Appendix B – Hydrology and Hydraulics Assessment

City of Newcastle

Richmond Vale Rail Trail

Hydrology and Hydraulics Assessment

March 2019

Table of contents

Table index

Figure index

Appendices

1. Introduction

The Richmond Vale Rail Trail is proposed to run along the former Richmond Vale Railway between Kurri Kurri and Shortland, along the former Chichester to Newcastle water main between Shortland and Tarro, and through the Hunter Wetlands National Park. The proposal would traverse Cessnock, Newcastle and Lake Macquarie local government areas.

1.1 Purpose of this report

The purpose of this report is to undertake necessary assessments required to determine the potential impact of the project on existing water resources.

1.2 Proposed project

The project will involve the construction of a shared pathway that will generally consist of a three metre wide pavement constructed on an existing cleared rail alignment. Construction activities will include removal of unsuitable subgrades, and importation of pavements such as gravel, asphalt and concrete. In addition, a number of existing rock cuttings will require stabilising treatments.

1.3 Scope and limitations

This report has been prepared by GHD for City of Newcastle (Council) and may only be used and relied on by Council for the purpose agreed between GHD and Council as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.3.1 Project assumptions

The following assumptions have been made as part of this project:

- Climate change has not been considered as part of the preliminary modelling undertaken as part of this assessment however it is expected that this will be considered as part of the design requirements in terms of drainage capacity sensitivity assessments.
- Water quality data utilised in this assessment has been sourced from what is publically available or already reported on previously. This information may not represent the most current conditions.

2. Legislation, policies and guidelines

2.1 Legislation

The following sections provide an overview of the legislation relevant to this Hydrology and Hydraulics Assessment (HHA).

2.1.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A), administered by the NSW Department of Planning and Environment, is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed.

This assessment has been prepared to support an Environmental Impact Statement (EIS) that is being prepared to support the project.

2.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal, and for water, air, land and noise pollution.

None of the project components (Section 1.2) are defined as 'Scheduled Activities' under Schedule 1 of the POEO Act. Therefore, an Environment Protection Licence is not required for the project.

2.1.3 Water Management Act 2000

The *Water Management Act 2000* (WM Act) aims to provide for the sustainable and integrated management of water sources of the State for the benefit of both present and future generations. The WM Act regulates such aspects as water sharing plans (WSPs) and controlled activities approvals, which are discussed below.

Water Sharing Plans

The WSP regulates the interception and extraction of unregulated and alluvial water sources within the defined WSP area. For the interference and extraction of surface water because of the project, a Water Access Licence (WAL) will be required.

The project is located within the area covered by:

- The Newcastle Water Source within the WSP for the Hunter Unregulated and Alluvial Water Sources, which commenced on August 1 2009
- The Tomago Groundwater Source within the WSP for the North Coast Coastal Sands Groundwater Sources, which commenced 1 July 2016
- The Sydney Basin – North Coast WSP for the North Coast Fractured and Porous Groundwater Sources, which commenced 1 July 2016

Whilst the project is not expected to impact local groundwater sources, any groundwater extractions from this source would require a WAL.

A total of 13 registered bores are located within approximately two kilometres of the proposal site (http://allwaterdata.water.nsw.gov.au/water.stm). The majority of the bores are registered as monitoring or test bores. The remainder of the bores are registered for stock or domestic use. The depth to groundwater ranges between 2.8 - 72 metres below ground level. Regional groundwater would generally be expected to flow in an easterly and south-easterly direction towards the Hunter River.

High priority groundwater dependent ecosystems listed in the WSP for the North Coast Fractured and Porous Rock Groundwater Sources and the WSP for the Hunter Unregulated and Alluvial Water Sources includes the wetlands associated with the Hexham Swamp.

Controlled activities approval

For development works within 40 metres of a declared waterway (blue line on a topographic map, at 1:25,000 scale) such as streams, lakes and lagoons, approval is required under the WM Act, unless an exemption is defined. Relevant works include excavations of land or any other works that would detrimentally influence the passage of water within a declared waterway.

2.1.4 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) includes provisions to list threatened species of fish and marine vegetation, including endangered populations, ecological communities and key threatened processes. If the proposal is likely to significantly impact on threatened species, populations or ecological communities, then a species impact statement is required.

Under Part 7 of the FM Act, a permit is required for dredging and reclamation, obstruction of fish passage, harm to marine vegetation and use of electrical or explosive devices in a waterway.

2.2 Policies

2.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The National Water Quality Management Strategy (NWQMS) provides a national framework for improving water quality in Australia's waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources, protecting and enhancing their quality, while maintaining economic and social development.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) is a benchmark document of the NWQMS, which provides a guide for assessing and managing ambient water quality in a wide range of water resource types, and according to specified environmental values such as aquatic ecosystems, primary industries, recreation and drinking water. ANZECC (2000) provides a framework for determining appropriate trigger values or performance criteria to evaluate the results of water quality monitoring programs. Guideline trigger values are conservative assessment levels that, if exceeded, provide an early indication of potential environmental impact and prompt further investigation or remedial action.

2.2.2 Managing Urban Stormwater

Managing Urban Stormwater: Soils and Construction Volume 1 (The 'Blue Book'; Landcom, 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters.

This document relates particularly to urban development sites however it is relevant to the project as it provides guidance on the configuration of erosion and sedimentation controls required during construction.

3. Existing conditions

3.1 Topography and land use

The Richmond Vale Rail Trail alignment may be divided into the following four landscapes.

Shortland

A short section of the trail in moderately undulating terrain. The trail starts on a north-facing slope that descends to Hexham Swamp, within a fenced easement bound on both sides by residential properties.

Hexham

A 13 kilometre section of the trail located within a vast, low lying plain which includes:

- Saline/brackish swamp, adjacent to the Hunter River
- Fresh water marsh
- Relic beach located on the margins of the swamp to the north and west

The margins of the swamp comprise open valleys of low relief with alluvial plains and terraces. Land use is predominantly farmland with fields and stands of trees adjacent to narrow creek lines.

The rail corridor crosses numerous watercourses/drainage lines including Ironbark Creek, Fishery Creek, Purgatory Creek and at least four unnamed creeks that cross the east west section of the alignment. All of these watercourses are located within the Hunter River catchment.

Sugarloaf

A 10.4 kilometre section of the trail located within an area characterised by moderate to steep terrain, which includes incised gullies and woodland vegetation with dense undergrowth along watercourses.

Kurri Kurri Plateau

A 5.8 kilometre section of the trail located in an area that is characterised by generally undulating terrain. The trail crosses a number of ephemeral and permanent narrow creeks, which have developed narrow terraces of flat alluvial deposits. The rail corridor crosses two major watercourses (Surveyors Creek and Wallis Creek).

Vegetation comprises cleared farmland or relatively open woodland. The last 500 metres of the trail is generally flat and is adjacent to residential dwellings.

3.2 Structure inspection

An inspection of the culverts along the corridor was undertaken to gain information relating to the structure size and form. Where structures were not located (generally due to excessive vegetation at the culvert locations), the structure was not included in the analysis.

Structure locations were determined from data supplied for the project.

3.3 Climate

The variation in rainfall and potential evaporation, estimated from daily observations from the Bureau of Meteorology (BOM) Raymond Terrace (Kinross) Station 061031, located about 9 kilometres from the project area, is summarised in Figure 3-1.

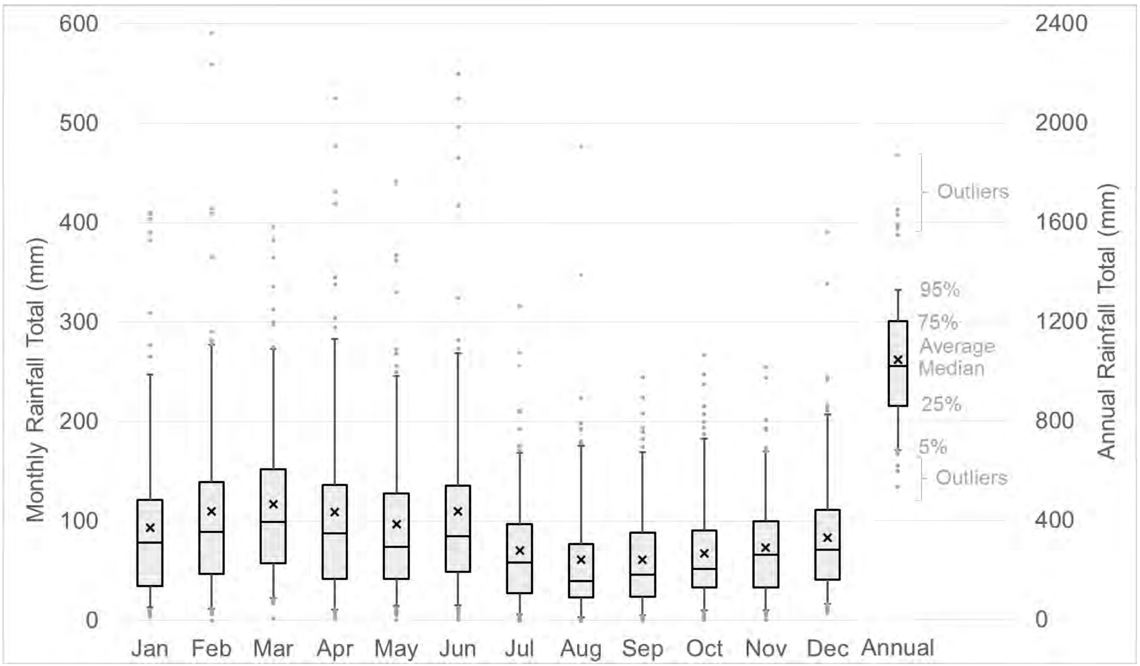


Figure 3-1 Monthly and annual rainfall totals (BOM station 061031, downloaded 30 November 2018)

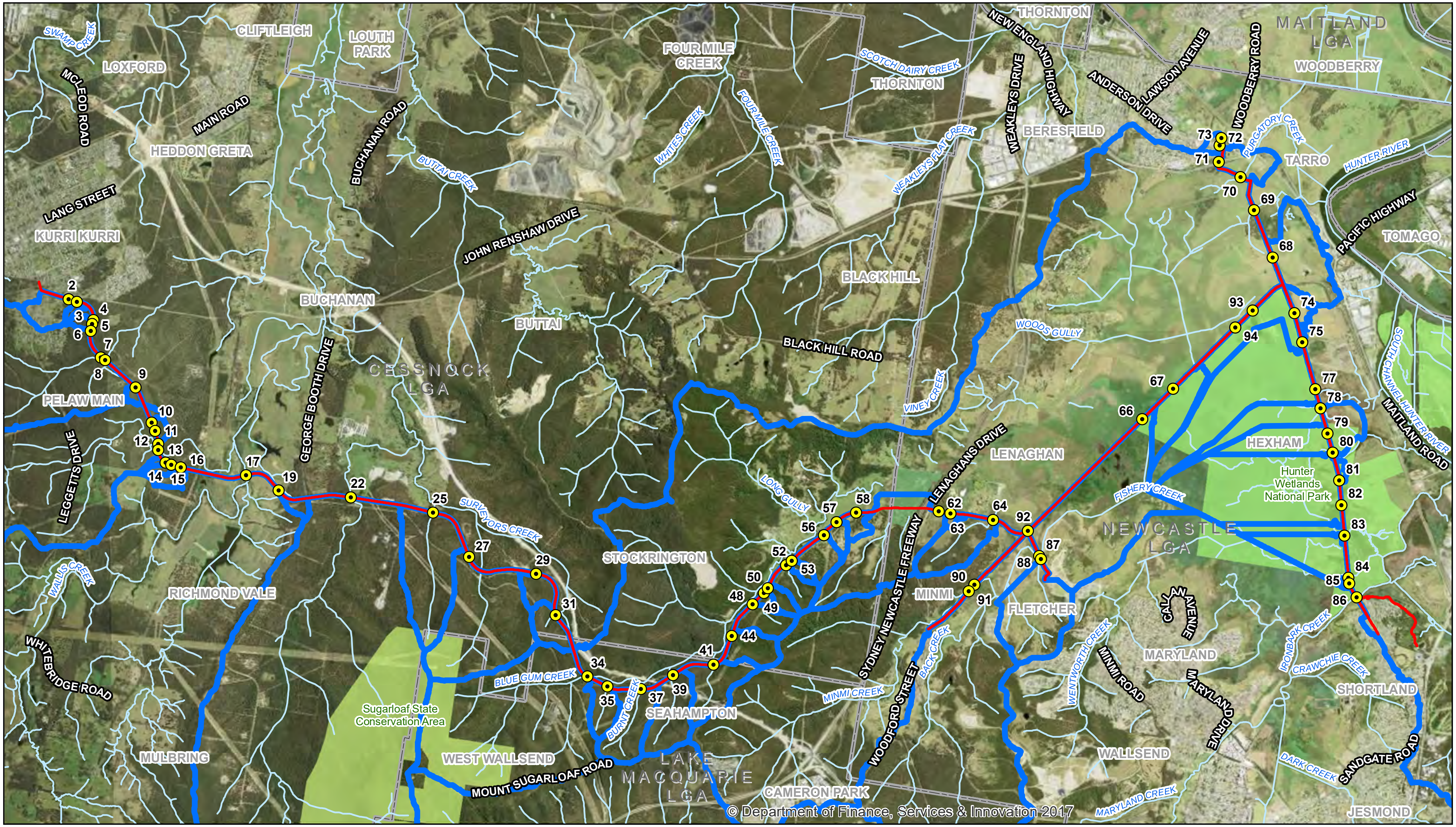
From Figure 3-1 it can be seen that monthly rainfall averages indicate generally higher rainfall during the summer and autumn compared with a relatively drier winter and spring period.

3.4 Hydrology

The proposal is located on the Hunter River floodplain. The Southern Channel of the Hunter River is approximately 2.5 kilometres to the east. The proposal crosses a number of creeks and drainage channels including Ironbark Creek, Fishery Creek, Purgatory Creek, Minmi Creek, Wallis Creek and Surveyors Creek.

The Hexham Swamp covers a large portion of the proposal site. It is mapped as a coastal wetland under SEPP 14 and coincides with part of the area gazetted as the Hunter Wetlands National Park.

The hydrological features of the study area, including the catchment areas draining to each structure, are shown in Figure 3-2.



Paper Size A4

0 0.6 1.2 1.8 2.4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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LEGEND

- Culvert locations
- Proposed route
- Subcatchment boundaries
- Watercourse
- LGA boundary
- National park
- Nature reserve
- State Conservation Area

GHD

Newcastle City Council
Richmond Vale Rail Trail
Hydrology and Hydraulics Assessment

Job Number	22-18317
Revision	0
Date	12 Mar 2019

Hydrological features

Figure 3-2

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB / DCDB, 2012, Aerial 2016. Created by: fmackay

3.4.1 Alluvial aquifers

Alluvial aquifers consist of deposits of unconsolidated silts, sand and minor fine gravels of mixed colluvial-alluvial origin. The Geotechnical Assessment Report (GHD 2016) indicates that alluvial aquifers are present in many of the valleys of creeks and gullies within the vicinity of the project, however it is understood that they do not have significant groundwater storage capacity.

3.5 Regional flooding

The proposal site is located within areas mapped as medium and high flood risk on Council's flood maps (see Figure 3-3). Due to its coastal location, the proposal site would be subject to flooding during high rainfall events, elevated ocean levels and a combination of both.

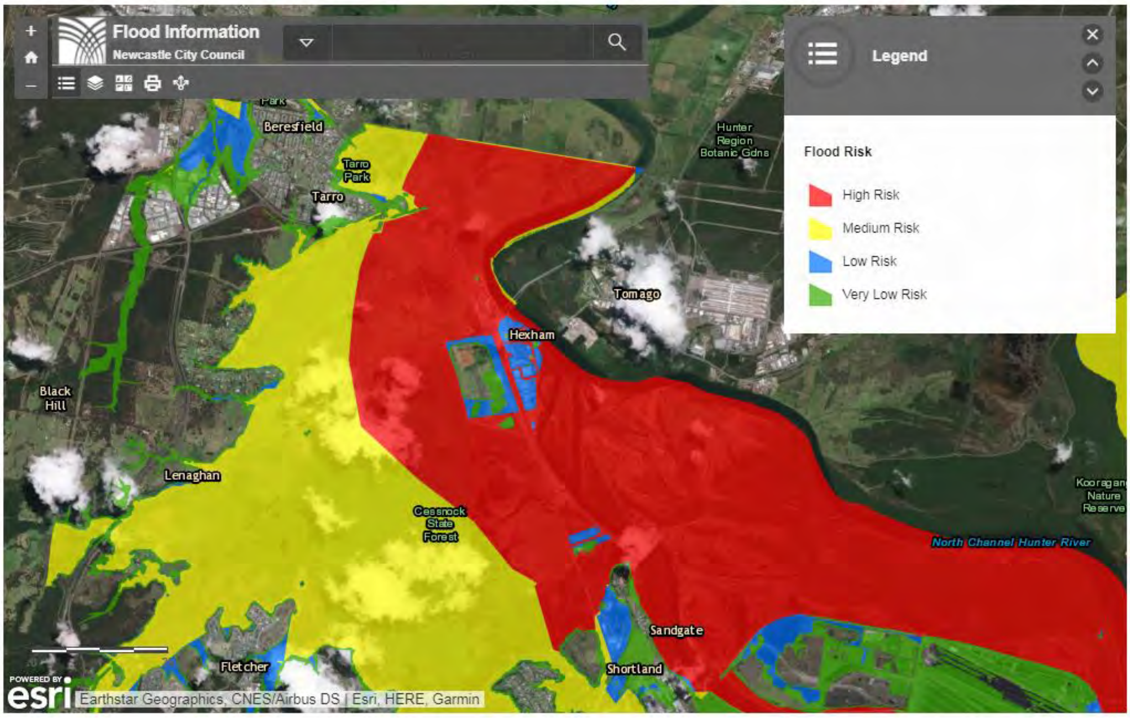

Figure 3-3 Flood risk of the study area (source: Council website, accessed 23 march 2018)

As the trail is located within an existing rail formation, the potential impacts of the trail on regional flooding is considered minimal. This includes the potential impacts of future sea level rise due to climate change. As the trail is located within areas of high flood risk, it is considered likely that the trail would be periodically inundated by floodwater.

3.6 Local flooding

A high-level analysis was undertaken to estimate the upstream flood levels for the existing culvert and bridge crossings, and identify potential modifications that may be required to minimise the flood impacts to the surrounding area and provide a reasonable flood immunity to the trail.

3.6.1 Peak local runoff estimation

Along the proposed alignment, 66 catchments were delineated ranging from 0.001 ha to 10,500 ha (Figure 3-2).

Two methods were used to determine the peak flood discharge based on the catchment size:

- The Probabilistic Rational Method (PRM) uses 1987 design rainfall (Engineers Australia 1987)
- The Regional Flood Frequency Estimation Model (RFFE) uses 2016 design rainfall (Geoscience Australia 2016)

Design rainfall intensities were obtained for a point located approximately within the middle of the trail for the 50%, 20%, 10%, 5%, 2% and 1% annual exceedance probability (AEP) design storm events using the BOM's intensity-frequency-duration (IFD) calculator web site, for both the 1987 and 2016 data series. For comparison purposes, it was assumed that 50%, 10% and 5% AEP events are equivalent to 2 year, 5 year and 10 year ARI events respectively.

The PRM was considered more representative for smaller sized catchments, as the smallest gauge available for the RFFE method was 2.3 square kilometres. Therefore, the PRM was used for catchments smaller than 0.5 square kilometres, and the RFFE method used for catchments larger than 2.3 square kilometres. For catchments with areas between 0.5 square kilometres and 2.3 square kilometres, either the PRM or RFFE method was used depending on shape factor anomalies and magnitude of design flow.

The estimated peak flood flows for each of the local catchments is summarised in Appendix A.

3.6.2 Upstream flood level estimation

The software package *Bentley CulvertMaster v3.3* was used to estimate the upstream design flood levels for 18 culverts and bridges for the 50% AEP, 20% AEP, 10% AEP, 5% AEP, 2% AEP and 1% AEP design storm events. Table 3-1 includes a summary of the assumptions and parameters used in the modelling.

Table 3-1 Hydraulic modelling assumptions and parameters

Item	Assumption/Parameter
Structure	• Structures inlet controlled • 1% slope • Roadway elevation is 1.5 times opening diameter or height • Manning's n = 0.013 for concrete pipe and culverts, and n = 0.035 for bridges • Well maintained crossings with no blockage
Overtopping	• Broad crested weir action (1.4 coefficient, 20 m length)

The maximum modelled flood levels upstream of each crossing structure (above the crossing invert) and the depth of overtopping of the trail are included in Appendix B.

Major creek crossings at Ironbark Creek Bridge (catchment 86), Fishery Creek Bridge (catchment 87), Purgatory Creek Crossing (catchment 69), Surveyors Creek Crossing (catchment 22), Wallis Creek Bridge (catchment 17) and boardwalks were not assessed for design flood levels using this methodology, as minimal geometric information was available for the identified infrastructure. Photographs indicate that some of these bridges exceed 5.0 m in height, which exceed the scope of this high-level hydraulic investigation.

Furthermore, there were a number of identified catchments less than 0.1 km^2. The upstream flood levels of the associated crossings were not included, as the flood depths were less than 100 millimetres. It is possible that these crossing locations receive flow contribution from adjacent catchments.

The modelling indicates that for the 18 analysed crossing structures, seven are estimated to include trail elevations that are expected to remain above the maximum-modelled flood level for the one per cent AEP local flood event. Of the remaining eleven structures, the flood immunity of the trail ranges from less than the 50 per cent AEP local flood event (catchments 68; 77; 82; and 90) to the two per cent AEP local catchment flood event (catchment 70).

3.7 Water quality

A search was carried out for publicly available water quality data near the study area, including data held by NSW Office of Environment and Heritage (OEH), Council and Waterwatch NSW. Very limited water quality data was available, although some data over the period 2006 to 2015 was provided by Council. The Council water quality dataset was all collected within the Dark Creek and Ironbark Creek catchments. The available water quality data is presented in Appendix C, and is summarised and compared to the relevant ANZECC (2000) trigger values in Table 3-2.

Table 3-2 Water quality summary

Analyte	Units	ANZECC default trigger values	Dark Creek		Ironbark Creek	
			Median	Range	Median	Range
Salinity (as EC)	µS/cm	125 to 2200 [(a)]	572	97 to 3400	424	100 to 22,700
Turbidity	NTU	6 to 50 [(a)]	17.1	2 to 280	10.8	0 to 286
DO	%	85 to 110 [(b)]	7.2 mg/L (80% [d])	0.1 to 15.3 mg/L (1% to 170% [d])	6.7 mg/L (74% [d])	0.4 to 18.2 mg/L (4% to 200% [d])
TN	mg/L	0.35 [(b)] 0.30 [(c)]	0.085	0.003 to 1.2	0.085	0.001 to 7.79
TP	mg/L	0.025 [(b)] 0.03 [(c)]	0.7	0.06 to 0.83	0.11	0.06 to 0.2
pH	-	6.5 to 8.5 [(b)] 7.0 to 8.5 [(c)]	7.1	4.1 to 9.2	7.0	4.4 to 9.6

[a] NSW Lowland rivers
[b] NSW Coastal rivers
[c] NSW estuaries
[d] at sea level and 20°C

The data indicate that water in the Dark Creek catchment is typically fresh to brackish and slightly acidic to slightly alkaline, with observed salinity and pH generally within the reference trigger ranges (Table 3-2). Total Nitrogen (TN) and total phosphorous (TP) is generally above the reference trigger range (Table 3-2), indicating a potential excess of nutrients under existing conditions.

The data indicate that water in the Ironbark Creek is generally good with respect to salinity, turbidity and pH, which are generally within the default trigger ranges (Table 3-2). However, as with Dark Creek, nutrient concentrations (i.e. TN and TP) generally exceed the default trigger values.

3.8 Sensitive receptors

The lower reaches of the Ironbark Creek catchment contain extensive areas of wetlands associated with the Hunter River floodplain. These wetland areas are protected by various legislation, agreements and planning instruments that in some cases include multiple listings for the same area:

- Hunter Estuary Wetlands Ramsar site (EPBC Act) – this is comprised of the Kooragang Nature Reserve (located on the north arm of the Hunter River) and Shortland Wetlands which is located about six kilometres downstream of the project.
- Hunter Wetlands Nature Reserve (NSW National Parks and Wildlife Act 1974) – this site is comprised of a number of areas on the south and north arms of the Hunter River, the nearest of which is about six kilometres downstream of the project. This area is also mapped as a nationally important wetland.
- There are a number of areas mapped under State environmental planning policy no. 14 – Coastal wetlands (SEPP 14) on the south and north arms of the Hunter River, the nearest of which is about three kilometres downstream of the project.

The downstream wetlands are generally brackish to saline due to tidal influence, and slightly acidic to slightly alkaline. Available water quality data is discussed in Section 3.7.

4. Impact assessment and mitigation

4.1 Hydrology

4.1.1 Construction

Construction activities will include the installation or modification of existing watercourse crossing structures and bridges. This will require works within existing drainage lines, which may require temporary diversions, which could affect flow pathways and flow volumes downstream.

The construction of the watercourse crossing structures and bridges should be undertaken outside of periods of extended wet weather in order to minimise the requirement to divert flows around the works site. If flows are to be diverted, they are to be intercepted, diverted and discharge as near as practical to the existing flow path(s).

These measures will minimise the potential changes to flow pathways and flow volumes in the downstream environment.

It is considered that water access licences will not be required for the construction stage of the project, as no surface water is to be stored or otherwise redirected, except those managed under the POEO Act.

4.1.2 Operation

The trail will include upgraded or modified watercourse crossing structures. These structures have the potential to alter the existing flow paths and flow rates, which could affect the downstream watercourses, including the wetlands.

The detailed design of the trail is expected to maintain the location of existing watercourse crossings, in order to maintain the existing flow pathways. Detailed hydraulic modelling should also be undertaken as part of the detailed design process in order to identify cross structure upgrades that, as far as reasonably practical, match the existing hydraulic response. This will minimise the potential changes to flow rates within the downstream environment.

It is considered that water access licences will not be required for the operational stage of the project, as no surface water is to be stored or otherwise redirected because of the project.

4.2 Flooding

4.2.1 Construction

Construction activities will require the excavation, stockpiling and placement of material associated with the track. These activities have the potential to alter flood flows.

Wherever practical, stockpiles will be located outside of high risk flood areas (i.e. away from existing drainage lines) in order to minimise the potential alteration of flood levels, pathways and velocities during construction.

4.2.2 Operation

The impacts on stormwater runoff, flood storage and flooding due to the proposal would be minimal. The detailed design would include relevant management measures to minimise impacts.

To protect trail users during periods of flood:

- Operational procedures would include measures to restrict access to the trail and ensure safety of users during proposal operation.
- Instructional signage would include historical flood levels, flood depth indicators and safety procedures for trail users to follow in the case of flood. This would include emergency contact details and assembly points.

The detailed design process should include detailed hydraulic modelling of the proposed upgrades in order to identify cross structure upgrades that, as far as reasonably practical, match the existing hydraulic response. This will minimise the potential indirect impacts on the wetland.

A preliminary assessment of the crossing options for a portion of the trail that crosses an area of swamp adjacent to Fletcher is included in Appendix D.

4.3 Water quality

4.3.1 Construction

During construction of the project, disturbance activities have the potential to impact on the downstream environment through increased total suspended solids, oils and grease concentrations and turbidity levels.

Construction of the proposal would be undertaken so that there would be a minimum amount of excavation of the existing soil to minimise potential impacts on the groundwater level. The period of excavation would be minimised to reduce the potential for groundwater impacts.

Given the size of the disturbance required to construct the project, a soil and water management plan will be required. This will include erosion and sediment control plans, and a consideration of increased environmental management requirements.

An emergency response plan would be prepared to include a procedure for managing flooding due to natural events. This would include an emergency procedure for ensuring the health and safety of construction workers.

Generally, the soil and water management plan will include:

- Environmental constraints analysis (climate, soil, topography, flooding, and contamination)
- Construction timing and staging
- Progressive erosion and sediment control approaches
- Sizing of temporary drainage requirements and controls
- Particular requirements for work in and over Ironbark and Fishery creeks
- Reporting requirements, responsibilities of team members and training
- Monitoring programs

The erosion and sediment control principles will include:

- The installation of erosion and sediment controls is the first stage in any clearing or construction activities.

- Clean runoff from areas upslope of works areas should be diverted around the work site to minimise the volume of sediment-laden water generated within the work area.
- Construction activities should be undertaken progressively along the construction corridor. Erosion and sediment control measures should be installed in advance of each construction section and only removed as each construction section is completed and stabilised.
- All erosion and sediment control devices are to be regularly inspected, especially following rainfall events, to ensure they remain in good order.
- Only after construction related activities have been completed and the site stabilised can any erosion and sediment control devices be removed.

4.3.2 Monitoring

During construction, water quality monitoring should be undertaken during rainfall events upstream and downstream of active works areas. The monitoring is intended to identify potential discharges of dirty water during rainfall events and should include, at a minimum, total suspended solids, turbidity, salinity and pH.

Water quality monitoring should be continued following the completion of each construction stage, in order to demonstrate that the site is rehabilitated and erosion and sediment controls can be removed.

Regular visual inspection of all erosion and sediment controls should be undertaken, at a minimum weekly and following rainfall, to allow potential issues with the controls to be identified and repairs undertaken in a timely manner.

4.3.3 Operation

The raising of the trail and modifications to the watercourse crossing structures has the potential to increase flow velocities downstream within the watercourses downstream of the trail. These increases could result in a localised increase in erosion and scour of watercourse bed and banks.

The detailed design of the watercourse crossing structures should include suitable scour protection measures to reduce the discharge velocities to minimise the risk of erosion and scouring within the watercourses downstream of the trail.

4.4 Groundwater

4.4.1 Construction

Earthworks for the proposal would be limited to minor cut and fill along the proposal route of generally 0.2 metres depth or less. There would be limited regrading of existing embankments and cuttings. Accordingly, there is little likelihood of significant impact to surface water during construction.

The excavation associated with construction of the Ironbark Creek and Fishery Creek crossings could intercept groundwater. If groundwater were intercepted, dewatering of excavations would be required. Any potential impact on groundwater level would be limited to the vicinity of the excavation and would have negligible impact on the seepage or flow of groundwater to the Hexham Swamp or high priority groundwater dependent ecosystems. Following construction any excavations associated with creek crossings would be backfilled. No other excavations are expected to intercept groundwater.

4.4.2 Operation

There is not expected to be any ongoing interception of groundwater during proposal operation, therefore it is considered that aquifer access licences will not be required for the operational stage of the project.

4.5 Coastal processes and sea level rise

The site is located about twelve kilometres upriver from the mouth of the Hunter River, meaning that hazards associated with natural coastal processes, such as beach erosion and recession, are not expected to extend sufficiently upriver to affect the project. As noted in Section 3.5, the low-lying nature of the site means that flood levels are influenced by both rainfall and the sea levels. With sea level rise predicted due to climate change, the lower portions of the site are likely to be flooded more frequently.

The detailed design process should include detailed hydraulic modelling that considers the potential influence of sea level rise (and changes to rainfall intensity) because of future climate change, in order to understand better the potential reduction in the flood immunity of the trail. The modelling could also be used to identify potential future design modifications that could be implemented, if required, to preserve the proposed flood immunity of the trail under future climate conditions.

5. Summary

The proposal includes the construction of a pedestrian and cycle path along the alignment of the former Richmond Vale Railway line and former Chichester to Newcastle pipeline alignment. The works will include:

- Modification of the existing formation to provide a suitable pathway. This includes sections where the formation is to be raised and widened.
- Upgrade or replacement of the existing watercourse crossing structures (i.e. culverts and bridges) to provide additional drainage capacity (where the formation is being raised) or extended to accommodate the widened formation.

The potential impacts associated with construction activities are expected to consist principally of water quality impacts to the downstream environment, due to the discharge of sediment-laden runoff from active construction areas. In order to minimise the potential impacts of these discharges, a soil and water management plan (including an erosion and sediment control plan) is to be prepared prior to the commencement of construction activities. The soil and water management plan and erosion and sediment control plan will provide details how surface water is to be managed on site during construction.

Water quality monitoring upstream and downstream and works areas, during rainfall events, should be undertaken to identify potential discharges of sediment-laden runoff from active construction areas. This monitoring should continue until construction activities have been completed, the work area rehabilitated and erosion and sediment controls removed.

Construction is expected to include minor excavation (less than 0.2 metres in depth) therefore, the potential to intercept groundwater is considered low.

The trail is not expected to result in appreciable changes to regional flooding, however changes to the formation height and cross drainage structures has the potential to impact local flow pathways flow volumes and velocities within the downstream environment. During the detailed design phase, detailed hydraulic modelling is to be undertaken to identify watercourse-crossing structures that, as far as practical, provide a comparable hydraulic performance to the existing structures, including the provision of suitable scour protection measures to reduce the potential for erosion and scouring within the downstream environment. The hydraulic modelling would also allow for the estimation of the potential reduction in the flood immunity of the trail due to sea level rise and changes in rainfall intensity due to future climate change.

6. References

ANZECC (2000). *National Water Quality Management Strategy, Paper No. 4, Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), October 2000.

Engineers Australia, 1987, *Australian Rainfall and Runoff.* Institute of Engineers.

Geoscience Australia, 2016, *Australian Rainfall and Runoff*.

GHD (2016), *Richmond Vale Rail Trail Geotechnical Assessment Report*, prepared on behalf of Newcastle City Council.

Landcom (2004) *Managing Urban Stormwater, Soils and Construction Volume 1*.

OEH (2018) *Data from the BioNet Atlas website*, State of NSW through the Office of Environment and Heritage, report generated on 8/01/2018.

Appendices

Appendix A – Local catchment peak flows

Catchment ID	Area (ha)	Method	Design flood flows (m³/s)					
			50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
2	26.3	PRM	1.1	1.7	2.1	2.7	3.5	4.3
3	3.9	PRM	0.23	0.35	0.45	0.57	0.75	0.92
4	4.0	PRM	0.23	0.36	0.46	0.59	0.77	0.94
5	0.1	PRM	0.01	0.01	0.01	0.02	0.02	0.03
6	4.8	PRM	0.27	0.41	0.53	0.69	0.89	1.1
7	**444**	**RFFE**	**14**	**31**	**49**	**70**	**110**	**140**
8	0.0	PRM	0.00	0.00	0.00	0.00	0.00	0.00
9	4.2	PRM	0.24	0.37	0.47	0.61	0.79	0.97
10	3.4	PRM	0.20	0.31	0.40	0.51	0.66	0.81
11	0.001	PRM	0.00	0.00	0.00	0.00	0.00	0.00
12	6.0	PRM	0.32	0.49	0.63	0.82	1.1	1.3
13	**716**	**RFFE**	**17**	**38**	**59**	**85**	**130**	**170**
14	3.0	PRM	0.19	0.28	0.36	0.47	0.61	0.75
15	5.5	PRM	0.30	0.46	0.59	0.76	0.99	1.2
16	9.7	PRM	0.48	0.74	0.95	1.2	1.6	1.9
17	10500	RFFE	80	180	290	410	630	830
19	**7.9**	**PRM**	**0.41**	**0.62**	**0.80**	**1.0**	**1.3**	**1.6**
22	1617	RFFE	30	68	110	150	230	310
25	132	RFFE	7.7	18	27	39	60	80
27	195.4	RFFE	9.7	22	35	50	76	100
29	20.8	PRM	0.89	1.4	1.8	2.3	2.9	3.6
31	26.4	PRM	1.1	1.7	2.1	2.7	3.5	4.4
34	431	RFFE	17	39	60	87	130	180
35	27.4	PRM	1.1	1.7	2.2	2.8	3.7	4.5
37	60.5	RFFE	5.4	12	19	28	42	56
39	62.3	RFFE	5.5	13	19	28	43	57
41	55.2	RFFE	1.9	3.0	3.8	4.9	6.4	7.8
44	33.4	PRM	1.3	2.0	2.6	3.3	4.3	5.2
48	28.2	PRM	1.1	1.7	2.2	2.9	3.7	4.6
49	5.5	PRM	0.30	0.46	0.59	0.76	0.99	1.2
50	11.0	PRM	0.53	0.82	1.1	1.4	1.8	2.2
52	24.7	PRM	1.0	1.6	2.0	2.6	3.4	4.1
53	6.8	PRM	0.36	0.55	0.71	0.91	1.2	1.5
56	26.4	PRM	1.1	1.7	2.1	2.7	3.6	4.4
57	10.9	PRM	0.53	0.81	1.0	1.3	1.7	2.1
58	11.9	PRM	0.57	0.87	1.1	1.4	1.9	2.3
62	160.6	RFFE	9.9	22	35	50	76	100
63	4.0	PRM	0.23	0.35	0.45	0.58	0.76	0.93
64	58.3	RFFE	5.3	12	19	27	41	54
66	**256**	**RFFE**	**12**	**28**	**43**	**62**	**95**	**130**
67	**51.0**	**PRM**	**1.8**	**2.8**	**3.6**	**4.6**	**6.0**	**7.3**
68	**89.7**	**RFFE**	**2.8**	**4.3**	**5.6**	**7.2**	**9.3**	**11**
69	2681	RFFE	48	110	170	240	370	490
70	**30.6**	**PRM**	**1.2**	**1.9**	**2.4**	**3.1**	**4.0**	**4.9**

Catchment ID	Area (ha)	Method	Design flood flows (m^3/s)					
			50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
71	0.001	PRM	0.00	0.00	0.00	0.00	0.00	0.00
72	0.4	PRM	0.04	0.05	0.07	0.09	0.12	0.14
73	6.6	PRM	0.35	0.54	0.69	0.89	1.2	1.4
74	**12.3**	**PRM**	**0.58**	**0.89**	**1.1**	**1.5**	**1.9**	**2.4**
75	**2.2**	**PRM**	**0.14**	**0.21**	**0.27**	**0.35**	**0.46**	**0.56**
77	**197**	**RFFE**	**11**	**25**	**38**	**55**	**83**	**110**
78	**53.7**	**RFFE**	**1.9**	**2.9**	**3.7**	**4.8**	**6.2**	**7.6**
79	**33.9**	**PRM**	**1.3**	**2.0**	**2.6**	**3.3**	**4.3**	**5.3**
80	**57.7**	**RFFE**	**4.7**	**11**	**16**	**24**	**36**	**47**
81	**3.7**	**PRM**	**0.22**	**0.33**	**0.42**	**0.55**	**0.71**	**0.87**
82	**236**	**RFFE**	**11**	**26**	**39**	**57**	**85**	**110**
83	**26.2**	**PRM**	**1.1**	**1.6**	**2.1**	**2.7**	**3.5**	**4.3**
84	58.3	RFFE	3.7	8.4	13	19	29	38
85	2.4	PRM	0.15	0.23	0.29	0.38	0.49	0.60
86	4085	RFFE	53	120	190	270	410	540
87	648	RFFE	19	43	67	97	150	200
88	110	RFFE	7.9	18	28	40	61	80
90	**827**	**RFFE**	**24**	**53**	**83**	**120**	**180**	**240**
91	0.1	PRM	0.01	0.01	0.01	0.01	0.02	0.02
92	0.01	PRM	0.00	0.00	0.00	0.00	0.00	0.00
93	**61.4**	**RFFE**	**2.1**	**3.2**	**4.1**	**5.3**	**6.9**	**8.5**
94	0.003	PRM	0.00	0.00	0.00	0.00	0.00	0.00

Appendix B – Local catchment flood depths

Catchment ID	Existing Crossing	Proposed Treatment	Total upstream flood level from invert (m)						Overtopped flood depth (m)					
			50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
07	3.8m x 3m high open channel	Replace with new bridge or low lying crossing	1.85	3.52	3.71	4.47	5.11	5.63	0.00	0.02	0.21	0.97	1.61	2.13
13	5-1800 RCP	No treatment required	1.48	2.81	3.39	3.91	4.65	5.24	0.00	0.11	0.69	1.21	1.95	2.54
19	600 RCP	Replace like for like	0.65	0.91	0.94	0.96	0.98	1.01	0.00	0.01	0.04	0.06	0.08	0.11
66	2/ 3.2m span bridge	Replace with concrete slab	1.29	2.00	2.37	2.75	3.31	3.78	0.00	0.50	0.87	1.25	1.81	2.28
67	2/ 3.1m span bridge	Replace with concrete slab	0.34	0.46	0.55	0.65	0.77	0.88	0.00	0.00	0.00	0.00	0.00	0.00
68	4/ 450 RCP	No treatment required	0.82	0.90	0.95	1.02	1.10	1.17	0.15	0.23	0.28	0.35	0.43	0.50
70	2/ 1200 x 900 RCB	Extend with 2/ 1200 x 900 RCB	0.49	0.67	0.78	0.93	1.11	1.38	0.00	0.00	0.00	0.00	0.00	0.03
74	5/ 900 RCP	No treatment required	0.26	0.33	0.36	0.43	0.49	0.55	0.00	0.00	0.00	0.00	0.00	0.00
75	2-1050 RCP	No treatment required	0.16	0.23	0.28	0.33	0.37	0.41	0.00	0.00	0.00	0.00	0.00	0.00
77	2900 x 900 RCBC	No treatment required	1.61	2.04	2.36	2.70	3.21	3.64	0.26	0.69	1.01	1.35	1.86	2.29
78	2900 x 900 RCBC	No treatment required	0.56	0.75	0.88	1.06	1.38	1.47	0.00	0.00	0.00	0.00	0.03	0.12
79	2/ 2100x900 RCBC	No treatment required	0.33	0.45	0.53	0.62	0.74	0.85	0.00	0.00	0.00	0.00	0.00	0.00
80	2/ 2100x900 RCBC	No treatment required	0.79	1.40	1.65	1.87	2.17	2.42	0.00	0.05	0.30	0.52	0.82	1.07
81	2/ 2100x900 RCBC	No treatment required	0.10	0.13	0.15	0.18	0.22	0.26	0.00	0.00	0.00	0.00	0.00	0.00
82	2/ 2100x900 RCBC	No treatment required	1.44	1.93	2.26	2.61	3.13	3.56	0.09	0.58	0.91	1.26	1.78	2.21
83	2/ 2100x900 RCBC	No treatment required	0.30	0.38	0.46	0.54	0.65	0.74	0.00	0.00	0.00	0.00	0.00	0.00
90	2/ 900 RCP	Replace like for like	2.12	2.78	3.31	3.89	4.74	5.46	0.77	1.43	1.96	2.54	3.39	4.11
93	2/ 3.3 span bridge	Replace with concrete slab with 2/3.3m spans	0.35	0.47	0.56	0.66	0.79	0.91	0.00	0.00	0.00	0.00	0.00	0.00

Appendix C – Water quality data

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek tributary – behind Heaton Public School	Dark Creek	26/7/2014	14.9	6.82	115	20	8.6	–	0.7	0.45	0.7
Dark Creek tributary – behind Heaton Public School	Dark Creek	9/9/2014	17.8	7.19	680	12	7.3	–	0.06	0.02	0.06
Dark Creek tributary – upstream of Sunset Boulevard	Dark Creek	19/2/2014	23.2	6.53	175	12	1.62	–	0.83	0.61	0.83
Blue Wren Creek Hasluck Drive	Ironbark Creek	2/11/2004	18.4	7.67	1530	50	4.05	–	–	0.62	0.15
Blue Wren Creek Hasluck Drive	Ironbark Creek	26/03/2006	19.7	7.26	227	2	12.1	–	–	0.3	0.032
Blue Wren Creek Hasluck Drive	Ironbark Creek	22/10/2005	19	7.36	252	0	9.09	–	–	0.14	0.018
Blue Wren Creek Hasluck Drive	Ironbark Creek	12/10/2006	19	8	220	0	8.5	–	–	0.48	0.036
Blue Wren Creek Hasluck Drive	Ironbark Creek	19/11/2011	22.23	7.45	614	5	6	–	–	0.03	0.072
Blue Wren Creek Hasluck Drive	Ironbark Creek	26/09/2012	16.21	6.12	910	5.6	10.39	–	–	3.35	0.076
Blue Wren Creek Hasluck Drive	Ironbark Creek	22/10/2014	15.98	7.11	598	0.3	6.72	–	–	–	–
McCaffrey Drive – Rankin Park	Ironbark Creek	24/10/2004	20.9	7.21	678	6	9.82	–	–	0.34	0.24
McCaffrey Drive – Rankin Park	Ironbark Creek	15/04/2005	20.2	7.48	1780	0	2.58	–	–	0.21	0.072
McCaffrey Drive – Rankin Park	Ironbark Creek	22/10/2005	20.4	7.48	1310	0	3.5	–	–	0.48	0.04
McCaffrey Drive – Rankin Park	Ironbark Creek	1/04/2006	19.1	7.46	715	10	7.33	–	–	0.84	0.028
McCaffrey Drive – Rankin Park	Ironbark Creek	12/10/2006	17	8.1	400	0	8.6	–	–	1.26	0.06
McCaffrey Drive – Rankin Park	Ironbark Creek	19/10/2011	20.7	7.98	424	7	9.52	–	–	0.05	0.105

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
McCaffrey Drive – Rankin Park	Ironbark Creek	15/10/2012	16.53	6.63	1730	47.7	5.18	–	–	0.18	0.059
McCaffrey Drive – Rankin Park	Ironbark Creek	8/10/2013	20	7.35	2110	1.9	9.43	–	–	0.04	0.01
Blue Wren Creek Rosedale Cres Reserve	Ironbark Creek	26/03/2006	19	7	222	3	9.4	–	–	0.4	0.13
Blue Wren Creek Rosedale Cres Reserve	Ironbark Creek	19/11/2011	28.86	7.35	580	1.1	4.38	–	–	0.66	0.085
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	24/10/2004	19.1	6.4	276	39	9	–	–	0.31	0.012
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	15/04/2005	19.9	7.02	381	9	0.9	–	–	0.25	0.089
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	22/10/2005	18.5	6.67	363	13	3.45	–	–	0.24	0.08
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	1/04/2006	19.1	6.71	178	208	7.22	–	–	0.7	0.68
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	12/10/2006	22	7.2	4100	0	2.2	–	–	0.81	0.11
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	19/11/2011	19.5	6.5	350	8	6.4	–	–	0.55	0.11
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	29/09/2012	19.38	6.54	310	8.6	3.05	–	–	0.7	0.1
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	19/10/2014	15.52	6.96	308	286	13.2	–	–	–	–
Ironbark Creek – Wallsend Pk off Cowper St	Ironbark Creek	9/11/2005	23.3	6.83	219	3	2.37	–	–	0.98	0.08
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	13/11/2006	20.6	6.9	351	6	0.94	–	–	0.78	0.36
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	20/04/2007	21	6.9	490	1	6.8	–	–	0.05	0.001
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	19/10/2011	19.7	7.4	1300	23	11.5	–	–	0.09	0.33
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	15/10/2012	16.27	6.21	376	6	3.43	–	–	0.15	0.16

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	20/10/2013	23.63	4.44	330	3.1	10.21	–	–	0.02	0.01
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	12/10/2004	18.7	6.54	608	10	6.55	–	–	3.35	0.085
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	5/04/2006	21.3	6.92	203	186	3.31	–	–	0.22	0.055
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	19/04/2007	17	7.9	270	90	0.4	–	–	0.14	0.036
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	17/10/2011	17.7	6.2	610	4.7	11.1	–	–	0.03	0.063
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	15/10/2012	20.67	6.47	464	13.7	3.54	–	–	0.76	0.32
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	8/10/2013	19.49	6.85	341	21.3	9.7	–	–	0.01	0.01
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	28/10/2014	22.59	7.26	366	9.6	10.09	–	–	–	–
Ironbark Creek – Canoe Trail Wetlands Centre	Ironbark Creek	25/11/2004	21.8	7.22	16200	20	8.51	–	–	0.44	0.076
Ironbark Creek – Canoe Trail Wetlands Centre	Ironbark Creek	20/04/2006	23.1	7.21	22500	13	6.41	–	–	0.18	0.08
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	23/10/2004	19.4	5.57	–	18	5.8	–	–	0.33	0.58
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	15/04/2005	20	7.4	250	19	2.3	–	–	0.1	0.043
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	15/10/2005	19.5	6.94	293	3	0.94	–	–	0.22	0.086
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	14/10/2006	21	6.7	360	5	2.1	–	–	0.61	0.15

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	18/10/2011	17.8	6.33	1520	5.6	12.8	–	–	0.04	0.13
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	20/10/2012	20.19	6.03	628	11.3	5.63	–	–	0.26	0.38
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	16/10/2013	16.24	6.11	342	10.4	2.56	–	–	0.03	0.19
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	25/10/2014	21.13	7.2	314	2	5.29	–	–	–	–
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	3/11/2004	23.6	7.29	552	40	9.32	–	–	0.39	0.009
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	25/11/2004	23.8	9.56	601	120	18.22	–	–	1.03	–
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	9/11/2005	27.7	7.05	478	70	10.17	–	–	0.18	0.07
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	29/03/2006	22.2	7.33	1030	12	6.74	–	–	0.89	0.063
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	30/10/2011	20.4	6.33	2260	106	4.1	–	–	0.95	0.12
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	17/10/2012	19.19	6.92	20800	28.3	8.41	–	–	0.055	0.43
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	23/10/2013	22.22	7.11	22700	115	7.39	–	–	0.01	0.01
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	29/10/2014	19.81	7.19	477	5.1	2.52	–	–	–	–
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	24/10/2004	19.3	6.2	870	20	7.5	–	–	0.41	0.38
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	22/10/2005	–	7.72	270	0	3.3	–	–	0.66	0.24
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	12/10/2006	16	7.2	400	2	0.9	–	–	1.46	0.009

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	19/11/2011	19.7	7	330	7.3	6.6	–	–	0.19	0.03
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	29/09/2012	17.51	7.35	312	5.2	10.33	–	–	3.35	0.055
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	20/10/2013	17.21	6.23	470	11.1	6.33	–	–	0.3	0.01
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	8/10/2013	17.53	6.9	579	16.3	5.24	–	–	0.01	0.02
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	25/10/2014	21	7.23	484	9.9	4.06	–	–	–	–
Elermore Vale Reserve	Ironbark Creek	28/02/2014	22.7	7.07	154	28	8.21	20	0.13	–	0.46
Elermore Vale Reserve	Ironbark Creek	27/01/2015	22.1	6.8	140	15	8.77	10	0.11	–	1.03
Elermore Vale Reserve	Ironbark Creek	4/04/2015	20	7.67	250	35	7.57	20	0.12	–	0.78
Wallsend Park	Ironbark Creek	28/02/2014	23.4	6.86	111	85	7.98	91	0.2	–	0.28
Wallsend Park	Ironbark Creek	27/01/2015	22.3	6.8	155	20	8.51	15	0.09	–	7.19
Wallsend Park	Ironbark Creek	4/04/2015	19.8	7.44	100	250	7.41	220	0.07	–	4.35
Ironbark Creek – Federal Reserve	Ironbark Creek	28/02/2014	23.2	6.88	100	100	8.01	112	0.18	–	0.19
Ironbark Creek – Federal Reserve	Ironbark Creek	27/01/2015	21.9	6.8	155	20	8.9	15	0.08	–	7.79
Ironbark Creek – Federal Reserve	Ironbark Creek	4/04/2015	19.9	7.33	150	260	7.81	230	0.06	–	5.26
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	23/10/2004	22.4	6.46	1160	25	7.75	–	–	–	–

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	20/04/2005	19.8	7.48	1800	7	2.35	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	15/10/2005	17.6	7.15	1150	18	1.71	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	5/04/2006	18.9	7.01	2690	12	3.86	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	26/10/2006	19	7.1	1600	40	1.5	–	–	–	–
Acacia Avenue Reserve, Lambton	Dark Creek	26/10/2011	16.6	7.13	1660	30	5.73	–	–	0.1	0.33
Acacia Avenue Reserve, Lambton	Dark Creek	21/10/2012	17.68	7.32	1840	17.1	3.52	–	–	0.2	0.085
Acacia Avenue Reserve, Lambton	Dark Creek	21/10/2013	21.58	8.1	681	262	10.05	–	–	0.01	0.11
Arthur Street Reserve, Lambton	Dark Creek	2/11/2004	17.3	7.32	532	10	6.55	–	–	0.42	0.003
Arthur Street Reserve, Lambton	Dark Creek	2/11/2006	18.5	6.29	572	239	7.2	–	–	0.86	1.2
Arthur Street Reserve, Lambton	Dark Creek	27/10/2011	16.7	4.1	880	16	10.7	–	–	0.08	0.077
Arthur Street Reserve, Lambton	Dark Creek	21/10/2012	17.35	6.47	788	28.3	1.82	–	–	0.66	0.3
Arthur Street Reserve, Lambton	Dark Creek	21/10/2013	19.87	6.87	628	7.2	6.12	–	–	0.03	0.01
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	19/10/2006	17	6.6	3400	7	0.1	–	–	0.58	0.24
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	20/10/2011	20.6	5.96	374	35	4.3	–	–	0.11	0.085
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	21/10/2013	19.09	6.47	98	22.5	10.17	–	–	0.01	0.01

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	19/10/2006	20	7.1	610	10	5.2	–	–	0.23	–
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	19/10/2011	18.2	7.72	2010	12	13.76	–	–	0.03	0.33
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	20/10/2012	22.8	7.18	787	14.3	11.49	–	–	0.76	0.24
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	21/10/2013	20.93	6.5	223	69.4	13.57	–	–	0.1	0.1
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	25/10/2014	18.96	7.15	700	2.7	2.33	–	–	–	–
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	3/11/2004	22	8.28	466	15	9.41	–	–	0.35	0.15
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	15/03/2005	32.7	9.2	388	7	6.97	–	–	0.69	0.068
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	31/03/2006	27.6	8.92	312	10	13.28	–	–	0.3	0.051
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	13/11/2006	25.4	9.23	489	48	10.41	–	–	0.76	0.38
Dark Creek Tributary – Jesmond Park East	Dark Creek	2/11/2004	18.1	7.24	477	2	3.87	–	–	0.35	0.003
Dark Creek Tributary – Jesmond Park East	Dark Creek	18/10/2011	15.8	6.7	1450	10	4.14	–	–	0.06	0.13
Dark Creek Tributary – Jesmond Park East	Dark Creek	20/10/2012	21.26	6.67	445	126	11.81	–	–	0.27	0.085
Dark Creek Tributary – Jesmond Park East	Dark Creek	21/10/2013	22.01	6.34	151	40.4	10.34	–	–	0.02	0.01

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek Tributary – Jesmond Park West	Dark Creek	2/11/2004	19	5.94	97	27	1.42	–	–	0.33	0.04
Dark Creek Tributary – Jesmond Park West	Dark Creek	18/10/2011	17.74	5.39	488	17.2	12.01	–	–	0.16	0.059
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	2/11/2004	24.8	7.33	438	2	13.54	–	–	0.2	0.04
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	22/03/2005	20.1	7.05	249	15	5.83	–	–	0.18	0.059
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	31/03/2006	27	7.13	353	149	15.3	–	–	2	0.043
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	3/11/2004	18.8	7.63	699	8	8.14	–	–	–	–
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	13/11/2006	20	6.85	1210	36	0.77	–	–	0.76	0.38
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	30/10/2011	19.49	7.09	941	280	3.5	–	–	–	–
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	17/10/2012	16.51	6.85	912	25.1	5.94	–	–	1.66	0.95
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	22/10/2013	22.52	6.88	1220	79.6	9.69	–	–	0.01	0.01

Appendix D – Fletcher connection hydrology & hydraulics assessment

Memorandum

04 May 2017

To	Kirk Rowe
Copy to	Lewis Schneider, Gilbert Whyte
From	Lachlan Hammersley — Tel 02 4979 9999
Subject	Fletcher connection from RVRT — Job no. 22/18317

1 Introduction

Newcastle City Council (NCC) require the assessment of the potential impacts to the surface water environment that could occur as a result of the proposed Richmond Valley Rail Trail (RVRT), which includes options for an embankment to cross a swamp near Fletcher.

This memorandum covers specific surface water design considerations to accompany the existing terrestrial ecology reviews and assessments undertaken as part of the design options assessment undertaken for the Fletcher connection track.

1.1 Suggested outcome

The assessment outlined as part of this memorandum shows that the length of the proposed boardwalk for the Fletcher connection on RVRT can be reduced without significant environmental impact. Our recommendation is that the following crossing configuration be adopted in the design:

- 120 m long boardwalk across the low point at the middle of the connection track.
- 12 m box culvert at the low point nearest to the junction of the Fletcher connection and the RVRT.

This configuration is expected to result in a reduction to NCC's cost's while also providing protection to the existing swamp environment and expected tidal flow movements from the Hunter River.

2 Scope

The following scope elements have been completed as part of this assessment:

- Review of existing information.
- Understand the constraints of the site.
- Prepare design options.
- Size crossing options.
- Recommend preferred option based on the design criteria.

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3 Review of information

The following key points were determined from a review of available existing information.

- Topographic mapping indicates one waterway (Fishery Creek) that crosses the proposed embankment (as identified from 1:25,000 scale mapping).
- Detail survey indicates that there are three low points in the longitudinal profile, where low points could be concentrated flow paths.
- Remnant ponding is likely through the swamp where overbank flows spill into other low-lying areas and areas where embankment has been established previously.
- Fishery Creek contributes to Ironbark Creek, which is influenced by tide and flood conditions of the Hunter River. Tidal influences within Fishery Creek are expected to be a key influencing factor to the swamp conditions at the surface and within the subsoil environment.

3.1 Flooding information

The Lower Hunter River Flood Study Update (DHI 2008) provided an estimate of the maximum flood levels within the swamp area near Fletcher. Flooding in the swamp is in response to Hunter River flooding where the resulting flood level from a number of design storm events was predicted. These flood levels are summarised in Table 1.

Table 1 Swamp flood levels (Floodplain 5, adapted from DHI 2008)

Annual Exceedance Probability (AEP)	Maximum modelled flood level (mAHD)
0.5 %	4.0
1 %	3.8
2 %	2.7
5 %	2.3
10 %	1.9

Based on the modelled flood levels from DHI (2008), and as the proposed embankment has a finished level of about 1.96 mAHD, it is apparent that the proposed embankment will remain generally flood-free for flood events up to and including the 10% AEP event (refer to Table 1).

Compared to the significant flood storage volume within the swamp area, the proposed fill embankment is considered to be relatively minor.

3.2 Tidal information

Publically available tidal information for a period of 5 days in May 2017 was obtained for the Hunter River from MHL gauging at Hexham Bridge. The observed tidal range for this period was:

- Maximum tide height – +1.015 mAHD.
- Minimum tide height - -0.472 mAHD.

- Mean tide height – +0.2715 mAHD (half way between minimum and maximum tide recorded over the 5 day period).

Three low points across the alignment are generally influenced by the high tide and flood tide. These areas correspond to the three low points along the alignment. The high tide influences the lowest section of the alignment by between 0.5 to 1.0 m of water depth.

Connectivity of waterways from the Hunter River upstream may influence the expression of tidal water within the swamp where the track is proposed, however as a minimum tidal conditions are expected to be a maintaining feature of subsoil moisture (in turn a key factor in sustaining vegetation within the swamp). The subsoil condition are a key constraint for the formation of any embankment.

Long term tidal information should be obtained with the progression of the design concept to confirm the annual variance in tide height (eg. consideration of spring and astronomical high tide).

4 Design Options

It is understood that NCC require a design that balances costs and environmentally sensitivities. Five options have been considered and assessment against these design criteria, specifically:

1. Complete embankment.
2. Complete boardwalk.
3. One crossing.
4. Two crossings.
5. Three crossings.

It is assumed that the construction of embankments is the most preferred option with respect to cost, but the least preferred option with respect to environmental sensitivity. Inversely, it is assumed that the minimising of embankments (ie using crossing structures and / or boardwalks) is the least preferred option with respect to costs but the most preferred option with respect to environment sensitivity (see below).

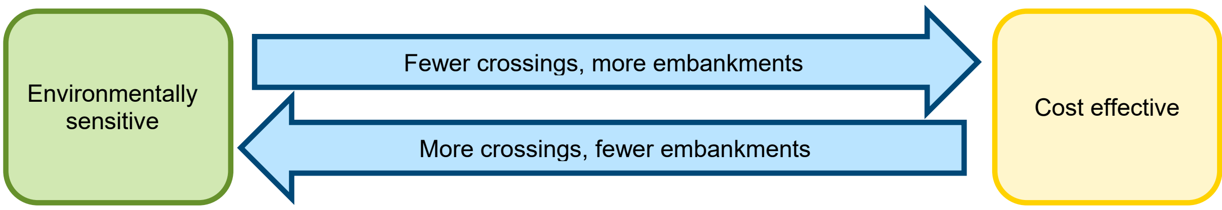

Figure 1 Flow diagram for optioneering

Of the options listed above, the option for the complete filling the alignment with embankment (Option 1) or covering with a boardwalk (Options 2) are considered the be the most environmentally insensitive and expensive respectively, and have therefore been omitted from further analysis.

Further hydrologic and hydraulic assessment was undertaken on the remaining design options in order to identify that which provides the most effective balance of crossing structures and embankment length.

4.1 Guidelines for fish passage

The *Policy and guidelines for fish habitat conservation and management* (DPI 2013) was reviewed with respect to classification of waterways for fish passage. It was determined from the policy that the Fishery Creek crossing at the Fletcher connection is likely a Class 1 or Class 2 habitat. The definition of these two classes are provided in Table 2.

Table 2 Classification of waterways for fish passage (DPI 2013)

Class	Characteristics
Class 1 (Major key fish habitat)	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
Class 2 (Moderate key fish habitat)	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and 2 habitats present.

The outcome from these classifications are the design options should either consider completely spanned crossings, or box shaped culverts without base slabs. Box shaped culverts may also be designed to have an invert below natural surface to make sure that water is always present within its base.

4.2 Disturbance area

An estimate can be made on the likely disturbance required to construct the Fletcher connection track. Considering a minimum track width of 3 m and a shoulder of 0.5 m a total top width of the track is in the order of 4 m. A fill batter of 1V in 4H would be developed with the an approximate fill height from natural likely to less than 2 m. Considering all these dimensions, the disturbance area per metre of track embankment can be approximated as 20 m^2/m. For comparative purposes construction of a total embankment across the swamp would result in approximately 13,720 m^2 of disturbance.

5 Assessment

5.1 Catchment hydrology

The proposed Fletcher connection considers a total contributing catchment associated with catchments 87, 88 and 90. The catchment area reporting to the proposed connection is approximately 1585.7 ha. Figure 1 in Attachment A presents the catchment plan and culvert locations conceptualised as part of the RVRT Project.

Using hydrology assessments previously completed for the other sections of RVRT, the following local hydrologic predictions (Table 3) where determined for design events at the crossings associated with the Fletcher connection. The flow rates included in Table 3 were used in the hydraulic assessment of the three design options (refer to Section 4.2).

Table 3 Local catchment contribution and hydrology estimates to the Fletcher connection

Catchment Node ID	Catchment (ha)	Estimate Method	AEP events (m^3/s)					
			50%	20%	10%	5%	2%	1%
Total of 87, 88 and 90	1585.7	RFFE	36.5	82.7	128	185	281	372

5.2 Open channel hydraulics

Figure 2 and 3 in Attachment A, provides a plan and longitudinal section of the proposed alignment for the Fletcher connection. Three low points have been identified within the proposal alignment. An approximate maximum flow area (up to the design track height of 1.96 mAHD) was estimated at each of the three low points. In order, starting at the connection point with the RVRT, the following maximum flow areas were estimated:

- Low point 1 – 17.6 m^2.
- Low point 2 – 214.7 m^2.
- Low point 3 – 72.6 m^2.

Option 3 (one crossing structure) would include only the central low point (low point 2) as it has such a greater flow area when compared to the low points 1 and 3.

Option 4 (two crossing structures) would include low points 2 and 3, as these are the two largest flow areas.

Option 5 (three crossing structures) would include all three low points.

Table 4 summarises the modelled flow depths and velocities expected when the flow rates from Table 2 are routed through low point 2 (ie Option 3), assuming a longitudinal grade of the crossing structure of about 0.3%.

Table 4 Hydraulic conditions of low point 2

AEP	Catchment flow rate (m^3/s)	Water Depth upstream of connection (m)	Velocity (m/s)
50%	36.5	0.83	0.8
20%	82.7	1.06	1.1
10%	128	1.23	1.3

AEP	Catchment flow rate (m^3/s)	Water Depth upstream of connection (m)	Velocity (m/s)
5%	185	1.42	1.5
2%	281	1.62	1.7
1%	372	1.91	1.9

From Table 4, it can be seen that low point 2 has the capacity to manage the estimated peak flows associated with the 1% AEP flood event.

A sensitivity analysis was undertaken to estimate the flows at which the embankment is likely to start overtopping. This analysis considered two scenarios:

- Setting the upstream water level is set to design road surface (1.96 mAHD) with a free flowing outlet condition.
- Setting the upstream water level is set to design road surface (1.96 mAHD) and a tail water equal to half the upstream water depth.

The sensitivity analysis indicated that the maximum permissible flow rate through low point 2 is about 430 m^3/s, with little difference between the two tail water conditions tested.

5.3 Crossing options

5.3.1 Option 3 - Single crossing

The adoption of a single crossing would consider locating the crossing over the lowest point in the alignment (low point 2). This option would allow for a boardwalk or culvert of a width equal to approximately 120 m, with the remaining crossing of the swamp achieved using an embankment about 566 m in length.

The embankment would result in the redirection of flows however given the local grades of the swamp and vegetation types it is considered that these redirections are unlikely to result in an increase in erosion within the upstream swamp area, but may result in increased areas of remnant ponding.

If reinforced concrete box culverts (RCBCs) are used, it is estimated that 29 RCBCs (0.9 m high x 3.6 m wide) would be required to achieve the flow capacities indicated in Section 4.2.

A culvert structure would be less hydraulically efficient than a boardwalk where the existing flow area would be generally maintained. The foundation requirements for either the culvert structure or boardwalk option would need to be confirmed during the subsequent design process.

5.3.2 Option 4 - Two crossings

Where two crossings were considered, the preferred crossings would be at low points 1 and 2. It is not expected that the use of an additional crossing would improve hydraulic performance however this option may improve maintenance and provide some redundant capacity to offset potential blockages of the crossing structures.

Low point 1 is the most incised flow path and may result in the persistent ponding of water against the embankment, which will need to be considered during the subsequent design stages.

It is estimated that the two crossings would result in a total boardwalk or culvert crossing length of about 132 m, with an embankment of about 554 m.

If RCBCs are used for low points 1 and 2, it is expected that low point 2 would consist of 29 cell RCBC (0.9 m high X 3.6 m wide), as per Option 3 (refer to Section 4.3.1), and low point 1 would consist of 3 cell RCBCs (0.9 m high X 3.6 m wide).

Constructability of this option is slightly complicated by the divided embankment formed as a result of the crossing structures included at low points 1 and 2.

5.3.3 Option 5 - Three crossings

The addition of a third crossing structure at low point 3 would result in crossing structures at all existing flow paths. This option would therefore maintain existing flow patterns and minimise the potential for the creation of new remnant ponding areas upslope of the embankment.

It is estimated that the three crossing structures would result in a total boardwalk or culvert crossing length of about 177 m with an embankment of about 509 m.

Where RCBCs are to be used, the crossing at low point 3 would likely consist of 10 cell RCBCs (0.9 m high x 3.6 m wide) in addition to those at low points 1 and 2 (refer to Section 4.3.2).

Constructability of this option is slightly complicated by the divided embankment formed as a result of the crossing structures included at low points 1, 2 and 3.

5.4 General design considerations

5.4.1 Modification of track design level

The optimisation of the track design level can be considered depending on the constraints considered. Reducing the design level can decrease the volume and hence the cost of fill material required for lengths of embankment. The following considerations were determined:

- The default track level was 1.96 mAHD
- Flood immunity from the Hunter River (regional flood conditions) is not a constraint. This is due to the fact that much of the existing RVRT is already impacted by these regional flood conditions and safe egress along the track is not expected in any flooding of the Hunter River.
- Local flood conditions (local catchment contribution) to Fishery Creek must achieve the safe conveyance of the 20% AEP event (5 year ARI).

Considering the above, the optimisation of the track level may be reduced from 1.96 mAHD down to 1.0 mAHD (approximately reduced by approximately 1.0 m).

Reducing the track level would result in a reduced extent of disturbance from areas of embankment. The reduced area of disturbance is estimated to be 10,976 m^2, when considering a complete embankment across the swamp area. This is a reduction of approximately 2744 m^2 from the higher track invert.

5.4.2 Drainage layer for groundwater egress

Due to soft soil conditions along the proposed alignment a rock bridging layer is to be considered in the alignment. This bridging layer is expected to serve to purposes which is to provide a solid foundation for areas of embankment and to maintain a free draining foundation. Due to the potential for subsoil groundwater flows, there is need to maintain any new embankments as free draining and a rock bridging layer will mitigate the embankment from becoming saturated.

6 Summary and Recommendations

6.1 Summary

This assessment has considered:

- Existing hydrology assessments for the RVRT.
- Flooding information for Hunter River.
- Tidal information at Hexham Bridge.
- Detailed survey for the proposed Fletcher connection track of the RVRT.

From the assessment of the available tidal information, it is likely that the Fletcher connection track is influenced by tidal inundation based on elevation of low points present along the proposed track alignment. Due to this tidal influence, a waterway crossing will be required to maintain tidal connectivity and minimise the potential impacts to the local vegetation.

The detailed survey and LIDAR provided an understanding of the topography of the proposed alignment with three low points defined and a general shallow grade from west to east. The topography indicated that the lowest point is about 200 metres in from the southern edge of the swamp.

Table 5 summarises the outcomes of the assessment of the swamp crossing options considered.

Memorandum

Table 5 Summary of option outcomes

Option	Flow conditions	Length of fill embankment (embankment disturbance area*)	Length of crossing/s	Environmental sensitivity	Constructability Crossing options	Cost
1. Complete crossing	Maintain existing conditions	0 m	686 m	Least potential impact	Standard Boardwalk crossing.	Highest cost
2. Complete embankment	Tidal influence of areas to the south west of connection will be cut-off	686 m ($13,720\ m^2$)	0 m	Greatest potential impact	Standard	Lowest cost
3. One crossing	Diversion of flow, some increased areas of ponding	556 m ($11,120\ m^2$)	120 m	Allowance for primary flow path. Other localised flow paths will either be redirected or form remnant ponding	Fill from either end of connection avoiding crossing area Boardwalk crossing, or Low point 2 – 29 cell RCBC 0.9 m high x 3.6 m wide	More expensive than complete embankment
4. Two crossings	Slightly improved conditions on one crossing	554 m ($11,080\ m^2$)	132 m	Improved drainage of localised flow paths	One island formed from two crossings 2 sections of boardwalk crossing, or Low point 2 - 29 cell RCBC 0.9 m high x 3.6 m wide Low point 1 - 3 cell RCBC 0.9 m high x 3.6 m wide	More expensive than one crossing

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Option	Flow conditions	Length of fill embankment (embankment disturbance area*)	Length of crossing/s	Environmental sensitivity	Constructability Crossing options	Cost
5. Three crossings	Slightly improved conditions on two crossings	509 m (10,180 m^2)	177 m	No benefit on option 4	Two islands formed from three crossings 3 sections of boardwalk crossing, or Low point 2 - 29 cell RCBC 0.9 m high x 3.6 m wide Low point 1 – 3 cell RCBC 0.9 m high x 3.6 m wide Low point 3 – 10 cell RCBC 0.9 m high x 3.6 m wide	More expensive than two crossings

* based on an invert of 1.96 mAHD of embankment

6.2 Recommendations

Option 4 was found to provide the best balance between environmental and cost constraints.

The hydrology and hydraulic assessment shows that construction a crossing (ie boardwalk) across the entire swamp area is not required. However, tidal egress from the Hunter River can theoretically extend (at the surface and as sub-surface) up to and beyond the proposed alignment. The introduction of fill for an embankment is expected to have a significant impact to the egress of water and viability of vegetation communities either side of the trail.

Assessment of the vegetation types via the aerial imagery and the low points from the survey shows tidal egress is occurring at low point 1, 2 and 3. There is limited connectivity of flow paths at low point 3. Therefore, providing crossings at low point 1 and 2 will provide sufficient connectivity of flow paths to support the existing vegetation either side of the trail.

Further consideration to the design will need to consider fish passage, reduction of disturbance area and constructability. Based on these factors the following crossings at the Fletcher are recommended:

- 120m long boardwalk along the low point at the middle of the connection.
- 12m box culvert at the second low point near the junction of the RVRT
- Rock bridging layer be provided under the fill embankments to promote ground water filtration.

6.2.1 Opportunity to reduce the embankment level and costs

One crossing structure of suitable capacity at the lowest point is expect to be sufficient to manage the 1% AEP catchment whether a culvert or boardwalk is considered. Despite this, regional flooding driven by the Hunter River (DHI 2008) is likely to result in the inundation of the track for events greater than a 10% AEP. Given that the design criteria for flooding is 20% AEP event, the embankment could be reduced. This reduction would save costs and likely settlement issues with the underlying soft soils.

Regards

L Hammersley

Lachlan Hammersley
Senior Water Engineer

<u>Attachments</u>

A Figures

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Attachment A – Figures

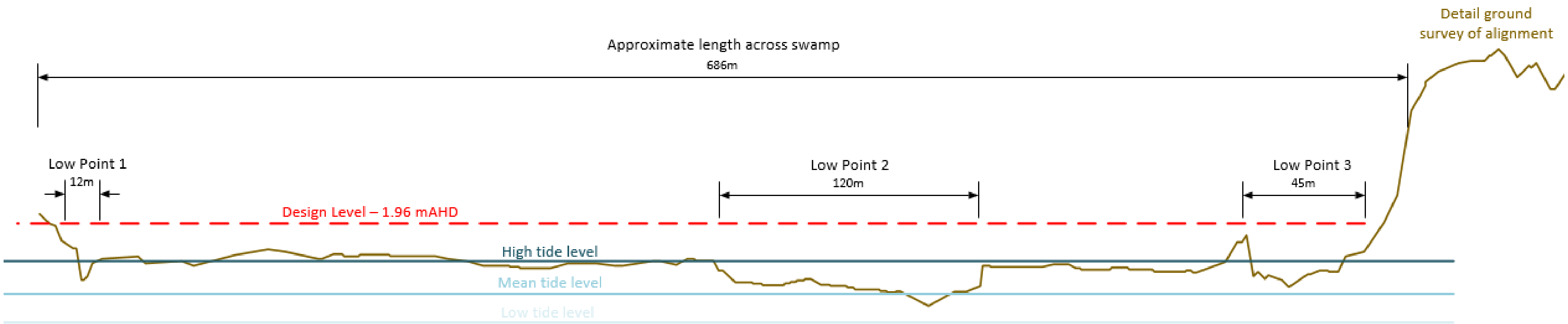

Figure 3 Concept longitudinal alignment of connection

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	L. Hammersley	L King A.Wyatt	[signature]	P Youman	[signature]	125/03/2019

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