6.6 Soils and surface water

This section provides a summary of the assessment of potential soils and surface water impacts during construction and operation of the proposal and identifies mitigation measures to address these impacts. A detailed assessment of soil and surface water quality impacts is provided in the technical working paper – soils and surface water assessment (Appendix I).

6.6.1 Methodology

Soils

A soils assessment for the proposal was conducted including:

- Assessment of soils based on the proposal geotechnical investigation report and publicly available data
- Identification of soil condition, erosion and sedimentation of soils (erodibility), soil risks and constraints, applicable erosion and sedimentation controls, management and mitigation strategies
- Assessment of Acid Sulfate Soils/Potential Acid Sulfate Soils and rock, saline and dispersive soils and areas prone to potential instability and/or settlement.

Surface water

The surface water assessment incorporated a desktop review and analysis of existing water quality information to understand existing water quality and identify potential water specific risks within the proposal and surrounding area. A qualitative and quantitative assessment of anticipated pollutants that may be produced through construction and operation of the proposal was conducted and the likely impacts to surface water quality in regard to relevant environmental values and guidelines outlined.

The assessment provided recommendations for appropriate treatment measures to mitigate the construction and operational impacts on surface water quality, including water quality controls and a suggested water quality monitoring program for pre-construction, construction and operation of the proposal.

The existing condition of surface water quality was assessed through a review of literature, water quality data, background information on land use and information on the design and operation of the proposal.

6.6.2 Existing environment

Catchment overview

The proposal is located within the mid Coxs River sub-catchment in Hawkesbury-Nepean Catchment region and covers an area of about 2630 square kilometres. The Coxs River catchment is part of the Sydney Drinking Water Catchment as it flows into the Warragamba Dam. The major waterway located within this catchment is the River Lett, which flows into Coxs River about two and a half kilometres downstream of the Great Western Highway. A variety of creeks and tributaries flow into River Lett near the proposal including Boxes Creek, Blackmans Creek, Butlers Creek, Finnigans Creek and other minor tributaries. Bowens Creek, located within the north western extent of the proposal, is in proximity to the proposal however does not cross the Great Western Highway. Bowens Creek flows into Coxs River about four kilometres downstream of the proposal.

Land use

The proposal is located within a low-lying valley west of the Blue Mountains escarpment. The land adjacent to the Great Western Highway is predominantly privately owned land cleared for agricultural purposes. Some of the creeks and tributaries entering River Lett, particularly Butlers Creek, have been modified for agricultural use including creation of farm dams and registered groundwater boreholes used for domestic stock purposes. Some locations along the major waterways, including River Lett and Blackmans Creek, have retained vegetation that provide recreational areas for public use, such as Hyde Park Reserve.

Climate

Rainfall data provided by the Bureau of Meteorology shows a trend of the wet season extending between November to March and the dry season between May to October. Average total annual rainfall for the area is 984.7 millimetres. The proposal is located within a temperate climatic region characterised by mild to warm summer and cold winters.

Soil landscapes and characteristics

Geology

Two resources were used to determine the surface geology within the construction footprint including the Sydney 1:250,000 Geology Sheet (third edition developed in 1966; NSW Resources and Geoscience, 2021) and the seamless geology data (Department of Regional NSW, 2020).

The Sydney 1:250,000 Geology Sheet shows the geology in the area is comprised of lower Carboniferous-age adamellite, granite and granodiorite, and the Permian-age Berry Formation of the Shoalhaven Group.

The seamless geology data shows the geology in the area is comprised of granites of the Carboniferous-age Bathurst Batholith Group and the Berry Siltstone of the Permian-age Shoalhaven Group.

The Bathurst Batholith Group consists of granites. The Berry Siltstone is described as a mid- to dark-grey siltstone that grades up-sequence to very fine-grained sandstone, is highly fossiliferous and includes sporadic-dropped pebbles. The Bathurst Bathlith Group underlies the Shoalhaven Group across the region whilst the Berry Siltstone is present across the majority of the construction footprint but is absent within River Lett Hill to Forty Bends section.

The geology of each of the four sections is as follows:

- Little Hartley to River Lett – mapped as Shoalhaven Group
- Coxs River Road – mapped as Shoalhaven Group
- River Lett to Forty Bends – northern half mapped as Shoalhaven Group and southern half mapped as Bathurst Batholith Group
- Forty Bends to Lithgow – mapped as Shoalhaven Group.

Soil landscapes

The Katoomba 1:100,000 Soil Landscape Sheet indicates that soils within the construction footprint are comprised of Lithgow, Hassans Walls, Cullen Bullen, Marrangaroo and Round Mount soil landscape types, with some minor areas of Disturbed Terrain. Soil landscape types present within the construction footprint are summarised in Table 6-76.

Table 6-76 Soil landscape types present within the construction footprint

Soil Landscape Name	Landscape	Soil characteristics	Qualities and Limitations
Lithgow	Flat to undulating rises and broad valley floors on Illawarra Coal Measures and the Berry Formation. Slopes <10%, localised rock outcrops, extensively cleared open forest/woodland	Moderately deep, moderately well-drained residual soils on upper slopes and well-drained areas. Moderately deep to deep imperfectly drained soils on lower slopes and in areas of poor drainage	Hardsetting topsoils, high run-on, localised mine subsidence district, localised rock fall hazard, localised high potential aluminium toxicity
Hassans Walls	Cliffs derived from Narrabeen Group sandstones and steep colluvial talus sideslopes developed over the Illawarra Coal Measures and the Shoalhaven Group. Slopes mostly >40%. Open-forest and open-woodland	Shallow, discontinuous, rapidly-drained colluvial sands on small rocky ledges on cliffs; moderately deep, stony, rapidly drained colluvial lithosols/sands on upper slopes and recently deposited talus; moderately deep, imperfectly to moderately well-drained soils on lower slopes; shallow, well-drained sands/lithosols along narrow steep, deeply incised drainage lines; and moderately deep, well-drained sands/lithosols along narrow drainage flats	Severe rock fall hazard, mine subsidence, steep slopes, extreme water erosion hazard, mass movement hazard, severe foundation hazard, rock outcrop and localised shallow soils, high run-on, non-cohesive soils (localised)
Cullen Bullen	Rolling low hills and rises on Illawarra Coal Measures and the Berry Formation. Slopes 10% to 25%. Localised rock outcrop occurs as small isolated low scarps (<5 m). Extensively cleared open-woodland and open-forest	Shallow to moderately deep, moderately well-drained erosional soils on crests, upper slopes, midslopes, and lower slopes near drainage lines. Shallow, well-drained soils associated with low scarps	Hardsetting topsoils, high water erosion hazard, localised mine subsidence district, high run-on, rock outcrop, localised rock fall hazard and localised high foundation hazard
Marrangaroo	Rolling hills and narrow flat to rounded convex crests on Carboniferous granites. Slopes <30%. Granite tors are common (<5 m) on upper slopes, and small swampy drainage depressions on lower slopes and drainage lines. Extensively cleared open-woodland	Shallow, rapidly drained erosional sands and deep, rapidly drained red earths on crests and moderately inclined sideslopes; moderately deep, imperfectly drained soils on lower slopes near drainage lines; imperfectly drained alluvial soils and minimal prairie soils along very narrow swampy drainage lines	Localised steep slopes, localised rock outcrop, acid soils of low fertility, seasonally high watertables in valley flats
Round Mount	Steep to very steep hills and mountains on Carboniferous granite in the Hartley Valley and Kanangra Gorge. Slopes	Shallow, rapidly drained colluvial sands associated with rock outcrop; shallow to moderately deep, rapidly drained sands on slopes with	Steep slopes, extreme water erosion hazard, mass movement hazard (localised), acid, sandy

Soil Landscape Name	Landscape	Soil characteristics	Qualities and Limitations
	generally >35%. Granite rock outcrop (tors) is commonplace. Occasional cliffs. Open-woodland	negligible rock outcrop; occasional moderately well-drained soils on lower slopes and along drainage depressions	soils of very low fertility, rock outcrop
Disturbed Terrain	Level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Local relief	Turfed fill areas commonly capped with up to 40 cm of sandy loam or up to 60 cm of compacted clay over fill or waste materials	Dependent on nature of fill material. Mass movement hazard, unconsolidated low wet strength materials, impermeable soil, poor drainage, localised very low fertility and toxic materials

The soil landscape type of each of the four sections is as follows:

- Little Hartley to River Lett – Lithgow, and a small area that is Hassans Wall across the eastern portion; Lithgow, Cullen Bullen and a small area that is Marrangaroo across the western portion.
- Coxs River Road – Lithgow and a small area of Cullen Bullen.
- River Lett to Forty Bends – from east to west, a small area at the eastern end that is Cullen Bullen, Marrangaroo, Disturbed Terrain at two localised areas, Round Mount, Lithgow, Cullen Bullen and Hassans Wall.
- Forty Bends to Lithgow - Lithgow, Cullen Bullen and Hassans Wall.

Soil landscape types are shown in Figure 6-21.

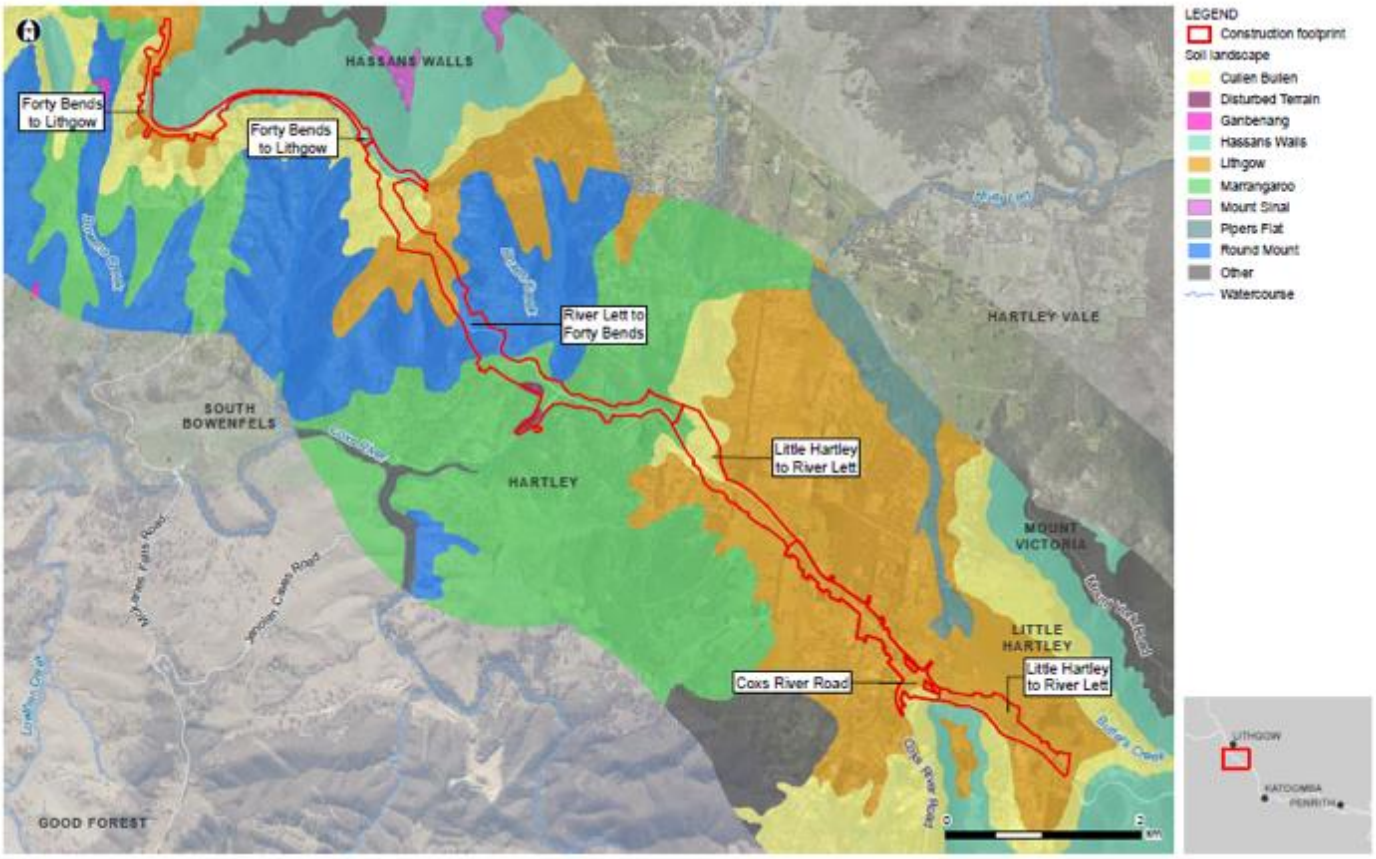

Figure 6-21 Soil landscape types present within the area surrounding the proposal

Soil erodibility

Dispersive soils are soils which are prone to erosion through dispersion of fine clay molecules, which may then be transmitted through groundwater flow. Internal erosion can result from the flow of fine materials through groundwater, forming pipes or tunnels within the soil. This internal erosion can pose a risk to earthwork embankments by weakening the internal structure and potentially leading to embankment failure. Dispersive soils are also prone to scour erosion resulting from surface run-off.

Water erosion hazard is categorised as extreme for the Hassans Wall and Round Mount soil landscape types and high for the Cullen Bullen soil landscape type. High risk areas for erosion include areas with erodible soils and steep and rugged terrain. Specific high-risk areas for soil erosion within the construction footprint include a large portion of both the River Lett Hill to Forty Bends and Forty Bends to Lithgow sections as well as the far eastern and western section of the Little Hartley to River Lett stage and far eastern section of the Coxs River Road section. Table 6-77 outlines the soil erodibility factors for each section as identified in the geotechnical report (Jacobs 2021a to 2021d).

Table 6-77 Soil erodibility for soils within the construction footprint

Section	Soil dispersion	K-Factor	Erodibility rating
Little Hartley to River Lett Hill	10 – 40 per cent	0.02 – 0.05	Moderate to High
Cox River Road	30 – 50 per cent	0.04 – 0.06	High
River Lett Hill to Forty Bends	50 – 70 per cent	0.01 – 0.04	Low to moderate

Section	Soil dispersion	K-Factor	Erodibility rating
Forty Bends to Lithgow	40 -70 per cent	0.025 – 0.04	Moderate

Salinity

The salinity hazard for the proposal is mapped as low indicating that the presence of sodic soils within the region is low.

Acid sulfate soils and rock

Acid sulfate soils mapped by the Commonwealth Scientific and Industrial Research Organisation show that there is a low probability of occurrence of Acid Sulfate Soils within the construction footprint. Acid rock is present in a number of locations within the construction footprint, including the Coxs River Road and River Lett to Forty Bends sections.

The Shoalhaven Group strata along the alignment are typically marine sediments and have the potential to contain sedimentary pyrite. Acid sulfate rock is only likely to be present within the fresher rock cuts in bedrock and areas above the existing groundwater table. Any available pyrite in weathered rock would likely have already oxidised and therefore no longer have the potential to form acid. Due to the weathering observed within the nearby cuttings in the Little Hartley to River Lett Hill section, acid sulfate rock is anticipated to be present within base of the cut batters.

Laboratory testing of rock core samples from the Shoalhaven Group undertaken for the proposal (Jacobs, 2021a to 2021d) suggest that significant quantities of acid may be generated over time by exposure of and seepage through the slightly weathered rock at each section of the proposal except at the River Lett to Forty Bends section where insufficient laboratory testing has been undertaken. Further laboratory testing is being undertaken as part of the proposal geotechnical investigations and will be completed prior to construction.

Waterways

There are numerous waterways and waterbodies including major perennial waterways, minor intermittent creeks, ephemeral drainage channels and waterbodies such as farm dams, present within proximity of the construction footprint. Waterways present within each section are listed in Table 6-78 and shown in Figure 6-22 to Figure 6-25.

Waterways included in the below table include those with a Strahler steam order of greater than 3, as these waterways are likely to have water present a majority of the time, if not permanently, and minor waterways which are specifically crossed by the alignment and/or have a drainage pathway to a key waterway. Key Fish Habitat (KFH) has been provided in accordance with the Biodiversity Assessment (Section 6.1 Biodiversity).

Table 6-78 Key waterways present within each section

Waterway name	Stream type	Crossed by the proposal alignment	KFH Type (DPI, 2013)
Little Hartley to River Lett/Cox River Road			
Tributary to Butlers Creek 1	Ephemeral	Yes (existing)	1
Butlers Creek	Intermittent	No	1
Tributary to Butlers Creek 2	Ephemeral	Yes	3

Waterway name	Stream type	Crossed by the proposal alignment	KFH Type (DPI, 2013)
Tributary to Moyne Creek	Ephemeral	Yes	3
Tributary to Coxs River 1	Ephemeral	Yes	3
Tributary to Coxs River 2	Ephemeral	Yes	3
River Lett to Forty Bends			
Tributary to River Lett 1	Ephemeral	Yes	1
River Lett	Perennial	Yes (existing)	1
Tributary to River Lett 2	Ephemeral	Yes	3
Tributary to River Lett 3	Ephemeral	No	2 or 3
Coxs River	Perennial	No (downstream of River Lett)	1
Boxes Creek	Perennial	Yes (existing)	1
Tributary to Boxes Creek 1	Ephemeral	Yes (existing)	3
Tributary to River Lett 4	Ephemeral	Yes (existing)	3
Tributary to River Lett 5	Ephemeral	Yes (existing)	3
Tributary to Boxes Creek 2	Ephemeral	Yes	3
Tributary to Whites Creek 1	Ephemeral	Yes	1
Forty Bends to Lithgow			
Tributary to Whites Creek 2	Ephemeral	Yes (existing)	3
Whites Creek	Ephemeral (perennial downstream)	Yes (existing)	1
Tributary to Whites Creek 3	Ephemeral	Yes (existing)	3
Tributary to Bowen Creek 1	Ephemeral	Yes (existing)	3
Bowen Creek	Ephemeral (perennial downstream)	No	1 or 2
Tributary to Bowen Creek 2	Ephemeral	Yes (existing)	3
Tributary to Bowen Creek 3	Ephemeral	Yes (existing)	3
Tributary to Bowen Creek 4	Ephemeral	Yes (existing)	3

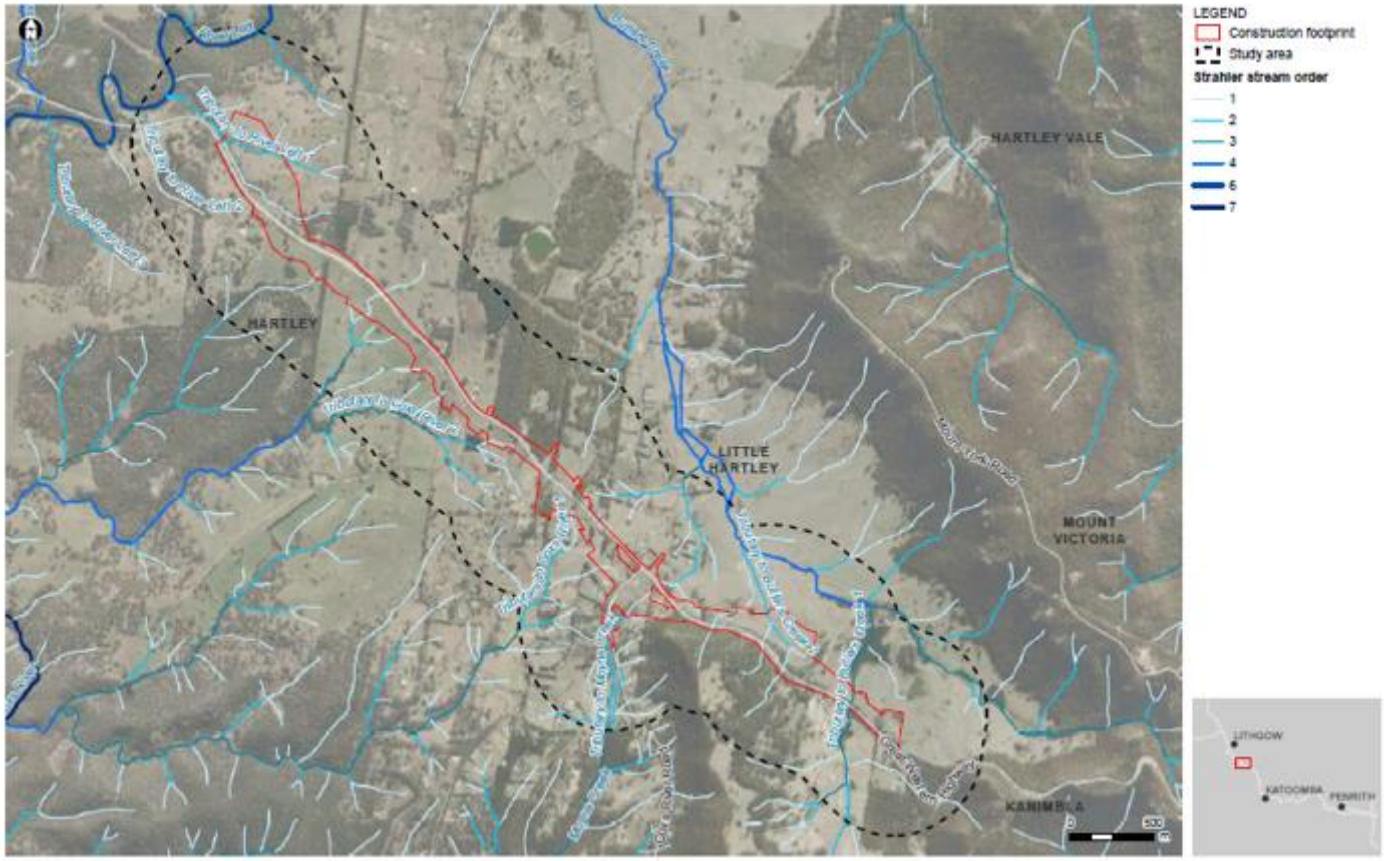

Figure 6-22 Soils and surface water quality study area - Little Hartley to River Lett Hill

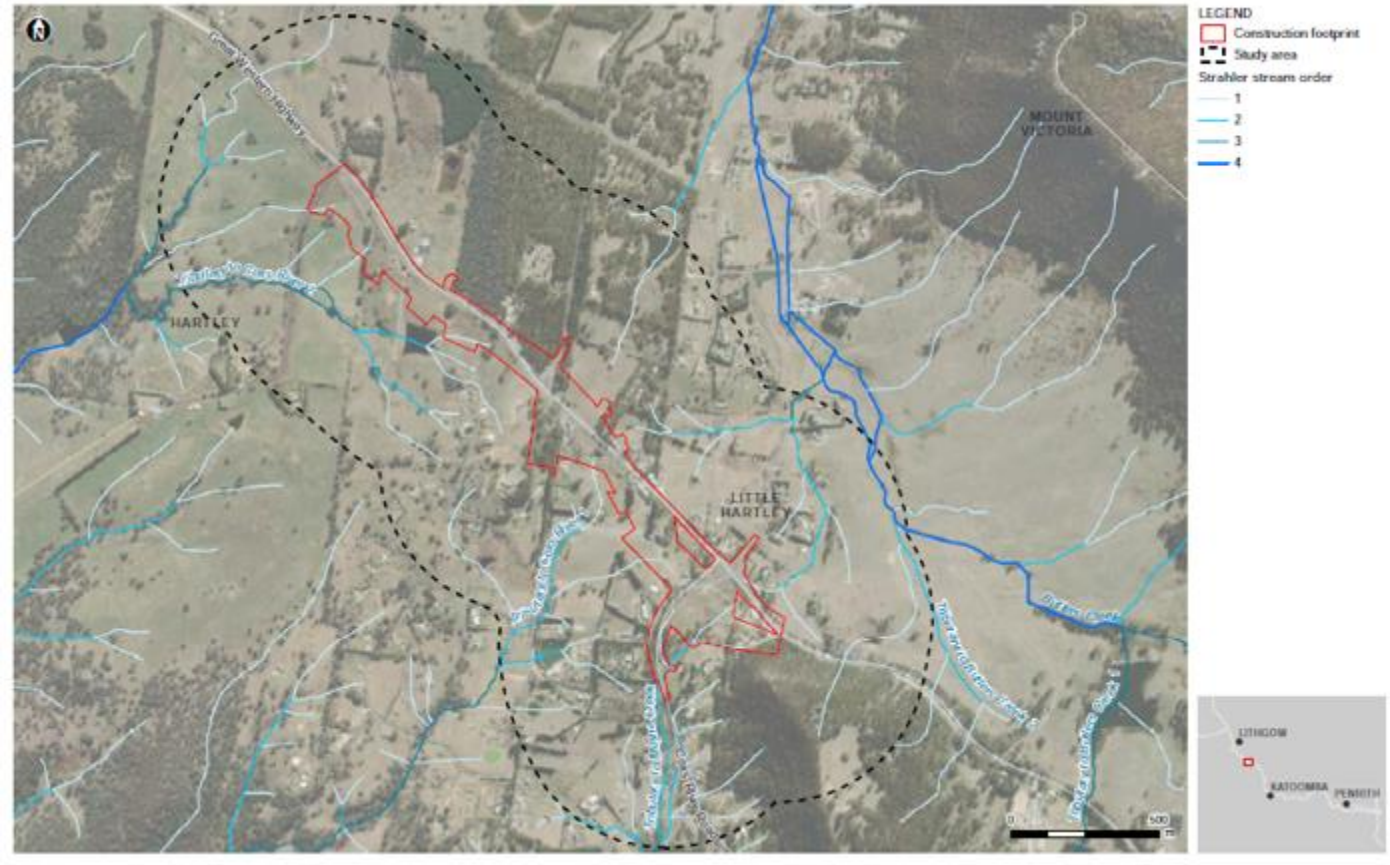

Figure 6-23 Soils and surface water quality study area - Coxs River Road

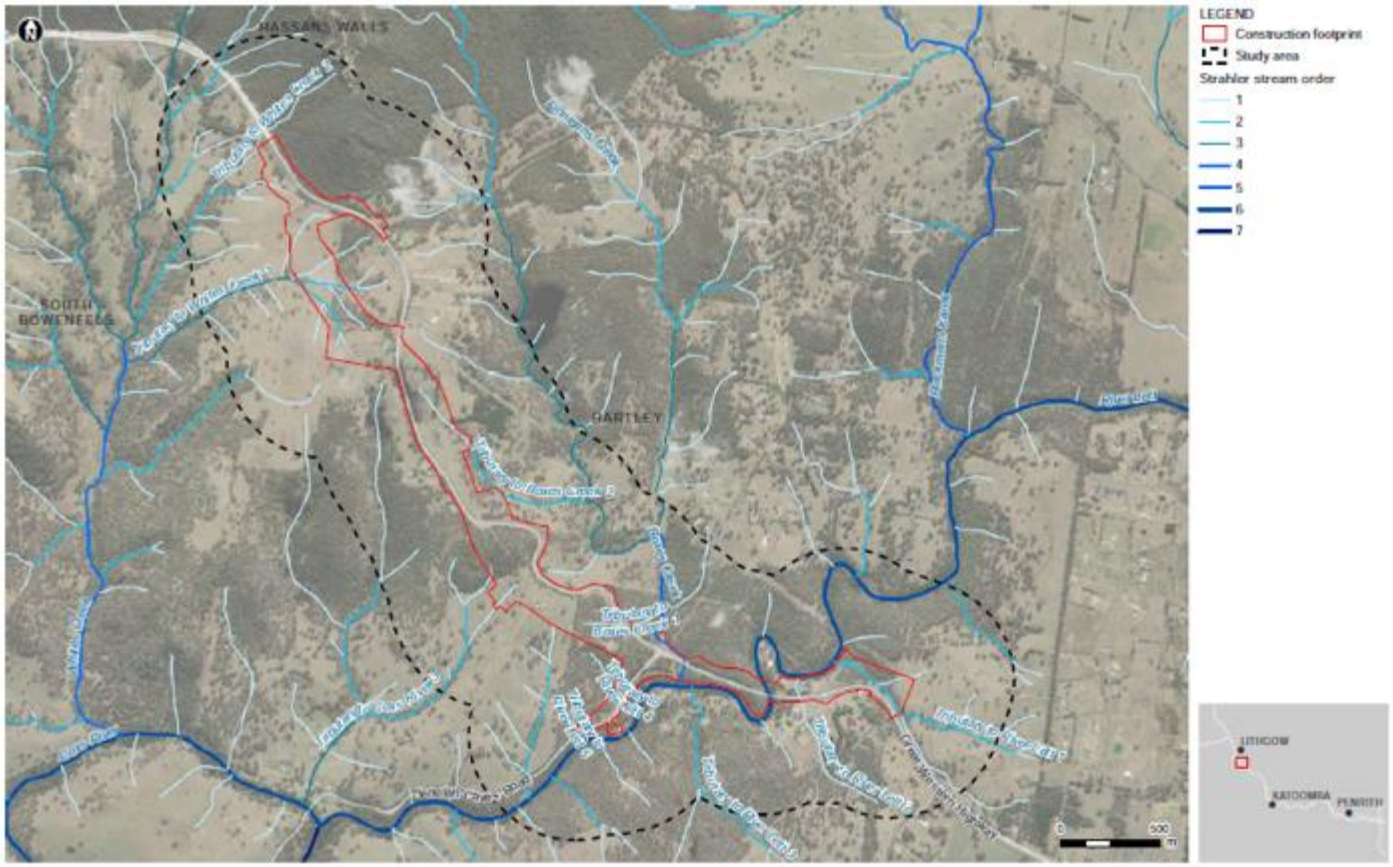

Figure 6-24 Soils and surface water quality study area - River Lett Hill to Forty Bends

Figure 6-25 Soils and surface water quality study area - Forty Bends to Lithgow

Existing surface water quality

Historic water quality data for the River Lett indicates that water quality is generally good and complies with the guidelines for protection of slightly disturbed upland river aquatic ecosystems for a majority of indicators. Water quality monitoring of waterways within the construction footprint will be carried out prior to construction and data will be reviewed to inform detailed design.

Historic water quality data was provided by Water NSW for the Coxs River at Glenroy Bridge for five years between 2016 and 2021. Based off this water quality data of the Coxs River has been variable and fails to comply with guideline values for a number of indicators. Overall, the water quality of the Coxs River does not currently meet the environmental value for protection of aquatic ecosystems due to elevated nutrient, pH and total aluminium.

Sensitive receiving environments

Sensitive receiving environments are areas that have a high conservation value or support ecosystems and/or human uses of water that are sensitive to degradation of water quality. All perennial waterways (Butlers Creek, River Lett, Coxs Creek, Boxes Creek, White Creek), and tributaries which flow to these waterways (tributary of Boxes Creek and tributary of White Creek) have been considered sensitive receiving environments because they are situated with the Sydney Drinking Water Catchment.

Neutral or Beneficial Effect (NorBE) on Water Quality Assessment

The proposal is located within the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 catchment area. Under the Drinking Water Catchment SEPP, there is a requirement to consider whether the proposal would have a neutral or beneficial effect (NorBE) on water quality. This was assessed using the 'Neutral or Beneficial Effect on Water Quality Assessment Tools' (the NorBE tool). The NorBE requires that pollutant loads are equal to or less than existing conditions. The pollutants modelled were Total Suspended Solids, Total Nitrogen and Total Phosphorus.

The results of the assessment are presented in Table 6-79. The assessment showed that without mitigation the proposal would increase the pollutant loads in comparison to the existing conditions. However once the proposed mitigation measures are implemented the pollutants load are reduced to a level that is better than the existing conditions.

The annual average pollutant loads for the upgraded road conditions with the proposed water quality controls are anticipated to provide between eight and 68 per cent improvement on existing conditions. These results demonstrate compliance with the NorBE requirements.

Table 6-79 Annual average pollutant loads and percentage improvements for all sections

Parameter	Existing conditions	Proposed conditions without any water quality controls	Proposed conditions with water quality controls	Percentage improvements from existing conditions	NorBE Compliant? Y/N
Total Suspended Solids	126,700	229,400	40,720	68 per cent	Y
Total Phosphorus	224	1,055	114	49 per cent	Y
Total Nitrogen	1,008	1,591	930	8 per cent	Y

During the construction and operation phases sediment basins are required to capture and treat runoff from all disturbed areas before discharging into the receiving waterways. An assessment has been undertaken as part of this REF work to identify appropriate locations where permanent water quality basins should be considered and sized during the concept and detailed designs.

6.6.3 Potential impacts

Construction

Soils

Construction of the proposal would include earthworks within the construction footprint, access tracks and site compounds. Earthworks would be undertaken for the establishment of the new road alignment, temporary haulage roads, cut and fill and drainage works, as well as stockpiling materials during the construction phase.

Construction activities have the potential to impact soils through erosion and sedimentation, however these would be temporary in nature and confined to the construction phase of the project. These activities include:

- Vegetation clearing and grubbing, including riparian areas
- Pavement removal
- Bulk earthworks, including cut and fill work in sloping terrain and forming slopes and batters
- Movement of heavy machinery and vehicles on unpaved areas
- Creek bridge work including bridge abutments and in-stream work
- Bridge abutments and piers over land or in water
- Sediment basins and other erosion controls
- Service relocation
- Drainage construction and stabilisation
- Ancillary site preparation and operation
- Generation of building and construction waste
- Importing, handling, stockpiling and transporting material resources
- General waste generation from construction compounds.

Details of key soil characteristics within the construction footprint and associated implications for the proposal are provided in Table 6-80.

Table 6-80 Summary of key soil characteristics

Soil characteristic	Details	Implication
Dispersive soils and soil erodibility	There is a high risk of soil erosion for the Hassans Walls, Cullen Bullen and Round Mount soils along the River Lett to Forty Bends and Forty Bends to Lithgow sections, and for the Hassans Walls soils in the Little Hartley to River Lett section	Potential for soil erosion to impact construction works, surrounding land uses and the water quality of surrounding waterways. Highest risk in sections Forty Bends to Lithgow, River Lett to Forty Bends and Little Hartley to River Lett.

Soil characteristic	Details	Implication
Topsoil structure	Hardsetting topsoils are present in the Lithgow and Cullen Bullen soil landscapes	Potential for increased rainfall runoff in these areas. All proposal sections at risk
Rockfall hazard	Severe rock fall hazard associated with the Hassans Wall soil landscape, and localised rockfall hazard associated with the Lithgow and Cullen Bullen soil landscapes	Potential to impact construction works and safety of workers. Areas along all proposal sections at risk.
Salinity	Salinity hazard is low within the construction footprint	Available data do not indicate salinity potential/impact
Acid sulfate rock	Potential acid forming rocks identified in the Cox River Road, Forty Bends to Lithgow and Little Hartley to River Lett sections. Data insufficient in River Lett to Forty Bends section to confirm presence of acid forming rocks	Oxidation of acid sulfate rock during construction has the potential to produce sulfuric acid, resulting in more aggressive conditions and potential impacts to groundwater and/or surface water quality.
Soil fertility	Low fertility associated with the Marrangaroo and Round Mount soil landscapes	Potential difficulty in vegetating slopes for erosion reduction and slope stability. Risk in River Lett to Forty Bends section

The main construction activities with the potential to cause impacts associated with soils and the relevant REF are presented in Table 6-81.

Table 6-81 Potential impacts on soils from construction activities

Construction activity	Details	Potential impact
Site establishment and access tracks	Activities involve movement and use of vehicles across exposed earth, excavation, vegetation clearing and grubbing, and transport of materials to and from site	Soil erosion, particularly in Forty Bends to Lithgow, River Lett to Forty Bends and Little Hartley to River Lett sections
Ancillary facilities/construction compounds	Activities occurring at ancillary facilities include movement and use of vehicles across exposed earth to transport material, stockpiling, vegetation clearing and grubbing	
Earthworks	Activities including cut and fill of existing soils, importing materials to work areas and stockpiling and treatment of soils. Potential cuts through acid sulfate rock, potential rockfalls	Soil erosion, particularly in Forty Bends to Lithgow, River Lett to Forty Bends and Little Hartley to River Lett sections. Acid rock formation resulting in more aggressive conditions and potential impacts to groundwater and/or surface water quality (potentially all proposal sections).

Construction activity	Details	Potential impact
		Rockfalls impact construction works and safety of workers (potentially all proposal sections).
Removal of pavements	Excavation of existing pavements	Soil erosion and waterway contamination.
Bridge work (construction of new bridge and refurbishment of existing bridge)	Involving instream work, vegetation clearing instream and on banks, concrete work, steel work	
Drainage work	Including excavation, vegetation clearing and grubbing, and construction of swales and water quality basins	
Excavation and relocation of utilities	Relocation of utilities using trenching and/or under-boring techniques	
Site restoration and landscaping	Restoration and landscaping of disturbed areas (including ancillary facilities and access roads) where required	

There is also potential to impact soils due to disturbance of existing contaminated soils during earthworks, and leaks or spills of contaminated materials from plant and equipment. Further assessment of potential contamination impacts is provided in Section 6.12 Contamination.

Surface water quality

Construction of the proposal presents a risk to downstream surface water quality through the disturbance of the existing ground surface for road and bridge construction. Potential water quality impacts associated with construction of the proposal include increased turbidity from sedimentation, which can reduce visual amenity, and increased nutrients which can lead to algal blooms. Specific works that have a high risk of impacting surface water quality include:

- Movement and use of heavy vehicle across exposed earth
- Earthworks – cut and fill
- Stockpiling
- Vegetation Clearing
- Relocation of Utilities
- Disturbance of contaminated land
- Concreting

The main construction activities with the potential to cause surface water quality impacts are described in

Table 6-82.

Table 6-82 Potential impacts on surface water

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
Site establishment and access tracks		
• Excavation • Movement and use of vehicles across exposed earth • Vegetation clearing and mulching • Transport of materials to and from site	Potential causes of downstream water quality impacts associated with the establishment and use of access tracks may include: • Transportation of soils, exposed sediments and contaminants associated with earthworks and vegetation clearing to downstream receiving environments via wind and stormwater runoff • Tannin leachate from vegetation clearing and mulching can enter downstream watercourses via stormwater runoff • Transportation of dust, litter and other pollutants (including spills or leaks of oils and/or fuels) associated with vehicle movements and transport of material loads along access tracks. As a result of the above, the following impacts to water quality may occur: • Erosion and sedimentation can result in increased turbidity and poor water clarity, impacting visual amenity and potentially leading to smothering of aquatic ecosystems due to clogging fish gills or decrease trophic interactions due to reduced visibility • Sediments may also contain high concentrations of nutrients which can lead to algal blooms and subsequently result in reduced light penetration that limits the growth of aquatic vegetation. Algal blooms may also result in a reduction of dissolved oxygen content of the water which can lead to the creation of 'dead zones' where aquatic life cannot survive • Mobilised sediments may contain elevated concentrations of metals and other contaminants, which can negatively impact aquatic life • Tannins can cause dark coloured water to be discharged into downstream watercourses from vegetation clearing. This can alter the instream pH and reduce visibility and light penetration. Tannins can also increase biochemical oxygen demand (BOD) which can decrease instream dissolved oxygen concentrations which can impact on aquatic ecosystems and lead to fish kills	**Little Hartley to River Lett and Coxs River Road** Unnamed first and second order ephemeral streams **River Lett Hill to Forty Bends** Boxes Creek River Lett **Forty Bends to Lithgow/South Bowenfels** Unnamed drainage lines (1st order ephemeral streams)

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
	• Mobilisation of pollutants from leaks and spills may lead to the introduction of hydrocarbons and heavy metals into the waterways which may be harmful to aquatic ecosystems.	
Ancillary facilities/construction compounds		
• Movement and use of vehicles across exposed earth to transport material • Stockpiling • Vegetation clearing and mulching, batching plants • Establishment of water quality controls	In addition to the transportation of soils and litter as discussed above; potential causes of downstream water quality impacts associated with the establishment and use of ancillary facilities may include: • Transportation of sediment-laden runoff from areas of excess spoil storage • Transportation of pollutants from accidental spills or leaks of fuels and/or oils from the maintenance or refuelling of construction plant equipment and vehicles in the ancillary facilities • Transportation of cement dust, concrete slurries or washout water from concrete works in batching plants and precast facilities. As a result of the above, impacts to water quality that may occur are the same as those for access tracks with the addition of: • Concreting and its by-products can result in increased alkalinity and pH which can be harmful to aquatic flora and fauna species. Water from concrete curing can additionally be high in chromium that can accumulate in the gills of fish affecting the health of aquatic organisms.	**Little Hartley to River Lett and Coxs River Road** Unnamed first and second order ephemeral streams **River Lett Hill to Forty Bends** Boxes Creek River Lett **Forty Bends to Lithgow/South Bowenfels** Unnamed drainage lines (1st order ephemeral streams)
Road Construction works		
• Vegetation clearing and mulching • Cut and fill of existing soils • Importing materials to work areas and stockpiling • Modification to existing roads and construction of new roads including concreting and steel works • Excavation and relocation of utilities • Establishment and use of water quality controls	Potential causes of downstream water quality impacts associated with the construction of new road infrastructure and modification to existing roads also include those mentioned above with the addition of: • Transportation of pollutants associated with rock blasting activities and steelworks • Transportation of dust, litter and other pollutants associated with on-site construction activities and use by construction workers • Transportation of poor-quality runoff from overflow captured water from construction sediment basins • Transportation of acidic runoff if exposure of Acid Sulfate Rock is not adequately mitigated. The impacts to water quality are as per those mentioned previously with the addition of: • Poor quality runoff may contain sediment that results in increased turbidity and poor water clarity impacting visual amenity and potentially leading to smothering of aquatic	**Little Hartley to River Lett** Unnamed tributary of Butlers Creek (3rd order ephemeral) Unnamed drainage lines (1st and 2nd order ephemeral streams) **Coxs River Road** Unnamed drainage lines (1st order ephemeral streams)

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
	organisms. Increased sediment can result in increased construction of nutrients, metals and other contaminants that can be toxic to aquatic life, result in algal blooms and reduce dissolved oxygen concentrations. • Acidic runoff may reduce pH of downstream receivers which may stress aquatic fauna and lead to reduced hatching and survival rates. Low pH can also encourage the solubility of metal pollutants which are more toxic to aquatic organisms in this state.	**River Lett Hill to Forty Bends** Boxes Creek River Lett Unnamed drainage lines (1st and 2nd order ephemeral streams) Farm dams **Forty Bends to Lithgow/South Bowenfels** Unnamed drainage lines (1st order ephemeral streams)
Bridge work (construction of new bridge and refurbishment of existing bridge)		
• Vegetation clearing near banks • Concrete work and steel work • Refurbishment of existing bridge (removal of panels potentially containing asbestos)	Potential causes of water quality impacts from the construction of bridge over creeks may include: • Disturbance of sediments • Transportation of sediment from vegetation clearing • Transportation of pollutants from accidental spills or leaks of fuels and/or oils from the maintenance or refuelling of construction plant equipment • Transportation of concrete dust, concrete slurries or washout water associated with concrete works and cast-in-place concreting • Transport of pollutants (ie steel cuttings) associated with steel works • Transportation of dust, litter and other pollutants associated with use of construction sites by construction workers. As a result of the above, the following impacts to water quality may occur: • Erosion and sedimentation can result in increased turbidity and poor water clarity, impacting visual amenity and potentially leading to smothering of aquatic ecosystems due to clogging fish gills or decrease trophic interactions due to reduced visibility • Sediments may also contain high concentrations of nutrients which can lead to algal blooms and subsequently result in reduced light penetration that limits the growth of aquatic and estuarine vegetation. Algal blooms may also result in a	**Lithgow to River Lett** River Lett **River Lett to Forty Bends** Boxes Creek

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
	reduction of dissolved oxygen content of the water which can lead to the creation of 'dead zones' where aquatic life cannot survive • Mobilised sediments may contain elevated concentrations of metals and other contaminants, which can negatively impact aquatic life • Tannins can cause dark coloured water to be discharged into downstream watercourses. This can alter the instream pH and reduce visibility and light penetration. Tannins can also increase BOD which can decrease instream dissolved oxygen concentrations that may impact on aquatic ecosystems and lead to fish kills • Concreting and its by-products can result in increased alkalinity and pH which can be harmful to aquatic flora and fauna species. Water from concrete curing can additionally be high in chromium and can accumulate in the gills of fish affecting the health of aquatic organisms • Mobilisation of litter, leaks and spills may lead to the introduction of gross pollutants, hydrocarbons and heavy metals into the waterways which may be harmful to aquatic ecosystems.	
Drainage work		
• Excavation and vegetation clearing • Instream works such as installation and/or extension of culverts, • Construction of swales and water quality basins	Potential causes of water quality impacts from the construction of drainage infrastructure may include: • Transportation of soils, exposed sediments and contaminants associated with earthworks and vegetation clearing to downstream receiving environments via wind and stormwater runoff. Tannin leachate from vegetation clearing and mulching can enter downstream watercourses via stormwater runoff • Altered flow rate and flow regime which may result in bank erosion that could subsequently lead to transport of sediments and other contaminants into the retained watercourses The impacts to water quality are those previously discussed.	**Little Hartley to River Lett** Unnamed tributary of Butlers Creek (3rd order ephemeral) Unnamed drainage lines (1st and 2nd order ephemeral streams) **Coxs River Road** Unnamed drainage lines (1st order ephemeral streams) **River Lett Hill to Forty Bends** Boxes Creek River Lett

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
		Unnamed drainage lines (1st and 2nd order ephemeral streams) **Forty Bends to Lithgow/South Bowenfels** Unnamed drainage lines (1st order ephemeral streams)
Excavation and relocation of utilities		
Relocation of utilities such as water main, telecommunication facilities underground	Potential causes of water quality impacts associated with relocation of utilities may include: • Soil disturbance from trenching and underboring and construction of new service routes • Erosion of disturbed soils from machinery The impacts to water quality from erosion and sedimentation are as per those already discussed.	**Little Hartley to River Lett** Unnamed tributary of Butlers Creek (3rd order ephemeral) Unnamed drainage lines (1st and 2nd order ephemeral streams) **Coxs River Road** Unnamed drainage lines (1st order ephemeral streams) **River Lett Hill to Forty Bends** Boxes Creek River Lett Unnamed drainage lines (1st and 2nd order ephemeral streams) **Forty Bends to Lithgow/South Bowenfels** Unnamed drainage line (1st

Construction activity	Potential surface water quality impacts	Waterway potentially impacted and relevant design section
		order ephemeral stream)
Site restoration		
Restoration and landscaping of disturbed areas (including ancillary facilities and access roads) where required	Potential causes of water quality impacts during site restoration may include: • Erosion of disturbed soils that have not yet stabilised during landscaping, with potential for sediment to be transported downstream by wind or runoff. The impacts to water quality from erosion and sedimentation are as per those already discussed.	All waterways

Water quality would be managed within the area bounded by the construction footprint.

During construction, temporary sediment basins are required to capture and treat runoff from all disturbed areas of the Proposal before discharging into the receiving waterways. The proposed erosion and sediment control measures and the sizing of temporary sediment basins used during the construction must meet the requirements of *Managing Urban Stormwater, Soils and Construction guidelines, Volume 1* (Landcom, 2004) and *Volume 2* (2008); and *Managing Urban Stormwater, Volume 2D*: Main Road Construction (DECC, 2008).

Where construction does not result in a high potential for erosion, such as resurfacing existing roads, or where sediment basins are not warranted as per the requirements of the Blue Book, local sediment controls, such as sediment fences, filter logs, level spreaders and other source controls would be required.

With the implementation of the safeguards and management measures listed in Section 6.6.4, construction of the proposal would have minimal impact on existing water quality.

Operation

Soils

The potential risk for erosion and sedimentation of soils is considered to be low during operation of the proposal. Soils disturbed during construction would be stabilised through rehabilitation and landscaping (see Section 6.9 Landscape Character and Visual Impact). All roads, bridges, batters, median strips and drainage channels would either be sealed or would have been stabilised with topsoil, hydromulching, landscaping or other scour protection.

There is potential for soil contamination on the road verges from contaminated stormwater runoff due to leaks and spills occurring from vehicles using the road. This is discussed further in Section 6.12 Contamination. Maintenance activities undertaken during operation, such as the management of vegetation, clearing of culverts and table drains, and the use of vehicles on unpaved areas, have the potential to disturb soils. The risk would be relatively low due to the scheduled nature of maintenance activities. The impacts associated with maintenance activities would be managed by adhering to Transport maintenance specifications.

Surface water quality

During the operational phase of the proposal, the site would be completely stabilised, all roads and bridges would be sealed, cleared areas would be landscaped and scour protection would be installed. There would be no exposed topsoils and therefore little or no risk of soil erosion and subsequent transport of sediment into downstream waterways. Water quality risks during operation therefore relate to increased pollutant deposition from increased traffic loading due to improved road conditions which are washed to downstream waterways following rainfall, accidental spills and operational basin discharges.

The proposal lies inside the Sydney drinking water catchment, therefore the design criteria for water quality are required to satisfy the requirements of the State Environmental Planning Policy (SEPP) for the drinking catchment. The key criteria are that the annual average pollutant loads for proposed mitigated conditions must be equal or better than the annual average pollutant loads for current conditions.

Proposed water quality controls consist of vegetated swales, water quality wet basins and dry biofiltration basins. Water quality controls for all roads with high traffic volumes need to be provided where practicable. Water quality treatment for local roads and access ramps with lower traffic volumes is not warranted due to minimal pollutant loads.

Proposed developments in the Sydney drinking water catchment must have a neutral or beneficial effect on water quality, as specified in the Sydney Drinking Water SEPP. This is assessed using the Neutral or Beneficial Effect on Water Quality (NorBE) Assessment Tool. A NorBE assessment was conducted for this phase of the proposal, with a summary provided in Appendix C. This assessment will need to be updated during the detailed design phase.

6.6.4 Safeguards and management measures

Table 6-83 Safeguards and management measures – soils and surface water

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
SW01	Erosion and sedimentation of soils / Surface water quality	A Construction Soil and Water Management Plan (CSWMP) would be developed as a subplan to the CEMP and will outline measures to manage water quality impacts associated with construction work. The CWSMP will provide: • An Erosion and Sediment Control Plan (ESCP) including measures to mitigate erosion and sediment transport both within the construction footprint and offsite including requirements for the preparation of erosion and sediment control plans for all progressive stages of	Contractor	Prior to construction Construction	Appendix I	All

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
		construction and the implementation of erosion and sediment control measures including the use of sediment basins. • Erosion and sediment control measures which would be implemented and maintained in accordance with *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom, 2004) and *Volume 2D* (DECC, 2008). • Measures to manage stockpiles including locations, separation of waste types, sediment controls and stabilisation. • Measures to manage waste including classification and handling of spoil. • Measures to manage tannin leachates. • Measures to manage accidental spills including requirement to maintain materials such as spill kits, an emergency response procedures and regular visual water quality checks when working near waterways. • Controls for sensitive receiving environments which may include but not be limited to designation of 'no go' zone for construction plant and equipment (where application).				

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
SW02	Erosion and sedimentation of soils / Surface water quality	A soil conservation specialist will be engaged for the duration of construction of the proposal to provide advice on the planning an implementation of erosion and sediment control including review of the Construction Soil and Water Management Plan and Erosion and Sediment Control Plan.	Transport / Contractor	Prior to construction Construction	Appendix I	All
SW03	Neutral or Beneficial Effect (NorBE) assessment for water quality	A further NorBE assessment will be undertaken during detailed design.	Contractor	Detailed design	Appendix I	All
SW04	Water reuse	A water reuse strategy will be developed as part of the CEMP for both construction and operation to reduce reliance on potable water. Any water from sediment basins will be checked to ensure compliance with *ANZG (2018) Water Quality Guidelines* for proper reuse.	Contractor	Detailed design Prior to construction Construction	Appendix I	All
SW05	Water balance	A water balance assessment may need to be undertaken at the design stages to determine if there is any impact on the quantity of surface runoff that is currently received at various private farm dams located at the downstream end (within approximately 500 meters) of the proposed road corridor. Any increases or decreases would need to be quantified based on an	Transport	Detailed design	Appendix I	All

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
		average yearly runoff yield assessment at each of the affected farm dams.				
SW06	Surface water quality impacts	A surface water quality monitoring program will be developed in accordance with the *Guidelines for Construction Water Quality Monitoring* (RTA, 2003). The program will monitor surface water prior to construction, during construction and during operation.	Transport / Contractor	Prior to construction Construction Operation	Appendix I	All
SW07	Surface water quality impacts	An Acid Sulfate Rock Management Plan (ASRMP) would be prepared to provide information on the mitigation and management of acid sulfate rock disturbed as part of the construction works.	Contractor	Detailed design Prior to construction Construction	Appendix I	All

Other safeguards and management measures that would address soils and surface water impacts are identified in Sections 6.1 Biodiversity, 6.7 Groundwater and 6.12 Contamination.