing waterways. If inappropriately designed or managed adjustment can increase flow velocity and scour potentially causing stream bed and bank stability issues.	• Badgerys Creek • South Creek • Kemps Creek.

Construction activity	Source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Temporary watercourse crossings	Increased sediments to downstream water courses due to scour and disturbance of creek banks. Spills from construction machinery and vehicles hauling material over crossings.	Sediment, nutrients, chemicals, heavy metal, oil and grease and petroleum hydrocarbon	Increased turbidity, lower dissolved oxygen levels and increased nutrient concentrations which could result in algal blooms and aquatic weed growth. Increased metal and toxicant concentrations which can impact the health of aquatic organisms and result in fish kills.	• Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Other unnamed/minor drainage lines.
De-watering	De-watering and infilling for farm dams. Discharges from sediment basins to downstream waterways.	Sediments, nutrients.	Increased suspended sediments resulting in high turbidity and poor water clarity impacting on visual amenity. Elevated nutrients and sediments can reduce dissolved oxygen resulting in proliferation of weeds and fish kills. De-watering activities during construction may mobilise sediments and contaminants and increase the turbidity of the receiving environments along the project, potentially having an impact on water quality.	All waterways within the project areas have the potential to be impacted. At greatest risk are the sensitive receiving environments of: • Cosgroves Creek • Badgerys Creek • South Creek • Kemps Creek • Hinchinbrook Creek.

Table 7-136 Project water balance

Construction activity	Total water demand (ML)	Annual average water demand (ML)
Dust suppression	270	90
Earthworks compaction	270	90
Concrete pavements	38	12.6
Potable water at main ancillary facility	10	2.86
Potable water at outpost sites (eight sites)	16	4.57
Concrete bridges	63	21
Wheel washing (nine sites)	9	3
Total	**676**	**224.03**

Where non-potable demand cannot be met through project opportunistic use of sediment basins or farm dams within the construction footprint, the demand would need to be supplemented with potable water either via the Sydney Water network or brought in by tanker in. Therefore, under a worst-case scenario the project may utilise about 224 megalitres of potable water annually for construction-phase activities.

It is anticipated that during construction, most of the water used for activities would either be absorbed by the construction activity or product (ie go into concrete or ground for compaction etc) or evaporate. Potential surface water runoff from construction activities would be minor and managed by local erosion and sediment controls. This is discussed further below and in **Section 7.9.6**.

Impacts on SEPP Coastal Wetlands

Costal Wetland ID117 is located in the north eastern portion of the construction footprint between the M7 Motorway and Elizabeth Drive. A temporary access track is required to be constructed within the 'proximity area' of this wetland during construction (for construction vehicles to access via Elizabeth Drive). As an informal access track already exists within the proximity area, construction of the formalised access track would utilise this pre-existing clearing, requiring minimal tree removal and earth works. The wetland is fed by four minor unnamed drainage lines of which the proposed access track crosses the uppermost extends of three. These ephemeral drainage lines are crossed at the ridgeline and receive minimal upstream catchment flows.

SEPP Coastal Wetlands ID113 and ID114 are located about 1.2 kilometres downstream of the construction footprint at the nearest point. Impacts on drainage lines which feed the wetlands is restricted to earth works and potential accidental spills within the uppermost extents of these drainage lines.

Coastal Wetland ID276 is located about 1.8 kilometres downstream of the construction footprint, at the nearest point, along Hinchinbrook Creek. Upstream, Hinchinbrook Creek consists of a series of disconnected pools, which would limit the potential water quality impacts on the Coastal Wetland by allowing any sediment laden water to settle out before discharging downstream to the wetland.

With the application of the water quality treatments that were incorporated into the design of the project and the management measures outlined in **Section 7.9.6**, potential impacts on surface water quality and hydrology within the Coastal Wetland during construction are negligible.

Construction discharges

Construction de-watering and general construction activities have the potential to affect the quantity and quality of surface water within the study area and affect downstream water quality.

There are two potential sources of water discharges during construction, including:

- Discharge of water from construction sediment basins
- De-watering of farm dams.

Key pollutants of concern during construction (as identified in the Blue Book) include:

- TSS
- pH
- Oil and grease.

The capture of the sediments via the construction sediment basins would also capture harmful nutrients and metals that are often bound to sediments. Therefore, the capture of surface water and sediments in sediment basins would reduce risks to downstream water quality.

Construction discharges from construction sediment basins and farm dams would comply with the discharge criteria (TSS 50mg/L, no visible oil or grease and pH 6.5-8.5).

Construction discharges would be controlled and would pose a low risk to the surface water quality and hydrology. Therefore, construction discharges are unlikely to impact on the nominated environmental values of aquatic ecosystems and visual amenity. The proposed locations of the temporary construction sediment basins are shown in Figure 6-2 of **Appendix M**. The water quality controls, including the locations, types and size of these basins are subject to confirmation during the detailed design phase of the project.

Erosion and sediment transportation

Highly erodible soils were identified within the study area. Construction activities such as vegetation removal and earthworks have the potential to impact on water quality and landforms as loose soil could be eroded during rainfall events by runoff. This can result in sediment transportation and the associated sedimentation of downstream drainage lines through mass movement of soils and change soil surface characteristics. Other construction activities that can directly or indirectly increase erosion and sedimentation include stockpiling, construction of new roads, construction of bridges, relocation of utilities and landscaping activities.

Hydrology and geomorphology

Project construction has the potential to impact on waterway form and geomorphic processes. Geomorphic and/or hydrological impacts could arise from:

- Temporary changes in flows and velocities in minor drainage lines and creeks across the project's construction footprint including within Kemps Creek, South Creek and Badgerys Creek downstream of the project while the creeks are adjusted. Adjustment works would be staged to ensure creek flows and velocities are not significantly changed and to avoid downstream erosion and bed and bank stability impacts
- Build-up of mobilised sediment in streams within the study area
- Increases in the volume and rate of runoff from impermeable surfaces created from the project which could cause erosion within the instream channel
- Impacts on geomorphology as a result of increased mobilised sediment or increased surface runoff (volume and/or velocity) could occur where activities are near watercourses; those watercourses where evidence of erosion and bank undercutting have a higher potential to be impacted, including Cosgroves and Badgerys Creeks
- Changes in localised flow paths along minor drainage lines during construction leading to increased scour and erosion potential. These changes also have the potential to modify/redirect flows to farm dams (eg either increase or decrease flows) and impact their embankments (eg increases in the frequency and rate of flow surcharging their spillways). Conversely, a reduction in flow associated with inter-catchment transfer of flow can also result in detrimental environmental effects. These impacts are discussed further in the operational impacts section and impacts from altered drainage would be further investigated during detailed design.

During construction, all runoff and localised flows within the construction footprint would be controlled by erosion and sediment control measures such as temporary sediment basins, temporary drainage and sediment fencing, to reduce the potential for scour and erosion.

Environmental water availability and flows

The construction of the project would cause soil compaction through the operation of construction machinery. This has the potential to change the distribution of flow as the compacted soils become less pervious and thereby could increase the quantity of water in the local catchment.

No water extraction directly from creek is proposed during construction of the project. Some water extraction from sediment basins and farm dams within the construction footprint would occur during construction. However, the total volume of water to be used is relatively low (see water balance above) and would have a minor impact on environmental water availability and flows.

Additionally, no construction machinery or structures would be place in waterways that would cease or block flow. Therefore, the project is unlikely to reduce the quantity of water in nearby waterways and drainage lines and would have no impact on environmental flows.

Performance against NSW WQO

There are a number of potential pollutants associated with the construction of the project including contaminated soils, fuels from machinery, tannins from cleared and mulched vegetation and sediment laden runoff. Each of these have the potential to impact on the water quality and subsequent environmental values of the downstream environment.

The proposed management measures including erosion and sediment controls are designed to minimise pollutant loading to downstream waterways during the construction of the project. Runoff from the construction phase of the project is designed to meet standards outlined in the Blue Book. These require that the treated runoff from the construction site through the sediment basins be less than 50 milligrams per litre for total suspended solids and have a pH of 6.5 to 8.5. Further water quality assessment would be undertaken during detailed design to establish site specific discharge criteria for sediment basins. Areas identified as potentially containing contaminated soils are addressed through mitigation measures provided in **Appendix O**. These mitigation measures will be implemented along with those provided in **Section 7.9.6**.

Due to limited water quality data, it cannot be confirmed if this discharge would be similar or better than existing water quality and may be higher than the required limit for the protection of environmental values under the relevant water quality objectives for the project (ie meeting the ANZECC Water Quality Guidelines). The key pollutants of concern from unsealed construction areas would be sediment, oil and grease and pH. Other pollutants (such as nutrients), however, may also be bound to the sediment or present in dissolved form.

It is expected that, with the implementation of the management measures (namely sediment basins), pollutant loading to the receiving waterways would be less when compared to pollutant loading from the wider respective catchments. The project pollutant loading is considered to pose a low risk to human health and the surface water environment. No further measures would need to be investigated, therefore, to further minimise water pollution and protect human health and the environment from harm.

Sediment basins would be designed to ensure that levels of TSS in the discharge would be less than 50 milligrams per litre and have a pH of 6.5 to 8.5. The ANZECC (2000) guidelines state that ranges for turbidity and TSS are similar. By limiting TSS to less than 50 milligrams per litre the project would generally meet the recommended trigger value for protection of aquatic ecosystems.

There is no data available currently on the expected toxicant levels with the project. It is, therefore, unknown at this stage if the water quality objectives will be met by the project. Whilst there is limited data to inform existing water quality, additional monitoring that is currently underway would be available during the detailed design phase and will assist in determining if water quality objectives will be met.

The results from the current monitoring program would be available during detailed design to further refine the water quality and hydrology controls for the construction of the project. This supplementary data, with particular consideration given to the potential for implementation of additional treatment measures, where reasonable and feasible, will be investigated to provide further improvements to water quality. These may further minimise water pollution and protect human health and the environment from harm.

The water quality objectives, as defined in Table 2-2 of **Appendix M,** are not currently being met and would not be met during the construction of the project. The construction of the project would, to the extent possible, aim to contribute to achieving the objectives during the operational phase, as far as practical, through implementation of controls discussed in **Section 7.9.6**.

Operational impacts

During the operational phase of the project all roads and bridges would be sealed, cleared areas would be landscaped and scour protection would be installed. There would be no exposed topsoil and therefore little or no risk of soil erosion and subsequent transport of sediment into nearby receiving waterways.

Water quality risks during the operation would instead be associated with runoff of pollutants from new road surfaces and increased vehicular traffic, accidental spills, increased impervious areas, changes to longitudinal drainage and introduction of and permanent structures within waterways. These potential impacts are discussed further in the following sections.

Surface water quality

The project includes a new dual carriageway located within a site that is predominately a greenfield area. As such, the project operation has the potential to impact on surface water quality, provided in **Table 7-137**. Receiving waters with the potential to be impacted by surface water quality are identified in **Figure 7-125**.

Table 7-137 Summary of potential operational impacts on surface water quality

Operational element / source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Stormwater runoff Untreated stormwater from impervious surfaces which are not conveyed to treatment systems.	Gross pollutants and litter, sediments, TSS, nutrients, BOD, heavy metals and hydrocarbons, oil and grease	Increased sediment loads and nutrients reduce light penetration through the water column or can smother aquatic flora and fauna. Decay of organic matter and some hydrocarbons can decrease dissolved oxygen levels resulting in fish kills, and can increase concentrations of heavy metals (including aluminium and iron) which are toxic to aquatic biota. Conversely, increased nutrients from sediments can result in excessive plant growth, resulting in algal blooms.	All waterways
Spill events Discharge of spill directly into waterways (should spill event happen on a bridge) or via runoff into the drainage system.	Oil and grease, fuel and various hazardous chemicals transported by vehicles.	Increased toxicant concentrations may be toxic to aquatic biota and fish. Oily surface films reduce the visual amenity of the waterway.	All waterways

Potential impacts on surface water quality would be reduced through the implementation of mitigation and management measures discussed in **Section 7.9.6**. An assessment of residual risk to surface water quality associated with operation of the project is provided in **Section 7.9.4**.

Stormwater quality

Project operation would lead to a change in catchment hydrology, with the most obvious effect being an increase in stormwater flow. Stormwater from impervious surfaces is typically of poorer quality than runoff from a greenfield catchment and may result in a progressive deterioration of the environmental values of downstream waterways. Additionally, stormwater runoff from roads contains pollutants that are not typically found in runoff from rural catchments (including litter/gross pollutants, rubber, suspended solids, nitrogen, phosphorus, oil and grease, hydrocarbons, petroleum, lead, zinc, iron, copper, cadmium, chromium, nickel, manganese, pesticides and herbicides).

The predicted water quality impacts during the operational phase of the project were modelled at the five main creeks which were identified as SREs: Badgerys; Cosgroves; South; Kemps and Hinchinbrook Creeks. The locations of these SREs are shown in **Figure 7-125**. The results of the water quality modelling are summarised in **Table 7-138** and assume the implementation of the proposed operational water quality basins and swales as shown in Figure 6-3 of **Appendix M**. The modelling for Hinchinbrook Creek reflects the impacts at the downstream SEPP Coastal Wetlands ID113, ID114 and ID276. SEPP Coastal Wetland ID117 would not receive road runoff from the project during operation and therefore no water quality impacts are expected/reported in this table.

Pollutant loads for all indicators (TSS, TP and TN) reduced during operation compared to the existing (pre-development) conditions, with the greatest per centage reduction in loads for TSS and TP. Therefore, overall the water quality improves within these catchments during project operation, provided the water quality controls are implemented (**Section 7.9.6**).

Spills

During project operation, there is potential for accidental spillage of hazardous materials. Spills of oils, lubricants, hydraulic fluids and chemicals can potentially occur due to vehicle or plant and equipment leakages or vehicle crashes. Without satisfactory means of containment, the spillage of contaminants could pass rapidly into the drainage system and impact downstream ecosystems. Spills of chemicals or petrol in accidents can impact the ecology of waterways and terrestrial ecosystems.

Based on the design as set out in this document, the proposed 12 operational water quality basins were designed to contain a 20,000 litre spill however the location and design of these basins is subject to change during detailed design. The final design would provide sufficient opportunity for any spill event to be contained near the project within the drainage system or immediate surrounds. For the proposed swales, it may not be possible to contain such a large spill volume and there is the potential for the spill to runoff to downstream waterways. In these instances the spill would be managed in accordance with standard operational emergency spill response procedures.

The risk associated with accidental spills within the project are considered comparable to those of similar roads, including others surrounding the study area. With the implementation of management measures in **Section 7.9.6**, this risk is considered manageable.

Performance against NSW WQO

The operational water quality modelling undertaken as part of this assessment indicates that the existing (ie pre-development) water quality in Cosgroves, Badgerys, South and Kemps Creeks does not meet the ANZECC Water Quality Guidelines.

With the implementation of erosion and sediment controls and water quality controls as part of this project (**Section 7.9.6**), the pollutant loading to these creeks would be reduced compared to existing conditions. Therefore, the project is unlikely to have a material impact on the ambient water quality of sensitive receiving waterways.

The water quality objectives are currently being met for all environmental values, with the exception of aquatic ecosystems (see **Table 7-139**). During operation, the project would, to the extent possible, continue to protect the receiving waters where the water quality objectives are currently being met. Where the objectives are not being met, the project would contribute to achieving the objectives over time, as far as practical, through implementation of controls discussed in **Section 7.9.6**.

The operation of the project would result in an improvement in overall water quality at the SREs with a reduction in total suspended solids and nutrient loads to downstream waterways. Whilst an improvement on existing water quality is anticipated, water quality remains unlikely to meet the ANZECC water quality guidelines in the short term. The operation of the project is not expected to impact on achieving the environmental values of primary and secondary contact recreation, as the key indicators of concern relevant are pathogens, algae and toxicants.

Table 7-138 Operational water quality impacts – Pollutant loads from water quality basins at the SREs

Location and catchment area*+		Indicator			Comment
		TSS (kg/year)	Total nitrogen (kg/year)	Total phosphorus (kg/year)	
Badgerys Creek (13.27 ha)	Pre-development	1570	33.3	4.44	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1250	32.8	3.56	
Cosgroves Creek (5.23 ha)	Pre-development	639	12.9	1.81	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	439	12	1.24	
Kemps Creek (13.55 ha)	Pre-development	1573	34.4	4.38	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1470	32.7	3.96	
South Creek (15.45 ha)	Pre-development	1970	37.6	5.35	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	1680	36.2	4.23	
Hinchinbrook Creek (26.95 ha)	Pre-development	29,600	220	52.5	Overall improvement in water quality and achieves water quality objectives to maintain or improve water quality
	Post-development	3450	49	7.26	
Notes:	*The water quality results presented for the Hinchinbrook Creek catchment are relevant to the downstream SREs including SEPP Coastal Wetlands ID113, ID114 and ID276. +As discussed above, SEPP Coastal Wetland ID117 would not receive road runoff from the project during operation and therefore no water quality impacts are expected/reported in this table.				

Table 7-139 Project performance against environmental values

Environmental value	Project performance against values
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term	None of the indicator values are currently being mat at any of the crossings. The total phosphorus and total nitrogen would be met with project controls, however, only at Hinchinbrook Creek.
	Note that toxicants have not been modelled. Toxicants are represented indirectly by TSS, however TSS is not a parameter on the NSW WQ objectives and is normally correlated to Turbidity. The results of the TSS would provide an indication of the toxicants. The desirable range of 6 to 50 NTU recommended by ANZECC (2000) for protection of aquatic ecosystems has been representative by an indicative only range of 20 to 75 milligrams per litre for TSS. TSS guideline levels would not be met but they would be reduced by the project.
Visual amenity – aesthetic qualities of waters	Visual amenity values are currently being met at all water crossings and would continue to be met with the project.
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Secondary contact recreation values are currently being met at all water crossings and would continue to be met with the project.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Primary contact recreation values are currently being met at all water crossings and would continue to be met with the project.
Irrigation water supply – protecting the quality of waters applied to crops and pastures	Irrigation water supply values are currently being met at all water crossings and would continue to be met with the project.
Homestead water supply – protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Homestead water supply values are currently being met at all water crossings and would continue to be met with the project.

The operation of the project would not result in an increase in bacteriological indicators. In addition, the project is not likely to result in increased algae as there would be a reduction in sediment laden runoff and thereby a reduction in nutrients. This reduction in sediment laden runoff will also reduce the level of toxicants entering downstream waterways which could have posed a risk to human health. The operation of the project, therefore, would not pose a significant risk to human health and the environment.

The results from the current monitoring program would be available during detailed design to further refine the water quality and hydrology controls for the project. This supplementary data together with additional MUSIC modelling, with particular consideration given to the potential for implementation of additional treatment measures, where reasonable and feasible, will be investigated to provide further improvements to water quality. These may further minimise water pollution and protect human health and the environment from harm.

The operational water quality modelling carried out as part of this assessment indicates that the existing (ie pre-development) water quality in Cosgroves, Badgerys, South and Kemps Creeks does not meet the ANZECC Water Quality Guidelines. With the implementation of erosion and sediment controls and water quality controls as part of this project (**Section 5.13.2**), the pollutant loading to these creeks would be reduced compared to existing conditions. Therefore, the project is unlikely to have a material impact on the ambient water quality of sensitive receiving waterways.

The operation of the project would result in an improvement in overall water quality at the SREs with a reduction in TSS and nutrient loads to downstream waterways. Whilst an improvement on existing water quality is anticipated, water quality remains unlikely to meet the ANZECC Water Quality Guidelines in the short term.

The results from the current monitoring program would be available during detailed design to further refine the water quality and hydrology controls for the project. This supplementary data together with additional MUSIC modelling, with particular consideration given to the potential for implementation of additional treatment measures, where reasonable and feasible, will be investigated to provide further improvements to water quality.

Surface water balance

The project would not extract water from local waterways during operation. Therefore, no impact is anticipated on waterways within the study area due to water take.

Hydrology and geomorphology

The potential impacts on hydrology during operation of the project relate to the increase in impervious surface from introduction of a road into an otherwise mostly greenfield area, a change in surface flow paths within minor drainage lines across the project and from creek adjustments.

The project’s design was developed to avoid diversion of drainage lines and catchments as far as practicable, to minimise hydrological impacts. Overall there is unlikely to be a significant change in hydrology and flow distribution across the broader catchment. However, there is the potential for localised changes in flow from one subcatchment to the next. All major and minor waterways and drainage lines would be impacted to some extent by the increase in impervious area of the M12 Motorway, leading to increased stormwater runoff, increase velocities and peak flows, and therefore increased potential for flooding or scour of creeks.

With the project, the overall increase in impervious surface area as a proportion of the total area of each major creek catchment would be minor, and this minor increase in catchment imperviousness would translate to negligible impact on the natural hydrological attributes including peak flow volumes and duration. Peak flow velocities were modelled for the four main creeks (Cosgroves, Badgerys, South and Kemps Creeks), with and without the project, to identify and assess potential impacts on hydrology from creek adjustments and other design elements relating to cross drainage and longitudinal drainage, and potential implications for flooding downstream. For the reasons discussed in **Section 7.9.2**, while the hydrology of Ropes Creek was assessed, flooding impacts were not modelled at Ropes Creek as the design of the bridge at this location was developed to match the existing bridges whose primary function is not as waterway bridges.

Modelling has also been carried out for the minor drainage lines with and without the project, to identify potential localised changes in flow from one subcatchment to the next, and potential downstream changes that could impact on the morphology of drainage lines or on existing infrastructure such as farm dams.

Potential flood impacts from the project are discussed in **Section 7.8.4**. The project would achieve a high level of flood immunity, with the levels of the main carriageways designed to be above the 100 Year ARI flood levels.

Figure 7-126 to **Figure 7-129** shows the comparison of peak velocities at Badgerys Creek, Cosgroves Creek, South Creek and Kemps Creek (ie the bridges near the identified SREs) with and without the M12 Motorway. Flood modelling results indicate that there would be some very small and localised areas of velocity increase above 20 per cent where velocities are above 1.0 metre per second with the project in operation, but these would be localised at the proposed bridges and generally contained within the project's operational footprint. Suitable scour protection measures would be provided where required to protect the geomorphology and water quality of the receiving waterway. The change in volumes and velocities are unlikely to impact on aquatic connectivity and habitat as discussed in **Section 7.1**.

The impacts on peak flow velocities outside the project's operational footprint are considered negligible because the increases in velocity would be minor, and the magnitude of the peak flood velocities with the project in operation would be less than 1.5 metres per second for all but one of the minor drainage lines assessed (see minor drainage line assessment below), which is considered within the scour or erosion threshold of bare ground.

Management of scour at bridges was accounted for in the design through setting the width of the bridges and embankments to avoid scour where possible, and the design of minor and localised creek adjustments where required (see section below on creek adjustments). Scour protection measures would be further considered during detailed design.

For the remainder of the project, scour protection measures would be provided in all areas susceptible to increased velocity and scour potential. These areas include outlets of cross drainage culverts and longitudinal drainage systems. The design of scour protection measures would be investigated further in detailed design and would be designed to minimise potential erosion and scour impacts.

Creek adjustments

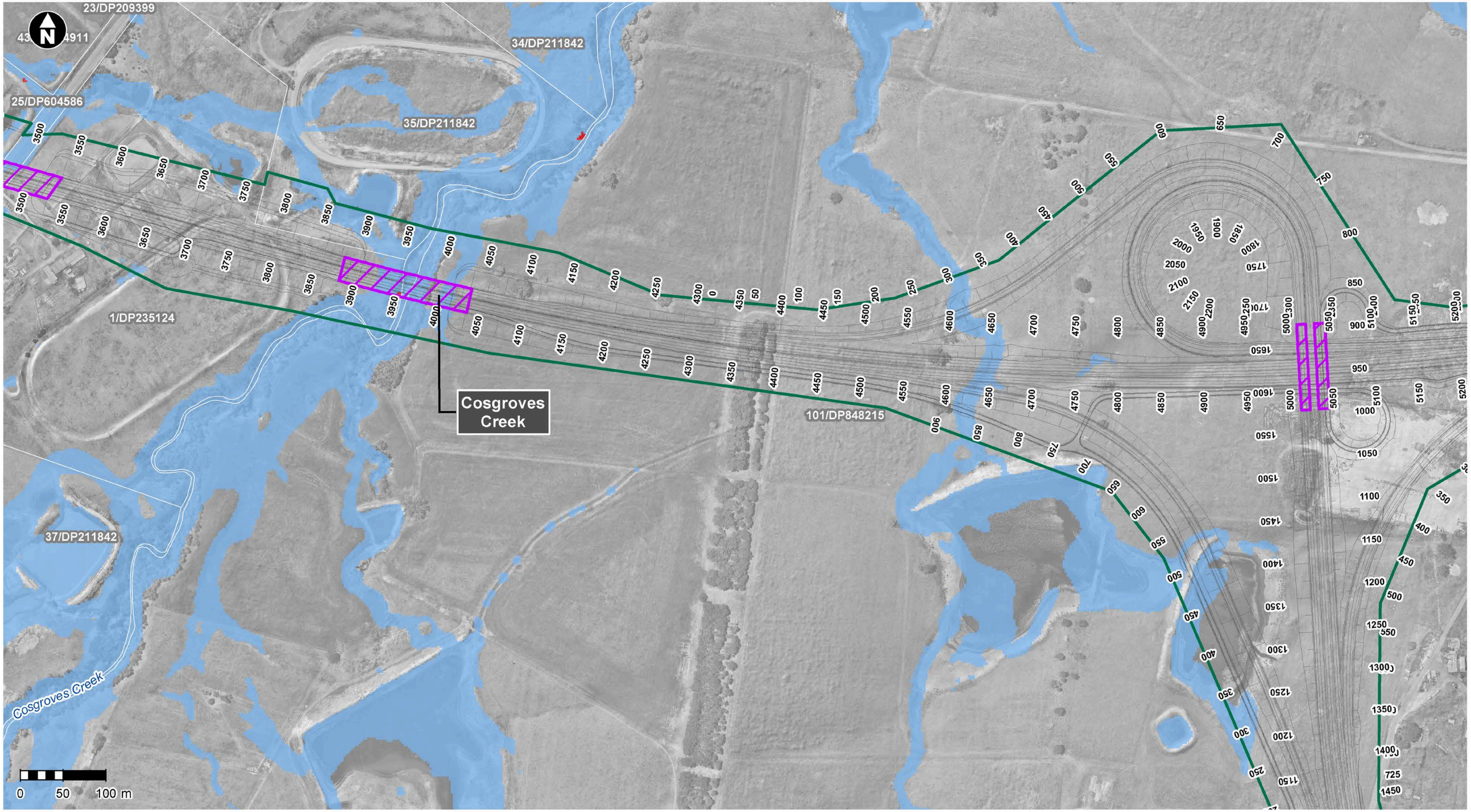
Badgerys Creek, South Creek and Kemps Creek would be permanently adjusted over a distance of 61 metres, 200 metres and 86 metres respectively. The adjustments are required within the creek to ensure that bridge piers are not located within the waterway, to avoid encroachment of the structure into the environmental flows, to minimise bridge lengths, reduce risk of erosion around bridge piers, provide suitable flood conveyance, to minimise creek disturbance during construction, and to minimise shading of the creeks. The adjustments were designed for the shortest lengths practicable.

The proposed creek adjustments would have a similar capacity to the existing creek channels and would be designed as far as practicable to mimic natural flow conditions. The creek corridors would be revegetated with native riparian vegetation suitable for the local area, in accordance with the requirements of the Policy and guidelines for fish habitat conservation and management (DPI, 2013) and Guidelines for instream works on waterfront land (DPI, 2012a). The creek channels would be rehabilitated following active construction works in accordance with the landscape plans for the project.

The extent and design of any creek adjustments would be refined during detailed design taking into account potential environmental benefits from minimising adjustments to the creeks' natural alignment and form. Any refinement of creek adjustments would take place in conjunction with detailed design of the bridges, with a particular focus on the placement of bridge piers to achieve an acceptable balance between the functionality of the bridges and the potential hydraulic, hydrological and ecological impacts of any creek adjustments.

Culverts

Changes in flow and velocity are sensitive to culvert design in terms of their location, capacity, roughness, and gradient, though the area of influence remains localised at the inlet and outlet of the culverts. The culverts would be located on existing flow paths, and designed so as to not restrict the free flow of water. The design methodology adopted has minimised changes to peak flows and velocity as much as practical, and wherever localised changes would still occur, scour protection would be provided to prevent erosion.



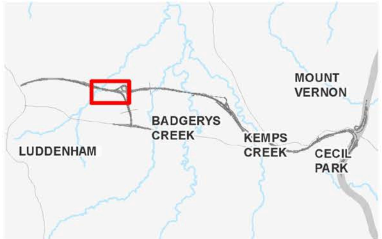
Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

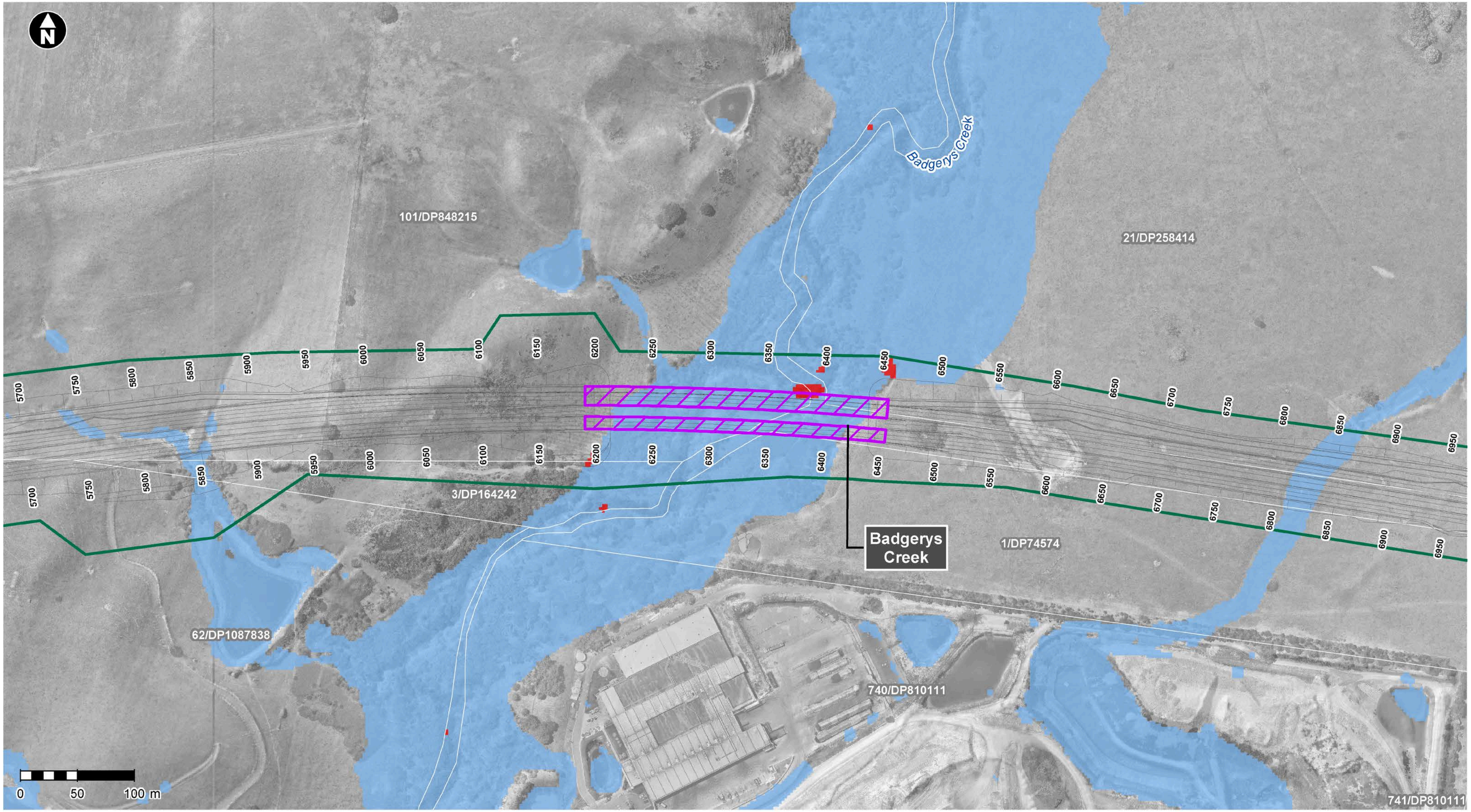


1:6,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

Figure 7-126 100 year ARI velocity impact at Cosgroves Creek

Date: 8/07/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_VelocityImpact\JAJV_FLD_All_100pc_F001_100yrARIFloodVDiff_DDP_A4L_v1.mxd
Created by : EM | QA by : RB



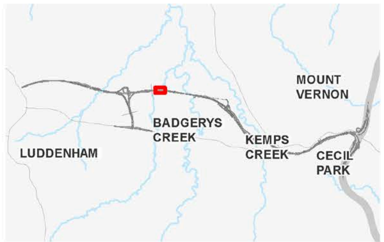
Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*



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Coordinate System: GDA 1994 MGA Zone 56

Figure 7-127 100 year ARI velocity impact at Badgerys Creek

Date: 8/07/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_VelocityImpact\JAJV_FLD_All_100pc_F001_100yrARIFloodVDiff_DDP_A4L_v1.mxd
Created by : EM | QA by : RB

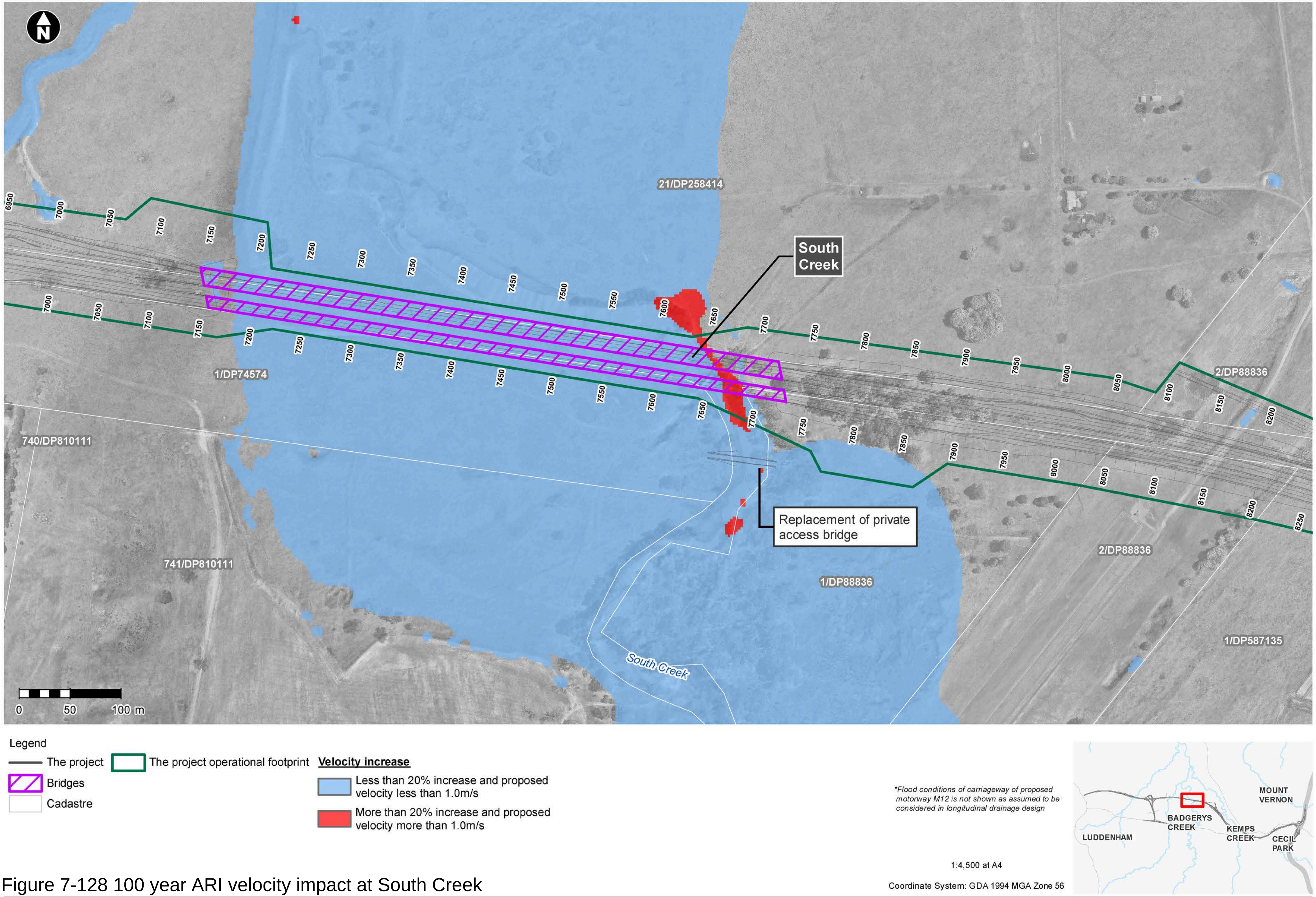
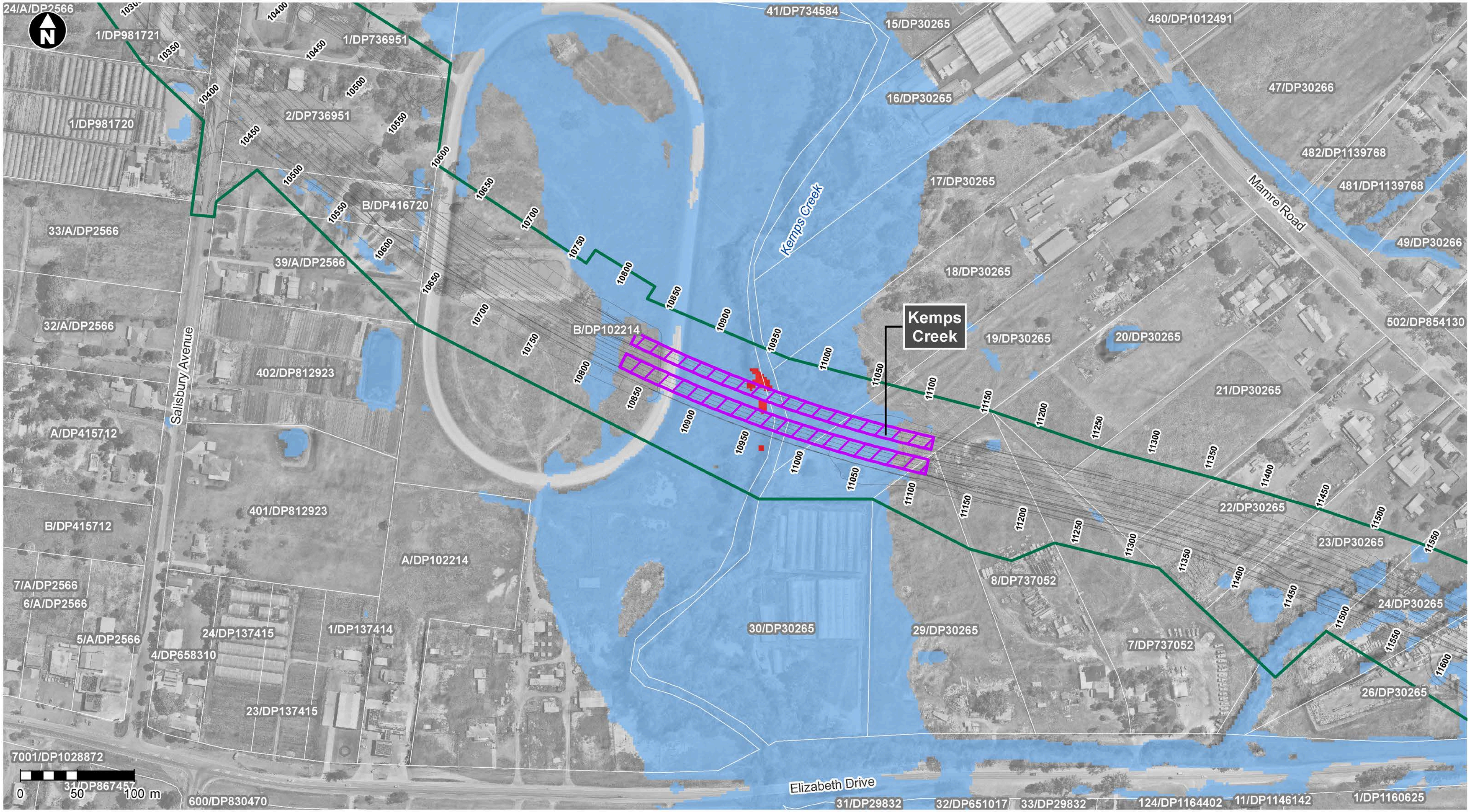


Figure 7-128 100 year ARI velocity impact at South Creek

Date: 8/07/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_VelocityImpact\JAJV_FLD_All_100pc_F001_100yrARIFloodVDiff_DDP_A4L_v1.mxd
Created by : EM | QA by : RB



Legend

- The project
- The project operational footprint
- Bridges
- Cadastre

Velocity increase

- Less than 20% increase and proposed velocity less than 1.0m/s
- More than 20% increase and proposed velocity more than 1.0m/s

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

Figure 7-129 100 year ARI velocity impact at Kemps Creek

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Created by : EM | QA by : RB

Culverts were designed with as low gradient as practical and sized so that headwater levels are no higher than existing. Even so, outlet velocities would be higher than existing. Scour protection would be provided at all culvert outlets, and in some cases an energy dissipation device would be required, or catch drains (open channels) to contain flow velocities and prevent scour.

Further detail about the project's potential hydrological impact on minor drainage lines downstream of proposed culvert outlets is provided below.

Minor drainage lines

The M12 Motorway project's alignment, longitudinal drainage and culvert designs may result in changes to the catchment characteristics and the catchment boundaries of minor natural drainage lines. These channels typically receive flows from upstream rural catchments and convey the flow through downstream properties to major creeks.

Increased imperviousness of a catchment would lead to increased stormwater runoff. An increase (or decrease) in the catchment area could also occur, which would also increase (or decrease) the peak flow rates and volume of runoff to the channels. An increase in flows could result in additional water supply and more frequent overtopping of some farm dams, and potentially increase the risk of flooding, scour and erosion. Conversely, a decrease in flow due to changed flow paths could result in a reduced water supply to some farm dams.

A detailed analysis was carried out of all minor drainage lines intersected by the project to understand the impacts the project would have on the hydrology and flooding behaviour downstream of the project corridor.

The analysis focused on changes in volume and peak flow rate for the 2 year, 10 year and 100 year ARI storm events at each minor drainage line, and involved:

- Identification of minor drainage lines and their catchments, and estimation of the per centage increase in impervious area in the catchment as a result of the project
- Identification of 'points of interest', at the project's operational boundary and the downstream location that defines the limit of impact, being where any measured increase in volume and peak flow rate is less than 10 per cent above the existing.

The detailed analysis for all of the minor drainage lines and their catchments is shown in **Appendix M.** Where the initial modelling results showed a change (increase or decrease) in peak flow rate or volume of more than 10 per cent at the project's operational boundary, further analysis was applied to determine the downstream impact, and the point downstream where the measured change in flow rate dropped below 10 per cent. This impact was assessed and the results included in Annexure 1 of **Appendix M**, and all of the assessed drainage lines are illustrated in **Figure 7-130**.

The analysis summarised in **Table 7-140** shows that increases in peak flow rate and volume of stormwater runoff are likely to impact on minor drainage lines and downstream farm dams at a number of locations. Without implementation of any mitigation measures, some farm dams would be at increased risk of overtopping after the more intense storm events. In addition, some drainage lines would receive increased concentration of flows with prolonged duration of higher peak flow rate and volume. For example, Kemps Creek drainage line DL9701 is shown in the table as potentially experiencing an increase in peak flow of up to about 150 per cent over existing (at the project's operational boundary), depending on the intensity of the storm event. This increase is mostly attributable to the large increase in the catchment area and the impervious component of the catchment that would result from the project's design as set out in this document, which would lead to increased concentration of flows at this drainage line.

Where the project would cause changes to runoff to minor drainage lines in steeper terrain, there is potential for increased peak flow velocities and increased risk of erosion. At drainage line DL14810, which flows east from the project into the Cecil Hills residential area south of Elizabeth Drive, peak flow velocity in the 100 year ARI storm event would exceed 1.5 metres per second, which is considered to be the threshold velocity for scour and erosion.

During more frequent (2 year ARI) rain events however, peak flow velocity in this drainage line would be less than 1.5 metres per second. Subject to further modelling during detailed design to verify and confirm the impact, and to better understand the capacity of the receiving drainage line, mitigation of the scour and erosion risk at this location would potentially include stormwater detention and scour protection measures (see **Table 7-140**).

Where there are more highly developed urban land uses situated in or close to minor drainage lines downstream of the project, such as near Elizabeth Drive between Mamre Road and the M7 Motorway, the project may result in increased flows at some locations with the potential to impact on downstream land use. In particular, **Table 7-140** and **Figure 7-130** show drainage lines flowing across Elizabeth Drive between Duff Road and Cecil Road (Ropes Creek catchment, drainage lines DL13910, DL14040, DL14190 and DL13890) where the modelled increases in peak flow rate and volume are potentially large. Similarly, there is one drainage line flowing south from the project's footprint into Kemps Creek (DL12300, south of the Kemps Creek Sporting and Bowling Club), where the modelled increase in peak flow rate and volume of stormwater runoff is also potentially large. At these locations, because of the nature of nearby and downstream land use, consideration of stormwater detention basins may be warranted, subject to further analysis during detailed design.

As discussed in **Table 7-140**, with the implementation of recommended management measures, the impacts of increased peak flow rates and volume on land and infrastructure downstream would be minimal. Further, the analysis showed that for each minor drainage line, the impacts diminish with distance downstream until the channel either joins with one of the major creeks, or the impact of project on peak flow becomes minimal.

Any management measures to be applied outside the project's operational boundary would be subject to further investigation and modelling of flows during detailed design. The measures would also be subject to negotiation and agreement with individual affected property owners.

Impacts on SEPP Coastal Wetlands

Potential water quality and hydrology impacts on SEPP Coastal wetlands 113, 114 and 276 associated with the operation of the M12 Motorway are expected to be negligible with the implementation of the proposed water quality controls included in the design of the project where it drains to Hinchinbrook Creek.

The construction access track adjacent to SEPP Coastal Wetland 117 would remain in place during the operational phase of the project. Very limited traffic is expected to access the track and impacts on water quality and quantity would be negligible.

Water quality modelling results

MUSIC water quality modelling was undertaken to determine volumes of the permanent water quality controls that comply with the project design targets. The pollutants modelled were Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP). In order to compare against environmental values and their concentration targets and desirable long term concentrations from catchment discharges, the model upstream was run to obtain outputs expressed in mean and 90^{th} percentile concentrations for the following:

- The catchment upstream of the project
- The project road pavement resultant treated concentrations immediately downstream of the proposed permanent water quality controls
- The combined resultant and upstream catchment, ie downstream of the project.

This was done for all the major crossings (water bodies defined as SREs that the project would pass over) and for each minor crossings, which are those that have not been identified as SREs, to obtain concentrations similar to the above scenario. Twenty-nine minor crossings have been included in the modelling and consist of unnamed creeks within the study area. Details on the modelling are presented in **Appendix M**.

Table 7-140 Summary impacts and suggested mitigations at minor drainage lines

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Cosgroves Creek	CC DL 1010	Private	+12 to +58	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increased flows to the farm dam (about 9%) would adversely impact on the performance of the existing spillway and its scour protection. • There would be increased outflow from the farm dam which is likely to cause increased depth of flow across the property access road to the dam. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner. • If updated modelling carried out during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located a short distance to the north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Cosgroves Creek	CC DL 1110	Private	-9 to -10	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measures are proposed at this location.	There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line confluences with the drainage line CC DL1010 a short distance downstream of the project operational footprint.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Cosgroves Creek (Luddenham Road)	CC DL BR01	Local Council	+3 to +4	• Increase in the peak flow rate is considered to be minor. However, this minor increase could adversely impact on the flood immunity of Luddenham Road. • The culverts would overtop Luddenham Road more frequently due to the increase in the peak flow rate.	During detailed design Roads and Maritime would carry out further modelling to confirm the impact, and the design of appropriate mitigation measures, which could include detention basin(s) and culvert upgrade(s)	• There would be minor increase in the peak flow rate to the culverts on Luddenham Road and the property access road.
South Creek	SC DL 1780	Private	+0 to +3%	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow	No mitigation measures are proposed at this location.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project corridor before the drainage line confluences with the drainage line SC DL2100 a short distance downstream of the project operational footprint.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
South Creek	SC DL 2100	Private	+8 to +13	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate would not cause scour of the downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located on the downstream drainage line north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
South Creek	SC DL 2200	Private	-10 to -12	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow	No mitigation measures are proposed at this location.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line SC DL2100 a short distance downstream of the project operational footprint.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Cosgroves Creek	CC DL 4600	Private	+3 to +28	• The flow to the tributary of Cosgroves Creek would increase by up to 1% in the 100-year ARI event. • The existing farm dam located about 300 metres from the project (operational) boundary, would be subjected to increased flow. This may have adverse impact on the performance of the spillway and its scour protection. • Increase in the peak flow rate would not cause scour of the downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located a short distance to the north of the project operational footprint. • The affected dam is likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
South Creek	SC DL 2500	Private	+21 to +34	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate would not cause scour of the downstream drainage line	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located on the downstream drainage line north of the project operational footprint. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • No other existing development or local infrastructures would be affected by the increased flow in the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
South Creek	SC DL 2780	Private	-11	Runoff to the farm dam at this location would be reduced by about 12%.	• Further modelling would be carried out during detailed design to verify the project impacts on flows to this receiving drainage line. • All potential management measures would be considered in consultation with the affected property owner	• There would be a reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
South Creek	SC DL 3380	Private	-4	Runoff to the farm dam at this location would be reduced by about 4%.	No mitigation measures are proposed on the receiving drainage line.	• There would be a minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.
Cosgroves Creek	CC DL 4900	Private	+5 to +20	• Increased flow may impact adversely on the performance of the spillway to the farm dam at this location. • The dam footprint would be partly impacted by the motorway road/drainage works.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop more frequently due to the increase in the volume of runoff.
Cosgroves Creek	CC DL 5050	Private	-22 to -26	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow	No mitigation measures are proposed on the receiving drainage line.	• There would be a minor reduction in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line CC DL 4600 a short distance downstream of the project operational footprint.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Badgerys Creek	BC DL 5150	Private	+12 to +61	• Afflux of 20 millimetres at the project (operational) boundary • Overall there would be increased flow to the farm dams at this location. This is likely to impact adversely on the performance of the dams and their spillways • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway and the drainage across the private access road to the dam • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap. All potential management measures would be considered in consultation with the affected property owner. • If updated modelling carried out during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located short distances to the west of the project operational footprint. • The affected dams are likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • There would be minor increase in the peak flow rate to Badgerys Creek, but this is not likely to cause any adverse impacts on the mainstream flooding. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Badgerys Creek	BC DL 5160	Private	-2 to +1	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor change in the rate and volume of the flow in the receiving drainage line downstream of the project operational footprint before the drainage line joins with the drainage line BC DL 5150 a short distance downstream of the project operational footprint.
Badgerys Creek	BC DL 5300	Private	-10	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	• Further modelling would be carried out during detailed design to verify the project impacts on flows to this receiving drainage line. • All potential management measures would be considered in consultation with the affected property owner	• There would be a minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff.
Badgerys Creek	BC DL 5870	Private	-3 to +3	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a very minor reduction in the rate and volume of runoff into the farm dam. • The affected dam is likely to fill and overtop less frequently due to the reduction in the volume of runoff. • There would be very minor change in the peak flow rate and volume of runoff to the receiving downstream drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
South Creek	SC DL 6820	Private	-2 to -3	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line downstream of the project operational footprint.
Kemps Creek	KC DL 8700	Private	-27 to -32	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Kemps Creek	KC DL 8930	Private	+2 to +7	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor increase in the rate and volume of runoff into receiving drainage line.
Kemps Creek	KC DL 9140	Private	-25 to -50	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Kemps Creek	KC DL 9701	Private	+90 to +156	• Afflux of 160 millimetres at the downstream project (operational) boundary. • Increased flow to Kemps Creek from this drainage line which could impact adversely on the mainstream flooding. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line. • Based on the available lidar data, the scour assessment did not identify any significant increase in flow velocities although the peak flow rates would double in the 100-year ARI event and almost triple in the 2-year ARI event.	• Further modelling would be carried out during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining. • . • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a substantial increase in the peak flow rate and volume of runoff to the receiving drainage line downstream of the project operational footprint. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Kemps Creek	KC DL 10510	Private	-2	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is proposed at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Kemps Creek	KC DL 12030	Private	+17 to +85	• Afflux of 20 millimetres at the downstream project (operational) boundary. • There would be increased flow to Kemps Creek from the motorway works. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining. • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a substantial increase in the rate and volume of runoff into the receiving drainage line if no detention basin is provided as a mitigation measure. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Kemps Creek	KC DL 12300	Private	+19 to +47	• Afflux of 30 millimetres at the downstream project (operational) boundary adjacent to quarry access road. • There would be increased flow to Kemps Creek from the motorway works. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining. • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a substantial increase in the rate and volume of runoff into receiving drainage line if no detention basin is provided as a mitigation measure. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Kemps Creek	KC DL 13180	Private	+52 to +113	• Afflux of 50 millimetres at the downstream project (operational) boundary • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the affected dam spillway • Adjustments would be required to the dam spillway that could include armouring using dumped rock rip rap • Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flows in the culvert across the property access road. Subject to modelled verification and confirmation of impacts, a detention basin and culvert upgrade may be required • All potential management measures would be considered in consultation with the affected property owner • If updated modelling carried out during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins	• There would be a minor increase in the rate and volume of runoff discharging to the existing dams that are located a short distance to the south of the project operational footprint. • The affected dam are likely to fill and overtop more frequently due to the increase in the peak flow rate and volume of runoff. • There would be a minor increase in the peak flow rate and volume of runoff to the receiving downstream drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.
Kemps Creek	KC DL 13080	Private	-31 to -35	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Ropes Creek	RC DL 13500	Private	-67 to -70	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.
Ropes Creek	RC DL 13790	Private	-2 to +11	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line before the drainage line confluences with drainage line RC DL 13910,
Ropes Creek	RC DL 13910	Private	+9 to +20	• Afflux of 10 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate does not cause scour of the downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts on the existing culverts.	• There would not be any increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Ropes Creek	RC sDL 14040	Private	+4 to +5	• Reduction in flood immunity to the existing culvert beneath Elizabeth Drive.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts on the existing culverts.	• There would not be any increase in the rate and volume of runoff into receiving drainage line downstream of Elizabeth Drive. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC DL 14190	Private	+14 to +16	• Afflux of 20 millimetres at the downstream project (operational) boundary. • Increase in the peak flow rate does not cause scour of the downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow in the existing culverts across Elizabeth Drive. Provision of a detention basin and scour protection within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts on the existing culverts.	• There would not be any increase in the rate and volume of runoff into receiving drainage line downstream of Elizabeth Drive. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC DL 13570	Private	-2 to -3	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff in the drainage line before it joins with drainage line RC DL 13700 at the inlet of the existing culvert beneath Elizabeth Drive.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Ropes Creek	RC DL 13700	Private	-7 to -8	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff in the drainage line before it confluences with drainage line RC DL 13890 at the farm dam on the northern side of Elizabeth Drive.
Ropes Creek	RC DL 13890	Private	+62 to +160	• Potential for impact on the capacity of the existing culvert beneath Elizabeth Drive causing flooding. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flow over the spillway of the affected dam and capacity of the existing culvert beneath Cecil Road • Subject to modelling and verification of project impacts, adjustments may be made to the spillway of the dam that could include armouring using dumped rock rip rap. • All potential management measures would be considered in consultation with the affected property owner.	• There would be a minor increase in the rate and volume of runoff discharging to the existing dam that is located in the private property a short distance north of Elizabeth Drive. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

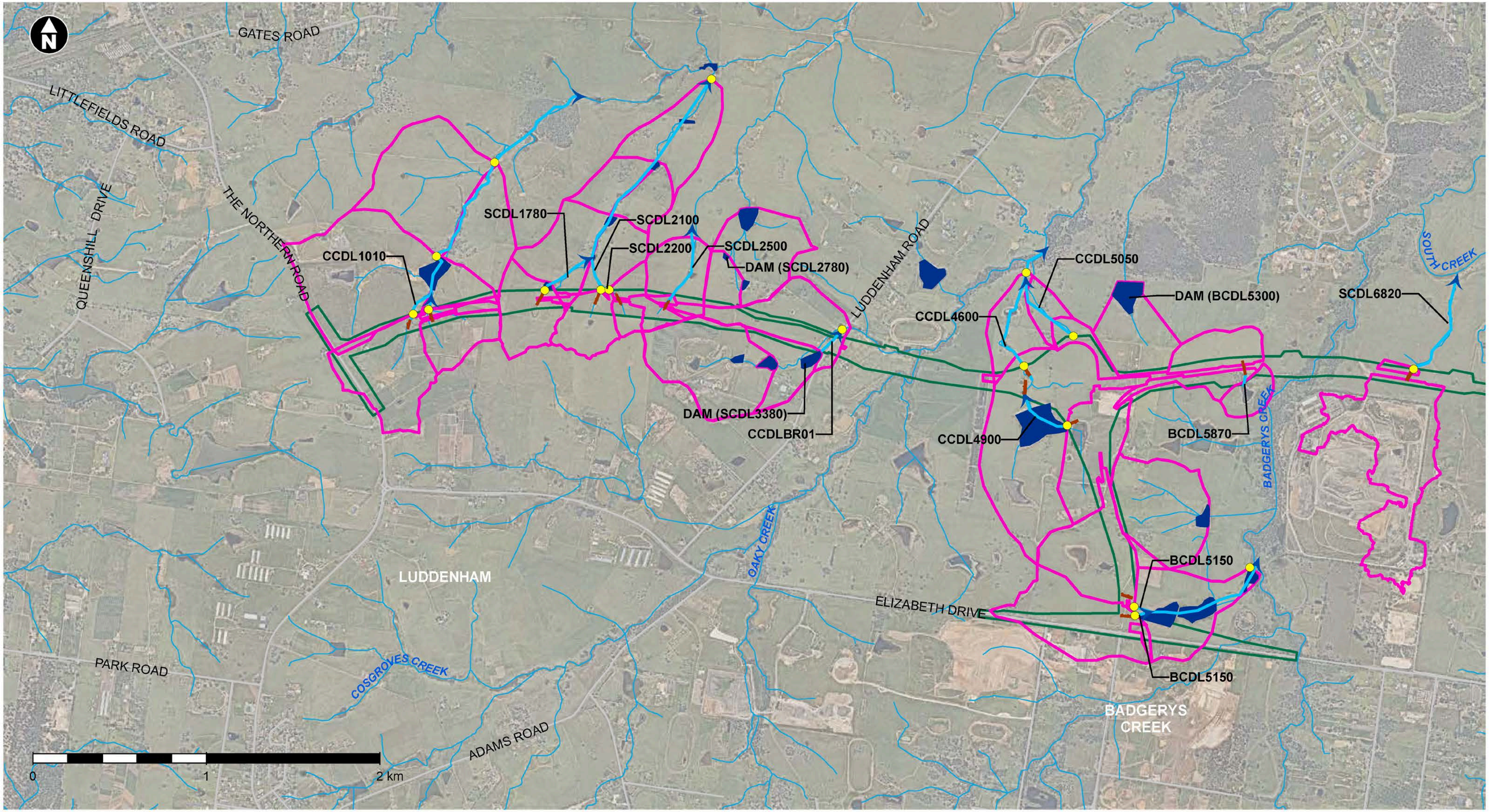
Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
					• Modelling during detailed design would also verify the project impact on the existing culverts across Elizabeth Drive. Provision of a detention basin within the project operational footprint, as part of an integrated approach with future widening of Elizabeth Drive, could be considered to minimise the potential adverse impacts on the existing culverts. • If updated modelling carried out during detailed design finds there is potential for scour in the downstream drainage line appropriate mitigation measures would be implemented such as rip rap lining or detention basins.	
Ropes Creek	RC DL 14000	Private	-50 to -67	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Ropes Creek	RC DL 14220	Private	-4 to +25	• The increase in the 2 to 10 year ARI flow may impact adversely on the existing culverts beneath Wallgrove Road/Elizabeth Drive intersection. This may cause flooding at the intersection for these storm events.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flows in the culverts beneath the Wallgrove Road/Elizabeth Drive intersection • Subject to modelling and verification of the project impacts, mitigation could include provision of a detention basin within the project operational footprint to minimise the potential adverse impacts on the existing culverts. • The modelling would also be used to demonstrate that the proposed mitigation measures will be effective based on the design as modelled.	• There would be a minor increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC DL 14640	Private	-20 to 0	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into the receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Unknown catchment	UC DL 14810	Private	+33 to +75	• Afflux 40 millimetres at the project (operational) boundary. • Velocity of flow in the downstream drainage line would increase. • The 10-year ARI flow would increase by 44%, which would impact adversely on the downstream pipe drainage system through the existing development. • Overland flow through the Jaquetta Close in the existing housing development would increase which could cause road overland flooding. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the existing pipe drainage in Jaquetta Close. • Further modelling would be carried out in respect of the capacity of existing pipe drainage in Jaquetta Close, to verify impacts on this infrastructure and confirm mitigation measures. • Subject to outcomes of modelling, provision of a detention basin and scour protection (such as rip rap lining) within the project operational footprint could be considered to minimise the potential adverse impacts on receiving drainage lines and existing drainage.	• There would not be an increase in the rate and volume of runoff into receiving drainage line. • Scour potential may increase in the receiving drainage line if appropriate mitigation measures are not implemented.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Hinchinbrook Creek	HB DL 15350	Private	-19 to +23	• No increase in peak flow rates for storm events from 10-year ARI to 100-year ARI. • Peak flow rate would increase in the 2-year ARI storm event, increasing risk of scour potential in the downstream receiving drainage line.	• Further modelling would be carried out during detailed design to verify the project impacts on the characteristics of flows in this receiving drainage line. • Subject to modelling outcomes and verification of project impacts, mitigation could include provision of scour protection and a detention basin within the project operational footprint.	• There would be a minor increase in the rate and volume of runoff into receiving drainage line in the frequent rain events. However, there would be a significant reduction in the rate and volume of runoff into the receiving drainage line in the major storms. • The assessment found that the project would not increase the scour potential in the receiving drainage line.
Ropes Creek	RC DL 15450	Private	+11 to +53	• Afflux 10 millimetres on the existing watercourse in the private property at the project (operational) boundary. • The increase in the peak flow rate attributable to the project has the potential to increase the scour potential in the receiving downstream drainage line.	• Further modelling would be carried out during detailed design to confirm the impact on flows to this drainage line and the appropriate mitigation measures which could include a detention basin and scour protection such as rip rap lining. • Modelling at detailed design would be used to confirm that proposed mitigation measures are effective and feasible • All potential management measures would be considered in consultation with the affected property owner	• There would be a minor increase in the rate and volume of runoff into receiving drainage line. • The assessment found that the project would not increase the scour potential in the receiving drainage line.

Catchment	Drainage Line	Land Ownership	Approximate Change in Peak Flow at Project Boundary (%)	Potential impacts	Proposed mitigation measures	Residual impacts
Hinchinbrook Creek	HB DL 15520	Private	-8 to -18	The project would not have an adverse impact on the receiving drainage line due to the minor change in flow.	No mitigation measure is required at this location.	• There would be a minor reduction in the rate and volume of runoff into receiving drainage line before it confluences with drainage line HB DL 15350 a short distance downstream of the project operational footprint. • The assessment found that the project would not increase the scour potential in the receiving drainage line.



Waterways

Main roads

The project operational footprint

Points of interest

Minor drainage lines that have been assessed

Direction of flow

Farm Dams that have been assessed

Cross drainage culverts

Minor drainage channel catchments - with project

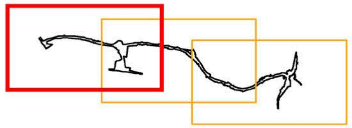


Figure 7-130 Minor drainage lines and farm dams

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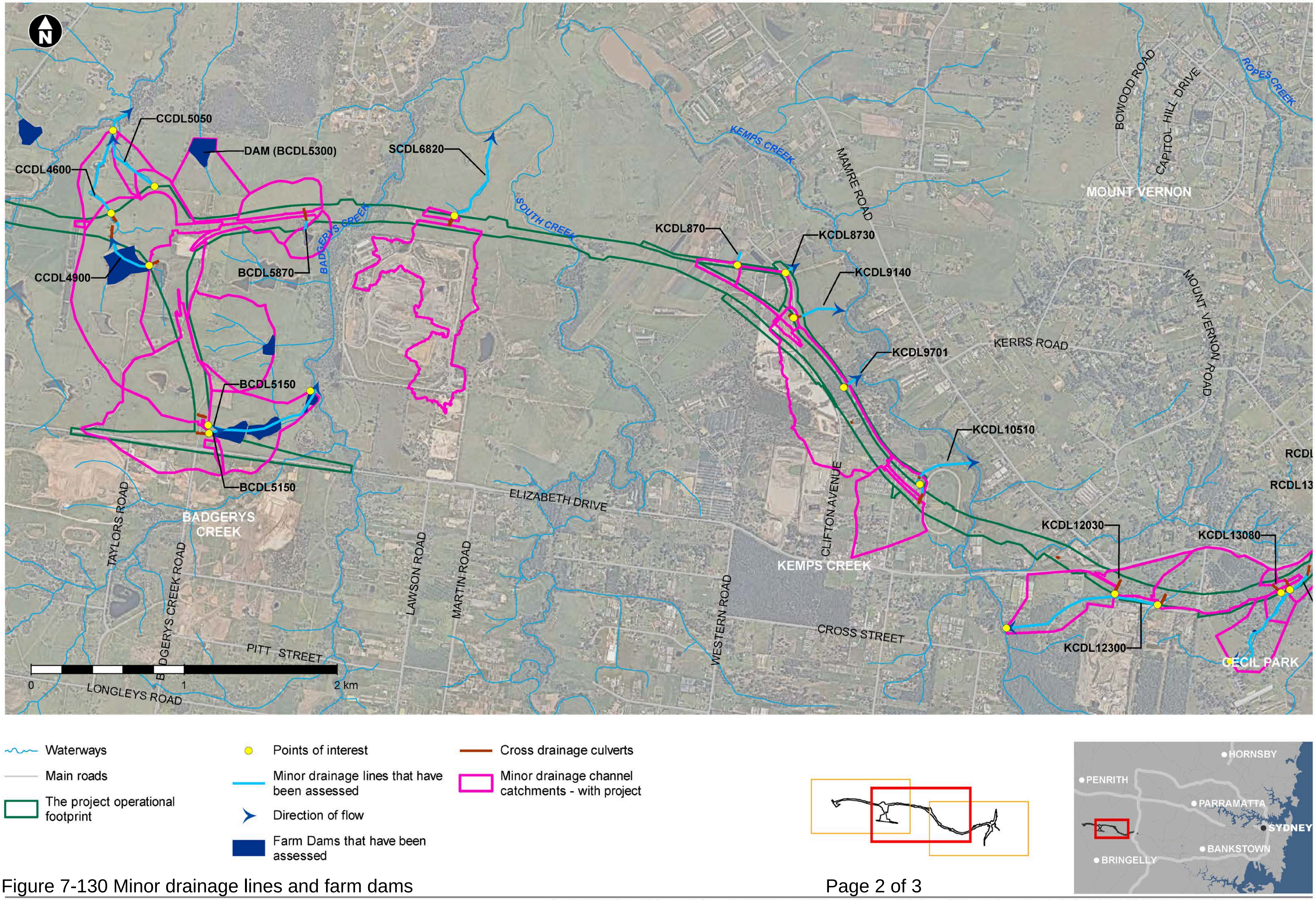

Figure 7-130 Minor drainage lines and farm dams

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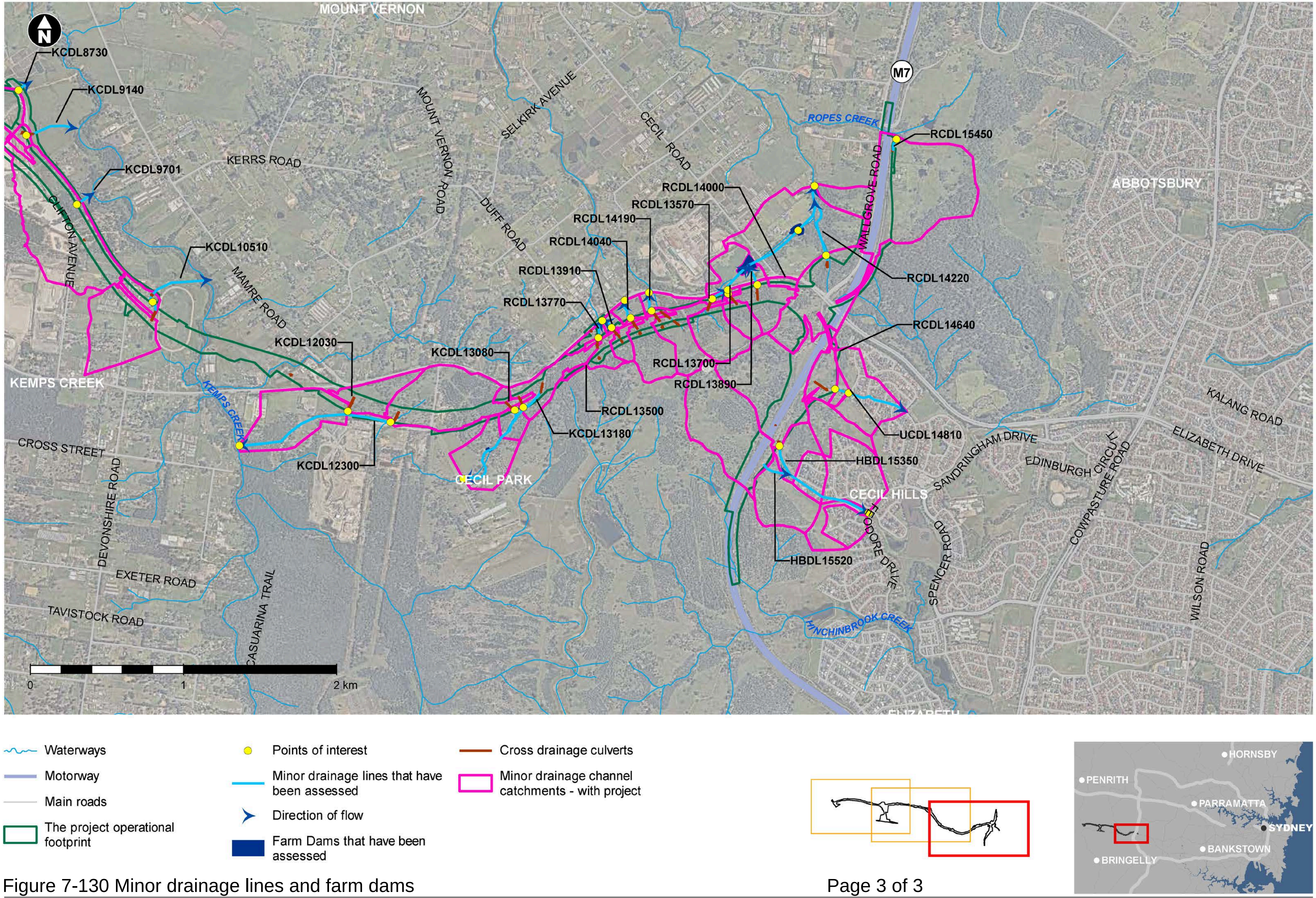

Figure 7-130 Minor drainage lines and farm dams

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Overall the results show that there is a noticeable reduction in nutrients and TSS for the major crossings, all classified as SREs, for runoff treated by proposed project water quality controls. The concentrations downstream of the project would be very slightly improved due to the mixing with the improved treated water quality from the project that will result in dilution. While; this improvement is not significant, it works towards meeting the nominated environmental values.

The results of the modelling indicate that the design targets would be met upstream of all the major crossings. This would be achieved as a result of the proposed project swales and basins that would reduce the annual average pollutant loads of TSS by more than 80 per cent.

Overall, the water quality from the project at minor crossings that are located upstream of non-sensitive aquatic environments continues to exceed the recommended guideline limit for protection of aquatic ecosystems, however, concentrations for TN and TP are somewhat reduced. As such, impacts on water quality from the project would not be desirable but would be unlikely to have a major impact on the environment.

it is believed that any surface runoff from these minor crossing travelling through non-sensitive areas would receive natural assimilation and improvements in water quality before reaching any downstream sensitive waterways with an identified environmental value. Therefore, the overall results of the combined major and minor crossings is considered to be an acceptable outcome for the protection of the nominated environmental values for downstream waterways.

7.9.5 Cumulative impacts

Cumulative surface water quality and hydrology impacts may arise from the interaction of construction and operation activities of the project and other approved or proposed projects in the area. When considered in isolation, specific project impacts may be considered minor. These minor impacts may be more substantial, however, when the impact of multiple projects on the same receivers is considered.

Numerous projects in varying stages of delivery and planning are currently underway near the M12 Motorway corridor. The cumulative flooding impacts associated with these projects are considered in **Table 7-141**, overleaf, and outlined in further detail in **Appendix M**. Additional details of each of the projects considered is provided in **Table 7-3**.

These projects are relevant to the consideration of cumulative flooding impacts both temporally and spatially as they would be in the same surface water catchment and construction and/or operation may have overlapping timeframes, as discussed further below.

7.9.6 Environmental management measures

Construction surface water quality monitoring program

A surface water monitoring program will be implemented during construction as an environmental management measure to observe any changes in surface water quality that may be attributable to the project and inform appropriate management responses.

The monitoring program will include collection of baseline data for comparison to construction and operational monitoring data to understand, and respond to, any impacts from the project.

The frequency, locations and indicators to be sampled would be confirmed during detailed design.

Table 7-141 Cumulative surface water quality and hydrology impacts

Project and status	Cumulative impacts
Western Sydney Airport Approved. Under construction	Construction and operation of the Western Sydney Airport would overlap with construction and operation of the project. The Western Sydney Airport EIS surface water quality assessment and surface water hydrology and geomorphology assessment (GHD, 2016b) concluded that while there are potential water quality impacts from construction airport, with the implementation of a SWMP and CEMP, construction is unlikely to have a significant impact on downstream water quality and potential impacts are likely to be localised and short term. During operation of the airport water quality is expected to improve compared to existing conditions for total phosphorus, total nitrogen and suspended solids. There would be an increase in impervious surfaces and therefore increased pollutants (suspended and dissolved solids, nutrients, gross pollutants, heavy metals and total petroleum hydrocarbons) and litter entering downstream waterways. While runoff would increase, the proposed detention basin strategy would be effective at limiting the downstream impacts, and therefore risks to changes in creek geomorphology would be low. Erosion and sedimentation is expected during construction of the M12 Motorway, with sediment basins located to best capture runoff before it enters the waterway. The location and size of basins would be further refined during the detailed design to ensure minimal impact on water quality. While increased runoff is expected to occur during operation of the project the associated pollutants transported in runoff are expected to decrease with the implementation of appropriate water quality controls outlined herein. Therefore, it is expected that there would be minor cumulative water quality and hydrological impacts associated with the construction and operation of the project and the Western Sydney Airport.
Sydney Metro Greater West Not yet approved	The Sydney Metro Greater West and the M12 Motorway would have overlapping construction and operational timeframes. During timeframes where construction activities are concurrent, increased water quality and hydrological impacts are likely. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for the Sydney Metro Greater West. The Sydney Metro Greater West would need to incorporate water sensitive urban design measures to meet water quality objectives. Additionally, as planning provisions require that future development cannot result in significant hydrological changes, it is expected that cumulative impacts on surface water quality and hydrology would be minor.
The Northern Road upgrade Approved. Construction has begun	Construction activities associated with Stages 5 and 6 of The Northern Road upgrade may overlap with the project construction and the roads would be operational at the same time. As the construction periods for the project and The Northern Road upgrade would overlap, there is the potential for increased likelihood of erosion and sedimentation from the project if the sites from the Northern Road upgrade have not completely stabilised. Potential to impact on water quality and hydrology from operation would be due to increased runoff (carrying pollutants), accidental leaks or spills of chemicals and fuels, and increased stormwater runoff from the change in land use to impervious areas. Implementation of standard stormwater practices and adherence to industry standards to meet water quality objectives, would result in minor cumulative impacts.

Project and status	Cumulative impacts
Other existing road network upgrades and potential road projects, including: • Elizabeth Drive upgrade • Mamre Road upgrade • Outer Sydney Orbital Not yet approved	The timing for construction and operation of the existing and potential road upgrade projects has not yet been announced, however, there is potential for overlaps between the M12 Motorway and some of these road upgrade works. The future development would be designed to minimise impacts on hydrology and geomorphology as much as possible during construction. Water quality impacts during construction and operation would be typical of large infrastructure projects and mitigated by the implementation of standard stormwater practices and adherence to industry standards. Therefore, there would be minor cumulative water quality and hydrology impacts associated with the construction and operation of the M12 Motorway and other road projects.
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area. Future strategic government project	The timing for construction of surrounding urban developments (growth areas) has not yet been announced. However, there is potential for overlaps between the M12 Motorway and surrounding projects located within the same hydrological catchment. Impacts will be dependent on the specific construction locations, activities and impacts which are yet to be determined for these projects. The future development would be designed to consider water sensitive urban design principles and to minimise impacts on hydrology and geomorphology as much as possible. It is expected that water quality impacts would be typical of large developments and mitigated by the implementation of standard stormwater practices and adherence to industry standards, there would be minor cumulative water quality and hydrology impacts. The operation of the growth areas would increase runoff volumes due to the transformation of the existing greenfield sites into mostly impervious sites. The growth areas would likely provide water sensitive urban design solutions and incorporate detention basins to manage flows out of their sites, however there is still the potential for changes to existing hydrology with development occurring within Western Sydney. Increased flows also have the potential to impact on water quality. The cumulative impact of the increased area of impervious surfaces between the growth areas and the M12 Motorway could result in a moderate increase in runoff within the and stormwater network and downstream waterways. While the implementation of standard stormwater practices and adherence to industry standards would somewhat reduce runoff, the cumulative hydrological impact (via stormwater to downstream waterways) could be moderate.

Monitoring would be carried out in accordance with the following guidelines:

- Guideline for Construction Water Quality Monitoring (RTA, 2003b)
- Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b).

Monitoring locations

Current monitoring locations for surface water quality are listed in and shown in **Figure 7-125**. Additional sites, reference and control sites (ie up and downstream of the project) will be identified before the start of construction. These sites are useful in determining impacts of a disturbance or pollution event.

Table 7-142 Water quality monitoring sites

Site number	Watercourse	Coordinates	Description and location details
M12_1	Unnamed tributary of South Creek	287282.71 m E 6251632.72 m S	Road bridge on Elizabeth Drive over South Creek. U/S of alignment
M12_2	Cosgroves Creek	289864.51 m E 6251080.48 m S	Road bridge on Twin Creeks Drive over Cosgroves Creek. D/S of alignment
M12_3	Unnamed tributary of Cosgroves Creek	290783.22 m E 6251120.36 m S	Road bridge on Elizabeth Drive over Cosgroves Creek. U/S of alignment
M12_4	Unnamed tributary of Badgerys Creek	291989.97 m E 6249633.41 m S	Road bridge on Elizabeth Drive over Badgerys Creek. U/S of alignment, and east of connecting road to Elizabeth Drive.
M12_5	Badgerys Creek	292402.94 m E 6251178.92 m S	Residential development area on Humewood Place, borders Badgerys Creek. D/S of alignment
M12_6	South Creek	293776.85 m E 6251029.82 m S	Residential development area on Humewood Place, borders South Creek. D/S of alignment
M12_7	Kemps Creek	296359.62 m E 6249256.72 m S	Industrial site K&N Mechanical 917 Mamre Road, borders on Kemps Creek. D/S of alignment
M12_8	Unnamed tributary of Kemps Creek	296876.16 m E 6249052.47 m S	Road bridge on Elizabeth Drive over Kemps Creek. U/S of alignment
M12_9	Ropes Creek	300775.63 m E 6250599.30 m S	Road bridge on Capitol Hill Drive over Ropes Creek. D/S of alignment
M12_10	Unnamed tributary of Ropes Creek	300453.12 m E 6249586.05 m S	Roundabout on Wallgrove Road over Ropes Creek. U/S of alignment? Was Site M12_9 for Jacobs work
M12_11	Unnamed tributary of Hinchinbrook Creek	298956.6 m E 6248415.48 m S	Hinchinbrook Creek tributary to Liverpool Offtake Reservoir. U/S of alignment. Access via locked road gate to the south.
M12_13	Hinchinbrook Creek	300407.62 m E 6247267.18 m S	Hinchinbrook Creek. Access via Kensington Close. D/S of alignment. Jacobs have accessed this site previously.

Baseline data collection

The baseline data collected to date is summarised in **Section 7.9.3**. Additional baseline surface water quality data will be collected for a minimum of 12 months before the start of construction and should begin at the earliest possible time. Sampling frequency would be monthly and after wet weather events for at least 12 months. As a minimum this should include three wet weather sampling events over six months. Wet weather monitoring events are defined as 22 millimetres or more of rain within 24 hours recorded at the Badgerys Creek AWS Bureau of Meteorology (BoM) gauge (#067108). Sampling will occur within 24 hours after the rain event. If rainfall events are regularly less than 22 millimetres, opportunistic wet weather monitoring would be carried out to ensure that some wet weather data is collected.

Construction phase surface water monitoring

Surface water monitoring during the construction phase will be carried out at all monitoring sites on a monthly basis and after wet weather events. Monitoring should also be carried out when discharge from a point source such as a controlled sediment basin occurs. Visual monitoring of other points of release and monitoring of downstream waterways will also be carried out during construction.

Operational phase surface water monitoring

Monthly monitoring will occur for a minimum of 12 months during operation of the project. Additional wet weather monitoring will occur when rainfall results in any discharge from control sites (or greater than a nominated rainfall threshold). The operational surface water monitoring period shall continue following the completion of construction until the affected waterways are certified by an independent expert as being rehabilitated to an acceptable condition and/or the permanent water quality structures are deemed to be operating satisfactorily.

Surface water monitoring indicators

The surface water monitoring program will include both field parameters and laboratory analysis of the following indicators:

- Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature)
- Heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, iron and manganese)
- Nutrients (including ammonia, NO2, NO3, TKN, total nitrogen, total phosphorus, SRP)
- Chlorophyll-a
- Oil and grease
- Major urban pollutants (ultra-trace Polynuclear Biphenyls, organochlorine and organo-phosphorus pesticides, fumigants, halogenated aliphatic and aromatic compounds)
- Benzene, toluene, xylene, naphthalene (BTXN)
- Phenols and poly-aromatic hydrocarbons (PAHs)
- Total dissolved solids (TDS)
- Total suspended solids (TSS).

Environmental management measures

The environmental management measures that would be implemented to minimise surface water quality and hydrology impacts of the project, along with the responsibility and timing for those measures, are presented in **Table 7-143**. These measures would be complemented by the environmental management measures outlined in **Section 7.10.6** and **Section 8.1.6**. The environmental management measures include a surface water quality monitoring program which would include collection of baseline data for comparison to construction and operational monitoring data to understand, and respond to, any impacts from the project. This is outlined below in the following section.

Table 7-143 Environmental management measures (surface water quality and hydrology)

Impact	Reference	Environmental management measure	Responsibility	Timing
General	SWH01	A construction soil and water management plan (CSWMP) will be prepared for the project. The plan will outline measures to manage soil and water impacts associated with the construction works, including contaminated land. The CSWMP will provide: • Measures to minimise/manage erosion and sediment transport both within the construction footprint and offsite including requirements for the preparation of	Contractor	Prior to construction

Impact	Reference	Environmental management measure	Responsibility	Timing
		erosion and sediment control plans (ESCP) for all progressive stages of construction • Measures to manage waste including the classification and handling of spoil • Procedures to manage unexpected contaminated finds including asbestos which would be outlined in the contaminated land management plan and asbestos management plan to be prepared for the project • Measures to manage stockpiles including locations, separation of waste types, sediment controls and stabilisation • Measures to manage groundwater de-watering and impacts including mitigation required • Processes for de-watering of water that has accumulated on site and from sediment basins, including relevant discharge criteria • Measures to manage potential tannin leachate • Measures to manage accidental spills including the requirement to maintain materials such as spill kits • Measures to manage potential saline soils • Details of surface water and groundwater quality monitoring to be carried out before, throughout, and following construction • Controls for sensitive receiving environments including SEPP Coastal Wetlands which may include but not be limited to: – Designation of ‘no go’ zones for construction plant and equipment – Creation of catch/diversion drains and sediment fences at the downstream boundary of construction activities where practicable to ensure containment of sediment-laden runoff and diversion toward sediment sump treatment areas (not sediment basins) to prevent flow of runoff to the SEPP Coastal Wetland. • Erosion and sediment control measures will be implemented and maintained at all work sites in accordance with the principles and requirements in *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom 2004) and Volume 2D (NSW Department of Environment, Climate Change and Water 2008b), commonly referred to as the “Blue Book”, as well as relevant Roads and Maritime Guidelines.		
	SWH02	A soil conservation specialist will be engaged for the duration of construction of the project to provide advice on the planning and implementation of erosion and sediment control including review of ESCPs.	Roads and Maritime / Contractor	Prior to construction and during construction
	SWH03	A water reuse strategy will be developed for both construction and operational phases of the project to reduce reliance on potable water. This strategy will be prepared during the detailed design stage and implemented throughout the project and will outline the construction and operational water requirements and	Contractor	Detailed design, prior to constructiona nd throughout

Impact	Reference	Environmental management measure	Responsibility	Timing
		potential water sources to supply the water demand in consultation with Sydney Water. Alternative water supply options to potable water will be investigated, with the aim of reusing water using recycled water where feasible.		construction and operation
Impacts of stockpiles	SWH04	Stockpiles will be managed to minimise the potential for mobilisation and transport of dust and sediment in runoff in accordance with Roads and Maritime Stockpile Sites Management Guideline (Roads and Maritime, 2015e). This will include: • Minimising the number of stockpiles, area used for stockpiles, and time that they are left exposed • Locating stockpiles away from drainage lines, waterways and areas where they may be susceptible to wind erosion • Stabilising stockpiles, establishing appropriate sediment controls and suppressing dust as required.	Contractor	Construction
Surface water quality impacts	SWH05	A construction water quality monitoring program will be developed and included in the CSWMP for the project to establish baseline conditions, observe any changes in surface water and groundwater during construction, and inform appropriate management responses. The program will be based on the water quality monitoring methodology water quality indicators and the monitoring locations identified in the Surface water and hydrology assessment report (**Appendix M**), and Groundwater quality and hydrology assessment report (**Appendix N**). Baseline monitoring will be carried out monthly for a minimum of 12 months before the start of construction. As a minimum this will include three wet weather sampling events over six months where feasible. Sampling locations and monitoring methodology to be carried out during construction will be further developed in detailed design in accordance with the Guideline for Construction Water Quality Monitoring (RTA 2003b) and the ‘ANZECC water quality guidelines’ (ANZECC/ARMCANZ (2000). It will include collection of samples for analysis from sedimentation basin discharge points, visual monitoring of other points of release of construction waters and monitoring of downstream waterways.	Roads and Maritime / Contractor	Prior to construction, and during construction and operation

Impact	Reference	Environmental management measure	Responsibility	Timing
		The monitoring frequency during construction will be confirmed during detailed design however will include at least monthly construction monitoring at all monitoring sites which will preferentially monitor following wet weather events. Should the results of monitoring identify that the water quality management measures are not effective in adequately mitigating water quality impacts, additional mitigation measures will be identified and implemented as required.		
	SWH06	An operational water quality monitoring program will be developed and implemented following the completion of construction to observe any changes in surface water and groundwater following construction and inform appropriate management responses. The program will be based on the water quality monitoring methodology, water quality indicators, and the monitoring locations presented in the Surface water and hydrology assessment report (**Appendix M**), and Groundwater quality and hydrology assessment report (**Appendix N**). The monitoring program will be carried out monthly and will preferentially monitor following wet weather events when rainfall results in discharge from control sites or is greater than a nominated rainfall threshold which will be identified in detailed design. Monitoring will be carried out for a minimum of 12 months following the completion of construction, or until the affected waterways are certified by a suitably qualified and experienced independent expert as being rehabilitated to an acceptable condition and/or the permanent water quality structures are deemed to be operating satisfactorily. Should the results of monitoring identify that the water quality management measures are not effective in adequately mitigating water quality impacts, additional mitigation measures will be identified and implemented as required.	Roads and Maritime / Contractor	Prior to operation and during operation
	SWH07	The performance water quality controls developed for the design as set out in this document (including but not limited to temporary and permanent sediment basins) will be verified as the detailed design develops for the project to ensure the objectives of the project are achieved. In the instance that during detailed design it cannot be demonstrated that the water quality controls would be effective in mitigation potential impacts, additional mitigation measures would be identified and implemented.	Contractor	Detailed design

Impact	Reference	Environmental management measure	Responsibility	Timing
	SWH08	Further water quality assessment will be undertaken during detailed design to establish site specific discharge criteria for construction sediment basins. Based on this, the number, location and size of the basins will be further refined during the detailed design with consideration to the relevant NSW EPA Environment Protection Licence application requirements and the environmental values of the downstream receiving waterway.	Roads and Maritime/ Contractor	Detailed design
	SWH09	Practical measures to prevent water pollution and control, abate or mitigate impacts to the environment will be investigated at the detailed design stages of the project with the aim to make improvements to the currently proposed water quality controls. Such measures may include: • Larger or high efficiency temporary basins • Alternative dry bioretention operational basins.	Roads and Maritime/ Contractor	Detailed design
Impacts of de-watering	SWH10	A de-watering management plan will be prepared as part of the CSWMP which will outline the de-watering methodology, supervision requirements, staff responsibilities and training, and approvals required before any de-watering activity begins.	Contractor	During construction
Impacts on water bodies	SWH11	The following measures will be carried out to manage activities within watercourses or on waterfront land: • Implementing practices to minimise disturbance of banks • Undertaking bank stabilisation and installing instream structures • Maintaining minimum flows to assist in maintaining the viability of aquatic communities and preventing barriers to fish passage • Constructing instream crossings during low flows and design so that drainage off crossing doesn't contribute sediment load to the stream • All drainage feature crossings (permanent and temporary watercourse crossings and stream diversions), drainage swales and depressions will be designed by a suitably qualified and experienced professional and will be designed and constructed in accordance with relevant guidelines.	Contractor	Prior to construction and during construction
	SWH12	A set of hydrologic and hydraulic models will be developed, which are to be used to define the nature of both main stream flooding and major overland flow along the full length of the project operational footprint under pre- and post-project conditions. The hydraulic model is to extend a sufficient distance upstream and downstream of the project operational footprint, to negate any boundary effects and to define the full extent of any impact that the project will have on patterns of both main stream flooding and major overland flow. The hydraulic model(s) is to be based on the TUFLOW (or equivalent) two-dimensional (in plan) hydraulic modelling software.	Contractor	Detailed design

Impact	Reference	Environmental management measure	Responsibility	Timing
		The models will be used to verify the nature and extent of impacts and to confirm the type of mitigation measures required. The models will also be used during detailed design to describe the interaction between the project and flows particularly with respect to culverts and to assist in refining the design for flows arriving at and travelling through culverts.		
Impacts on SEPP Coastal Wetlands	SWH13	Consideration will be given to the design of operational water quality, erosion and sediment controls incorporated into the design of the construction access track being left in place upstream from the SEPP wetland, and within the proximity area of the SEPP Coastal Wetland ID117.	Contractor	Detailed design