LIDSDALE SIDING UPGRADE PROJECT

IMPACT ASSESSMENT - AQUATIC ECOLOGY

Lidsdale Siding Coal Conveyor

REPORT PREPARED FOR
Centennial Ivanhoe

MARINE POLLUTION RESEARCH PTY LTD
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Marine, Estuarine and Freshwater Ecology, Sediment and Water Quality Dynamics

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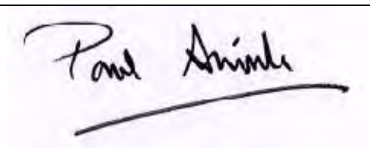
MPR APPROVAL: PAUL ANINK	 3 Aug 2012

EXECUTIVE SUMMARY

This report describes and assesses the value of the current aquatic ecology of the lower Pipers Flat Creek and Coxs River above and below the confluence, around the Lidsdale Siding site:

- The Coxs River up to the junction of Pipers Flat Creek is designated "Major River Key Fish Habitat" under the FMA and the Coxs River above the junction plus Pipers Flat Creek are both designated as "key fish habitat" under the FMA.
- Whilst there are no threatened aquatic species, as listed under the NSW FMA or Commonwealth EPBC (and none are expected), both streams support native fish and provide fish passage upstream past the site.
- There are no aquatic Groundwater Dependent Ecosystems (GDEs) in the lower Pipers Flat Creek or Coxs River within the vicinity of the upgrade site.
- Whilst both streams provide suitable habitat for a variety of aquatic plants and aquatic macroinvertebrates the habitat values are compromised by lack of riparian vegetation along the Coxs River, weed riparian species (mainly Willows) along and in Pipers Flat Creek and bank instability in both streams.
- Both waterways are accordingly classified as Class 2 “Moderate Fish Habitat” under the DPI Fisheries’ stream classification scheme.

The present site surface water management for protection of aquatic ecological values of the receiving waters includes internal drainage to control ponds and extensive water re-use facilities for dust suppression and mobile plant washing. However, parts of the site do not drain to these internal controls but drain directly to Pipers Flat Creek. Further, some off-site stormwater drainage flows through the site. By virtue of the historic location of this site it is also prone to occasional flood impacts.

Potential construction impacts on aquatic ecology arising from the proposed Lidsdale Siding upgrade are generally related to site stormwater control and control of stockpile water runoff associated with site excavations. Operational impacts are also generally related to control of site process waters and diversion of stormwater around the site and include the legacy problems already identified for the present site.

The potential construction and existing and potential operational impacts on adjacent aquatic habitats can be satisfactorily managed and mitigated via Construction and Operational Environmental Management Plans (EMPs). These provide the management

measures for control, storage and treatment of site waters and set out the proposed mitigation measures that will be used to both minimise potential impacts from operations of the proposed upgrade plus reduce the overall site impact on surface water drainage and surface water quality to the creek and river.

The proposal also incorporates mitigation measures that have a direct benefit for the aquatic ecology of Pipers Flat Creek north of the site and on Coxs River east of the site:

- Riparian and stream bank improvements along Pipers Flat Creek and into Coxs River below the confluence that will address current bank erosion problems, improve the water quality of stormwater draining overland to the creek and confluence and improve flood transport through the creek.
- Eradication of riparian and creek pest plant species (principally willows) plus re-planting of riparian and stream banks with local indigenous species.

It is concluded that the proposed upgrade works coupled with improved site water management measures and creek plus river riparian and stream bank stabilisation and vegetation management measures will result in an overall improvement of water quality and aquatic habitat condition for the benefit of the aquatic biota residing in the creek and river adjacent to the site and for fish passage past the site.

The proposed works would maintain and improve the Key Fish Habitat and Class 2 features of the lower Pipers Flat Creek and of the Coxs River below the confluence, and the proposed riparian and stream bank stabilisation and revegetation measures are in line with the Hawkesbury-Nepean Catchment Management Authority Action Plan 2007-2016 for the upper Coxs River catchment.

The environmental outcomes of the Lidsdale Siding Upgrade construction, operation and remediation programs will be specified in an Environmental Management Strategy (EMS) that will incorporate all aspects of environmental control including aquatic ecology. An aquatic ecology monitoring program incorporating the base-line data from the present study will be undertaken as part of the EMS and will use a guiding set of criteria and protocols to establish if additional mitigation measures would be required. These would be specified in Trigger Action Response Plans (TARPs) contained in the EMS.

1 INTRODUCTION

Centennial proposes to upgrade the existing Lidsdale Siding rail loading facility (Figure 1) by automating the transfer of coal from the exiting overland conveyor onto trains. The project involves establishing an elongated conical stockpile with underground reclaimers that feed coal to a ground conveyor, which then reports to a trainloading bin. Trains would be automatically loaded in a continuous operation as the train drives away from the bin. The project would reduce the need for mobile plant and equipment, such as front-end-loaders, to load trains. Mobile equipment would still be required for stockpile management. For a more detailed project description refer to Section 4 of the Environment Assessment Report (EAR).

The main components of the upgraded facility are shown in Figure 2 and the locality of the project in relation to the township of Wallerawang is shown in Figure 3. The main physical components of the project include:

- a new diversion chute at the end of the existing overland conveyor
- an elevating conveyor to feed the existing coal stream to the elongated conical stockpile
- augmentation of the existing major stockpile to create an elongated conical stockpile
- an underground tunnel with reclaimers
- a ground conveyor from the reclaim tunnel elevating to the train loading bin
- a diversion stockpile
- a train loading bin with a nominal 250 tonne capacity
- a spillage reclaim pit beneath the train loading bin
- an extension of the existing rail siding
- upgrades to the power supply and electrical distribution systems
- lighting for night operation and security
- site shaping and water management
- perimeter fencing and signage
- site landscaping.

Changes to the facility's operation as a result of the project would include:

- an increase in the quantity of coal processed from 2.0 million tonnes per annum (Mtpa) to 6.3 Mtpa
- an increase in the number of train movements from 3 to 5 train movements per day and with a peak of 7 train movements per day
- an increased rate of operation of the existing conveyor

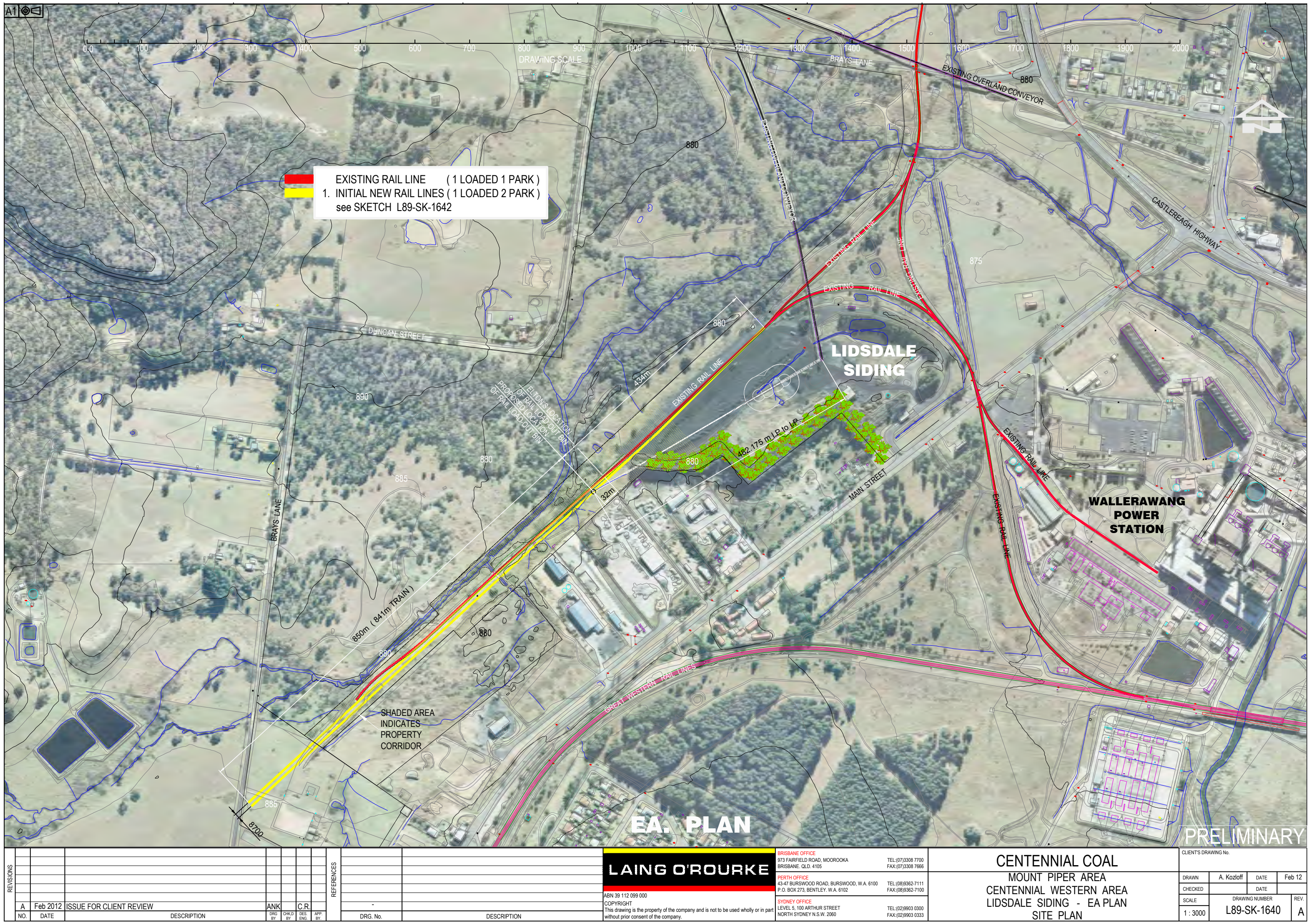


Figure 1 Aerial View of Existing Lidsdale Siding Facilities showing EA Project and Study Areas

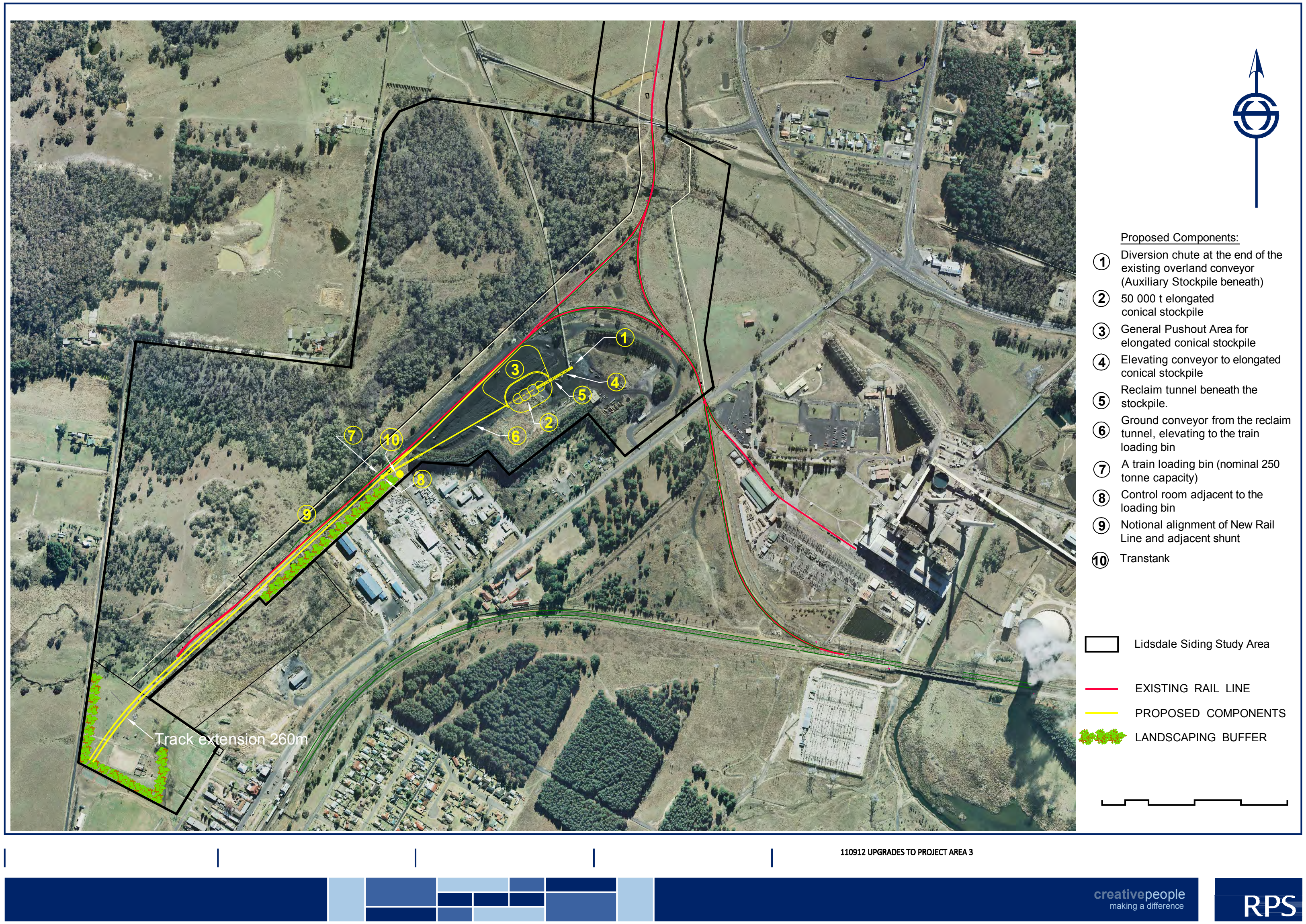


Figure 2 Plan showing Lidsdale Siding Upgrade Project

Figure 3 Topographic Map of lower Pipers Flat Creek (Lands Department 2012)

- operation of the new components of the facility including the reclaimers and conveyors
- reduced mobile plant and equipment.

Existing operational activities such as stockpile management, weighing of trains, refuelling of plant and equipment, maintenance activities, and environmental management and monitoring would continue.

The NSW Department of Planning & Infrastructure (DoPI) issued Director General's Requirements (DGRs) on 31 January 2012, which required, *inter alia* the assessment of the potential impact of the project on aquatic ecology. Marine Pollution Research Pty Ltd (MPR) was commissioned to undertake this assessment, which is provided here.

1.1 Aquatic Study Aims and Objectives

The DGRs provide the overall requirements for the preparation of the Environmental Assessment and these are summarised in Section 1.3 below. In terms of overall study aims, the Aquatic Ecology study endeavoured to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the aquatic habitats within the study area?
- Which of the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Is there fish passage between Coxs River and Pipers Flat Creek?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?
- Are there aquatic Groundwater Dependent Ecosystems (GDEs) in the study area?

1.2 Compliance with DGRs

Table 1 summarises compliance with the DGRs in relation to aquatic ecology assessment.

Table 1 Compliance of Aquatic Ecology Report with DGRs

Agency	Requirement	Response	Report Sections
DP&I General Requirements	Description of existing environment using sufficient baseline data.	Streamhealth assessment in Pipers Flat Creek and Coxs River up and downstream of confluence, including two or more seasonal surveys undertaken as per AusRivAS methods.	2.1 methods 5 results
DP&I General Requirements	Assessment of potential impacts and cumulative impacts as per relevant guidelines.	Assessment against guidelines as listed in Section 1.3 below.	6 Impact Assessment
DP&I General Requirements	Avoidance, minimisation, mitigation, offsets and contingency plans.	Assessed against guidelines as listed in Section 1.3 below.	6 Impact Assessment
DP&I Key Issue Biodiversity	Detailed assessment of potential impacts on aquatic threatened species or populations and habitats.	There are no listed aquatic threatened species or EECs and none are expected.	3 databases, 5.4, 5.5 & 5.6 study results
DP&I Key Issue Biodiversity	Detailed description of measures to avoid or mitigate impacts on biodiversity.	Assessed against guidelines as listed in Section 1.3 below.	6 Impact Assessment

1.3 Relevant Legislation & Guidelines

With regard to the assessment of aquatic ecology impact, a prime task is to determine whether there are any listed species or endangered ecological communities (EECs) in the study area or in areas that could be impacted by the proposal. Species and EECs are listed under the NSW *Fisheries Management Act 1994* (FMA) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC). Assessment for Threatened Aquatic Species and for Aquatic Biodiversity are undertaken against the DEC *Draft Guidelines for Threatened Species under Part 3A of the EP&A Act 1979* and the NSW DPI Fisheries *Policy and Guidelines - Aquatic Habitat Management and Fish Conservation* respectively, as specified in the DGRs.

One of the objectives of the Fisheries Management Act 1994 is to 'conserve key fish habitats (KFH)' - those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. Accordingly, the aquatic ecology impact assessment needs to show how *Key Fish Habitats* are to be conserved or, if they are to be impacted, how these impacts can be minimised, mitigated or offset as per the DPI Fisheries' Guidelines (NSW Fisheries 1999a,b).

DPI Fisheries has produced a series of KFH maps based on LGA boundaries and a portion of the Lithgow Regional KFH map is shown below as Figure 4. This map indicates that Coxs River and Pipers Flat Creek are defined as KFH (shown in red), and that Coxs River below the confluence with Pipers Flat Creek is defined as a major river KFHs (shown in blue).

DPI Fisheries' guidelines also provide a Fish Habitat Classification Scheme (NSW Fisheries 1999b and Annexure Table A1), and the results of the baseline studies within the KFHs defined above are used to provide site-specific fish habitat classifications of Pipers Flat Creek and Coxs River within the study area.

Aquatic ecosystems include aquatic biota that are groundwater dependent, and protection of potential Groundwater Dependent Ecosystems (GDEs) is set out in the NSW State Groundwater Dependent Ecosystem Policy (2002). Aquatic GDEs need to be identified using the eight-step rapid assessment (DLWC 2002), with specific potential aquatic GDEs including base-flow dependent GDEs, wetland GDEs and aquifer/cave GDEs. Terrestrial GDEs (i.e., those that are not associated with aquatic biota) are considered separately in the Terrestrial Ecological Assessment.

Where relevant, the following additional guidelines have been taken into account when assessing the Lidsdale Siding Project impacts and mitigation for aquatic ecology (see Section 5 for full citations):

- DEC/DPI (2005) *Draft Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).*
- OEH Website based *Survey and Assessment guidelines.*

http://www.environment.nsw.gov.au/threatenedspecies/surveymethodsfauna.htm#1).

- AMBS (2011) *Survey guidelines for Australia's threatened fish*
- DLWC (2002) *NSW State Groundwater Dependent Ecosystem Policy*
- NSW Fisheries (1999a) *Policy & Guidelines - Aquatic Habitat Management and Fish Conservation*
- NSW Fisheries (1999b) *Policy & Guidelines - Fish Friendly Waterway Crossings*.
- Rutherford et al (2000) *A Rehabilitation Manual for Australian Streams*.

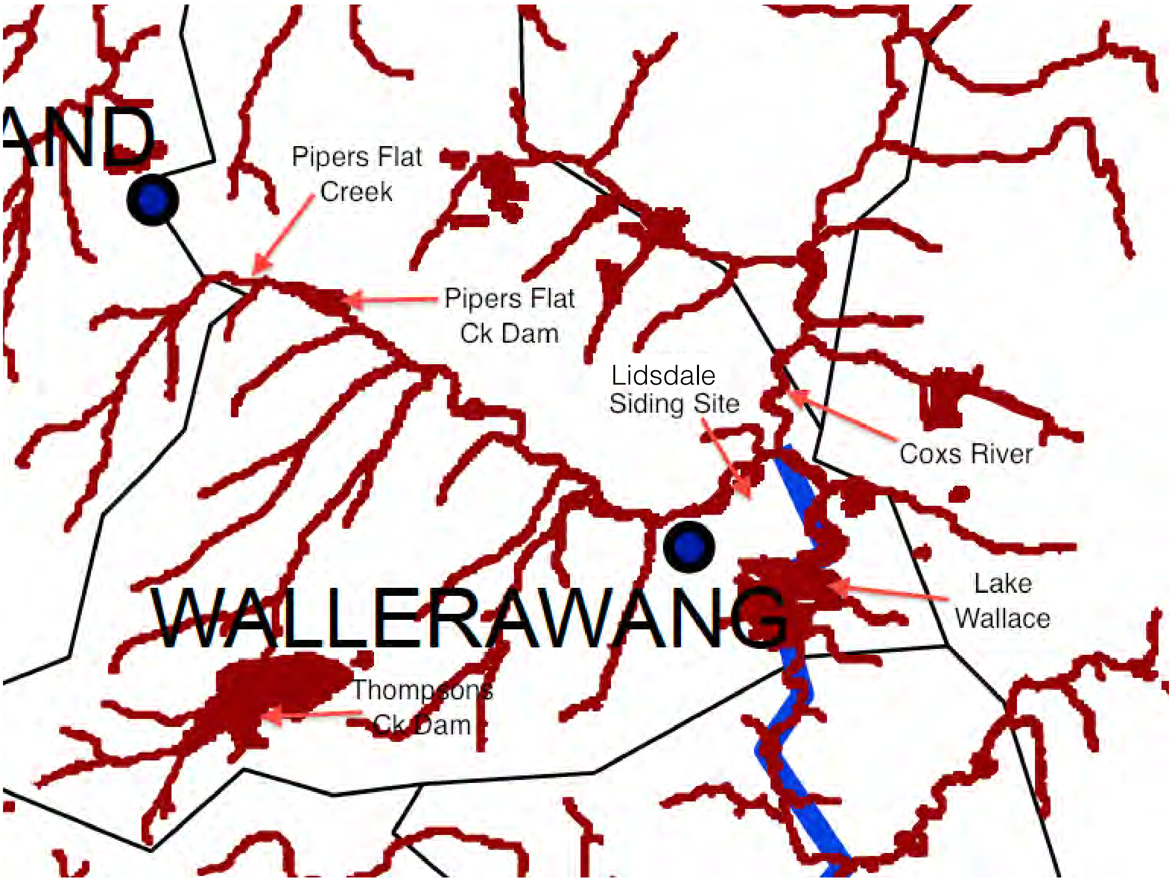


Figure 4 Portion of the DPI (Fisheries) Lithgow LGA Key Fish Habitat (KFH) Map showing KFHs in red and Major River KFHs in blue. The proposed Lidsdale Siding area is adjacent to the Piper Flat Creek KFH, which drains to the Coxs River KFH. Note that the Coxs River KFH becomes major river KFH at this confluence.

1.4 Literature Review and Database Searches

Relevant aquatic ecology information has been sought from ecological studies conducted in the broader upper Coxs River catchment, generally from assessments of major developments and infrastructure projects. Relevant fish data, including records of threatened aquatic species listed under FMA were obtained from a search of records on the DPI (Fisheries) and the Australia Museum databases. The online search tool for aquatic species listed under the EPBC Act was also consulted.

MPR (2010) and Cardno Ecology Lab (2010) provided reviews of available aquatic ecological information for the upper Cox River above Lake Wallace and for the Coxs River between Lake Wallace and Lyall respectively:

- TEL (2007) undertook electrofishing and macroinvertebrate surveys in two creeks within the upper Coxs River catchment; Kangaroo Creek and Sawyers Swamp Creek and in Marrangaroo Creek, which flows to the Coxs River below Lake Wallace.
- Cardno Ecology Lab has been undertaking fish and macroinvbertbrate surveys in the Coxs River between Lakes Wallace and Lyall since 2005.
- MPR has undertaken seasonal macroinvertebrate and fish trapping studies at multiple sites in Coxs River, Kangaroo Creek, Wangcol Creek, Pipers Flat Creek and Springvale Creek since 2010.

The Hawkesbury Nepean Catchment Management Authority (HNCMA) has assessed the upper Coxs River aquatic and riparian habitats as part of their River Health Strategy (HNCMA 2007). The upper catchment river was found to be under "severe and immediate threat from riparian weed invasion and coarse sediment as a result of erosion, which creates a severe downstream impact". HNCMA (2007) recommended that the most effective land management strategy for the Upper Coxs River is riparian revegetation.

RPS Aquaterra (2012a) concluded that Pipers Flat Creek is mainly ephemeral, as groundwater baseflow discharge is insufficient to sustain continuous flow, and extensive periods of no-flow occur naturally. However, in the study reach alongside Lidsdale Siding, the Creek receives artificial recharge from the upstream Wallerawang Sewage Treatment Plant (STP), and therefore there are flows most of the time in the lower reaches below the STP. RPS Aquaterra also note that in the 1950's Pipers Flat Creek was diverted to the north of the rail line, south-west of the main operational section of the site and there are remnant natural drainage lines through the site from Main Street and from a combination of properties to the south and south-wet of the site.

With respect to macroinvertebrate communities, there is limited publically available information for the river and creeks above Lake Wallace prior to the commencement of the MPR seasonal surveys in 2010. TEL (2007) noted that the macroinvertebrate fauna of Sawyers Swamp Creek was dominated by pollution tolerant taxa such as midge flies (sub-families Chironominae and Tanypodinae) and biting midge larvae (family Ceratopogonidae), whereas locations in two other creeks showed higher proportions of pollution sensitive taxa: caddis-flies (family Leptoceridae) and mayflies (family Leptophlebiidae) in Marrangaroo Creek and dragonflies (family Telephlebiidae) and stone-flies (family Gripopterygidae) in Kangaroo Creek.

With respect to the fish fauna of the upper Coxs River, both the main artificial impoundments on the upper Coxs River (Lake Wallace and Lake Lyell) have no fishways and they represent impassable barriers to most fish species (Gehrke and Harris 1996). Nevertheless, Lake Wallace and the upper Coxs River catchments do support several native and a number of introduced fish species:

- The native flathead gudgeon and the introduced brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), mosquito fish and carp (*Cyprinus carpio*) have all been reported previously from Lake Wallace (Jones et al 1994).
- The two trout species plus the native Australian bass (*Macquaria novemaculeata*) have been stocked in Lake Wallace and Coxs River (NSW Fisheries 2003).
- TEL (2007) found a small number of mountain Galaxias in Sawyers Swamp Creek and there were no fish recorded from Kangaroo Creek. Three introduced species were recorded in Marrangaroo Creek; brown trout, rainbow trout, and gambusia. Although there is inhibited fish passage between Marrangaroo Creek and the study area upstream of Lake Wallace, there is passage to the lower end of the study area below Lake Wallace dam.

The following threatened species or populations listed under the FMA and EPBC Act are relevant to the assessment:

- Macquarie perch (*Macquaria australasica*) are listed as Endangered under both the NSW *Fisheries management Act 1994* (FM Act) and the EPBC Act. Whilst Macquarie perch have been reported from the Coxs River below Lake Lyell, they have not been found in the upper river and, owing to the impassable Coxs River impoundments, these species are not expected to occur.

- Australian grayling (*Prototroctes maraena*) are listed as Vulnerable under the EPBC Act. Whilst Australian Grayling are known from high altitude rivers on the Australian east coast it is also severely impacted by impoundments, and has not been recorded in the Coxs River above or below the impoundments.
- The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: Somersby Falls and Floods Creek in Brisbane Waters National Park near Gosford; Tunks Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 5). Considering these observations, and taking into account the habitat requirements for this species it is concluded that the aquatic habitats available in the lower Pipers Creek and Coxs River above Lake Wallace do not provide suitable habitat for Adams Emerald Dragonfly and none have been located in the aquatic ecology sites studied seasonally in the upper Coxs River since at least 2007.

In summary, no threatened aquatic plants, fish or macroinvertebrate species or populations listed, under the threatened species provisions of the Commonwealth EPBC Act or under the threatened species provisions of the NSW FMA have been found or are likely to occur in the upper Coxs River catchment above Lake Wallace.

2 STUDY & ASSESSMENT METHODS

Whilst the study area and project areas are defined as indicated in Figure 2 above, the actual construction works are confined to an area south of the lower part of Pipers Flat Creek:

- The area identified from the road crossing northwards along the northern rail easement does not comprise any proposed works. Centennial requires this area to be included because it is part of the existing operation and therefore would be included as part of any consent.
- The area to the south of the proposed extension of the rail siding has been included because Centennial anticipates needing this area for visual screening and noise barriers.
- The area to the east is extended to cover the current creek monitoring sites and licensed discharge point which need to be covered by any consent.

2.1 Study Design and Study Elements

Figures 2 and 3 show the relationship of the proposed works to the river and creek drainage sub-catchments draining to or through the study site and Figure 4 shows the DPI Fisheries classification of Key Fish Habitats for streams in the locality. Figure 3 show the sites that were selected and sampled for the base-line studies undertaken for the proposal. The base-line study assessed the aquatic habitats and biota of these five in-line stream sites within these defined *Key Fish Habitats*.

The adopted sampling methodology to achieve the study aims incorporated the following tasks to be undertaken at each site (for detailed methodology see MPR 2010b):

- Sampling the aquatic macroinvertebrate fauna twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 1.2.2 below). Note that for AusRivAS standardised sampling purposes the ‘autumn’ sample season is defined as March 15 to June 15 and ‘spring’ is defined as September 15 to December 15.
- Recording of changes in site riparian and aquatic habitat condition and of aquatic plant distribution within the study areas at each sampling time.
- Estimation of fish occurrence by a combination of overnight or short-term bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released wherever possible.

- Metered depth profiles of basic water quality parameters at each site.
- Observations of turtle, reptile and aquatic birds noted during field sampling activities.

2.2 Aquatic Macroinvertebrate Sampling

The aquatic macroinvertebrate assemblages are determined using the standardised AusRivAS sampling protocol (Turak et al 1999, Turak et al 2004, Chessman 2003b), which provides a number of definitions of sites, and of habitats within sites, for selection of sampling locations:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater"
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum". However, “sampling riffles where the substratum consists predominantly of large boulders may be difficult and may not produce reliable results".
- Edge habitat is "an area along the creek with little or no current".

Ideally, AusRivAS recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site. In practice, given that the creek sub-catchments are often dry or have no flow with consequent isolated pools, it was decided that pool 'edge' samples would comprise the main sampling unit, as riffle samples could not be guaranteed for all sites at all sample times.

Macroinvertebrate assemblages are sampled using a 250 μm mesh dip net over as many aquatic 'edge' habitat types as can be located within each of the pools along the defined stream reach. Net samples are then placed into white sorting trays for in situ live sorting. Live sorting (picking) is undertaken for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations are made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms are collected and added to the dip net samples.

Specimens for which positive identifications can be made in the field - especially the rarer specimens (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopt a 'sampling with replacement' policy. Notwithstanding this procedure, for most taxa that can be positively identified in the field, at least one of each of the field identified taxa are retained as a representative of that taxa for that sampling event. For all other macroinvertebrate taxa where field identifications are not definitive, specimens are retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies).

All retained specimens are placed in sample jars preserved in 70% ethanol for subsequent laboratory identification. Sample jars are labelled and paper laundry tags are inserted noting the sample site, sample date and sample collector/picker initials.

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes. The following taxonomic guides have been found to be the most useful; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999) & Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars. Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed. At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies. Following this procedure, and if there have been anomalies, an additional 10% of the remaining samples are chosen and the QA/QC re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.1 Macroinvertebrate data evaluation

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL (Stream Invertebrate Grade Number Average Level) score. SIGNAL is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a). Whilst site SIGNAL scores are graded into the following generalised categories (Chessman *et al*. 1997), in practice the SIGNAL scores are used to provide relative assessments within site and across seasons:

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

Once individual taxa SIGNAL indices have been applied, site SIGNAL scores are calculated as the mean of the individual taxa SIGNAL indices. For coherent groups of sites (e.g., all sites within a stream/river or all dam sites within a catchment), combined stream or habitat type (dams) scores can be calculated in the same way from the combined taxa for the stream/habitat types. Site and stream/habitat SIGNAL scores can then be compared across each survey and between surveys.

2.3 Field Sampling Methods for Fish and other Vertebrates

At each macroinvertebrate sampling site four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified in situ and released. Any fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released. Fish specimens that become deceased during the sample process are retained with macroinvertebrate samples, and identified using Allen et all (2002) and McDowall (1996). Any fish retained that are not positively identified are sent to the Australian Museum for confirmation of species identification. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted, with fish species-name only noted if positively identified.

For each survey, tadpoles and frogs (amphibians) are noted in the results but tadpoles are not kept or identified (see the Terrestrial Fauna report for details of amphibians). Notes are also kept of the presence of reptiles, turtles, aquatic birds and bats that directly utilise the aquatic habitats. Sightings and searches for possible platypus burrows and Australian water rat tracks are made at suitable river and creek locations, preferably at dusk to detect the emergence and activity of these aquatic animals. Reports of amphibians, reptiles, birds and mammals are provided to the Terrestrial Fauna team for incorporation into their assessments where required.

2.4 Stream Condition, Aquatic Plants and Field Water Quality

A standardised description of aquatic and riparian site condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by rating each RCE descriptor (13 in total) a score between 0 and 4, then summing the scores to reach a maximum possible score of 52. Scores are expressed as a percentage.

The aquatic edge sampling for macroinvertebrates includes the assessment of aquatic plants (macrophytes) within the site length and more generally within the greater study area.

A submersible Yeo-Kal 911 water quality data logger was used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. Where possible depth profiles of water quality are made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.).

2.5 Aquatic Groundwater Dependent Ecosystems (GDEs)

Both the Terrestrial and Aquatic Ecology studies included inspections for Groundwater Dependent Ecosystems (GDEs) within the study area, as required under the DGRs Key Issue for *Biodiversity*). Aquatic GDEs include all aquatic biota of aquatic habitats that are dependent on baseflow for their continued existence, and this definition does not include ephemeral aquatic habitats that depend on sporadic surface water flow. Any potential sites identified are required to be assessed using the eight-step rapid assessment (DLWC 2002) and the significance of any GDEs found would need to be assessed against the GDE Policy *Management Principles*:

- Identifying the values of and threats to GDEs.
- Managing groundwater extraction so the GDEs are maintained.
- Giving priority to protecting GDEs identified as being under immediate or high degree of threat.
- Application of the precautionary principle.

The search for possible surface expressed aquatic GDEs was based on analysis of current aerial photography, on available topographic information, on discussions with the project groundwater experts and on field stream assessments. From these combined sources no potential aquatic GDEs were located and no further investigations were required.

3 AQUATIC ECOLOGY OF THE STUDY AREA

3.1 The Study Catchment

The project site is located on the southern banks of Pipers Flat Creek just above the confluence with Coxs River at the township of Wallerawang (Figures 1 and 4). Pipers Flat Creek drains a catchment that is situated along the eastern edge of the Great Dividing Range to Coxs River some 19km downstream:

- The upper catchment drains to the north-east into Pipers Flat Creek Dam, 8km downstream. The whole upper catchment has been cleared, predominantly for grazing.
- Pipers Flat Dam and lands immediately upstream and downstream are owned by Centennial, and upstream includes land over the old Ivanhoe No1 Mine (closed in early 1950's), which Centennial Coal is currently rehabilitating. The dam is a "prescribed dam" (covered by the NSW Dam Safety Committee), holds about 550 ML and is currently licensed to supply up to 145 ML per year, though this is not used.
- Pipers Flat Creek dam discharges flows south east for 7 km towards Wallerawang township (Figure 3). The northern side of the catchment is bounded by Mount Piper (Ben Bullen State Forest), and there are a number of large sub-catchments draining to Pipers Flat Creek from the south; the largest being Thomsons Creek, which contains a water supply reservoir in the upper sub-catchment. The floodplain of Pipers Flat Creek is totally cleared, predominantly for grazing.
- The lower section of Pipers Flat Creek is some 2.5km long (see Figure 3). The Wallerawang STP discharges to the creek from the north and the township of Wallerawang west of James Parade drains to the creek. This includes the industrial area and the Lidsdale Coal loader north of Main Street.
- Pipers Flat Creek below Brays Lane crossing has been diverted into a 1 km long straight channel alongside the existing Lidsdale Siding (Figure 3). The old creek line has been blocked off at its upstream end but remains connected at the downstream end, as it captures additional drainage from the western portion of Wallerawang township (flowing north-east from the town sports field).
- The last section of the creek is about 1.5km long. It has good riparian cover through to the rail crossing that includes a mix of native and introduced species, mainly willows. The willows have obstructed much of the channel at many locations. There is a small creek discharging into Pipers Flat Creek from a sub-catchment to the north of the Lidsdale Siding property. This sub-catchment has

several in-line dams (see Figure 3).

- The Lidsdale Siding site drainage is substantially collected and directed to a water management pond (the Control Pond) with the collected water generally re-used on site for dust suppression and plant washing). Excess site waters (generally arising from high localised rainfall or sub-catchment flood events is direct to a Licensed Discharge Point 4 (LDP4) which is located inside the triangle of the rail loops (Figure 3) and discharges via a culvert to a pool located under the northern rail loop. This pool then discharges to Coxs River, which then discharges to Lake Wallace a further 1.5km downstream. See RPS Aquaterra (2012a) for more detail on site drainage.

3.2 Aquatic Flora and Fauna Assessment

This assessment is based on the results of the following aquatic ecology surveys:

- Two seasons (Autumn and Spring 2011) for two sites in Pipers Flat Creek, one located upstream and one downstream of Lidsdale Siding LDP4 discharge.
- Four seasons (Autumn and Spring 2010 and 201) for three sites in Coxs River; two sites up- and down-stream of the confluence of Coxs River and Pipers Flat Creek and one site downstream below Lake Wallace Dam.

Table 2 Seasonal Aquatic Ecology Sample Schedule & Site Descriptions

Creek/River	Site	E	N	Au10	Sp10	Au11	Sp11	Description
Pipers Flat Creek	PFup	227738	6300763			x	x	Pipers Flat Ck site located around 650m upstream from the confluence with Coxs River.
	PFdn	228119	6300988			x	x	Pipers Flat Ck monitoring site around 90m upstream of the Coxs R confluence, where LDP4 discharges into Pipers Flat Creek.
Coxs River	CR4	228348	6302775	x	x	x	x	Coxs River site located upstream of Pipers Flat Creek confluence at Maddox Lane.
	CR5	228529	6300752	x	x	x	x	Coxs River site located downstream of Pipers Flat Creek confluence at Main St bridge, Wallerawang.
	CR6	228533	6297741	x	x	x	x	Lower Coxs River monitoring site located below Lake Wallace Dam.

Figure 3 provides the locations of the stream health sites sampled over the period in relation to the study area and Table 2 provides site descriptions and GPS locations for the study sites. Annexure Table A-2 provides field notes for all sampling seasons. The Annexure also provides site photographs for all sites sampled each season.

3.3 Sampling Periods, Weather and Stream Flow

Autumn 2011

Initial site inspections and sampling for the Autumn 2011 aquatic ecology field survey was undertaken between the 7th and 10th June 2011. In the six months leading into the Autumn 2011 survey, rainfall patterns – as sourced from the Bureau of Meteorology Lidsdale rain gauge are summarised as follows:

- 68.6mm of rain fell in the first half of November 2010, followed on by a 190.4mm rain event over a two-week period from late November and into December.
- Total monthly rainfall figures for January to March 2011 were similar to the average monthly totals.
- Although April is historically the driest month (with a mean total of 42.6mm), April 2011 recorded only 23.8mm.
- 35.2mm of rain fell over the 7 days leading up to the Autumn 2011 survey, with a total of 57.8mm of rain falling over the month prior to when sampling began.

Seasonal flow rates in the Coxs River (recorded at the Wallerawang Power Station just downstream from CR5) for all seasonal survey sample dates are shown below in Table 3.

Table 3 Coxs River Seasonal Flow Rates

Season	Date	Flow (ML/day)
Au10	8/06/10	10.9
Au10	9/06/10	13.0
Au10	10/06/10	14.4
Sp10	27/10/10	27.7
Sp10	28/10/10	19.6
Au11	7/06/11	9.6
Au11	8/06/11	9.2
Au11	9/06/11	9.1
Au11	10/06/11	8.8
Sp11	1/11/11	8.8
Sp11	2/11/11	7.3
Sp11	22/11/11	17.4

A high flow event occurred in response to the rainfall event in November- December 2010 where flows in the Coxs River at Wallerawang reached a daily mean discharge of 3831.7 ML/day, and river levels rose from 0.29m on the 28th November to a peak of 1.78m on the 4th December.

At The Coxs River study sites CR5 and CR6 there was evidence that high flow water levels had reached between 2.5m and 3.5m above the normal prevailing water levels, and caused the removal of instream and edge bank vegetation (mainly cumbungi (*Typha* sp) stands). At CR6 there had also been some minor bank erosion. At Pipers Flat Creek site PFdn there were a number of established willow (*Salix sp*) trees that had been toppled from the high flow event (see Annexure A site photographs 19 to 21).

Spring 2011

The Spring 2011 aquatic ecology field sampling was undertaken over the 1st and 2nd November for the Coxs River sites and on the 22nd November for the Pipers Flat Creek sites. Over the period since the Autumn 2011 survey in June 2011, the study area had been receiving varying amounts of rainfall;

- The combined total rainfall for the months of June, August and September 2011 (161.4mm) was similar to the combined mean totals for the same three months (168.6mm).
- Although the rainfall for July was scattered over 9 rainfall days, the monthly total of 18.2mm was much less than the monthly mean of 51.6mm.
- October was also relatively dry receiving a total of 36.6mm (compared to the monthly mean of 69.4mm), and in the three weeks leading up to the Spring 2011 Coxs River site sampling a total of 4.6mm rain fell.
- There was no rainfall in the first week of November, however a total of 58.8mm rainfall occurred between the 9th and 22nd November leading up to the Spring 2011 Pipers Flat Creek sampling (including 9mm falling on the 22nd).

There was surface flow at all of the monitoring sites for Spring 2011 aquatic ecology survey. Mean daily flow readings for the Coxs River at Wallerawang indicated similar flow rates as the Autumn 2011 survey for the early November Coxs River sampling at 8.8 ML/day and 7.3 ML/day for the 1st and 2nd November respectively. Flow rates in the Coxs River were higher on the 22nd November for the Pipers Flat Creek sampling at 17.4 ML/day, in response to the scattered showers over the preceding week.

Summer 2011

An additional site walk-over was undertaken on 20 December 2011 specifically for this assessment. There had been another high flow event in Pipers Flat Creek since the field sampling survey in late November 2011. This event uprooted some of the willows established at a nick point at the lower end of the straight portion of the re-aligned creek line where it turns to the north (Figure 5).

Figure 5 Photo of nick point in Pipers Flat Creek diversion channel where willows have established. Storm flows prior to the date of this photo (20 December 2011) had uprooted some of the willows and flow under the root mat has doubled the willow root mat over itself as indicated, partially clearing the creek obstructions at this point.

3.4 Aquatic Plants and Aquatic Habitat Assessments

Annexure Table A3 details the occurrence of aquatic plants and emergent macrophytes for all seasonal surveys and the results are summarised in Table 4 below.

A total of 6 macrophytes were recorded from the two Pipers Flat Creek sites over the two surveys, and 11 macrophytes were recorded from the three Coxs River sites over all four seasonal surveys. Three of the macrophytes listed are introduced species; starwort (*Callitriche stagnalis*), jointed rush (*Juncus articulatus*) and watercress (*Nasturtium officinale*).

Over both surveys there were consistent beds of blunt pondweed (*Potamogeton ochreatus*) observed throughout the length of Pipers Flat Creek from PFup downstream to the confluence with the Coxs River. Isolated stands of the emergent macrophytes tall spike rush (*Eleocharis sphacelata*) and cumbungi (*Typha sp*) were observed in the lower sections of Pipers Flat Creek in the vicinity of PFdn where broader, lower flow sections of channel prevail. During the Spring 2011 survey observations were made of very sparse occurrences of common reed (*Phragmites australis*) at PFup.

Table 4 Macrophyte Occurrence

Common name	Genus/spp	Site	CR4	CR5	CR6	PFup	PFdn
Starwort	*Callitriche stagnalis*					1	1
Tall Spikerush	*Eleocharis sphacelata*				1		1
Jointed Rush	*Juncus articulatus*		1		1		
Rush	*Juncus sp*		1				
Water Primrose	*Ludwigia peploides*			1	1		
Watercress	*Nasturtium officinale*			1	1		
Knotweed	*Persicaria sp*				1		
Common Reed	*Phragmites australis*		1			1	
Curly Pondweed	*Potamogeton crispus*			1			
Blunt Pondweed	*Potamogeton ochreatus*			1		1	1
River Clubrush	*Schoenoplectus validus*			1			
Duckweed	*Spirodela sp*					1	
Cumbungi	*Typha sp*		1	1	1		1
Charophytes			1	1			

Cumbungi is the most commonly occurring macrophyte throughout the Coxs River sites, at times forming extensive stands along the river edges. However, as observed between consecutive surveys cumbungi can undergo seasonal fluctuations due to die-back and is also subjected to scouring by flooding (such as that observed at CR5 during the period between Spring 2010 and Autumn 2011).

Extensive beds of charophytes (which are an algae and not true flowering plants) have been observed at the upstream Coxs River monitoring site CR4, in addition to common reed stands and the introduced jointed rush along the waters edge. Site CR5 has consistently supported widespread and dense beds of curly pondweed (*Potamogeton crispus*) and to a lesser extent blunt pondweed along the site length deeper pool sections.

Full results of seasonal riparian and aquatic habitat condition as estimated by RCE (Riparian, Channel and Environment) analysis are provided in Annexure Table A4 and the results are summarised in Table 5 below. The RCE results have been expressed as percentages with higher percentages indicating better aquatic habitat condition.

Low RCE scores were recorded over most of the sites and ranged from 58% at CR4 to 75% at PFup. The overall lowest category scores were recorded for (i) completeness of riparian corridors, (ii) land use beyond the riparian zone, (iii) aquatic vegetation and (iv) stream bank undercutting. With the exception of PFup, all sites are surrounded by cleared agricultural lands and industrial areas, with very few sections of continuous riparian woody corridors.

Table 5 Summary of RCE Results

Category	AU11 CR4	AU11 CR5	AU11 CR6	AU11 PFup	AU11 PFdn	SP11 CR4	SP11 CR5	SP11 CR6	SP11 PFup	SP11 PFdn
Land-use pattern beyond immediate riparian zone	2	2	2	2.5	2	2	2	2	2.5	2
Width of riparian strip-of woody vegetation	2	2	2	4	2.5	2	2	2	4	2
Completeness of riparian strip of woody vegetation	1	2	1	3.5	1.5	1	2	1	3.5	1
Vegetation of riparian zone within 10 m of channel	2	3	3	3	2.5	2	3	3	3	2.5
Stream bank structure	2	2	2.5	3.5	2	2	2	2.5	3.5	2
Bank undercutting	2	2	3	2	2	2	2	3	2	2
Channel form	4	3	4	4	3.5	4	3	4	4	3.5
Riffle/pool sequence	2	3	4	4	1	2	3	4	4	1
Retention devices in stream	2	3	3	3	3	2	3	3	3	3
Channel sediment accumulations	3	3	3	2.5	2.5	3	3	3	2.5	2.5
Stream bottom	3	2	3	3	3	3	2	3	3	3
Stream detritus	3	3	3	3	2	3	3	3	3	2
Aquatic vegetation	2	3	2.5	1	1	2	3	2.5	1	1
RCE Score	30	33	36	39	29	30	33	36	39	28
RCE %age	57.7	63.5	69.2	75.0	54.8	57.7	63.5	69.2	75.0	52.9

Whilst the condition of the aquatic habitats and riparian environments remained largely unchanged for the period of assessment, there were minor fluctuations in RCE scores for Pipers Flat Creek site PFdn and Coxs River site CR5.

- The RCE score at site CR5 improved due to a decrease in macrophyte coverage within the site between consecutive (pre and post flood) surveys.
- Site PFup condition decreased for the Spring 2011 survey owing to the lower category scores received for "width and completeness of riparian strip of woody vegetation" as a result of willow tree removal between surveys.
- Although willow trees constitute a large proportion of the established in stream tree cover at PFup, there is also a continuous strip of native eucalypt corridor which extends laterally along the site length, a factor which none of the other study sites possessed.
- The presence of the willow trees also contributed to higher scores received for

stream bank structure category at PFup, in which the willow tree root structures provided the only stream bank stabilisation.

A search was made of the project and study areas for springs and wetlands that may have supported aquatic GDEs but none were found and, given the long history of mining, creek diversions and industrial land use undertaken in the lower Pipers Flat Creek area, none are expected.

3.5 Field Water Quality Results

Annexure Table A5 provides the full results of the metered water quality sampling for all sites (including any targeted depth profile readings) over all surveys, and Table 6 summarises the site surface water quality data.

Table 6 Stream Surface Water Quality Readings Autumn 2010 to Spring 2011

Site	Date	Time	Depth	Temp	Cond	Sal	DO	DO	pH	Turb
			M	°C	μS/cm	ppt	%sat	mg/l	Units	ntu
CR4	10/06/10	08:01	0.1	7.16	950	0.52	71.2	8.6	8.69	16.1
CR5	8/06/10	12:52	0.1	9.53	829	0.46	115.0	13.1	9.24	12.9
CR6	8/06/10	15:54	0.1	10.95	998	0.55	72.3	8.0	9.41	22.4
CR4	27/10/10	13:07	0.1	17.90	666	0.36	74.5	7.1	7.84	6.4
CR5	28/10/10	8:09	0.1	14.80	558	0.31	63.3	6.4	7.97	10.7
CR6	28/10/10	14:52	0.1	14.70	620	0.34	67.1	6.8	8.05	6.4
CR4	8/06/11	15:51	0.1	6.38	930	0.46	76.0		8.02	5.3
CR5	7/06/11	12:56	0.2	7.23	860	0.42	83.9		8.47	3.7
CR6	7/06/11	15:19	0.2	9.68	865	0.44	80.3		8.99	10.9
PFup	10/06/11	11:30	0.1	7.71	540	0.25	66.2		7.37	5.0
PFdn	10/06/11	9:54	0.1	6.12	594	0.28	68.7		7.45	2.4
CR4	1/11/11	18:16	0.1	19.82	853	0.43	101.2	8.4	7.99	5.9
CR5	2/11/11	12:39	0.1	19.51	764	0.38	171.2	14.2	8.67	15.2
CR6	2/11/11	11:09	0.1	15.66	866	0.43	98.3	8.8	7.94	14.3
PFup	22/11/11	8:10	0.2	17.42	609	0.30	40.6	3.5	7.07	11.3
PFdn	22/11/11	7:29	0.1	17.07	648	0.32	48.2	4.2	7.14	6.8

Note: For the Autumn 2011 survey there were no DO (mg/l) readings due to meter calibration errors.

Site water quality results are summarised as follows;

- Surface water temperatures ranged between 6.1°C and 11.0°C for the Autumn surveys and 14.7°C and 19.8°C for the Spring surveys.
- Surface water conductivity in Coxs River sites ranged from 558 μS/cm to 998 μS/cm and for all four surveys CR5 recorded the lowest conductivity readings

compared to other Coxs River sites.

- For the two 2011seasonal surveys, water conductivity was around 200μS/cm lower in the Pipers Flat Creek sites compared to the Coxs River sites and site PFdn conductivity was around 50μS/cm higher then PFup readings.
- Surface water dissolved oxygen (DO) results for the Coxs River sites were mostly in the moderate to high range. Sites CR4 and CR6 recorded similar DO values for all surveys, and for the Autumn 2010 and Spring 2011 surveys CR5 recorded significantly higher DO readings when compared to the other Coxs River sites up and downstream.
- DO values were correspondingly low in Pipers Flat Creek for both surveys; around 66% saturation in Autumn 2011 and 44% in Spring 2011.
- Water pH was alkaline at Coxs River and Pipers Flat Creek with lower values in Pipers Flat Creek (around 7.2 pH units) with Coxs River values between 8.0 and 9.0 pH units.
- Water turbidity is generally low with ranges in Coxs River from 3.7 to 22 NTU (mean 10.8 NTU) and in Pipers Flat Creek 2 to 11 NTU (mean 6.4 NTU).

3.6 Aquatic Macroinvertebrate and Fish Survey Results

Annexure Table A6 shows the results of taxonomic identifications of aquatic macroinvertebrates to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates, fish and reptiles over all seasonal surveys. The tables provide site statistics including site and weighted SIGNAL scores and these are summarised in Table 7 below.

Table 7 Macroinvertebrate Summary Statistics

Season	Diversity (No Taxa per Site)				
	CR4	CR5	PFup	PFdn	CR6
Au10		20			19
Sp10	26	32			19
Au11	21	23	19	18	19
Sp11	22	23	22	25	20
	Site SIGNAL Index				
Au10		4.00			3.88
Sp10	4.00	4.32			3.41
Au11	4.14	4.00	3.63	4.60	3.59
Sp11	4.64	3.90	3.84	3.91	3.18

Over the term of the study period, a total of 15 macroinvertebrate samples were collected from the five sites within the study area, and aquatic macroinvertebrate sampling results for the baseline survey may be summarised as follows:

- A total of 53 macroinvertebrate taxa were recorded from the study area over all four of the baseline surveys between Spring 2010 and Spring 2011.
- The majority of the fauna were insects (35 taxa), with the remainder of the taxa comprising 6 crustacean taxa, 4 gastropod and 1 bivalve molluscs, and one of each of the following taxa; leeches and freshwater worms, water mites, seed shrimps, hydras and flatworms.
- The most common taxa were caddis fly family Leptoceridae, freshwater worms (class Oligochaeta) and the introduced snail family Physidae recorded from 14 of the 15 sites sampled.
- Other common taxa (present from 12 or more sites) included bloodworms (sub-families Chironominae, Orthocladiinae and Tanypodinae), lesser water boatmen (family Corixidae) and mayfly family Caenidae.
- On a creek/ river basis, a total of 47 taxa were recorded from the 11 Coxs River samples (3 sites), 37 taxa were recorded from the 4 Pipers Flat Creek samples (2 sites).
- In terms of SIGNAL values, the most pollution sensitive taxa were dragonfly family Telephlebiidae (with a SIGNAL score of 9), and mayfly family Leptophlebiidae, stonefly family Gripopterygidae, and caddis-fly families Hydrobiosidae and Philorheithridae (each with a SIGNAL score of 8).
- Of these five sensitive taxa, two Leptophlebiidae (3 occurrences) and Philorheithridae (1 occurrence) were found in Pipers Flat Creek.
- None of the sensitive taxa were recorded at Site CR6.
- Individual site diversity throughout the study area ranged between 18 taxa at PFdn (Autumn 2011) and 32 taxa at CR5 (Spring 2010).
- Mean site diversity (± standard error) values were similar for both streams at 22.2 ± 1.2 taxa for the Coxs River sites and 21.0 ± 1.6 taxa for the Pipers Flat Creek sites.
- For Coxs River sites, CR4 mean diversity was 23.0 ± 1.5 taxa, CR5 mean diversity was 26.0 ± 2.6 taxa and CR6 mean diversity was 19.3 ± 0.3 taxa.
- Site SIGNAL scores indicated probable mild to severe pollution across most sites in the study area over consecutive seasons.
- Site SIGNAL in Pipers Flat Creek ranged between 3.63 at PFup and 4.60 at PFdn, and for the Coxs River sites SIGNAL scores ranged between 3.18 at CR6 and 4.64 at CR4.

- Lower Coxs River site CR6 recorded the lowest SIGNAL score on each sample occasion.

Table 8 provides a listing of the fish reported from the upper Coxs River catchment over the survey period (Autumn 2010 to Spring 2011). For the four combined surveys to date there were five fish species noted, which included two native and three exotic pest species. Two other introduced species (carp and rainbow trout) that have been reported previously from the upper Coxs River were not caught or observed, and Australian Bass, previously reported as being stocked into Lake Wallace was also not caught or observed.

Table 8 Fish species recorded from the upper Coxs River sub-catchment Autumn 10 to Spring 11

Species	Common Name	Stream**					
		CR	KC	NC	PF	SC	WC
Carassius auratus	Goldfish***	1					
Philypnodon grandiceps	Flathead Gudgeon	1					1
Galaxias olidus	Mountain Galaxias	1	1			1	1
Gambusia holbrooki	Eastern Gambusia***	1			1		1
Salmo trutta	Brown Trout***	1					
	Fish larvae*					1	1

Notes: *Mountain galaxiid or Australian smelt larvae. **CR = Coxs River, KC = Kangaroo Creek, NC = Neubecks Creek, PK = Pipers Flat Creek, SC = Springvale Creek, WC = Wangcol Creek. *** Introduced species

3.7 Classification of Pipers Flat Creek and Coxs River

Notwithstanding the major impediments to fish passage presented by the combined dams over the Coxs River downstream of the Pipers Flat Creek study site there is still viable native fish aquatic habitat available in Pipers Flat Creek and good connectivity to Coxs River. There are suitable drought refuge pools available up- and down stream of the lower Pipers Flat Creek study area thus there remains a need for fish passage from Coxs River into and upstream Pipers Flat Creek. Accordingly the creek at the proposed Lidsdale Siding Upgrade Project is classified Class 2 Moderate Fish Habitat under the NSW DPI (Fisheries) stream classification (see Annexure Table A1).

If there were no major impoundments over Coxs River, the upper Coxs River would need to be classified as a Major Fish habitat (Class 1) on the basis that threatened fish species could reach the upper catchment. However, given the number of impoundments that prevent native fish passage the classification for the Coxs River above Lake Wallace remains Class 2 Moderate fish habitat.

4 IMPACT ASSESSMENT

4.1 Construction Impacts

The Lidsdale Siding Upgrade project description is detailed in Section 4 of the EAR and summarised in Section 1 of this report. The main feature of the proposed upgrade that has the potential for direct impact on aquatic habitats is related to contaminated water runoff from the construction works into Pipers Flat Creek, and the main contaminant of concern arising from construction works is sediment in the form of high Total Suspended Solids (TSS) loads that could smother creek aquatic habitats and biota, or as turbidity that could inhibit photosynthesis of aquatic plants.

The main potential mechanisations of TSS and turbidity generation to Pipers Flat Creek from construction are as follows:

- Construction of new reclaimers situated in a reclaim tunnel beneath the stockpile and construction of a spillage reclaim pit beneath the train-loading bin. These works require major excavations with potential impacts on shallow groundwater quality and issues relating to overburden storage and surface water and sediment runoff control.
- A track extension to the existing rail siding and a parallel siding adjacent to existing. These works are located alongside Pipers Flat Creek with direct stormwater drainage to the creek and will require careful management of sediment and stormwater control to prevent construction related contaminated waters and sediments from entering the creek.
- The track extension works will also be undertaken over existing minor drainage lines currently transporting stormwater runoff from small urban and industrial sub-catchments to the south-west of the property under the rail line to Pipers Flat Creek, and these works will require suitable bunding to prevent TSS and turbidity entering the creek plus there will need to be suitable bridging to facilitate stormwater flow to Pipers Flat Creek as well as protecting the existing aquatic ecological habitats within these drainage line connections.

The other items required for the upgrade as listed in Section 1 are generally located within the exiting site that currently drain to the sediment control pond within the site, and provided normal best-practice water and sediment runoff controls are implemented there are no significant potential impacts on adjacent aquatic habitats expected from these activities.
Provided the construction is managed in a manner that prevents contaminated waters

(including turbid waters) reaching the creek, there would be no construction impacts. Construction would be managed via a Construction Environmental Management Plan (CEMP) that would include construction related stormwater diversion around the site and collection, storage and treatment of construction site related waters (including potentially contaminated groundwater from the excavations) - with possible discharge of treated waters to creek. There may need to be separate treatment streams for site construction surface stormwater and site groundwater collection and treatment. These measures are outlined in the Surface and Groundwater Water management reports (RPS Aquaterra (2012a,b) and would be detailed in Construction Surface Water Management Plans (SWMPs).

4.2 Operational Impacts

In addition to TSS and turbidity associated with site runoff, other potential contaminants of concern arising from operational site water runoff are salinity (from mixed surface and shallow groundwater sources and from coal dust) and hydrocarbon residues (fuel and oil spills from refuelling and plant maintenance works:

- Refuelling and storage infrastructure will require tanks for bunkering plus fuel delivery facilities and these facilities and activities will need to be sufficiently bunded and controlled to prevent spillages from reaching the creek and prevent leakages from contaminating surrounding soils and seeping to the creek.
- Provision of an auxiliary stockpile will require appropriate controls to prevent contaminated runoff or dust leaving the site and entering the stream.

With regard to operational impacts, the present site is relatively well managed from the point of view of separation of site related runoff from creek plus other off-site related stormwater diversions with a few exceptions that would need to be remediated for this project:

- There are off-site stormwater issues from waters flowing along Main Street and into the site at the eastern end then flowing to the site stormwater dams above the LDP. This would be addressed by appropriate site bunding and stream separation.
- There is unconstrained runoff from the northern side of the rail siding to Pipers Flat Creek allowing coal dust and other residues to be carried into Pipers Flat creek by storwater runoff. This would be addressed by appropriate isolation bunding from the creek plus collection and treatment of the bunded waters - probably in the existing site stormwater treatment stream.

- There is also potential for coal spillages from the rail corridor into the drainages carrying stormwater from the south-west industrial lands through the rail culverts. This can be managed by appropriate design of culverts to allow for capture and diversion of spillages to suitably bunded drainages that flow into the site stormwater management system.
- Existing flood problems around the rail corridor and on the site would be lessened by both planned site water management improvements, strategic use of additional bunding and improvements to the flood carrying capacity of Pipers Creek itself, chiefly by the implementation of riparian revegetation works comprising removal of invasive willow species and riparian plus stream bank stabilisation with local native species. These rehabilitation works would be undertaken along the property creek line through to the confluence with Coxs River.

4.3 Impacts during Rehabilitation Works

As outlined above there are a number of rehabilitation works planned to improve overall water management on and offsite, and there are also potential disturbance impacts on riparian and aquatic habitats from stabilisation works along the watercourses. The control of these impacts relate generally to prevention of disturbed soils reaching the water courses during storms via suitable silt fencing and stabilising new banks with staged planting including initial fast growth grasses that can hold banks until the slower growing native species have taken hold.

4.4 Cumulative Effects of the Proposal in Relation to Other Projects

Assessment of existing and approved projects in the locality indicate that there will be no adverse cumulative effects on the aquatic ecology of Pipers Flat Creek or Coxs River arising. In fact the proposed creek line rehabilitation works in the lower Pipers Flat Creek are likely to benefit some of the other projects by facilitating flood flow out of the creek to Coxs River:

- Increased flood flows from Pipers Flat Creek to Coxs River arising from improved flow past the Lidsdale Siding site have the potential to exacerbate existing Coxs River bank instability below the confluence with Pipers Flat Creek. This possibility can be mitigated by extending riparian and bank stabilisation works past the confluence.
- The Wallerawang Sewage Treatment Plan (STP) upgrade project will provide overall better water quality supply to the lower Pipers Flat Creek and, combined

with aquatic habitat improvements associated with the Lidsdale Siding Project should result in overall improvements in the aquatic ecology of the locality.

- The Western Rail Coal Uploader for Mt Piper Power Station is located upstream of Lidsdale Siding and of the Wallerawang STP (SKM 2007) and the project has the potential to obstruct flood flows in Pipers Flat Creek. If not mitigated this could have consequences for flood frequencies and flood peaks at the Lidsdale Siding Site and downstream.
- There are a number of Lithgow Council development consents for additional accommodation and industrial sites in Wallerawang that discharge to Pipers Flat Creek. The proposed improvements to Lidsdale Siding site stormwater separation plus the improvements to the carrying capacity in Pipers Flat Creek should benefit all projects.
- There are a number of coal mining or power generation projects associated with Coxs River and its tributaries (principally Neubecks and Wangcol Creeks) both upstream and downstream of the Pipers Flat Creek confluence. In terms of aquatic ecological impacts, there projects interact in various ways to affect the immediate drainage areas in which they are situated but do not impact the Lidsdale Siding study area. As noted above, improvements to water quality arising from both the Wallerawang STP and Lidsdale Siding upgrades will only benefit the aquatic ecology of the downstream catchments.

4.5 Mitigation Measures

As discussed in Sections 4.1 to 4.3 above there are a number of suggested mitigation measures incorporated into the proposal that have a direct benefit for the aquatic ecology of Pipers Flat Creek north of the site and on Coxs River east of the site:

- The proposal incorporates a number of measures to improve the overall separation of site dirty water from clean stormwater runoff, including better separation of other non-site related stormwater runoff from Wallerawang township that currently flow thorough the Lidsdale Siding site. These improvements benefit the aquatic ecology of the receiving waters by minimising discharge of contaminated waters to the creek and maximising discharge of clean stormwater flows around the site to the creek.
- The proposal includes additional stormwater management recommendations to capture and treat stormwaters on the northern side of the existing and proposed extended rail lines that currently drain directly to Pipers Flat Creek. These stormwaters currently carry coal dust residues accumulated alongside the rail line from spillages and wind-blown sources.

- The proposal also includes recommendations for riparian and stream bank improvements along Pipers Flat Creek and into Coxs River below the confluence that will address current bank erosion problems, improve the water quality of stormwater draining overland to the creek and confluence and improve flood transport through the creek. These works include the eradication of riparian and creek pest plant species (principally willows) plus re-planting of riparian and stream banks with local indigenous species. These works will directly enhance the overall aquatic ecology of the creek.

4.6 Residual Consequences Following Mitigation

As noted in Section 4.2, bunding is proposed to eliminate some of the present site flood risk. However, as noted in RPS Aquaterra (2012a), whilst the bunding constructed in areas prone to floods breaching creek banks will reduce the risk of flood inundation, it cannot achieve total protection from flooding due to the need to maintain culverts and open drainage below the railway line.

As noted in Section 4.5, the improvements to flood carrying capacity through the lower Pipers Flat Creek will benefit the overall aquatic ecology of the creek, but there is a possibility that increased flood flow to Coxs River could cause additional bank destabilisation downstream in Coxs River. This possibility would be minimised by extending bank stabilisation works into the Coxs River, and this is in line with the objectives and recommendations of the HNCMA Action Plan for 2007 to 2016.

5 MONITORING & MANAGEMENT OF POSSIBLE IMPACTS

To ensure the environmental outcomes of the Lidsdale Siding Upgrade construction, operation and remediation programs an Environmental Management Strategy (EMS) will be developed to incorporate all aspects of environmental control including aquatic ecology. The EMS will outline a set of Environmental Management Plans (EMPs) that contain specific strategies to encourage and enhance the natural ecology within the designated site and rehabilitation areas. The success of these strategies are to be monitored on a periodic basis and the plans would be 'live' and modified as necessary to address any identified issues so that issues can be resolved and management measures can be implemented in a timely and professional manner. Management for aquatic ecology would form part of a *Flora and Fauna Management Plan* which will detail the basis for monitoring programs to be undertaken and these programs will build on monitoring studies already undertaken for this EA.

5.1 Aquatic Ecology Monitoring and Management Program

The aquatic ecology (streamhealth) monitoring program will incorporate the existing aquatic ecology study sites and data plus data from on-going studies to provide base-line data against which changes that may be attributable to construction or operation of the Lidsdale Siding facility can be measured. In order to provide successful management measures, aquatic ecology monitoring will be undertaken using a guiding set of criteria and protocols developed to establish the circumstances under which additional mitigation measures would be required, and these would be specified in Trigger Action Response Plans (TARPs). Thus, where perceptible impacts are noted through site monitoring activities, the following general procedure would be applied:

- Undertake additional investigations to ascertain the actual cause (site-related or other cause) of deteriorating aquatic conditions;
- If site related, notify relevant government authorities;
- Develop and implement a specific response plan to prevent further impacts, and
- Undertake remediation as required.

As set out in the TARPs, the response plans would be prepared on a case by case basis, with suggested short-term mitigation measures such as minor physical repair works, which could be implemented until such time that necessary long-term remediation works have been completed.

6 CONCLUSIONS

This report describes and assesses the value of the current aquatic ecology of the lower Pipers Flat Creek and Coxs River above and below the confluence, around the Lidsdale Siding site, and assesses the consequences of the present site surface water management for protection of aquatic ecological values of the receiving waters. Both waterways are designated Key Fish Habitat and are classified as Class 2 Moderate Fish Habitat under the DPI Fisheries' stream classification scheme.

The report addresses the potential construction and operational impacts on aquatic ecology arising from the proposed Lidsdale Siding upgrade and sets out the proposed mitigation measures that will be used to both minimise potential impacts from the proposed upgrade plus reduce the overall site impact on surface water drainage and surface water quality to the creek and river.

It is concluded that the proposed upgrade works coupled with improved site water management measures and creek plus river riparian and stream bank stabilisation and vegetation management measures will result in an overall improvement of water quality and aquatic habitat condition for the benefit of the aquatic biota residing in the creek and river adjacent to the site and for fish passage past the site.

The proposed works would maintain and improve the Key Fish Habitat and Class 2 features of the lower Pipers Flat Creek and of the Coxs River below the confluence, and the proposed riparian and stream bank stabilisation and revegetation measures are in line with the Hawkesbury-Nepean Catchment Management Authority Action Plan 2007-2016 for the upper Coxs River catchment.

The environmental outcomes of the Lidsdale Siding Upgrade construction, operation and remediation programs will be specified in an Environmental Management Strategy (EMS) that will incorporate all aspects of environmental control including aquatic ecology. An aquatic ecology monitoring program incorporating the base-line data from the present study will be undertaken as part of the EMS and will use a guiding set of criteria and protocols to establish if additional mitigation measures would be required. These would be specified in Trigger Action Response Plans (TARPs) contained in the EMS.

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ANNEXURE A

STREAM CLASSIFICATION

AQUATIC ECOLOGY

SAMPLING FIELD NOTES,

SITE PHOTOGRAPHS

&

SAMPLING DATA

LIDSDALE SIDING UPGRADE PROJECT

AUTUMN 2010 TO SPRING 2011

Table A1 Fish Habitat Classification Scheme (NSW Fisheries (1999b)
Class 1 - Major fish habitat Large named permanently flowing stream, creek or river. Threatened species habitat or area of declared "critical habitat' under the threatened species provisions of the Act. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 2 - Moderate fish habitat Smaller named permanent or intermittent stream, creek or watercourse. Clearly defined drainage channels with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 3 - Minimal fish habitat Named or unnamed watercourse with intermittent flow, but has potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). None to minimal defined drainage channel. Semi- permanent pools, ponds, farm dams or wetlands nearby, or form in the watercourse after a rain event. Watercourse interconnects wetlands or stream habitat.
Class 4 - Unlikely fish habitat Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free standing water or pools after rain event finishes (e.g. dry gully, shallow floodplain depression with no permanent wetland aquatic flora present). No aquatic or wetland vegetation present.

Table A2 Field Comments Lidsdale Siding Aquatic Ecology Monitoring Sites		
Date	Site	Comments
8/6/11	CR4	Coxs River site located downstream from Maddox Lane pipe culverts (access restricted to site length upstream of culverts). Channel form up and downstream of section adjacent road crossing is narrow and flat bottomed, incised to a depth of 3m below surrounding floodplain, with minimal riparian woody vegetation. Maximum creek width to 8m (adjoining road crossing), through average width 2-3m, maximum pool depth to 1.0m. Water moderately clear and flowing through site length. Edge habitats sampled included trailing bank vegetation and grasses, charophytes, rushes and detritus. Substrate a mix of cobbles and boulders, with varying amounts of sandy and muddy deposits in areas of lower flow. Algal mat smothering parts off pool substrate. Filamentous green algae present in moderate amounts.
7/6/11	CR5	Cox's River site located upstream of Main St crossing, above Wallerawang power station. Upper end of site consists of the end of a long broad pool, followed by a constricted flow channel downstream into another long pool below and downstream of the road bridge. Maximum pool width 10m, maximum depth to 1.5m. Water clear and flowing throughout site length. Indications of recent water levels to +3m to 3.5m above current water level. Blackberry on eastern bank under bridge has been scoured out. Cumbungi stands throughout site length were also scoured out, and were in a state of die-back during the survey period. The edge habitats sampled consisted of curly pondweed (*Potamogeton crispus*), logs, cumbungi (*Typha sp*), river clubrush (*Schoenoplectus validus*) and trailing bank vegetation. Substrate was mostly soft muddy sand within the pool area upstream of the bridge which extends into bedrock, boulder and cobble at the downstream end. Filamentous green algae smothering substrate and all submerged surfaces, making it difficult to locate areas free of algae to sample. Mat-like algae prevalent also. Three large fish (15cm to 25cm) observed briefly during sample process.

7/6/11	CR6	Lower Cox's River site located downstream of Rocky Waterhole Drive below Lake Wallace. Water of moderate clarity and flowing throughout site length. Maximum width to 8m, average width 4m, maximum depth between 1.5m and 2m. The pool edge areas have been subjected to some erosion of the pool edge banks, and scouring of cumbungi stands has occurred. Evidence of scouring high flows to +2.5m to 3m above current water level. Iron precipitate present in isolated areas along eastern bank, and abundant in parts. Edge habitat sampled consisted of watercress (*Nasturtium officinale*), cumbungi and trailing bank vegetation and detritus. Substrate a mix of bedrock, boulder and cobbles with some sections of firm sand in backwaters and areas of lower flow. Filamentous green algae abundant and smothering all submerged surfaces.
10/6/11	PFup	Site sampled in Pipers Flat Creek adjacent Lidsdale siding coal stockpile area. Water clear and flowing throughout site length. Maximum stream width to 5m, average width 1.5m, maximum depth 1.2m to 1.5m. Site length consists of a highly meandering channel, which consists of a series of deeper pools intersected by shallow and constricted pseudo riffle zones most of which are created by willow roots. Banks steep and undercut. Riparian cover is high provided by the consistent and dense corridor of willow trees, which are growing on the channel banks and in creek channel. The edge habitats sampled include undercut banks, willow roots, blunt pondweed (*Potamogeton ochreatus*), detritus and trailing bank vegetation. Substrate consisted of soft muddy sediments in pool basins and firm sandy sediments with some larger rock fragments in the shallower fast flow areas. Filamentous green algae present in moderate amounts through site length.

10/6/11	PFdn	Large pool under rail bridge sampled at outflow point of LDP4 channel. Willow trees form the dominant riparian tree along the site length, many of which have been recently toppled from a high flow event. Banks steep and undercut. Edge pool access restricted by blackberry, which is prominent throughout the site length banks. Water clear and flowing throughout site length. Site consists of a narrower meandering channel 6-10m width, which broadens into a wide pool underneath the rail bridge, with a maximum width of 22m, average width 18m. Maximum pool depth estimated at 1.5m, average depth 1m. Edge habitats sampled include undercut banks, blunt pondweed, detritus and trailing bank vegetation. Substrate mostly construction rubble with sections of very soft fine mud and sand deposits. Layer of fine silt smothering most of the pool edge areas and areas of low flow. Entire pool substrate and submerged surfaces smothered in filamentous green algae, which was prevalent in sample contents. Most of site pool exposed to direct sunlight, with willow trees providing very little shade.
1/11/11	CR4	Site water levels and sample conditions similar to previous surveys. Water clear and flowing throughout site length. Maximum pool depths reaching between 1m and 1.2m. Sampled edge habitats included submerged bank vegetation including rushes, charophytes, detritus and undercut banks. Channel substrates made up of cobbles and boulders, with varying amounts of sandy and muddy deposits in areas of lower flow. Filamentous green algae abundant throughout site length.
2/11/11	CR5	Site water levels and pool dimensions similar to previous survey. Water clear and flowing throughout site length. Maximum site pool depth to 1.2m. Blackberry bushes have dies back significantly and willow trees along edge banks have been cut back and poisoned since previous sample. Filamentous green algae abundant, smothering all submerged surfaces, with clumps of algae floating downstream. The edge habitats sampled consisted of curly pondweed, logs, cumbungi, river clubrush and trailing bank vegetation. Substrate was mostly soft muddy sand within the pool area upstream of the bridge which extends into bedrock, boulder and cobble at the downstream end. Filamentous green algae smothering substrate and all submerged surfaces, making it difficult to locate areas free of algae to sample. Mat-like algae prevalent also. Three large fish (15cm to 25cm) observed briefly during sample process.

2/11/11	CR6	Site pool dimensions, water levels and aquatic habitat availability similar to previous sample. Water clear and flowing throughout site length. Maximum pool depths around 1.3m to 1.5m deep. The trailing bank vegetation has proliferated since the previous Autumn 2011 sample. Some of the isolated edge bank areas with iron precipitate emanating from bank. The edge habitats sampled were comprised of watercress, cumbungi and trailing bank vegetation and detritus. Substrate a mix of bedrock, boulder and cobbles with some sections of firm sand in backwaters and areas of lower flow. Filamentous green algae abundant and smothering all submerged surfaces.
22/11/11	PFup	Site pool dimensions, aquatic habitats and water levels similar to previous sample occasion. Water clear and flowing throughout site length. Maximum pool depth to 1.2m deep. Riparian willow trees and blackberry have grown back significantly since Autumn 2011 sample. The edge habitats sampled include undercut banks, willow roots, blunt pondweed, detritus and trailing bank vegetation. Substrate consisted mostly of soft muddy sediments in pool basins and firm sandy sediments with some larger rock fragments in the shallower fast flow areas. There was a prominent layer of willow leaf detritus in most of the pool areas. Filamentous green algae present in moderate amounts.
22/11/11	PFdn	General pool dimensions, water levels and habitat availability consistent with previous sample occasion. Water clear and flowing through site. Maximum depth to 1.2m, average depth 1.0m. All of the riparian willow trees on the downstream side of the railway crossing have been cut and poisoned since previous sample, leaving no riparian trees downstream from the railway crossing. Most of the pool edge areas access still restricted by blackberry bushes. Edge habitats sampled include undercut banks, blunt pondweed, detritus and trailing bank vegetation. Substrate consisting of rock rubble with sections of very soft fine mud and sand deposits. Cobble banks present in some channel areas. Entire pool substrate and submerged surfaces smothered in filamentous green algae.

Table A-3 Macrophyte Occurrence

	Season	Sp10	Au11	Sp11	Au10	Sp10	Au11	Sp11	Au10	Sp10	Au11	Sp11	Au11	Sp11	Au11	Sp11
Common name	Genus/spp Site	CR4	CR4	CR4	CR5	CR5	CR5	CR5	CR6	CR6	CR6	CR6	PFup	PFup	PFdn	PFdn
Starwort	*Callitriche stagnalis*												1	1		1
Tall Spikerush	*Eleocharis sphacelata*										1				1	1
Jointed Rush	*Juncus articulatus*	1	1	1								1				
Spiny Rush	*Juncus spp*	1														
Water Primrose	*Ludwigia peploides*						1					1				
Watercress	*Nasturtium officinale*					1	1		1	1	1	1				
Knotweed	*Persicaria sp*										1					
Common Reed	*Phragmites australis*	1	1	1										1		
Curly Pondweed	*Potamogeton crispus*				1	1	1	1								
Blunt Pondweed	*Potamogeton ochreatus*						1	1					1	1	1	1
River Clubrush	*Schoenoplectus validus*				1	1	1	1								
Duckweed	*Spirodela sp*													1		
Cumbungi	*Typha spp*		1		1	1	1	1	1	1	1	1			1	
Charophytes		1	1	1		1										

Appendix Table A-4

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor	**Category**		**Value**	AU10	AU10	AU10	SP10	SP10	SP10	AU11	AU11	AU11	AU11	AU11	SP11	SP11	SP11	SP11	SP11
				CR4	CR5	CR6	CR4	CR5	CR6	CR4	CR5	CR6	PFup	PFdn	CR4	CR5	CR6	PFup	PFdn
1	Land-use pattern beyond immediate riparian zone																		
		Undisturbed native vegetation	4																
		Mixed native vegetation and pasture/exotics	3																
		Mainly pasture, crops or pine plantation	2	2	2	2	2	2	2	2	2	2	2.5	2	2	2	2	2.5	2
		Urban, some vegetation	1																
		Industrial, little vegetation	0																
2	Width of riparian strip-of woody vegetation																		
		More than 30 m	4										4					4	
		Between 5 and 30 m	3																
		Less than 5 m	2	2	2	2	2	2	2	2	2	2		2.5	2	2	2		2
		No woody vegetation	1																
		No Vegetation	0																
3	Completeness of riparian strip of woody vegetation																		
		Riparian strip without breaks in vegetation	4																
		Breaks at intervals of more than 50 m	3										3.5					3.5	
		Breaks at intervals of 10-50 m	2		2			2			2					2			
		Breaks at intervals of less than 10 m	1	1		1	1		1	1		1		1.5	1		1		1
		No riparian strip at all	0																
4	Vegetation of riparian zone within 10 m of channel																		
		Native tree and shrub species	4																
		Mixed native and exotic trees and shrubs	3		3	3		3	3		3	3	3			3	3	3	
		Exotic trees and shrubs	2	2			2			2				2.5	2				2.5
		Exotic grasses/weeds	1																
		No vegetation at all	0																
5	Stream bank structure																		
		Banks fully stabilized by trees, shrubs, concrete	4																
		Banks firm but held mainly by grass and herbs	3			3			3				3.5					3.5	
		Banks loose, partly held by sparse grass, rubble	2	2	2		2	2		2	2	2.5		2	2	2	2.5		2
		Banks unstable, mainly loose sand or soil	1																
		Banks actively eroding	0																
6	Bank undercutting																		
		None, or restricted by tree roots or man-made	4																
		Only on curves and at constrictions	3			3			3			3					3		
		Frequent along all parts of stream	2	2	2		2	2		2	2		2	2	2	2		2	2
		Severe; bank collapses common	1																
		Total bank collapse	0																
7	Channel form																		
		Deep; width:depth ratio less than 8:1	4	4		4	4		4	4		4	4		4		4	4	
		Medium; width:depth ratio 8:1 to 15:1	3		3			3			3			3.5		3			3.5
		Shallow; width:depth ratio greater than 15:1	2																
		Artificial; concrete or excavated channel< 8:1	1																
		Artificial; concrete or excavated channel > 8:1	0																
8	Riffle/pool sequence																		
		Frequent alternation of riffles and pools	4			4			4			4	4				4	4	
		Long pools with infrequent short riffles	3		3			3			3					3			
		Natural channel without riffle/pool sequence	2	2			2			2					2				
		Artificial channel; some riffle/pool sequence	1											1					1
		Artificial channel; no riffle/pool sequence	0																
9	Retention devices in stream																		
		Many large boulders and/or debris dams	4																
		Rocks/logs present; limited damming effect	3		3	3		3	3		3	3	3	3		3	3	3	3
		Rocks/logs present but unstable; no damming	2	2			2			2					2				
		Stream or channel with few or no rocks/logs	1																
		Artificial channel; no retention devices	0																
10	Channel sediment accumulations																		
		Little or no accumulation of loose sediments	4																
		Some gravel bars but little sand or silt	3	3	3	3	3	3	3	3	3	3			3	3	3		
		Bars of sand and silt common	2										2.5	2.5				2.5	2.5
		Braiding by loose sediment	1																
		Complete in-filled muddy channel	0																
11	Stream bottom																		
		Mainly clean stones with obvious interstices	4																
		Mainly stones with some cover of algae/silt	3	3		3	3		3	3		3	3	3	3		3	3	3
		Bottom heavily silted but stable	2		2			2			2					2			
		Bottom mainly loose and mobile sandy sediment	1																
		Bottom mainly loose and mobile muddy sediment	0																
12	Stream detritus																		
		Mainly unsilted wood, bark, leaves	4																
		Some wood, leaves, etc. with much fine detritus	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	
		Mainly fine detritus mixed with sediment	2											2					2
		Little or no organic detritus, mainly sandy	1																
		No organic detritus, mainly mud	0																
13	Aquatic vegetation																		
		Little or no macrophyte or algal growth	4																
		Substantial algal growth; few macrophytes	3								3					3			
		Substantial macrophyte growth; little algal growth	2	2		2	2		2	2		2.5			2		2.5		
		Substantial macrophyte and algal growth	1		1			1					1	1				1	1
		Total cover of macrophytes plus algae	0																
		RCE Score		30	31	36	30	31	36	30	33	36	39	28.5	30	33	36	39	27.5
		RCE %age		57.7	59.6	69.2	57.7	59.6	69.2	57.7	63.5	69.2	75.0	54.8	57.7	63.5	69.2	75.0	52.9

Table A5 Metered Water Quality Data Piprs Flat Ck & Coxs River Spring 10 to Sp 11										
Site	Date	Time	Depth	Temp	Cond	Sal	DO	DO	pH	Turb
			M	°C	µS/cm	ppt	%sat	mg/l	Units	ntu
CR4	10/06/10	08:01	0.1	7.16	950	0.52	71.2	8.6	8.69	16.1
CR5	8/06/10	12:52	0.1	9.53	829	0.46	115.0	13.1	9.24	12.9
CR6	8/06/10	15:54	0.1	10.95	998	0.55	72.3	8.0	9.41	22.4
CR4	27/10/10	13:07	0.1	17.90	666	0.36	74.5	7.1	7.84	6.4
CR5	28/10/10	8:09	0.1	14.80	558	0.31	63.3	6.4	7.97	10.7
CR5	28/10/10	8:10	0.3	14.80	558	0.31	64.0	6.5	7.92	9.6
CR6	28/10/10	14:52	0.1	14.70	620	0.34	67.1	6.8	8.05	6.4
CR6	28/10/10	14:52	0.4	14.70	638	0.35	67.1	6.8	8.05	7.5
CR4	8/06/11	15:51	0.1	6.38	930	0.46	76.0		8.02	5.3
CR5	7/06/11	12:56	0.2	7.23	860	0.42	83.9		8.47	3.7
CR6	7/06/11	15:19	0.2	9.68	865	0.44	80.3		8.99	10.9
PFup	10/06/11	11:30	0.1	7.71	540	0.25	66.2		7.37	5.0
PFdn	10/06/11	9:54	0.1	6.12	594	0.28	68.7		7.45	2.4
CR4	1/11/11	18:16	0.1	19.82	853	0.43	101.2	8.4	7.99	5.9
CR4	1/11/11	18:16	0.4	19.82	854	0.43	101.5	8.4	7.98	5.7
CR5	2/11/11	12:39	0.1	19.51	764	0.38	171.2	14.2	8.67	15.2
CR5	2/11/11	12:39	0.3	19.52	757	0.37	172.1	14.3	8.68	32.9
CR6	2/11/11	11:09	0.1	15.66	866	0.43	98.3	8.8	7.94	14.3
CR6	2/11/11	11:10	0.3	15.65	870	0.43	99.7	9.0	7.94	14.3
PFup	22/11/11	8:10	0.2	17.42	609	0.30	40.6	3.5	7.07	11.3
PFdn	22/11/11	7:29	0.1	17.07	648	0.32	48.2	4.2	7.14	6.8
Note:	For the Autumn 2011 survey there were no DO (mg/l) readings as the DO (% sat) readings were adjusted according to calibration figures.									

Appendix Table A-6 Lidsdale Siding Aquatic Ecology Monitoring Macroinvertebrate and Fish Results													Au10	Au10	Sp10	Sp10	Sp10	Au11	Au11	Au11	Au11	Au11	Sp11	Sp11	Sp11	Sp11	Sp11		
										Life Stage			8/06/10	8/06/10	######	######	######	8/06/11	7/06/11	7/06/11	10/06/11	10/06/11	1/11/11	2/11/11	2/11/11	22/11/11	22/11/11		
Phylum	Class	Sub-C	Order	Sub-Order	Family	Sub-F	Genus/spp	Common name	Description	L	N	A	CR5	CR6	CR4	CR5	CR6	CR4	CR5	CR6	PFup	PFdn	CR4	CR5	CR6	PFup	PFdn	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles		x		x				1		1		1	1			1	1	1	1	8	2
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles		x		x				1							1			1		3	4
Arthropoda	Insecta		Coleoptera		Hydraenidae			Scavenger Water Beetles				x															1	1	3
Arthropoda	Insecta		Coleoptera		Hydrophilidae			Scavenger Water Beetles		x		x					1		1	1								3	2
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles		x																1		1	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges		x					1	1								1		1		4	4
Arthropoda	Insecta		Diptera		Chaoboridae			Phantom Midges		x										1					1			2	2
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms		x			1	1	1	1	1		1	1	1	1		1	1	1	1	13	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae		Bloodworms		x			1	1	1	1	1		1		1	1	1	1	1		1	12	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms		x			1	1	1	1	1		1	1	1	1	1	1			1	12	4
Arthropoda	Insecta		Diptera		Simuliidae			Black Flies		x			1	1	1	1		1	1	1	1	1	1	1				11	5
Arthropoda	Insecta		Ephemoptera		Baetidae			Mayflies			x		1		1	1		1	1	1	1	1	1	1			1	11	5
Arthropoda	Insecta		Ephemoptera		Caenidae			Mayflies			x		1	1	1	1	1		1	1		1	1	1	1		1	12	4
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies			x		1		1	1		1	1			1		1		1	1	9	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Water Boatmen					1	1	1	1	1	1	1	1		1		1	1	1	1	13	2
Arthropoda	Insecta		Hemiptera		Notonectidae			Backswimmers					1					1							1			3	1
Arthropoda	Insecta		Hemiptera		Veliidae			Small Water Striders						1		1							1					3	3
Arthropoda	Insecta		Lepidoptera		Pyralidae			Moths		x								1					1					2	3
Arthropoda	Insecta		Megaloptera		Sialidae			Alderflies		x			1			1			1									3	5
Arthropoda	Insecta		Odonata	Epiproctophora	Aeshnidae			Dragonflies		x																	1	1	4
Arthropoda	Insecta		Odonata	Epiproctophora	Gomphidae			Dragonflies		x					1	1		1					1	1				5	5
Arthropoda	Insecta		Odonata	Epiproctophora	Hemicorduliidae			Dragonflies		x			1		1	1	1	1		1			1	1	1	1		10	5
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae			Dragonflies		x													1					1	9
Arthropoda	Insecta		Odonata	Zygoptera	Coenagrionidae			Damselflies		x			1	1	1		1	1	1				1		1	1		9	2
Arthropoda	Insecta		Odonata	Zygoptera	Megapodagrionidae			Damselflies		x					1								1			1		3	5
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies		x					1								1				1	3	7
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies			x				1	1							1					3	8
Arthropoda	Insecta		Plecoptera		Notonemouridae			Stoneflies			x					1										1		2	6
Arthropoda	Insecta		Trichoptera		Calamoceratidae			Caddis Flies		x			1			1	1	1	1			1	1				1	8	7
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies		x				1		1	1	1	1		1		1				1	8	4
Arthropoda	Insecta		Trichoptera		Hydrobiosidae			Caddis Flies		x						1		1										2	8
Arthropoda	Insecta		Trichoptera		Hydropsychidae			Caddis Flies		x				1		1		1	1	1	1	1		1	1			9	6
Arthropoda	Insecta		Trichoptera		Hydroptilidae			Caddis Flies		x					1	1		1	1	1	1	1		1		1	1	10	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies		x			1	1	1	1	1	1	1	1	1	1	1	1	1		1	14	6
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies		x			1									1						2	8
Arthropoda	Arachnida		Acarina	Hydracarina				Freshwater Mites						1			1			1					1	1	1	6	6
Arthropoda	Crustacea	Branch	Diplostra	Cladocera				Water Fleas											1	1	1	1		1	1	1	1	8	*
Arthropoda	Crustacea	Copep	Calanoida		Centropagidae			Copepods												1								1	*
Arthropoda	Crustacea	Copep	Cyclopoida		Cyclopidae			Copepods					1	1	1		1		1		1	1		1	1	1	1	11	*
Arthropoda	Crustacea		Amphipoda		Ceinidae			Side Swimmers																		1	1	2	2
Arthropoda	Crustacea		Decapoda		Atyidae			Freshwater Shrimp					1	1	1	1	1		1					1	1			8	3
Arthropoda	Crustacea		Decapoda		Parastacidae		*Cherax destructor*	Yabbies								1		1					1	1				4	4
Arthropoda	Ostracoda							Seed Shrimps						1	1	1	1				1	1		1	1	1	1	10	*
Annelida	Hirudinea				Erpobdellidae			Leeches																			1	1	1
Annelida	Oligochaeta							Freshwater Worms					1	1		1	1	1	1	1	1	1	1	1	1	1	1	14	2
Cnidaria	Hydrozoa				Hydridae			Hydra						1											1			2	3
Mollusca	Bivalvia				Sphaeriidae			Pea Shells						1	1	1		1	1		1		1			1	1	9	5
Mollusca	Gastropoda				Ancylidae			Freshwater Limpets						1	1	1					1					1		5	4
Mollusca	Gastropoda				Lymnaeidae			Freshwater Snails					1		1	1	1				1			1				6	1
Mollusca	Gastropoda				Physidae		*Physa acuta*	Freshwater Snails					1		1	1	1	1	1	1	1	1	1	1	1	1	1	14	1
Mollusca	Gastropoda				Planorbidae			Freshwater Snails							1	1		1	1	1								5	2
Platyhelmint	Turbellaria		Tricladida		Dugesiidae			Flatworms							1		1				1				1	1	1	6	2
Chordata	Amphibia							Tadpoles							1	1							1			1		4	*
Chordata	Osteichthyes				Cyprinidae		*Carassius auratus*	Goldfish					1															1	*
Chordata	Osteichthyes				Eleotridae		*Philypnodon grandiceps*	Flathead Gudgeon					1	1		1	1		1	1					1			7	*
Chordata	Osteichthyes				Poeciliidae		*Gambusia holbrooki*	Eastern Gambusia					1	1	1	1	1	1	1	1	1	1	1	1	1			13	*
Chordata	Osteichthyes				Salmonidae		*Salmo trutta*	Brown Trout							1									1				2	*
								Total number of invertebrate taxa per site:					20	19	26	32	19	21	23	19	19	18	22	23	20	22	25	52	48
Notes:	* represents those taxa for which SIGNAL-2 scores are not available								Site SIGNAL2 Scores:				4.00	3.88	4.13	4.32	3.41	4.14	4.00	3.59	3.63	4.60	4.64	3.90	3.18	3.84	3.91		
												EPT:	6	4	6	11	4	8	8	5	5	8	6	6	3	3	7		


Plate 1: Looking upstream at Pipers Flat Creek from Brays Lane.


Plate 2: Looking downstream at Pipers Flat Creek from Brays Lane.


Plate 3: Looking upstream from Brays Lane into Wallerawang Sewage Treatment discharge drainage channel.


Plate 4: Looking downstream from Brays Lane into Wallerawang Sewage Treatment discharge drainage channel.


Plate 5: Looking downstream at former drainage channel on northern side of existing Pipers Flat Creek channel.


Plate 6: Upstream end of PFup looking downstream (Spring 2011).


Plate 7: Upstream end of PFup looking downstream (Autumn 2011).


Plate 8: Looking downstream at PFup (Spring 2011).


Plate 9: Looking downstream at PFup (Autumn 2011).


Plate 10: Looking downstream at PFup (Spring 2011).

Plate 11: Looking downstream at PFup (Autumn 2011).

Plate 12: Downstream end of PFup looking upstream (Spring 2011).


Plate 13: Downstream end of PFup looking upstream (Autumn 2011).


Plate 14: Downstream end of PFup looking downstream (Spring 2011).


Plate 15: Downstream end of PFup looking downstream (Autumn 2011).

Plate 16: Dowsntream end of PFup looking downstream (Spring 2011).

Plate 17: Upper end of PFdn looking upstream.


Plate 18: Upstream end of PFddn looking downstream.


Plate 19: Looking downstream from railbridge at PFdn (Autumn 2011).

Plate 20: Looking downstream towards Coxs River at PFdn (Spring 2011).

Plate 21: Looking downstream towards Coxs River at PFdn (Autumn 2011).

Plate 22: Site CR4 looking upstream from Maddox Lane crossing.

Plate 23: Looking downstream from Maddox Lane crossing at CR4.

Plate 24: CR5 looking downstream toward bridge (Autumn 2011). Note the absence of cumbungi (emergent reed) from this photo when compared with Spring 2010 (Plate25).

Plate 25: Looking downstream at CR5 toward bridge Autumn 2010.

Plate 26: Looking downstream at CR5 under bridge.

Plate 27: Looking downstream from bridge at CR5.


Plate 28: Looking upstream at CR6.


Plate 29: CR6 edge bank area scoured free of vegetation (Autumn 2011).

Plate 30: Spring 2010 CR6 same location as Plate 29- note the variation in edge vegetation between surveys.

Plate 17: Looking downstream at CR6.