Water Quality Assessment - Hexham Relief Roads

April 2012

UHVA

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Our reference 2110501B PR_5737

26 April 2012

Mr Jonathan Dowling
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KMR Environmental
PO Box 5487,
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Dear Mr Dowling

Water Quality Assessment - Hexham Relief Roads

Please find attached the final draft water quality technical note for the Hexham Relief Roads Environment Impact Statement.

Yours sincerely

Dr Dan Evans
Senior Environmental Scientist
Parsons Brinckerhoff Australia Pty Limited

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Glossary

%	Percentage
$	Dollars (Australian)
ARTC	Australian Rail Track Corporation Ltd
ASS	Acid Sulfate Soil
°C	Degree Celsius
ANZECC	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
CEMP	Construction Environmental Management Plan
CFU	Colony Forming Unit
CTGM	Chichester Trunk Gravitation Main
DO	Dissolved Oxygen
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ha	Hectare
e.g.	For example
Km	Kilometre
m	metre
Mg	Magnesium
mg/L	Milligrams per litre
na	Not applicable
ND	Not Determined
NSW	New South Wales
NTU	Nephelometric Turbidity Units
QRN	QR National
RFO	River Flow Objectives
S	Sampling Point
SEPP	State Environmental Planning Policy
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
The Proposed Project	Hexham Relief Road Project
TSF	Train Support Facility
TSS	Total Suspended Solids
µg/L	Micrograms per litre
µS/cm	Micro Siemens per centimetre
WQO(s)	Water Quality Objective(s)

Executive summary

Australia Rail Track Corporation Ltd (ARTC) proposes to develop five Relief Roads (tracks) and associated infrastructure at Hexham in the NSW Hunter Valley (the proposed Project). The proposed Project is located approximately 16km north west of the town of Newcastle (Figure 1.1). Key components of the proposed Project comprise:

- Five Up Relief Roads (train lines) to the west of the existing Up Main, Down Main and Up Coal including:
  - The removal of the existing Down Coal (located to the west of the Up Coal);
  - The construction of five new train lines (tracks) for the Relief Roads;
  - The construction of a new Down Coal to the west and outside of the proposed Relief Roads;
  - Each Relief Road to accommodate trains generally comprising two or three locomotives and up to 91 wagons (1,543m long) requiring a minimum standing room of 1,670m; and
  - New turnouts, return curves and associated track changes.
- Installation of new signal infrastructure for the five Relief Roads including signal location cases, huts and gantries.
- Earth and civil works of approximately 265,000 cubic metres, including cut to fill, track formation, drainage and minor structures.
- Ancillary infrastructure including vehicle access tracks, temporary construction compounds and stockpile sites.
- Land acquisition and the upgrading of existing rail infrastructure and public utilities as required.

The estimated cost of the proposed Project is approximately $90million and it is expected to take approximately 18 months to construct.

The proposed Project Area is defined as the area containing the existing Down Coal, south and west of the Newcastle Highway and west of the Hexham industrial area. The proposed Project Area boundaries are shown in Figure 2-1.

Water quality of the surface water features located within the proposed Project Area is assessed through literature review of existing data and collection of recent water quality samples.

The water quality data shows high nutrient, low dissolved oxygen and low pH along with turbid water. This indicates eutrophic conditions in the proposed Project Area watercourses which are subjected to high nutrient and sediment inflows. According to the water quality results, the Hexham Swamp and Hunter River do not meet the ANZECC guidelines (2000) criteria for a ‘slightly to moderately disturbed ecosystem’ and as such indicate a degraded aquatic ecosystem.

Potential impacts during construction include surface water contamination from fuel/chemical spills, waste and litter, vegetation clearing, exposed acid-sulfate soils (ASS), soil / bank / in-stream erosion resulting in associated increases in water acidity, sediment load, nutrient and toxicant loadings into surface watercourses/wetlands.

During operation, the proposed Project Area will sit on a layer of pervious gabion rock with inherent permeability. This will have the effect of decreasing stormwater runoff, leading to lower bank erosion and decrease scour around culverts. The potential for reduced flushing of stagnant water from the low gradient channels is increase however, possibly leading to increased siltation, accumulation of nutrients and subsequent algal blooms.

Mitigation measures are provided to address these potential impacts based on guidelines from Office of Water, Hunter-Central Rivers Catchment Management Authority and good site practice. This reduced residual impacts to a short term increase in sediment load during construction.

Cumulative impacts from the QR National (QRN) Train Support Facility are not envisaged to be significant, providing mitigation measures suggested for these schemes and application of the Construction Environmental Management Plan and water quality monitoring is run in parallel with all stages of the construction phase works.

1. Introduction

1.1 General

The ARTC proposes to develop five Relief Roads (tracks) and associated infrastructure at Hexham in the NSW Hunter Valley (the proposed Project). The proposed Project is located approximately 16km north west of the town of Newcastle (Figure 1.1). Key components of the proposed Project comprise:

- Five Up Relief Roads (train lines) to the west of the existing Up Main, Down Main and Up Coal including:
  - The removal of the existing Down Coal (located to the west of the Up Coal);
  - The construction of five new train lines (tracks) for the Relief Roads;
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  - Each Relief Road to accommodate trains generally comprising two or three locomotives and up to 91 wagons (1,543m long) requiring a minimum standing room of 1,670m; and
  - New turnouts, return curves and associated track changes.
- Installation of new signal infrastructure for the five Relief Roads including signal location cases, huts and gantries.
- Earth and civil works of approximately 265,000 cubic metres, including cut to fill, track formation, drainage and minor structures.
- Ancillary infrastructure including vehicle access tracks, temporary construction compounds and stockpile sites.
- Land acquisition and the upgrading of existing rail infrastructure and public utilities as required.

The estimated cost of the proposed Project is approximately $90million and it is expected to take approximately 18 months to construct.

The proposed Project Area is defined as the area containing the existing Down Coal, south and west of the Newcastle Highway and west of the Hexham industrial area. The proposed Project Area boundaries are shown in Figure 2-1.

This report considers water quality, as part of the wider assessment for the Environmental Impact Statement (EIS) relating to the development of 5 relief roads at Hexham. The water quality assessment will review the proposed Project Area, with particular emphasis on the potential receptors of poor quality water as a result of the development (Section 2.3). Following this, an assessment methodology will be outlined in Section 3 including recognition of relevant legislation and evaluation of current information sources, additional sampling and analysis required and definition of an impact assessment methodology.

In Section 4 the water quality baseline conditions are assessed which will consist of an appraisal of water quality targets in receptor watercourses and a review of current and additional water quality data. The potential impacts of the development, recommended mitigation measures and residual impacts will be identified in Sections 5, 6 and 6.3, respectively. Each of these sections will be separated into construction and operational phases of the Project. Potential cumulative impacts will also be identified in Section 7.

1.2 Director General's requirements and agency letters

The Director General's Requirements and Agency Responses relevant to surface water quality are listed in Table 1-1 along with the location in the report where they are addressed.

Table 1-1 Director General's Environmental Statement Requirements' or comment in Agency letters

Requirement/comment	Section addressed in
Director General's Environmental Statement Requirements	
The EIS must address surface water and stormwater management, including consideration of water quality (sedimentation and acid sulfate soils); hydrological regimes, watercourses (including ephemeral), riparian and receiving areas (including Hexham Swamp Nature Reserve);	Section 6 and Section 9 Also refer to Flood Report in EIS, Appendix B
Agency Letter – NSW Office of Environment and Heritage	
Describe existing surface water quality	Section 4
State the water quality objectives for the receiving waters relevant to the proposal	Section 3
State the indicators and associated target values or criteria for the identified environmental values	Section 3
State any locally specific objectives criteria or targets which have been endorsed by the NSW Government	Section 3
Describe the nature and degree of impact that any proposed discharges will have on the receiving environment.	Section 5
Assess impact against relevant ambient water quality outcomes. Demonstrate how the proposal will be designed and operated to; ▪ protect Water Quality Objectives for receiving waters where they are currently being achieved and ▪ contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved.	Section 5 and Section 6
Where discharge is proposed that includes a mixing zone, the proposal should demonstrate how wastewater discharged to waterways will ensure that ANZECC guidelines (2000) water quality criteria for relevant chemicals and non-chemical parameters are met at the edge of the initial mixing zone of the discharge and that any impacts in the initial mixing zone are demonstrated to be reversible	Refer to Flood Report in EIS, Appendix B
Describe how stormwater will be managed both during and after construction	Section 6 and Section 9 and Construction Environmental Management Plan Also refer to Flood Report in EIS, Appendix B
Describe how predicted impacts will be monitored and assessed over time.	Section 9

1.3 Objectives

The objectives for the surface water quality report include:

- Describe existing surface water quality
- Establish background water quality data
- Identify water quality objectives for the receiving waters relevant to the proposal
- Assess potential impacts of the proposed Project to surface water quality
- Propose further investigations and mitigation measures to minimise the identified potential impacts
- Assess the residual impact and cumulative impacts

1.4 Scope of work

In order to meet the above objectives, the following scope of works was undertaken:

- Review of previous reports carried out on this site and adjacent sites
- A walkover of the proposed Project Area to assess current watercourses conditions
- Collection of water quality samples
- Laboratory analysis of selected physico-chemical and toxicants parameters
- Data assessment and preparation of this report.

2. Proposed Project Area

The proposed Project Area is defined as the area containing the existing Down Coal, south and west of the Newcastle Highway and west of the Hexham industrial area. The proposed Project Area boundaries are shown in Figure 2-1.

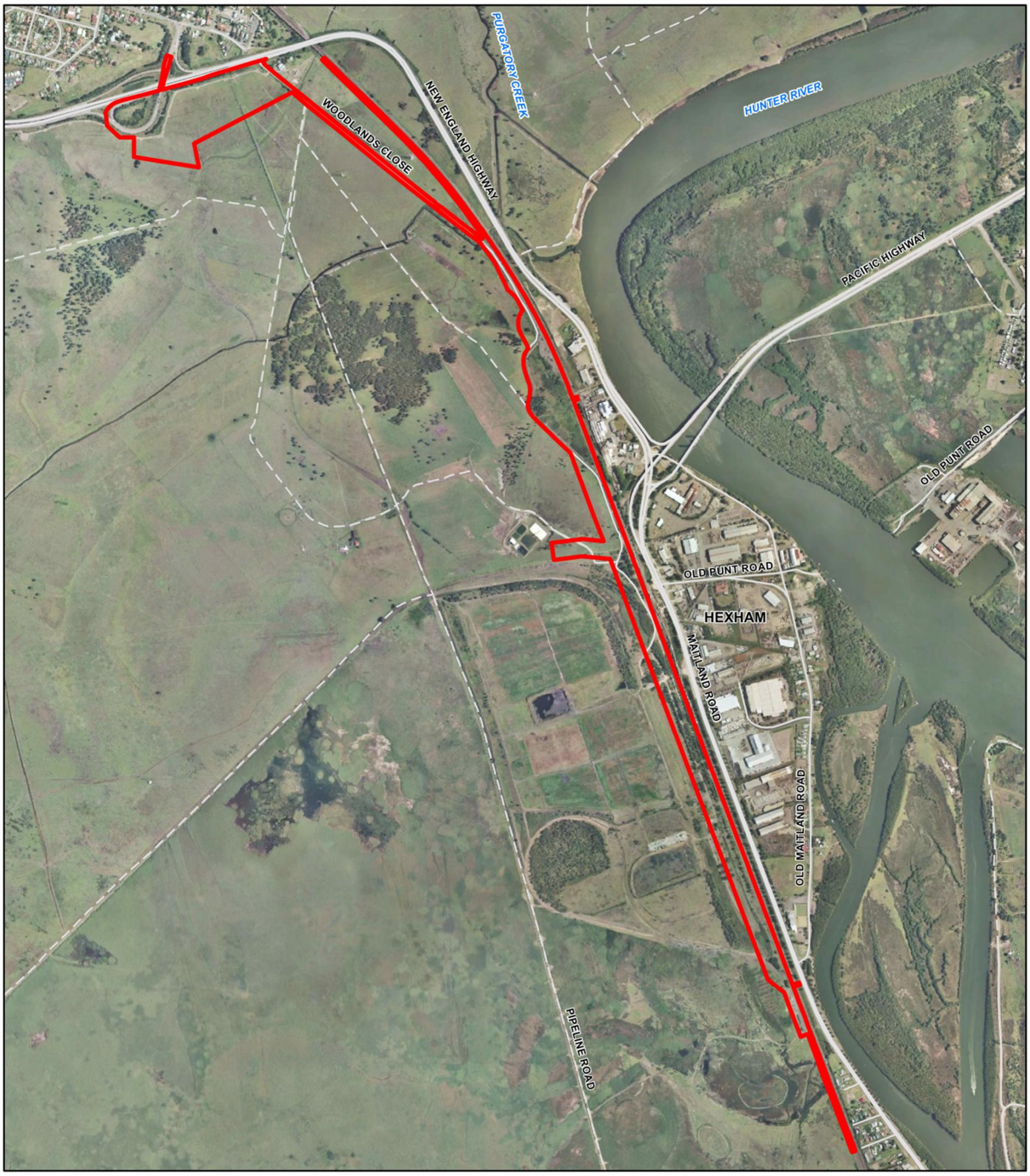
The wider Study Area includes the proposed Project Area and extends to a 10km radius.

This section considers the physical characteristics that control water quality in the Study Area and then defines the potential receptors within this area that could potentially be affected by this proposed Project. This provides a geographical focus for more detailed baseline assessment using data from 3 sampling runs.

2.1 Site location

The Relief Roads Project Area is surrounded by Hexham Swamp to the west and Pacific and New England Highways (**Figure 2-1**). Hexham is directly to the east of the site and the town of Tarro is to the north. Newcastle lies approximately 12km to the South East of the development site. The site lies within the Hunter River Catchment and potential receptors within this catchment are defined in Section 2.3.

Figure 2-1 Hexham Relief Roads proposed Project general location



Major Road
Local Road
Minor Road
Project Area

A4 Original
0 250 500 750
Metres
GDA 1994 MGA Zone 56

N

UHVA
ARTC

ARTC
Hexham Relief Roads

Hexham Relief Roads
Project Extent

Job Number	2110501B
Revision	A1
Date	29.02.2012
Scale	1:18,000

Figure 2-1

\\auncl\2110501A\HR - Hexham Relief Roads\DE_Design\DE06_Design_Doc\Phase_3\Drafting\GIS\Projects\ESRI\2110501B_PHP3_GIS_F044_A1.mxd Author: wilkinsa 29/02/2012

2.2 Site characteristics

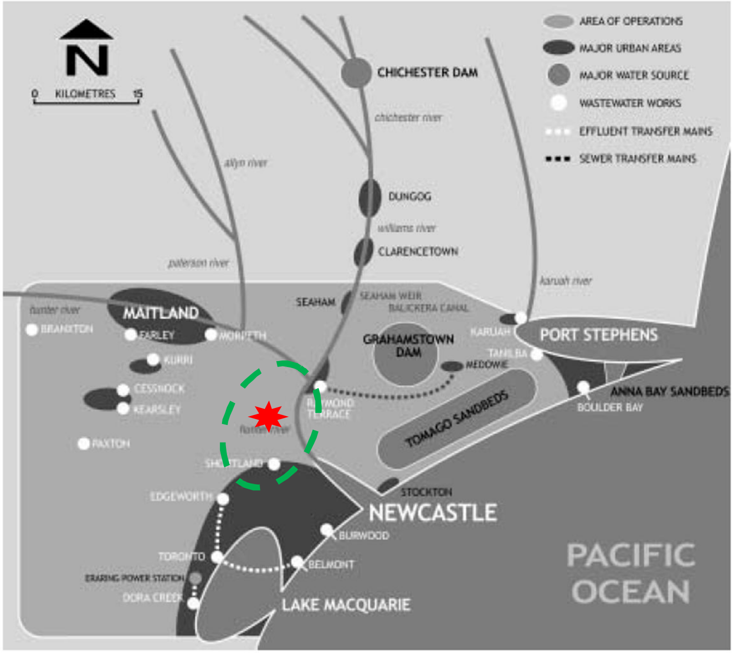
The lower Hunter River is a barrier estuary formed by the deposition of sediments in swamps and flats lying between the inner and outer coastal barrier sands (NPWS, 1998). The site is located on a back plain on the true right bank of the Hunter River (south arm) and lies within the extensive river floodplain (maximum width approximately 8km). Consequently, the topography is both flat and low lying (UHVA, 2012). The Study Area is dominated by a large coal stockpile, located 2km south of the Woodlands Close turn off from the New England Highway. This measures approximately 850m long (north-south) and 500m wide (east-west) and ranges up to RL13.6m (up to 12m above surrounding levels) (Worley Parsons, 2011). The Project Area, including the relief roads, lie to the east of this coal stockpile. Hexham Swamp, the largest wetland in the Lower Hunter floodplain (Winning and Saintilan, 2009), lies to the west of the site and a SEPP14 wetland is located in the central region of the site (partially inside the proposed Project boundary).

Beneath the undifferentiated Quaternary alluvial sediments, at depths of between 10 and 40 metres, lie older bedrocks composed of fine to medium grained massive sandstone and siltstone interspersed with shales and coal (UHVA, 2012c). To the north of the site, however, the Tomago coal measures are at surface level. Soil unit Gb10 peaty and organic dermosol soils over acid clays predominate in the Hunter floodplain around the site. The areas surrounding Hexham Swamp comprise residual clay soils and weathered rock associated with the Tomago Coal Measures (NPWS, 1998). These are hard acidic yellow mottled Tb40 and Tb42 soil units, with potential acid-sulphate generating conditions.

The site is framed to the east by the Hunter River and is separated hydrologically into two major parts by the abandoned Minmi-Hexham railway embankment. The area to the north-west is drained by Purgatory Creek, a tributary of the Hunter River. The area to the south-east of the embankment is drained by a number of small intertidal streams. The proximity of the Hunter Estuary (60 – 900m) makes the site vulnerable to both fluvial and tidal surge flooding, particularly at the northern end (PWD, 2004). The typical tidal range in the Hunter River at Hexham Bridge is 0 – 2.0m with a lag between low and high tide ranging between 5 – 8 hours (WillyWeather, 2011). Water levels in the Hunter River at high tide are only between 0.0-0.7m lower than the ground (UHVA, 2011). The tidal limit for the Hunter River is approximately 63km upstream from the Estuary mouth at Greta. During low freshwater flows and high tides, salinity can be detected at this point but in normal circumstances, the saline limit is more likely to lie some distance further downstream than this location (Kingsford, 2010). Three creeks drain the proposed Project Area from west to east into the Hunter River – Purgatory Creek and two unmade drainage channels, hereafter referred to as Mid-site Channel (Central region) and Maitland Road Channel (Southern region). In the 1970’s, floodgates were installed on channels draining Hexham Swamp to stop the incoming tide from flooding low-lying land (HCRCMA, 2010). Recently, some floodgates on these channels, such as Iron Bark Creek to the south of the proposed Project Area, have been opened and saltwater incursion into Hexham Swamp is being actively managed. Despite tidal inflows, saline levels are migrating very slowly into the majority of the Swamp and the wetland is still largely a freshwater body of water (HCRCMA, 2010).

The three main land uses in the proposed Project Area have been transport infrastructure, conservation and grazing. The focus for conservation is the Hexham Swamp Nature Reserve and a SEPP 14 wetland. Grazing has focussed on a small number of commercial beef cattle operations, particularly when other areas within the region experience drought conditions. Other minor land uses include small hobby farms (horses) and residential (backyard) use. Eight sewage treatment works managed by Hunter Water Corporation discharge within the immediate catchment area into the proposed Project Area (Figure 2-2 and Table 2-1).

Figure 2-2 Location of sewage treatment works within the Lower Hunter Valley



Source: Maitland Council, 2007. Approximate location of proposed Project marked

Of these, Shortland and Raymond Terrace sewage treatment works are closest to the site centroid (<10km) and are likely to influence the quality of water in the Hunter River downstream from the discharge points off the Proposed site. The other discharges will be diluted to the extent that their influence is not detectable.

Table 2-1 Sewage treatment works in the Study Area (Hunter Water Corporation, 2011)

Name	Urban areas served	Grid reference	Volume treated (ML/day)	Treatment type	Receiving watercourse
Branxton	Branxton, East Branxton, Greta	-32.660649 151.361475	1.0	Secondary	Unknown tributary – Hunter River
Cessnock	Cessnock, Aberdare, Bellbird, Nulkaba	-32.813824 151.362033	5.8	Tertiary (inc.. nutrients)	Black Creek – Hunter River

Farley	Aberglasslyn, Bolwarra, Gillieston Heights, Largs, Lorn, Oakhampton, Phoenix Park, Telarah, Rutherford	-32.743537 151.517129	5.6	Tertiary (inc. chemical dosing for nutrient removal)	Fishery Creek – Wallis Creek – Hunter River
Kearsley	Kearsley, Neath	-32.843178 151.406643	0.4	Primary	Tailings Pond – Unknown Trib – Swamp Creek – Hunter River
Kurri Kurri	Abermain, Weston, Kurri Kurri, Stanford Merthyr, Pelaw Main, Heddon, Greta, Cliftleigh	-32.804518 151.485844	3.4	Unknown	Swamp Creek – Hunter River
Morpeth	Maitland, East Maitland, Ashtonfield, Metford, Morpeth, Thornton, Beresfield	-32.737906 151.626005	10.0	Secondary (inc. biological removal of nutrients)	Hunter River
Raymond Terrace	Raymond Terrace, Medowie, Heatherbrae	-32.773816 151.750631	7.3	Secondary (inc. biological removal of nutrients)	Windeyers Creek via Grahamstown Drain – Hunter River
Shortland	Sandgate, Shortland, Birmingham Gardens, Maryland	-32.883786 151.681623	6.0	Secondary	Hunter River

2.3 Potential receptors

Potential receptor watercourses were identified as part of this Report. The identified receptor watercourses represent the zone of influence in which the proposed Project could impact. These are listed in Table 2-2 and shown in **Figure 3-1**.

Identification of receptor watercourses was completed on the basis of surface water drainage flow paths to the largest water feature in the catchment, the Hunter River. Information required to compile this information were previous local drainage assessments (RTA, 2006), Digital Terrain Modelling and site observations. These receptors have also been classified according to their likely residence time (based on observed velocities and discharge distance), in order to give an idea of the duration of impact in the case of a contamination event.

Table 2-2 Potential receptor watercourses

Watercourse name	Description	Residence time	Water quality implications
Purgatory Creek	Small ephemeral channel drains via a culvert under the Main Northern Railway into Purgatory Creek on the eastern side of the New England Highway.	3+months. Only likely to discharge during high flow events.	This channel receives water from residential and highway runoff to the north and is probably already impacted by poor water quality inflows. It flows from SW to NE direction and will receive drainage from the proposed access road as part of this development.
Mid-site channel	Collects water from South East Tarro, residential areas in Black Hill and sections of Hexham Swamp to the North of the site. The concentrated runoff flows along the constructed drain in an easterly direction to the new England Highway, contracting into a culvert under Old Maitland Road / Woodlands Close and discharging into Purgatory Creek just upstream from Hexham Bridge	½ day. High flow velocities and a small wetted permitter ensure rapid transfer of water through the channel.	This channel receives water from residential and highway runoff to the north and west and is probably already contaminated. It flows from SW to NE direction across the top of the site and could receive drainage from the northern part of the site.
Wetlands	To the north and west of site, large areas of semi-permanently flooded pasture land.	5+ years. Shallow waterbodies with limited fluvial recharge / groundwater interaction and low	Lack of direct connectivity to other watercourses and low water volumes means that contamination events could be managed more easily.

Watercourse name	Description	Residence time	Water quality implications
		elevation.	
Hexham Swamp Wetland	To the South West of the site, a large area of SEPP 14 wetland. Based on terrain, this probably receives water from the west and is maintained by rainfall but in storm events and flooding could potentially receive water from the site lying directly to the north east.	5+ years. Shallow waterbodies with limited fluvial recharge / groundwater interaction and low elevation.	Limited flow leads to semi-permanent wetland with limited opportunity for flushing / dilution if a contamination event were to occur
Plateau drainage ditch	Trough receiving drainage from site running west to east direction at the cut point below the northern edge of the site plateau.	5+ years. No connectivity to other watercourses and limited infiltration through saturated ground.	Lack of direct connectivity to other watercourses and low water volumes means that contamination events could be managed more easily.
Maitland Road Creek	Collects runoff from the site, Hexham swamps and flows under the New England Highway in a culvert to discharge into the south channel arm of the Hunter River approximately 500m south of Hexham Park	Day+. Moderate velocity and short transfer distance.	A potential route for contamination from the site into the Hunter river.
Hunter Estuary	The southern arm of the Hunter river flows within 200 m of the site at its closet point. It collects runoff from all the waterbodies mentioned previously. This river has a large tidal range up to Greta approximately 60km upstream.	2+ weeks. Similar estuaries modelled with numerical models by using Lagrangian particle tracking and flushing times estimated by using tracer patches (Office of Coast Survey, 2011).	Potential for contamination transfer from channels draining the site to the Hunter River. This contamination could become trapped in the estuary by the incoming tide and transferred further upstream in a ‘sloshing’ effect. The significant volume of dilution afforded by the waterbody and slow transfer times from the feeder channels should mean that contamination is not significant.

The SEPP 14 Hunter Wetlands are located on the northern arm of the Hunter Estuary and are therefore not considered further in this assessment.

The Hexham swamps are located on the west side of the proposed Project Area. A small section of the Hexham SEPP is classified SEPP14. All reference to SEPP14 Wetlands from this point on in the report will refer to that section of the Hexham Swamp.

The review of potential receptors in Table 2-2 will be used to guide selection of sites for additional monitoring in Section 3.3.1.

2.4 Pollution sources

Multiple urban and industrial activities, such as livestock grazing, transport corridors and an old coal stockpile storage were and/or are carried out in or adjacent to the proposed Project site and in close proximity. These activities present a range of potential contaminant sources that could affect surface water quality of the identified watercourses in Section 2.3. These pollution sources are listed in Table 2-3.

Table 2-3 Potential surface water contaminant sources

Source	Type
Acid sulfate soil (ASS) (Section 2.5)	Run-off containing sulphuric acid.
Adjacent industrial land use	Contamination on industrial properties may have migrated via groundwater and enter surface water via shallow alluvial pathways. Potential contaminants include Hydrocarbons (BTEX, oil and grease etc.), metals and pesticides.
Brancourts dairy processing plant	Effluent application to two utilisation areas: discharge to coal heap and farm irrigation. The Hunter River and Mid-site Creek (via tidal inflow) could be impacted by accidental spillages of effluent containing high concentrations of BOD, conductivity, nitrogen, oil / grease, phosphorus and total suspended solids. Routine spreading is regulated as per Environmental Protection Licence #816 conditions which include no surface water runoff generation and no exceedance of soil absorbance capacity.
Cattle grazing	Run-off containing high nutrient loads and sediments from disturbed areas.
Infrastructure (roads, roofs, etc.)	Stormwater run-off from road, infrastructure areas containing oils, greases, detergents, sediments and heavy metals.
Old Coal stockpile area (including legacy use as a coal washery)	Run-off containing dissolved salts, heavy metals, hydrocarbons and sediments. High TPH and lead concentrations have been recorded (UVHA, 2012e).
Sewage (Section 2.2)	As the watercourses in the surroundings of the proposed Project Area are tidal, discharge from both upstream and downstream sewage treatment plants (e.g. Raymond Terrace and Shortlands WWTP, respectively) into the Hunter River could contribute to higher nitrogen, nitrate, phosphorus and faecal coliform concentrations. However, these two WWTP's have secondary treatment and are subject to strict release criteria and the cumulative effect should be low.

2.5 Ground contamination

2.5.1 Local

Reference to the 1:250,000 scale Newcastle Geological Map indicates that the proposed Project Area is underlain by Quaternary deposits of gravel, sand, silt and clay. These are judged to be Estuarine/Alluvial soils associated with the flood plains of the Hunter River and the Hexham Wetland.

Hexham Swamp soil is characterised as predominantly brackish in its lower reaches, with heavy, dark and acidic clay and is described as having high probability of Acid Sulfate Soils (ASS) within 1m of the ground surface (Acid Sulfate Soils Risk Map - Lower Hunter NSW DECC, 2008 and New South Wales Government, 1995). Contamination is further discussed in the contamination Report provided in the EIS, Appendix F.

Possible on-site activities such as excavations have the potential to expose the estuarine soils with a high probability of being potential ASS. If exposed, ASS (pyritic/iron sulphide) sediments will react with oxygen resulting in the formation of sulphuric acid that can be washed by rainfall into the estuary and affect the ecosystem. In addition, tidal inundation and drainage recorded in the Hexham Swamp are expected to increase the problem (NWPS, 1998).

2.5.2 Proposed Project Area

Phase 1 & 2 contamination assessment was undertaken by Coffey Environments (2012[b]) at the proposed relief roads and associated infrastructure at Hexham, NSW.

According to the report, six areas of environmental concern were identified within the proposed Project Area including rail ballast, fill materials of unknown origin and quality, former building footprints, historical rail use, adjacent industrial land use, and groundwater.

Soil samples were collected in four of the areas of environmental concerns while the two remaining areas of environmental concerns which relate to groundwater contamination, have not been assessed in this report.

The soil analysis indicated that Total Petroleum Hydrocarbons (TPH C10-C36) were present above adopted criteria for commercial/industrial land use in several fill material samples. One sample of fill material also showed lead contamination. However, the contamination did not appear to be associated with particular fill types or depths, and appeared to be localised in nature.

Based on the results of the site history assessment and the soil sampling and analysis, the potential for widespread contamination within the proposed Project Area is considered to be low.

For more detail, refer to the report “Proposed Hexham Relief Roads, Hexham – Phase 1 & 2 Contamination Assessment (Coffey Environments, 2012[b]).

2.6 Aquatic ecology

An ecology survey was undertaken at the proposed Project site, the following conclusions were drawn from the assessment:

- Within and surrounding the subject site there were two types of estuarine habitats; mangroves and coastal saltmarsh. The habitats throughout the proposed Project Area were heavily degraded and affected by grazing, constructed channels, tracks and reclamation works.

- The water quality across the subject site and within the Lower Hunter Estuary was of low value and largely fell outside the ANZECC guidelines (2000) values. The catchment water quality has historically been characterised by high nutrient levels and undesirable variability in dissolved oxygen (Newcastle City Council, 2004). The water quality of the estuary is particularly vulnerable given the mixture and extent of industry, agriculture and urban development along the river.

- Within and surrounding the proposed Project Area there were three types of freshwater aquatic habitats; drainage channels, wetlands and ponded pastures The habitats throughout the proposed Project Area were heavily degraded and affected by grazing, constructed channels, tracks and reclamation works.

3. Assessment methodology

3.1 Legislative context

Specific guidance incorporated into this report includes:

- ANZECC (2000) guidelines for Fresh and Marine Water Quality.
- Approved Methods for the Sampling and Analysis of Water Pollutant in NSW (NSW, 2004).
- Australian Runoff Quality: Australian Rainfall and Runoff (Institution of Engineers Australia, 1998).
- Hunter-Central Rivers Catchment Action Plan (HCRCMA, 2007).
- Managing Urban Stormwater: Soils and Construction (Landcom) guidelines.
- NSW Water Quality and River Flow Objectives (DECCW, 2006).
- Water Management Act 2000: Considered best practice including development constraints and riparian setback for controlled activities occurring within 40m of a watercourse.

3.1.1 NSW water quality and river flow objectives

Developing plans and actions affecting river health in the Hunter River catchment are subject to the Water Quality Objectives (WQOs) managed by the Office of Environment and Heritage in the "*Proposed Interim Environmental Objectives for NSW Waters" (*DECCW, 2006*)*

According to the Hunter River Catchment classification (DECCW, 2006) waterways within and in close proximity of the proposed Project Area are affected by urban developments. As such, these waterways are generally substantially modified and of poor water quality due to stormwater inflow. WQOs for waterways affected by urban development have been specified by the NSW government (DECCW, 2006) and included the following:

Protection of:

- Aquatic ecosystem
- Visual amenity
- Secondary contact recreation
- Primary contact recreation.

3.2 Information sources

3.2.1 Reports

Numerous reports relating to aspects of water quality have previously been produced for Hexham Swamp and the surrounding environment. These are utilised in the report baseline section and are listed in the "Reference section" of this report (Section 8).

3.2.2 Data

The following information was used as part of this investigation:

- Historical data (RTA, 2006)
- NSW monitored stream gauging station data (NSW Office of Water)
- On site water quality measurements
- GPS handheld readings for sampling point locations
- Site inspection observations and photographs.

Part of this information was gathered during site visits on 15/08/2011, 02/09/2011 and 06/09/2011.

3.3 Additional sampling and data analysis

3.3.1 Sampling locations

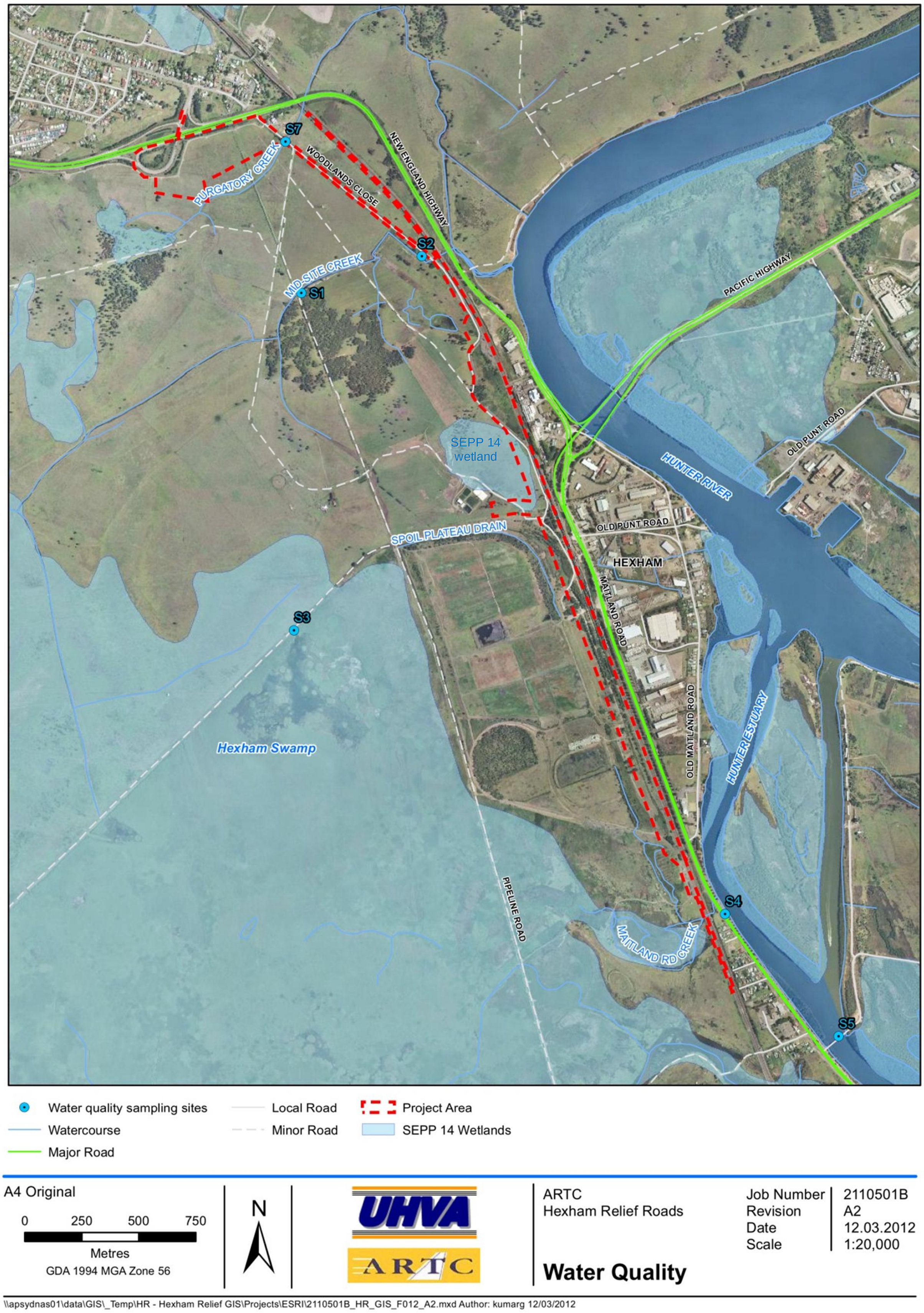
It was important to understand the water quality baseline conditions in a representative set of watercourses within the zone of influence defined in Section 2.3. However, the data collected at the NSW stream gauging station (current water quality data) does not adequately represent the potential spatial variability in water quality in waterbodies within this zone and thus additional monitoring was required. The locations where additional samples were collected are listed below, in Table 3-1 and shown on **Figure 3-1**:

Table 3-1 Sampling locations

Site	Site name/description	Grid location
S1	Mid-site drainage ditch west	375639; 6368085
S2	Mid-site drainage ditch east	376168; 6368246
S3	Hexham Swamp	375607; 6366607
S4	Drainage ditch next to Maitland Road	377498; 6365359
S5	Hunter Estuary at Aash Island Bridge	037799; 6364823
S6	Hunter River at Luskintyre Bridge	-32.686609,151.430955
S7	Purgatory Creek	375570; 6368749

Part of the development will encroach onto the SEPP14 wetland so it was important to understand current conditions both here and in the channel draining these wetlands into the Hunter River. At all these sites, limited knowledge of water quality conditions exist so a full suite of parameters were measured (Section 3.3.3). The two Hunter River sites are defined by the tidal limit (Section 2.2) and proximity to the site. Luskintyre, 63km from the ocean, is downstream of Greta and this is the freshwater sample point. The Estuary site is the closest downstream crossing point to the development at Hexham. Only limited parameters were tested here as there are long term records at these sites (Section 4.3).

Figure 3-1 Water quality sampling locations



3.3.2 Sample timing

Monitoring locations were sampled on three occasions. Sample date, weather description and tidal sequence during the sampling are described in Table 3-2.

Table 3-2 Sample timing

Sample round	Date	Weather conditions	Tidal sequence
1	15/08/2011	Cold / Wet	High
2	02/09/2011	Cold / Dry	High
3	06/09/2011	Warm / dry	High

3.3.3 Parameters analysed

Based on technical expertise and professional experience on similar projects (e.g. RTA, 2006; GHD, 2008; Worley Parsons, 2011), monitoring parameters relevant to the proposed development activities have been identified and listed in Appendix A of this Report.

A NATA accredited laboratory was used to perform the required analysis for this study and all procedures for collecting, labelling, transporting and storing samples and necessary ancillary field data were carried out in accordance with the Australian Standard 5667.6 (1998) and Approved Methods for the Sampling and Analysis of Water Pollutant in NSW (NSW 2004). Decontamination of reused sampling equipment involved a thorough rinse in distilled water.

Primary samples were stored in an ice-cooled esky during site works and during transport to the laboratory. To ensure the integrity of the samples from collection to receipt by the analytical laboratory, samples were sent by courier to the laboratories with accompanying Chain of Custody documentation.

3.3.4 Sample representativeness

All samples were taken during high tide period to ensure that sufficient water was present to collect representative samples and reflect the worst case condition in terms of water quality condition / potential transport of pollutants arising from the proposed Project Area upstream.

Samples were purposely collected in a range of different temperature, rainfall and flow conditions (Table 3-2). Although the samples were collected during a small period of time (due to Project timelines), the data is consistent with larger datasets reported in Section 4.3.1, collected over a larger seasonal period of time (encompassing flow and seasonal effects). It is therefore considered adequate for the purposes of this assessment.

At sampling point S5 (Hunter Estuary at Aash Island Bridge), depth and width profile were established to determine the representativeness of grab samples collected from the sampling point.

The depth profile shows the following:

- Temperature, pH, and TDS parameters were fairly constant throughout the depth range (0-4 m).

- Dissolved oxygen (DO) saturation values decreased slightly with depth which can partly be attributed to reduced oxygen transfer over the air-water interface and increased biological oxygen demand associated with bed sediment at lower depths.
- Specific conductivity shows an increasing trend with depth from 28500 µS/cm at 0 m to 30500 µS/cm at 4 m. This could indicate that denser saline water coming up the estuary during high tide conditions resides at the bottom of the estuary and that less dense freshwater sits above this. This would indicate that any potential pollution from the site would not fully mix in the Hunter River water column and would lie in the top of the water column for some distance downstream during high tide conditions. At this level of salinity however the increase is not considered significant.

The width profile shows the following:

- Temperature, pH, Total Dissolved Solids (TDS) and DO saturation parameters are fairly constant throughout the width range (0-100 m).
- As per the depth profile, the specific conductivity shows an increasing trend with width. At this level of salinity however the increase is not considered significant.

From the depth and width profiles it can be concluded that the samples are representative.

3.4 Water quality modelling

A MUSIC model was created for the Hexham Relief Roads Project to determine the change in water quality. Three cases were analysed; the existing scenario was measured against the construction scenario and then the built scenario.

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was created for the Hexham Relief Roads Project using the following data;

- Rainfall data
- Sampling results (Section 3.3 and 4.4)
- Catchment areas based on existing, construction and as built Project boundaries
- Bore logs (soil type)
- Draft NSW Music Modelling Guidelines provided mean and standard deviation values for events not covered in the field tests.

Model results are summarised in Table 3-3.

Table 3-3 Model results

Northern Catchment	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Existing	35,100	65.8	216
Construction	102,000 (291%)	46.8 (71%)	236 (109%)
Built	64,700 (184%)	78.4 (119%)	261 (121%)
Southern Catchment			
Existing	10,700	8.47	37.3
Construction	16,700 (156%)	9.45 (112%)	42.4 (114%)
Built	18,300 (171%)	10.9 (129%)	49.6 (133%)

* Percentage compared to existing case

The results show a large increase in Total Suspended Solids (TSS) while Total Phosphorus (TP) and Total Nitrogen (TN) are only slightly higher on average. The large increase in TSS can be attributed to the earthworks and stockpiles which will be onsite during construction. Under the built scenario, loose sediments in the unsealed roads and rail line are likely to contribute to the increase in TSS.

The increase in TP in the built scenario when compared to the construction scenario can be attributed to the increase in impervious area due the new construction. It is assumed that the area used for construction stockpiles is returned to agricultural land post construction. This accounts for the decrease in TSS in the northern catchment. The southern catchment is assumed to become either rail or access road post construction and therefore there is only a minor reduction in TSS.

It is worth noting that discharge outlets from the site were modelled on the mid site drainage channel and the Maitland Road Creek, both of which discharge in the Hunter River. Therefore, the increased nutrient and TSS loads will, according to the model, impact the Hunter River.

Further information on MUSIC and the modelling developed for the proposed Project, can be found in Appendix B of this Report.

4. Baseline conditions

4.1 Level of aquatic ecosystem condition

To assess the baseline condition of the watercourses in the surroundings of the proposed Project Area, historical and recently collected data need to be compared to target values. These target values are established in the ANZECC guidelines (2000).

ANZECC 2000 (Section 3.1.3.1) distinguishes three levels of aquatic ecosystem conditions:

1. **High conservation/ecological value systems (HEV)** — effectively unmodified or other highly–valued ecosystems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological value systems is regarded as intact.

2. **Slightly to moderately disturbed systems (SMD)** — ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly to moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoral activities, or marine ecosystems lying immediately adjacent to metropolitan areas.

3. **Highly disturbed systems (HD)** — measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture.

For each level of aquatic ecosystem conditions, the ANZECC guidelines (2000) assign a level of protection with target values. Therefore the level of aquatic ecosystem conditions needs to be determined for the proposed Project Area to assign target values.

The Project Area is located directly downstream and adjacent to urban area and major roads. It is likely that most streams within the area are contaminated by road and stormwater run-off and are highly disturbed. However, because of the declared SEPP14 wetland, it is expected that a certain level of protection and stricter development conditions be applied to the area. Therefore the ecosystem condition that is considered to be most appropriate for the receiving waters in the vicinity of the proposed Project is **‘slightly to moderately disturbed system’**.

4.2 Target values

4.2.1 Physico-chemical parameters

For physical and chemical stressors the ANZECC guidelines (2000) distinguish between six categories of ecosystems – estuarine, coastal and marine, lakes and reservoirs, wetlands, upland rivers and streams and lowland rivers and streams.

Sampled locations S4, S6 and S7, were identified as estuarine streams although a majority of the time, these three sites are largely freshwater in composition.
Estuarine streams are defined as a body of water semi-enclosed by land with sporadic access to water from the open ocean, where ocean water is at least occasionally diluted by freshwater runoff from land and subject to tidal flow.

S1, S2, S3, and S5 were identified as wetlands. There is no formal definition of wetlands in the ANZECC guidelines (2000). However, in the ANZECC guidelines (2000) 'wetlands' essentially refer to palustrine wetlands. This was confirmed by the SEPP 14 and the Coastal Wetlands Survey Report (Adam *et al.*, 1985).

Using the default ANZECC guidelines (2000) approach for regionalisation, the sampling point area is in the South East Australia region.

Target values for physical and chemical stressors are listed in Table D-1 in Appendix D.

4.2.2 Toxicants

For toxicant stressors the ANZECC guidelines (2000) distinguish between two categories of ecosystems – freshwater and marine. The freshwater ecosystem target values are relevant to the water bodies within the proposed Project Area.

ANZECC guidelines (2000) default value for freshwater species, a 95% level of protection was adopted, except for toxicants for which the ANZECC guidelines (2000) recommend the $99^{\%}$ level of protection for specific parameters. These values are considered appropriate to assess slightly to moderately disturbed ecosystems. The ANZECC guidelines (2000) indicate that it is appropriate to compare dissolved concentrations of metals to the target values.

Target values for toxicants are listed in Table D-2 in Appendix D

Target values outlined in the ANZECC guidelines (2000) for 95% and 99% level of protection for freshwater species (see Table D-2, Appendix D) are soft water target values. Table D-3 in Appendix D, summarises the conversion factors that should be applied at each sampling event to determine an appropriate specific target value for selected metals depending on the hardness of the water (adopted from Table 3.4.4 ANZECC guidelines, 2000).

4.3 Current information

4.3.1 Existing data

The NSW Office of Water department collects and manages data on the quantity and quality of water in the state's streams and aquifers, as the basis for water resource planning and water management activities. The data available includes gauging station information, stream flow data summaries and results of chemical analysis of water samples.

The closest Office of Water monitoring site to the proposed Project Area is:

- 210009 HUNTER @ LUSKINTYRE

The station description includes:

- latitude 32.6862 deg S
- longitude 151.4311 deg E
- monitoring commenced on 11/07/1997

- monitoring ended on 03/06/2011.

The HUNTER @ LUSKINTYRE is in close proximity to the monitoring point S6. Therefore water quality data from the HUNTER @ LUSKINTYRE site will be compared to the data collected at S6 during the site sampling.

For the physico-chemical parameters, target values (as per Table D-1) were compared to the median value of the collected data. For toxicants, guidelines values were compared to the 95th percentile as per the ANZECC guidelines (2000) recommendations.

As not all the parameters were consistently analysed from 1997 to 2011, the number of readings for each parameter are indicated as 'n'. Values in red text indicate exceedances compared to target values identified above (see section 4.2.1 and 4.2.2).

Table 4-1 Water quality data at HUNTER @ LUSKINTYRE

Parameters	Unit	Target value (wetland)	Count	Median	95th %
Height - Water Column	m	No data	17	0.30	0.76
Temperature - Water	°C	No data	131	21.30	31.95
pH		No data	186	8.3	8.6
Dissolved oxygen	%	No data	8	90	96
Turbidity	NTU	No data	257	20.0	117.4
Electrical Conductivity	µS/cm	No data	243	704	1000
Solids - total suspended	mg/L	No data	48	28	136
Alkalinity (Total) as CaCO3	mg/L	No data	3	110.0	132.5
Ammonia as N - total	mg/L	No data	28	0.02	0.10
Nitrate + nitrite as N (NOx)	mg/L	No data	141	0.02	0.37
Nitrogen - Kjeldahl	mg/L	No data	69	0.37	1.10
Nitrogen - total	mg/L	No data	170	0.54	1.40
Phosphorus - total	mg/L	No data	194	0.07	0.22
Faecal Coliform - membrane filtration count	CFU/100mL	No data	27	380	3630
Silica as SiO2 - soluble	mg/L	No data	2	1.75	1.80

Water quality data collection has been undertaken within the Hunter River estuary since 1972 by various entities for research purpose or for development application. The report "F3 to Raymond Terrace Pacific Highway Upgrade – Hydrology, Hydraulics and Water Quality Working Paper" (RTA, 2006) offer a complete overview of the water quality information and summarises this data. The results of the water quality data collected since 1972 is summarised in Table 4-2 below.

Table 4-2 Summary of water quality data (RTA, 2006)

Parameters	Unit	ANZECC guidelines	Count	Median	90th %	10th %
pH		7-8.5	91	8	8.5	7.4
Dissolved Oxygen	mg/L	--	33	6.6	8.8	4.6
Turbidity	NTU	0.5-10	18	8.05	40	3.2
Ammonia	mg/L	0.9	80	0.06	0.15	0.01*
Nitrate	mg/L	0.7	33	0.1	0.19	0.01*
Nitrite	mg/L	--	33	0.01	0.02	0.01*
Total nitrogen	mg/L	0.3	117	0.11	0.3	0.01
Total kjedahl nitrogen	mg/L		60	1.76	7.6	0.5
Total phosphorus	mg/L	0.03	121	0.14	0.46	0.08

*Limit of detection

The water quality data shows high nutrient and chlorophyll-concentrations along with regular peaks in turbidity. This indicates eutrophic conditions with the watercourses subject to high nutrient and sediment inflows and with corresponding algal development.

According to the water quality results, the Hunter River does not meet the ANZECC guidelines (2000) criteria for slightly to moderately disturbed ecosystem and as such suggest a degraded aquatic ecosystem (RTA, 2006).

Microbiological components have also been tested in watercourses at 12 locations within the proposed Project Area (Coffey, 2012a). Faecal coliforms and E coli were recorded in surface water on or adjacent to the site above the ANZECC (2000) recreational water use, secondary contact (Table 4-3). There was no spatial trend in the presence / absence and sources could include livestock and / or bird defecation, effluent irrigation or leakage from septic tanks.

4.3.2 Data from recent sampling events

Additional sampling was conducted on three site visits in 2011 as described in Section 3.3. The data from this monitoring are shown in Table 4-4.

Table 4-3 Microbiological data

Analyte	Unit	Adopted Guideline*	Sample ID											
			CSW1	CSW2	CSW3	CSW4	CSW5	CSW6	CSW7	CSW8	CSW9	CSW10	CSW11	CSW12
Faecal coliforms	cfu/100ml	1000	730	130,000	1000	27,000	2,100	15,000	7,000	270	270	270	3,500	33,000
E. Coli	cfu/100ml	230	450	130,000	1000	27,000	2,100	15,000	5,000	91	270	270	3,500	33,000

*ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality - 5.2.2 Recreational Water Quality (secondary contact)

Key	Concentration below adopted guideline	Concentration equal to or similar to adopted guideline (±20%)	Concentration significantly exceeds adopted guideline

Table 4-4 Event sampling

Parameters	Unit	Target value		S1		S2		S3		S4		S5		S6		S7	
		Wetland	Lowland River	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %
Temperature	°C	No data	No data	16.5	19.47	16.7	20.17	15.4	16.65	18.4	18.58	16.7	19.27	20.4*	20.4*	16.9	17.92
pH		No data	7-8.5	6.0	7.5	6.4	7.8	5.3	6.8	5.9	6.8	6.2	7.6	6.0*	6.0*	6.5	7.2
EC	µS/cm	No data	No data	978	2800	953	2906	1213	1378	1080	20028	3816	25884	672*	672*	5385.0	5735.00
DO	%	No data	80-110	22	69	33	71	20	165	65	100	69	86	59*	59*	50	49
Total dissolved solids (TDS)	mg/L	No data	No data	0.6	1.8	0.6	1.9	0.8	0.9	14.4	22.9	18.4	24.30	0.4	0.4	3.5	4.4
Suspended Solids (SS)	mg/L	No data	No data	33	75	54	86	195	278	45	46	22	22	---	---	100	177
Total Hardness as CaCO3	mg/L	No data	No data	114	494	142	538	152	166	2840	4208	3215	3364	147	147	966	1600
Ammonia as N	mg/L	0.90	0.90	0.05	0.32	0.10	0.32	0.26	0.37	0.20	0.38	<0.10	<0.10	---	---	0.10	0.12
Nitrite as N	mg/L	No data	No data	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	---	---	<0.01	<0.01
Nitrate as N	mg/L	No data	No data	0.01	0.02	0.01	0.02	<0.01	<0.01	0.03	0.039	0.08	0.08	---	---	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.015	0.015	0.010	0.020	0.010	0.020	<0.010	<0.010	0.030	0.039	0.050	0.080	---	---	<0.010	<0.010
Total Kjeldahl Nitrogen as N	mg/L	No data	No data	1.75	3.63	1.80	1.98	2.90	28.10	0.80	1.79	0.70	1.15	---	---	2.05	2.19
Total Nitrogen as N	mg/L	No data	0.3	1.8	3.6	1.8	2	2.90	28.10	0.8	1.8	0.8	1.3	---	---	2.1	2.2
Total Phosphorus as P	mg/L	No data	0.03	0.60	0.98	0.87	0.88	4.10	7.32	0.09	0.45	0.05	0.08	---	---	0.81	1.07
Reactive Phosphorus as P	mg/L	No data	0.005	0.31	0.65	0.49	0.66	3.75	4.09	0.05	0.28	0.02	0.02	---	---	0.10	0.15
Aluminium (dissolved)	mg/L	0.055	0.055	0.19	0.37	0.24	0.33	0.09	0.12	0.13	0.181	0.02	0.04	0.09	0.09	0.06	0.08
Arsenic (dissolved)	mg/L	0.024	0.024	0.002	0.002	0.001	0.002	0.003	0.003	0.005	0.009	0.006	0.014	<0.001	<0.001	0.002	0.002

Parameters	Unit	Target value		S1		S2		S3		S4		S5		S6		S7	
		Wetland	Lowland River	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %	Median	95th %
Cadmium (dissolved)	mg/L	0.0002**	0.0002**	<0.0001[a]	<0.0001[c]	<0.0001[b]	0.0001[c]	<0.0001[b]	<0.0001[b]	0.0001[c]	0.0001[c]	0.0002[c]	0.0003[c]	<0.0001[b]	<0.0001[b]	0.0001[c]	0.0001[c]
Chromium (dissolved)	mg/L	0.001**	0.001**	<0.001[d]	<0.001[f]	0.001[e]	0.001[f]	<0.001[e]	<0.001[e]	0.004[f]	0.009[f]	0.002[f]	0.003[f]	<0.001[e]	<0.001[e]	<0.001[f]	<0.001[f]
Copper (dissolved)	mg/L	0.0014**	0.0014**	0.002[g]	0.003[i]	0.002[h]	0.003[i]	0.001[h]	0.001[h]	0.012[i]	0.019[i]	0.003[i]	0.004[i]	0.001[h]	0.001[h]	0.002[i]	0.002i
Nickel (dissolved)	mg/L	0.011**	0.011**	0.002[j]	0.005[l]	0.002[k]	0.005[l]	0.002[k]	0.003[k]	<0.001[l]	<0.001[l]	0.001[l]	0.002[l]	<0.001[k]	<0.001[k]	0.002[l]	0.004[l]
Lead (dissolved)	mg/L	0.0034**	0.0034**	0.029[m]	0.892[o]	0.056[n]	1.158[o]	0.205[n]	0.552[n]	0.335[o]	0.532[o]	0.026[o]	0.040[o]	0.016[n]	0.030[n]	0.407[o]	0.89[o]
Zinc (dissolved)	mg/L	0.008**	0.008**	0.011[p]	0.032[r]	0.016[q]	0.027[r]	0.003[q]	0.019[q]	0.019[r]	0.045[r]	0.004[r]	0.005[r]	0.004[q]	0.005[q]	0.004[r]	0.011[r]
Manganese (dissolved)	mg/L	1.9	1.9	0.012	0.281	0.017	0.278	0.014	0.485	0.018	0.077	0.014	0.033	0.014	0.020	0.023	0.26
Iron (dissolved)	mg/L	No data	No data	2.48	2.86	2.56	2.99	1.14	1.53	0.85	1.48	0.23	0.43	0.31	0.36	0.84	4.47
Mercury (dissolved)	mg/L	0.00006	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total petroleum																	
C6 - C9 Fraction	mg/L	No data	No data	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction	mg/L	No data	No data	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction	mg/L	No data	No data	<100	<100	<100	<100	150	177	<100	180	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction	mg/L	No data	No data	<50	<50	<50	<50	135	157.5	<50	155	<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	mg/L	No data	No data	<50	<50	<50	<50	285	289.5	<50	290	<50	<50	<50	<50	<50	<50
Recoverable hydrocarbons																	
C6 - C10 Fraction	mg/L	No data	No data	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction	mg/L	No data	No data	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	mg/L	No data	No data	<100	<100	<100	<100	240	240	<100	240	<100	<100	<100	<100	<100	<100
>C34 - C40 Fraction	mg/L	No data	No data	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	mg/L	No data	No data	<100	<100	<100	<100	240	240	<100	240	<100	<100	<100	<100	<100	<100

* based on one monitoring event

**See hardness adjusted target values below:

a: 0.0005
b: 0.0008
c: 0.002
d: 0.003
e: 0.004
f: 0.008
g: 0.004
h: 0.006
i: 0.013
j: 0.028
k: 0.043
l: 0.099
m: 0.014
n: 0.026
o: 0.091
p: 0.02
q: 0.03
r: 0.072

4.4 Analysis of monitoring data

For the physico-chemical parameters, guidelines values were compared to the median value of the collected data. For toxicants, guidelines values were compared to the 95th percentile as per the ANZECC guidelines (2000) recommendations.

No target values exist for physico-chemical parameters for wetlands sites (S1, S2, S3, and S5). Therefore, for comparison purposes, the data was compared to the next closest water type target values available (i.e. lowland river).

Recent monitoring and historical data confirmed that that the area is slightly to moderately disturbed aquatic system.

The main findings include:

- The pH median value is consistently below the ANZECC guidelines (2000) recommended range. Most sites range from 0.5 to 1.5 point below the target value which indicates acidic conditions at sampling locations. As per the “Ground contamination” Section 2.5 of this report, ASS are present in the areas and might be responsible for the low pH.

- The available historical turbidity at HUNTER @ LUSKINTYRE showed above average median turbidity levels when compared to the recommended target (0.5-10 NTU). The 95th percentile indicated high turbidity values. No turbidity measurements were performed on site samples. However the consistent high levels in TSS at all sampling sites confirm this trend. This suggests that the catchment condition is somewhat degraded / subjected to erosion and / or accumulation of organic materials and is likely to be impacted during heavy rainfall events. The multiple creek crossing and culverts in the proposed Project Area promotes sediment–laden runoff associated with soil erosion from banks which leads to high turbidity. This also consolidates the assumption that the watercourses are likely to be characterised as ‘moderately to slightly disturbed’ aquatic systems.

- The median value of DO saturation was consistently below 80% saturation for all sites and below the 95th percentile value for all sites except S3, S4 and S5 Historical data indicate that the water within the proposed Project Area generally conform to the ANZECC guidelines (2000) for DO. This low values could be a result of limited flushing of aerated water due to high residence times within the creek channels and / or high organic loading which exerts an oxygen demand on the water. Some evidence of eutrophication such as algal blooms was acknowledged at certain sampling points which could explain the low values. In addition, carbon dioxide produced during microbial respiration increases acidity which could partially explain the low pH values. However without chlorophyll-a data it is difficult to conclude.

- TP and TN concentrations consistently exceeded ANZECC guidelines (2000) target values, as shown in the tables above. This identifies elevated nutrient concentrations in the proposed Project Area and upstream (S6). However, the relatively high organic nitrogen and reactive phosphorus levels indicate that these nutrient concentrations are typically generated from degrading organic matter or diffuse runoff from areas under agricultural land use such as cattle grazing. No or extremely low inorganic nitrogen loads were present which discounts industry, treated sewage or fertiliser run-off as a potential source.

During the first sampling event sampling at S3, an algal bloom was visible at the sampling point (Figure 4-1). This eutrophic condition is generated by high load of nutrients which would explain the peak value for the 95th percentile in the table above.

Figure 4-1 Hexham Swamp sampling point S3 with excessive algal growth

- S4 95th percentile for chromium and copper marginally exceeded its hardness adjusted target values.
- Measures for lead significantly exceed the hardness adjusted ANZECC guidelines (2000) at all sites except S5. There are no known sources of lead contamination upstream of the monitoring stations; it is therefore assumed that the elevated levels are naturally-occurring, possibly due to elevated levels in the underlying geology. High lead concentrations in proposed Project Area soils were noted in a previous study (Coffey Environments, 2012[b]).

For toxicants it is appropriate to apply ANZECC guidelines (2000), as the effects on the biota under stagnant conditions will be similar to those during flowing conditions. However, the ANZECC (2000, p. 8.3–44) guideline also states the following in relation to stated guideline target values for metals:

'Natural background concentrations of some chemicals, particularly metals, may exceed the stated guideline target values due to mineralisation from the catchment substrate, as distinct from anthropogenic sources. In such cases, it would be unreasonable to insist on a guideline value below the background concentration. High levels of naturally–occurring metals in highly mineralised areas are not necessarily indicative of adverse environmental effects due to possible adaptation of the local fauna'.

Therefore the application of the target values provided by the ANZECC guidelines (2000) is inappropriate due to the elevated concentration values for lead.

Hardness levels from historical data indicate that the mean hardness levels are generally within the hard water range. Therefore, changes to the metal target values are expected. Peaks in hardness values at S4 and S5 correspond to marine water inflow with high chloride content.

Total metal concentration levels were not measured for either historical and event sampling. Therefore, there was insufficient data to assess the potential effect of pH and hardness on the concentration of soluble metals that could be made bioavailable to the receiving environment.

There was insufficient data available to discuss the existing water quality in terms of seasonal variations or variations with flow.

5. Potential impacts of development

This report considers the potential impacts of the proposed Project to water quality. The construction methodology for the proposed Project has been set out in an internal communication (21/07/2011) and the drainage strategy is reported in UHVA (2012a).

5.1 Proposed Project summary

The construction phase involves site establishment, construction of the relief roads, testing and commissioning and demobilisation sub-phases. Activities during site establishment will include installing environmental controls, clearing vegetation and construction of access roads.

A pervious formation with open channels is the preferred drainage solution (UHVA, 2012a). This would maintain the preconstruction drainage behaviour and would involve deployment of 200mm graded igneous rock providing a large volume of intercedes. Drainage from the formation will be divided into three regions, southern (103 points and chainage 174.900), central (chainage 174.900 and 175.350) and northern (chainage 175.350 and 104 points). The northern region would flow into the Mid-site creek and the southern region into Maitland Road Creek, whilst the central portion would be divided by the ridgeline with water to the west flowing north and water to the east flowing south.

5.2 Construction

5.2.1 Operation and maintenance of vehicles and other equipment

5.2.1.1 Fuel spills

Fuel and oil required for the operation of vehicles and construction machinery presents a risk to water quality only if spills enter watercourses (via either surface or ground waters).

Spilt diesel and petrol are both likely to form a layer on the surface of the water. The volatility of both diesel and petrol contributes to substantial evaporative loss, while neither product is likely to form water-in-oil emulsions due to their low viscosity. Lubricating oils, of the kind used in diesel engines and gearing, are of a relatively similar density to diesel oils. As such, lubricants would be expected to behave in a similar fashion to diesel oil, and form a surface layer. Lubricants are much less volatile, however, and thus would not evaporate as rapidly. Once incorporated into the sediment, the degradation of oils is significantly slowed, and hydrocarbons may persist in sediments for some time (Boehm *et al.* 1987 and Struck *et al.* 1993, both cited in Nicodem *et al.* 1997).

The risk to water quality from a fuel spill within the temporary construction-phase maintenance workshop and fuel and oil storage facilities is likely to be very low due to the high level of control demanded by the Australian Standard 1940 – The storage and handling of flammable and combustible liquids (AS 1940-2004), and the drainage of refuelling and maintenance areas into a sump (to be collected and treated by a contractor) or water treatment storage facility (such as oil and grease separator)

Spilt fuel is most likely to enter the creeks via an accidental spill on the roads near creek crossings. A significant fuel spill to a watercourse is likely to have a locally significant impact on water quality in the proposed Project Area drainage channels and Hexham Swamp, with the quantity spilt, the volume of water in the creeks and the residence time of this water being the most significant factors influencing the area of watercourse impacted. In this case, it is difficult to define what a Project-wide ‘significant’ volume might be, as it is dependent on the ability of the watercourse to dilute and export this contamination out of the area. As such, a ranking has been developed based on estimated residence times (Table 2-2):

- Wetlands / Hexham Swamp, Plateau drainage ditch: > 5 litres
- Purgatory Creek: >10 litres
- Hunter Estuary, : Maitland Road Creek, Mid-site Creek: > 20 litres

However, the risk of an accidental spillage to aquatic flora and fauna in the plateau drainage ditch and wetland area waters is reduced as these watercourses have limited flow and therefore many spills could be effectively isolated and cleaned up before they disperse over a larger area.

Implementation of best practice fuel management will effectively address this risk.

5.2.1.2 Litter and waste

Litter and waste associated with vehicle maintenance operations also has the potential to contribute to the degradation of water quality. As appropriate controls will be in place, such as a waste management system, the risk to water and sediment quality from litter and spilt waste from the proposed Project Area is likely to be very low during construction and operation.

5.2.2 Vegetation clearing and earthworks

There is a high potential for soil erosion and sedimentation following vegetation clearing and earthworks due to potentially intense seasonal rainfall and soil characteristics present on-site (UHVA, 2012b). This could lead to impacts on water and sediment quality via increased turbidity and nutrient and associated contaminant levels in these waterways.

It is expected that un-contained and un-treated runoff from vegetation clearing and earth works pose a moderate risk to water quality through increases in suspended fine sediment loads and associated nutrients and contaminants during rainfall events (Section 3.4). However, where runoff from disturbed areas is effectively managed, the estimated increase in the suspended sediment, nutrient and metal loads to the receiving environment is predicted to be negligible. As such, the risk to receiving surface water quality would be very low, and any impacts would be negligible.

Similarly, if properly implemented impacts to surface water quality from water usage are not likely to occur due to associated earthwork activities such as dust suppression.

5.2.3 Management of Water Resources

5.2.3.1 Loss of catchment area within the proposed Project Area

Loss of catchment area leads to lower dilution and flushing capacity in the watercourse which in turn increases the concentration of contaminants and the impact on water quality.

The proposed Project will have no significant impact during the construction phase on Purgatory Creek or Hexham Swamps. As the formation will be constructed of ballast and gabion rock (pervious surfaces), the volume of run-off will be equivalent to what is currently experienced. There will be a variation in the discharge location to the south-west due to the formalisation of two existing channels – the locations of these diverted discharge points will be detailed in the Flood Technical Note (UHVA, 2012d). Although there may be a minor impact from removal of backing-up-flows due to progressively more efficient west-east drainage, this is not expected to result in any significant draw-down of water in the Hexham Swamps. Therefore, the construction of the Relief Roads will not result in loss of catchment.

It is therefore unlikely that the proposed Project will have any significant impacts on the river flow objective (see section 3.1.1) in the downstream receiving environment.

5.2.4 Changes to flow regimes

Changes to the flow regime and the timing and magnitude of flows in watercourses, have the potential to impact on water and sediment quality (UHVA, 2012c).

As described above, minor flow changes are expected to impact Purgatory Creek and Hexham Swamps due to more efficient west-east drainage and this is not expected to result in any significant draw-down of water in the Hexham Swamps

There are, however, potential impacts to the other creeks in the area. Work in watercourses / the wetland may require channel diversion or water barriers to be constructed. Extended periods of low flow can lead to increased nutrient concentrations, elevated electrical conductivity, and reduced DO, while more frequent high flow events can result in high turbidity and TSS through erosion (ANZECC guidelines, 2000).

Impacts from changes in flow regime are, however, expected to be insignificant as their implementation will be short-lived and localised.

5.2.5 Construction of creek crossings

There is potential for significant bank and in stream erosion impacts due to work close to the waterbodies (UHVA, 2012c). Currently, most creek crossings in the proposed Project Area are culverts. Construction of new permanent and temporary crossings may disturb sediments, leading to increases in localised turbidity and sediment deposition. Re-suspension of material during the disturbance, direct physical damage to banks and change in flow character following re-culverting may occur. Wetting and drying related to dewatering / draining of ground adjacent to river banks could cause damage to the structural integrity of the banks.

When construction is carried out during the dry period, these impacts will be minimal. However, after installation of crossings, the newly formed bed and banks may continually erode during high flows events. This may result in an increase in suspended solids and turbidity as well as channel width and a loss in channel definition, which could in turn lead to a decrease in downstream flow.

5.2.6 Exposed ASS

There is potential for disruption to the soil surface across the entire proposed Project Area due to movement of construction machinery / materials, excavation and demolition activities, temporary stockpiling of material and wheel washing.

The soil in the proposed Project Area has been identified as potentially containing ASS. In addition, soils are highly susceptible to sheet and rill erosion particularly where the vegetation cover / topsoil has been removed or disturbed (UHVA, 2012c).

According to the current drainage system, sediment derived from this erosion could eventually impact both the Swamp and the Hunter River. This could result in additional sediment load and acidification of the Swamp and Hunter River.

5.2.7 Construction amenities

During construction work, fully contained portable toilets will be installed on-site to cater for construction works. Discharges and spills of construction amenity effluent have the potential to introduce nutrient-rich discharge with high oxygen demand to the receiving environment. If un-treated sewage effluent is accidentally discharged into the aquatic environment, it can result in elevated nutrient concentrations and reduced DO in the receiving environment. The impacts to water and sediment quality due to a 'one off' sewage spill are likely to be short-lived and not widespread. There is also a risk of ground works releasing microbiologically contaminated water from the site into adjacent watercourses (Section 4.3.1). Spills may impact on the suitability of water in the receiving environment if levels of bacteria (such as faecal coliforms and E. coli) are elevated and it should be noted that high faecal coliform and E.coli counts have already been recorded on the site sourced from either effluent irrigation or un-sewered properties on the Hexham Industrial estate (Section 4.3.1); again such impacts would be short-term and not widespread.

5.3 Operation

5.3.1 Stormwater runoff

Volume and velocity (flashiness) of runoff from site are not expected to increase.

Train lines formation will be constructed on ballast and gabion rock. The surface roughness of the material is higher than the current bare earth of 0.03 to 0.04 which will help decrease stormwater runoff rates and attenuate the peak flows. The result will be a flattening of the discharge hydrograph profile (UHVA, 2012b). However, lower stormwater runoff rates might result in higher residence times and accumulation of sediment and nutrients. This in-turn could lead to increased magnitude and frequency of algal blooms.

The volume of stormwater run-off will be equivalent to what is currently experienced as construction material will be pervious. Therefore no reduction in the infiltration rate into the existing soil is expected (UHVA, 2012b).

6. Mitigation measures

- A number of measures would be implemented to mitigate potential impacts from construction and operation of the site. A preliminary outline of such measures is provided below, based on guidelines for controlled activities (Office of Water, 2011), Hunter-Central Rivers Catchment Management Authority Catchment Action Plan guidelines and general good site practice detailed in the Construction Industry Research and Information Association (CIRIA, 2006). A Construction Environmental Management Plan would be developed and implemented (UHVA, 2012a) – see Section 6.1.7.

6.1 Construction

6.1.1 Operation and maintenance of vehicles and equipment

Risks associated with the spillage of fuels and other contaminants will be substantially reduced, if not eliminated, where the following measures would be implemented

- Vehicle maintenance areas, refuelling stations and storage of fuels, oils and batteries would be undertaken in bunded areas, designed and constructed above the 10% AEP flood level and in accordance with AS1940 (2004) – The storage and handling of flammable and combustible liquids.

- Appropriate spill containment kits would be available, and used for the clean-up of spills in the field. Equipment that is susceptible to spills and / or leakages would have a spill kit located nearby to the equipment at all times. The kits would contain equipment for clean-up of both spill on land or in dry creek beds, and spills to water.

6.1.2 Vegetation clearing and earthworks

The risk of sediment-laden runoff to nearby waterways would be managed through the implementation of the following:

- Development and implementation of an erosion and sediment control management plan as part of the Construction Environmental Management Plan (UHVA, 2012a).

- Management of vegetation clearing and earthworks done in stages over the life of the Project, and

- Schedule clearing and earthworks for construction of creek crossings during a dry period if possible.

During and after construction, water quality and ecosystem health of nearby waterways would be protected through the implementation of the following:

- Placement of erosion control in ditches and drainage lines running from cleared areas, especially on slopes and levee banks.

- Prepare and implement a water monitoring programme, and

- Stabilise the site, as per Blue Book Guidelines.

6.1.3 Management of Water Resources

The impact from the proposed Project Area on the catchment is considered low and no mitigation measures are required.

6.1.4 Creek crossings

It is understood that no new creek crossings will need to be established as part of the proposed Project. Purgatory, Mid-site and Maitland Road Creeks all flow underneath existing roads / tracks / rail lines. Impacts associated with the modification of existing creek crossings by roads and railways, however, would be minimised through the implementation of the following:

- If relevant, mitigation measures for temporary creek crossings / waterlogged land will be dealt with in CEMP (UHVA, 2012a).
- Implement stormwater and erosion control measures (UHVA, 2012a).

Where modification of a permanent creek is undertaken during a rainfall event the workspace would be isolated, irrespective of an isolated pool or flowing water. The isolation should be designed such that it is completed within one work-day, to minimise the impact.

6.1.5 Management of ASS

Excavation and dewatering of the low-lying lands located within the proposed Project Area have the potential to cause acidification. During excavation of areas where potential ASS have been identified, acidic water generated during excavation, dewatering and soil treatment works would be undertaken using neutralisation technics with a suitable agent (such as hydrated lime) until pH readings become equivalent to the receiving waters pH. The management of AAS is dealt with in more detail in the Construction Environmental Management Plan (UHVA, 2012a). Further information is contained in Volume I of the EIS.

Acidified water should be stored and treated within suitable containment structures to prevent migration of untreated water into nearby sensitive environments. The Construction Contractor should have the appropriate acid-resistant equipment in place to treat and store water to prevent unexpected overflow from excavations and storage areas. Release of water to the surrounding environment shall occur only following confirmation of adequate treatment. The requirements of the site-specific Construction Management Plan must also be taken into account during treatment and release of water (UHVA, 2012a).

6.1.6 Site water discharges

Mitigation measures for any discharges from the site (including water potentially contaminated with faecal coliforms or E.Coli) will be covered in the Contaminated Land report (UVHA, 2012e).

6.1.7 Construction management plan

A construction environmental management plan (CEMP) would be established for the construction phase of the Project (UHVA, 2012a).

The CEMP would document mechanisms for demonstrating compliance with the Minister for Planning's Conditions of Approval, other relevant proposed Project approvals and the Statement of Commitments. It would also set out the auditing and inspection frameworks for the site which will cover water and soil management issues related to surface water quality.

The CEMP would provide the framework for the management of all potential environmental impacts resulting from the construction activities including:

- ASS Management Plan
- Erosion and Sediment Control Management Plan
- Stormwater Management Plan

The CEMP would outline the environmental mitigation measures to be implemented during the construction phase. This might include water quality monitoring downstream of the proposed Project Area and specific monitoring during creek diversions / culverting.

All water quality monitoring should be undertaken in accordance with the Approved Methods for the sampling and Analysis of Water Pollutant in NSW (2004). When modifying creek crossings, daily monitoring of physico-chemical parameters (pH, EC, turbidity) in the creeks is recommended. It is recommended that physico-chemical parameters be measured:

- Upstream of the crossing site immediately prior to modification, to determine background conditions.
- Daily during modifications, at locations both upstream and downstream of the crossing.
- Daily after modifications at locations both upstream and downstream of the crossing until water quality returns to background conditions, as established by Section 4.3 of this report. For the purposes of this report, Parsons Brinckerhoff recommended using the following background levels:
    - pH = >7 and < 8.5 (target value lowland rivers)
    - EC = <2900 µS cm-1 (95%-ile S1, S2 and S4 monitoring data)
    - Turbidity = 40 NTU (Hunter River 90%-ile)

Where monitored parameters levels downstream of the crossing site are more than 20% above background turbidity levels, it is recommended that construction cease and that stormwater and erosion and sediment control measures be revised prior to re-commencement of construction (RTA, 2005).

6.1.8 Monitoring and management

The water quality of the proposed Project Area can be protected by the comparison of sample concentrations with the collected background data maximums in Section 4.3. Monitoring should be conducted to determine any large magnitude variations from the baseline (±20%) and inform adaptive management if there is non-compliance.

6.2 Operation

No specific mitigation measures are required during the operation phase.

6.3 Residual impacts

Following application of the mitigation measures suggested above, impacts listed in Section 5 need to be reviewed to assess any residual impact.

6.3.1 Construction

A short-term increase in sediment load into the Hunter River is anticipated despite the implementation of the mitigation measures, during channel diversion works and improvements to the infrastructure of existing channels.

All other identified potential impacts should be insignificant, based on adoption of the mitigation measures proposed.

6.3.2 Operation

Identified potential impacts should be insignificant.

7. Cumulative impacts

Cumulative issues arise due to the influence or impacts of other construction and development activities in the local area. Any such activities have the potential to compound or exacerbate the specific impacts and effects of the proposed Project, thereby forming a cumulative impact. For the purpose of this Project, the area of influence was defined as directly located within the Hexham Swamp including the SEPP 14 Wetlands and the section of the Hunter River directly adjacent to the proposed Project defined below, and therefore only assesses the potential environmental impacts within this spatial extent.

According to these criteria the following Project would create cumulative impacts with the proposed Project:

- QR National (QRN) National Train Servicing Facility (TSF)

7.1 Description of proposed Project within the cumulative impact area

QRN owns 264ha of land adjacent to the Project Area and has proposed to redevelop this area as follows:

- A 42 ha TSF is proposed in the eastern portion of the Great Northern Railway. The TSF is required to aid its coal logistics operations and would incorporate locomotive and wagon maintenance facilities as well as a freight rail yard and associated maintenance infrastructure.

This proposed Project has not yet been approved by authorities.

Construction of the proposed TSF would involve the construction of up to 10 parallel tracks up to about 3 km in length, construction of access roads, buildings including operations and administration office, locomotive /wagon wash area and maintenance shed, associated hardstand and staff parking, railway lines and fuel storage area.

The proposed site would largely be developed on the large coal stockpile area located centrally to the site and about 2 km south of the Woodlands Close turnoff from the New England Highway. The coal stockpile is currently heavily grassed and is used by the adjoining land owner to the north-east, Dairy Farmers, to irrigate treated effluent from the factory adjacent to the site.

South of the stockpile is a flat area some 350 m long and 600 m wide. This area contains a former rail loop to the site however is now predominantly grassed with some areas of regrowth.

To the north of the site is an abandoned rail corridor and a parcel of low lying land. This area contains a small wastewater treatment facility that is operated by Dairy Farmers. Treated effluent is irrigated in this area.

7.2 Assessment of potential cumulative impacts

All the Projects have the potential to impact the surface water quality of the SEPP 14 wetland and the Hunter River. The cumulative effect of these impacts is discussed below:

7.2.1 Cumulative impact on surface water quality from change of land use

All Projects will target changes in land use.

Most of the affected areas by the proposed Project have previously experienced a change in land use and were subject to land clearing, industrial development, building construction and / or transport corridor development. Widening of the railway is expected to have a small effect on land use at the northern section of the proposed Project where the land is less industrialized. However, the impacts are expected to be short-lived as revegetation will be undertaken once the construction phase is completed. Erosion along the roads and railways will only occur until the vegetation develops properly. In the meantime, impact from sediment-laden runoff would be minimised via the implementation of a Drainage Management Plan and Erosion and Sediment Control Plan.

The QRN TSF proposed Project will change a small area of grazing area and coal stockpile storage area to develop rail infrastructures and associated buildings. While the land use change could have a positive impact on the watercourses / wetland water quality (due to soil remediation etc.), land use change in the north grazing / wetland section of the proposed development (north of the coal stockpile area) would have an effect on water flow and flooding on the remaining wetland in that area. It is likely that the wetland would receive more water as the hydraulic gradient mean flow would discharge into the Wetland from the drainage channel and no water quality impacts are foreseen, as long as mitigation measures are adopted.

Although under the operation of Flood gates since the 1970's, the swamp is inundated by flows from the Hunter River during floods generally around the 10 year Average Recurrence Interval (ARI). The area would experience an increase in water flow velocity and volume due to the development proposal. This would create higher erosion rate and sedimentation of the area.

7.2.2 Cumulative impact on surface water quality from land clearance

Clearing of land for the two proposals would potentially result in adverse cumulative impacts associated with disturbance of sodic (i.e. high salt content) and dispersible soil leading to increased soil erosion and potential water quality degradation.

As per the land use change section, the QRN TSF proposed Project is expected to have a greater impact on watercourses/wetland water quality. Land clearing will be required on a large section of the grazing/wetland.

To limit the effect of land clearing on surface water quality an Erosion and Sediment Control Plan should be developed and implemented for both proposed Projects.

7.2.3 Cumulative impact on surface water quality from earthwork

All Projects have the potential to disturb ASS and cause acidification of watercourses / wetland if not properly managed. Cumulative impact would result from the construction phase if the Projects intake earthwork simultaneously.

All Projects have committed to manage ASS via the implementation of ASS Management Plan or similar to manage its effects on surface water quality.

7.2.4 Cumulative impact on surface water quality from water management

Hydrodynamics within the two Project sites are likely to have been significantly altered by current infrastructures such as the coal stockpiling, infilling of wetlands, construction of industrial area and irrigation of waste water effluent (Worley Parsons, 2011).

Although, the resulting landform is considered highly disturbed for both sites, improper water management from the proposed Projects would lead to important cumulative impacts to the sensitive surrounding environment.

The stormwater management recommended for the site (Worley Parsons, 2011) would offset any potential impacts by the restoration of favourable conditions in other areas of the Swamp.

7.3 Cumulative impacts - Conclusion

The cumulative impact assessment indicates that the proposed Project will have limited cumulative impact from land use changes and land clearance with the other proposed Project in the area.

The proposed Project will have greater impact on a local scale if exposed ASS from earthworks and stormwater are not mitigated properly. To limit the cumulative impact from these activities with the QRN TSF proposed Project in the area, both proposed Projects will implement the following:

- Potential Acid Sulphate Soil Management Plan
- Erosion and Sediment Control Management Plan
- Drainage Master Plan (overall drainage masterplan coordinated by both Projects).

Through developing and implementing the above plans, impacts from the proposed Project will be reduced and cumulative impacts would be limited.

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Appendix A

Analysis details

Parameters		Sampling locations	
	15/07/2011	02/09/2011	06/09/2011
Suspended Solids (SS)	All sites except S5, S6	All sites except S5, S6	All sites except S6
Total Hardness as CaCO3	All sites	All sites except S5, S6	All sites except S6
Aluminium (dissolved)	All sites	All sites	All sites except S6
Arsenic (dissolved)	All sites	All sites	All sites except S6
Cadmium (dissolved)	All sites	All sites	All sites except S6
Chromium (dissolved)	All sites	All sites	All sites except S6
Copper (dissolved)	All sites	All sites	All sites except S6
Nickel (dissolved)	All sites	All sites	All sites except S6
Lead (dissolved)	All sites	All sites	All sites except S6
Zinc (dissolved)	All sites	All sites	All sites except S6
Manganese (dissolved)	All sites	All sites	All sites except S6
Iron (dissolved)	All sites	All sites	All sites except S6
Mercury (dissolved)	All sites except S5, S6	All sites	All sites except S6
Ammonia as N	All sites except S5, S6	All sites except S6	All sites except S6
Nitrite as N	All sites except S5, S6	All sites except S5, S6	All sites except S6
Nitrate as N	All sites except S5, S6	All sites except S5, S6	All sites except S6
Nitrite + Nitrate as N	All sites except S5, S6	All sites except S6	All sites except S6
Total Kjeldahl Nitrogen as N	All sites except S5, S6	All sites except S6	All sites except S6
Total Nitrogen as N	All sites except S5, S6	All sites except S6	All sites except S6
Total Phosphorus as P	All sites except S5, S6	All sites except S6	All sites except S6
Reactive Phosphorus as P	All sites except S5, S6	All sites except S5, S6	All sites except S6
C6 - C9 Total petroleum	All sites	All sites	All sites
C10 - C14 Total petroleum	All sites	All sites	All sites
C15 - C28 Total petroleum	All sites	All sites	All sites
C29 - C36 Total petroleum	All sites	All sites	All sites
C10 - C36 sum Total petroleum	All sites	All sites	All sites
C6 - C10 recoverable hydrocarbons	All sites	All sites	All sites
>C10 - C16 recoverable hydrocarbons	All sites	All sites	All sites
>C16 - C34 recoverable hydrocarbons	All sites	All sites	All sites
>C34 - C40 recoverable hydrocarbons	All sites	All sites	All sites
>C10 - C40 sum recoverable hydrocarbons	All sites	All sites	All sites

Appendix B

Music Model - Memo

B.1. Introduction

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was created for the Hexham Relief Roads Project to determine the change in water quality. Three cases were analysed; the existing scenario was measured against the construction scenario and then the built scenario.

MUSIC provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block up to many square kilometres. MUSIC is able to simulate the effect of a wide range of natural, urbanised or agricultural catchments on the quantity and quality of runoff downstream.

Conversely, MUSIC is not a detailed design tool; it does not contain the algorithms necessary for detailed sizing of structural stormwater quantity and/or quality facilities. As such, MUSIC is viewed as a conceptual design tool.

Further information on MUSIC and its configuration parameters, applications and input data can be found in 'BMT WBM Draft NSW Music Modelling Guidelines, R.N1224.001.02, April 2008'.

B.2. Methodology

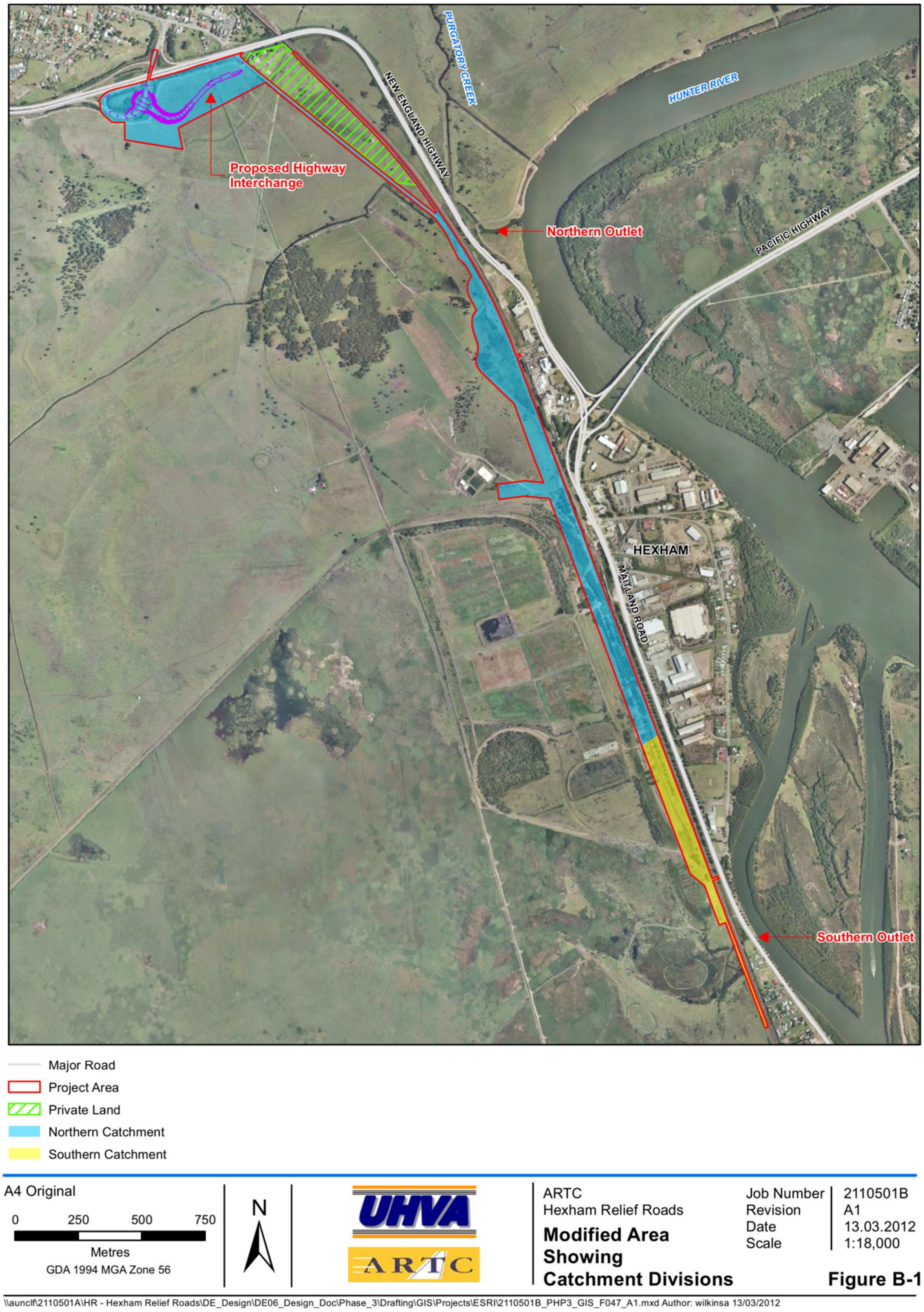
A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was created for the Hexham Relief Roads Project using the following data:

- Rainfall data in 6 minute intervals from data provided by the University of Newcastle weather monitoring system.
- Water tests of local creeks and tributaries passing through the Hexham site to determine levels of TSS (Total Suspended Solids), TP (Total Phosphorus) and TN (Total Nitrogen) on the site.
- Catchment areas based on existing, construction and as built Project boundaries.
- Bore logs were used to determine the soil type to be used in the infiltration calculations for the site.
- Draft NSW Music Modelling Guidelines provided mean and standard deviation values for events not covered in the field tests. As well as infiltration values based on the bore logs.

The area modelled is shown in Assumptions were made as to the proportion of pervious and impervious areas in each of the three scenarios (existing, construction and built). The rail line was assumed to be similar to an 'unsealed road' and based on the Draft NSW Music Modelling Guidelines is 50% impervious, open fields were considered pervious, while structures were considered impervious.

The construction scenarios footprint was adopted in the MUSIC model for the existing, construction and built scenarios. The construction scenario assumed that the entire area within the Project extents would be used for construction or stockpiles and is therefore the most disturbed of the three scenarios. In addition, no mitigation measures are applied to either the construction or operation scenarios. As such, the predicted loads are very much a worst case scenario in terms of potential impacts.

Figure B-1 Modelled area showing catchment divisions



The existing scenario footprint took in the area that is currently disturbed by the rail access roads and the existing Tarro interchange. Areas outside this footprint but within the construction scenario footprint were assumed to be undisturbed area.

The built disturbance boundary was based on the current design including the new roundabout to be built at the Tarro interchange. The rest of the area within the construction boundary was assumed to be restored and the same as the undisturbed area.

The water test data was collated and the average from the three field tests at each location was averaged to give a single mean log concentration (in mg/L) for the base flow scenario. Standard deviation values were those listed in the Draft NSW Music Modelling Guidelines for agricultural land (Table B-1).

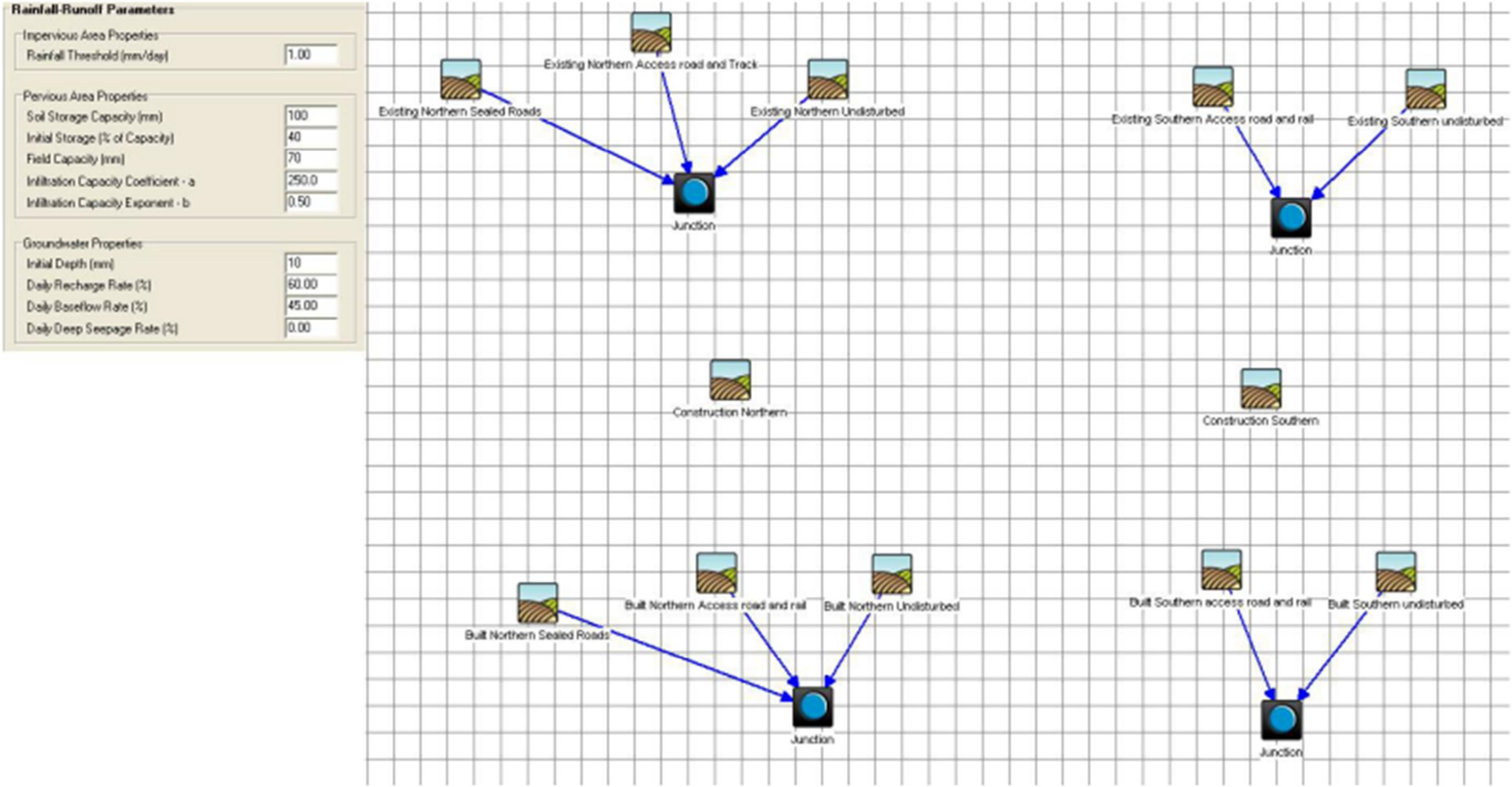
Table B-1 Input concentration values

Land use/ Zoning	Base flow		Storm flow	
	Mean (log mg/L)	Std Dev (log mg/l)	Mean (log mg/L)	Std Dev (log mg/l)
Sealed Roads				
TSS	1.20	0.17	2.43	0.32
TP	-0.85	0.19	-0.30	0.25
TN	0.11	0.12	0.34	0.19
Unsealed Roads/ Rail				
TSS	1.20	0.17	3.00	0.32
TP	-0.85	0.19	-0.30	0.25
TN	0.11	0.12	0.34	0.19
Eroding Gullies				
TSS	1.20	0.17	3.00	0.32
TP	-0.85	0.19	-0.30	0.25
TN	0.11	0.12	0.34	0.19
Agricultural Land North - Field measured				
TSS	1.74	0.13	2.15	0.31
TP	-0.14	0.13	-0.14	0.30
TN	0.24	0.13	0.48	0.26
Agricultural Land South - Field measured				
TSS	1.61	0.13	2.15	0.31
TP	-0.66	0.13	-0.22	0.30
TN	0.00	0.13	0.48	0.26

Storm flow mean values and standard deviations for each of the contaminants (TSS, TP, TN) were taken from Draft NSW Music Modelling Guidelines.

The rainfall-runoff parameters were calculated using the bore log data for soil type provided by Coffey Environments, 2012. The Draft NSW Music Modelling Guidelines provide different parameters based on varying soil types. The bore logs showed that the site is predominantly underlain by clayey sandy gravel. Interpretation of the bore logs was required to determine the input data to MUSIC. This input data and catchment plan are presented in the Figure B-2.

Figure B-2 MUSIC model conceptual representation of proposed Project Area



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B.3. Results

Data from the modelling runs is presented in Table B-2. The results show a large increase in TSS while TP and TN are only slightly higher on average. The large increase in TSS can be attributed to the earthworks and stockpiles which will be onsite during construction. Under the built scenario, loose sediments in the unsealed roads and rail line are likely to contribute to the increase in TSS.

Table B-2 MUSIC model predicted chemical loads

Northern Catchment	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Existing	35,100	65.8	216
Construction	102,000 (291%)	46.8 (71%)	236 (109%)
Built	64,700 (184%)	78.4 (119%)	261 (121%)
Southern Catchment			
Existing	10,700	8.47	37.3
Construction	16,700 (156%)	9.45 (112%)	42.4 (114%)
Built	18,300 (171%)	10.9 (129%)	49.6 (133%)

* Percentage compared to existing case

The increase in TP in the built scenario when compared to the construction scenario can be attributed to the increase in impervious area due the new construction. The area used for construction stockpiles is returned to agricultural land post construction. This accounts for the decrease in TSS in the northern catchment. The southern catchment becomes either rail or access road post construction and therefore there is only a minor reduction in TSS.

Appendix C

Levels of aquatic ecosystem conditions

ANZECC guidelines (2000) (Section 3.1.3.1) distinguishes three levels of aquatic ecosystem conditions:

4. **High conservation/ecological value systems (HEV)** — effectively unmodified or other highly–valued ecosystems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological value systems is regarded as intact.

5. **Slightly to moderately disturbed systems (SMD)** — ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly to moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoral activities, or marine ecosystems lying immediately adjacent to metropolitan areas.

6. **Highly disturbed systems (HD)** — measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture.

Appendix D

Water quality target values

Table D-1 specifies target values applicable to waterways in "South East Australia "region under the associated ecosystem type (i.e. estuarine and wetland).

Table D-1 Physico-chemical parameters

Parameters		Unit	Target value	
			Estuary	Wetland
pH	Low		7	No data
	High		8.5	No data
DO	Low	%	80	No data
	High	%	110	No data
EC		µS/cm	No data	No data
Turbidity		NTU	0.5-10	No data
Nitrite + Nitrate as N		µg/L	15	No data
Total nitrogen as N		µg/L	300	No data
Total phosphorus as P		µg/L	30	No data
Reactive Phosphorus as P		µg/L	5	No data

Relevant target values for toxicant for the proposed Project are outlined in Table D-2.

Table D-2 Toxicant target values

Parameters	Unit	Target value - Freshwater
Suspended Solids (SS)	µg/L	No data
Total Hardness as CaCO3	µg/L	No data
Aluminium (dissolved)	µg/L	55
Arsenic (dissolved)	µg/L	24
Cadmium (dissolved)	µg/L	0.2
Chromium (dissolved)	µg/L	No data
Copper (dissolved)	µg/L	1.4
Nickel (dissolved)	µg/L	11
Lead (dissolved)	µg/L	3.4
Zinc (dissolved)	µg/L	8.0
Manganese (dissolved)	µg/L	1900
Iron (dissolved)	µg/L	No data
Mercury (dissolved)	µg/L	0.06
Ammonia as N	µg/L	900
C6 - C9 Fraction (Total petroleum)	µg/L	No data
C10 - C14 Fraction (Total petroleum)	µg/L	No data
C15 - C28 Fraction (Total petroleum)	µg/L	No data
C29 - C36 Fraction (Total petroleum)	µg/L	No data
C10 - C36 Fraction (sum) (Total petroleum)	µg/L	No data
C6 - C10 Fraction (recoverable hydrocarbons)	µg/L	No data
>C10 - C16 Fraction (recoverable hydrocarbons)	µg/L	No data
>C16 - C34 Fraction (recoverable hydrocarbons)	µg/L	No data
>C34 - C40 Fraction (recoverable hydrocarbons)	µg/L	No data
>C10 - C40 Fraction (sum) (recoverable hydrocarbons)	µg/L	No data

Table D-3 Approximate factors to apply to soft water target values for selected metals in freshwaters of varying hardness

Category	Hardness (mg/L of $CaCO_3$)	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Soft (0 – 59)	30	No adjustment – use target values in Table D-2, Appendix D					
Moderate (60 – 119)	90	X 2.7	X 2.5	X 2.5	X 4.0	X 2.5	X 2.5
Hard (120 – 179)	150	X 4.2	X 3.7	X 3.9	X 7.6	X 3.9	X 3.9
Very hard (180 – 240)	210	X 5.7	X 4.9	X 5.2	X 11.8	X 5.2	X 5.2
Extremely hard (400)	400	X 10.0	X 8.4	X 9.0	X 26.7	X 9.0	X 9.0