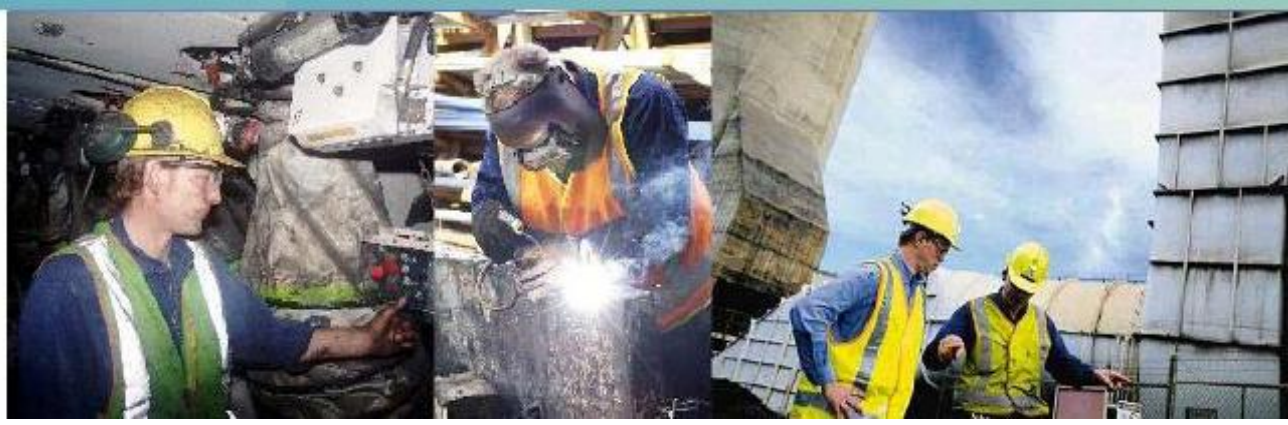
Application to vary EPL 2504

Supporting Material

September 2012
Final



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Contents

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1 INTRODUCTION

The purpose of this document is to support the application to vary EPL 2504, in order to include additional pollutants and concentration limits for discharge Point 10. Known pollutants with the potential to impact the health of the Georges River were examined.

The application is in accordance with the EPA's request (EPA Reference DOC12/32275 & DOC12/35641).

1.1 Site Information

West Cliff Colliery is located 26km northwest of Wollongong, NSW. West Cliff Colliery is operated by Endeavour Coal Pty Ltd, a subsidiary company of ICHPL with BHP Billiton as the parent company. BHP Billiton owns 100% of the West Cliff assets.

Illawarra Coal has conducted underground coal mining operations at West Cliff since 1997. Prior to this, West Cliff was operated by Kembla Coal and Coke Pty Limited (KCC).

Figure 1-1 provides an overview of surface water management at West Cliff Colliery including; Brennans Creek catchment, Brennans Creek dam, Georges River, confluence, Environmental Protection Licence (EPL 2504) discharge and water quality monitoring points.

1.2 Methodology to support the application

The proposed additional pollutants and concentration limits have been determined using the National Water Quality Guideline methodologies and the extensive scientific dataset from a series of Pollution Reduction Programmes (refer to Appendix A) completed during the last 10 years.

The NWQG methodologies help ensure a holistic risk management approach to meet water quality and river flow objectives for the Upper Georges River catchment. The discrete process steps undertaken were:

1. ***Define the water body*** – Brennans Creek and the Upper Georges River
2. ***Establish the environmental values*** – The Upper Georges River catchment water quality and river flow objectives were used. These included aquatic ecosystems, recreational use, irrigation and livestock water supply, protection of pools in dry times, protection of natural low flows and the minimisation of effects of dams on water quality;
3. ***Identification of key environmental concerns*** – The relevant environmental issues for the Upper Georges River identified by DECC 2006 and GRCCC were used;
4. ***Define management goals*** – Management goals were developed using the Upper Georges River catchment water quality and river flow objectives and possible effects of West Cliff operations water management system;

5. ***Determination of guideline trigger levels for selected indicators*** - This involved the review of the extensive dataset from PRPs and ecological studies undertaken in the Upper Georges River, chemical analysis, ecotoxicity testing and speciation modelling;

Illawarra Coal used the outcomes of Step 5 and knowledge of future operational changes to determine:

1. The proposed additional pollutants and concentration limits,
2. Recommended monitoring requirements for the EPL variation, and
3. Proposed further work and options to continue pollution reduction improvements.

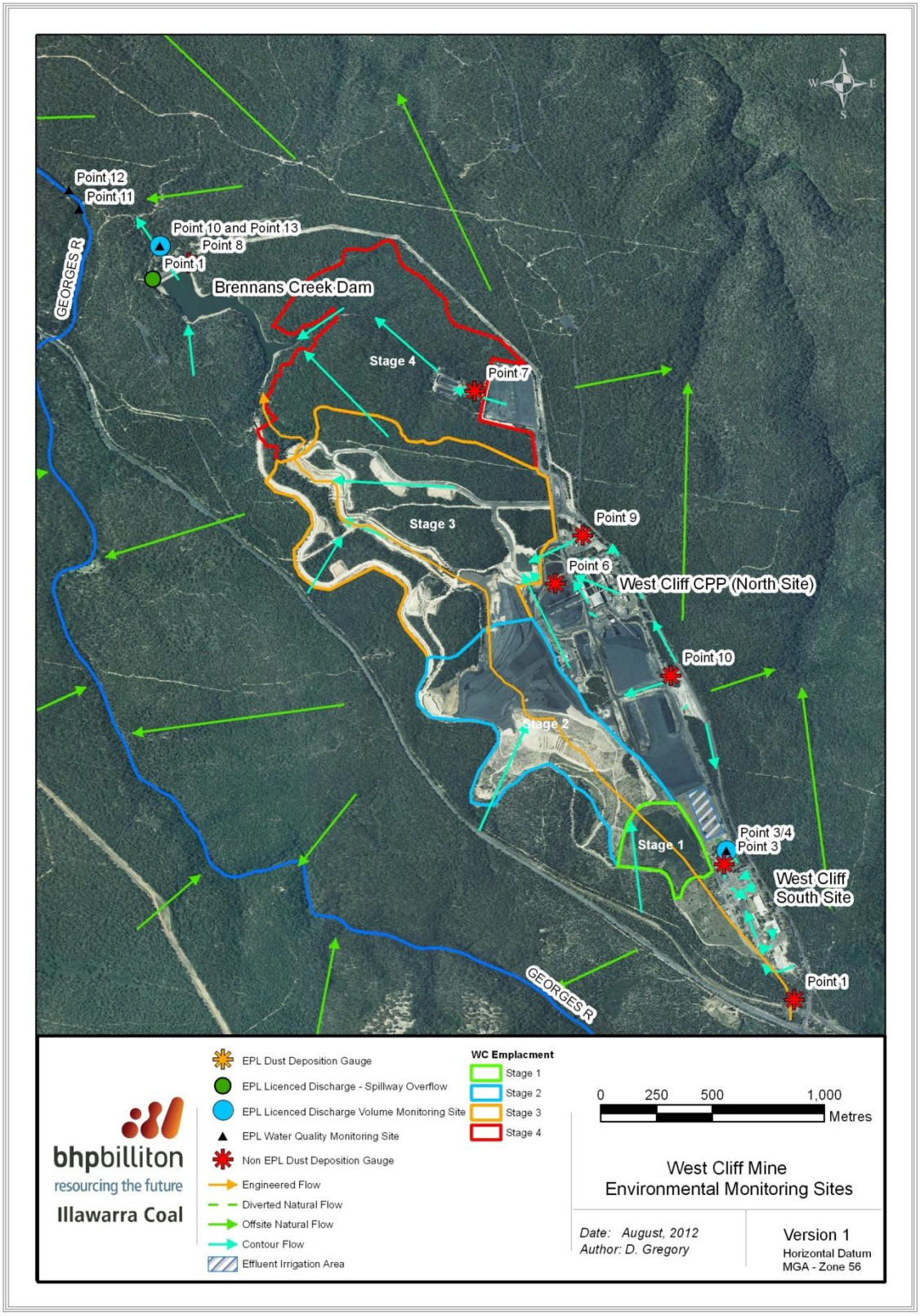

Figure 1-1: West Cliff Colliery Site Plan showing Brennans Creek dam and EPL 2504 water discharge and quality monitoring points

2 WATER QUALITY AND RIVER FLOW GUIDELINES

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

The main objective of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the National Water Quality Guidelines - NWQG) is to provide a framework to set water quality objectives and environmental values (including human uses) in Australia and New Zealand. The NWQG are not meant to be applied directly to contaminant levels in discharges from industry or mixing zones. A complement of biological indicators such as macroinvertebrates, species richness, physical and chemical stressors and toxicants, salinity, flow changes and metal contaminants, should all be considered when setting the Water Quality Objectives.

The NSW Government in consultation with local communities has developed catchment specific Water Quality and River Flow Objectives. These Objectives are intended mainly for Catchment Management Authorities, state agencies and local councils to integrate into planning activities to achieve an acceptable balance between environmental, social and economic needs.

The NWQG provide an agreed framework to assess water quality in terms of whether the water is suitable for a range of environmental values, including human uses). The New South Wales Water Quality and River Flow Objectives provide for specific catchment based environmental values for NSW waters and the NWQG provide the technical guidance to assess the water quality needed to protect those values (DECC 2006)

2.2 New South Wales Water Quality and River Flow Objectives

Eleven Water Quality Objectives (WQOs) are specified and based on; measurable environmental values for protecting aquatic ecosystems, recreation, visual amenity, drinking water and agricultural water. Twelve River Flow Objectives (RFOs) aim to maintain or improve river health by protecting pools and natural low flows and minimizing the effects of dams on water quality (DECC 2006).

2.3 Determination of catchment specific appropriate guidelines trigger values

The NWQG processes were utilised to determine catchment specific guideline trigger values as shown in
Figure 2-1: Flow chart of the steps involved in applying the guidelines.

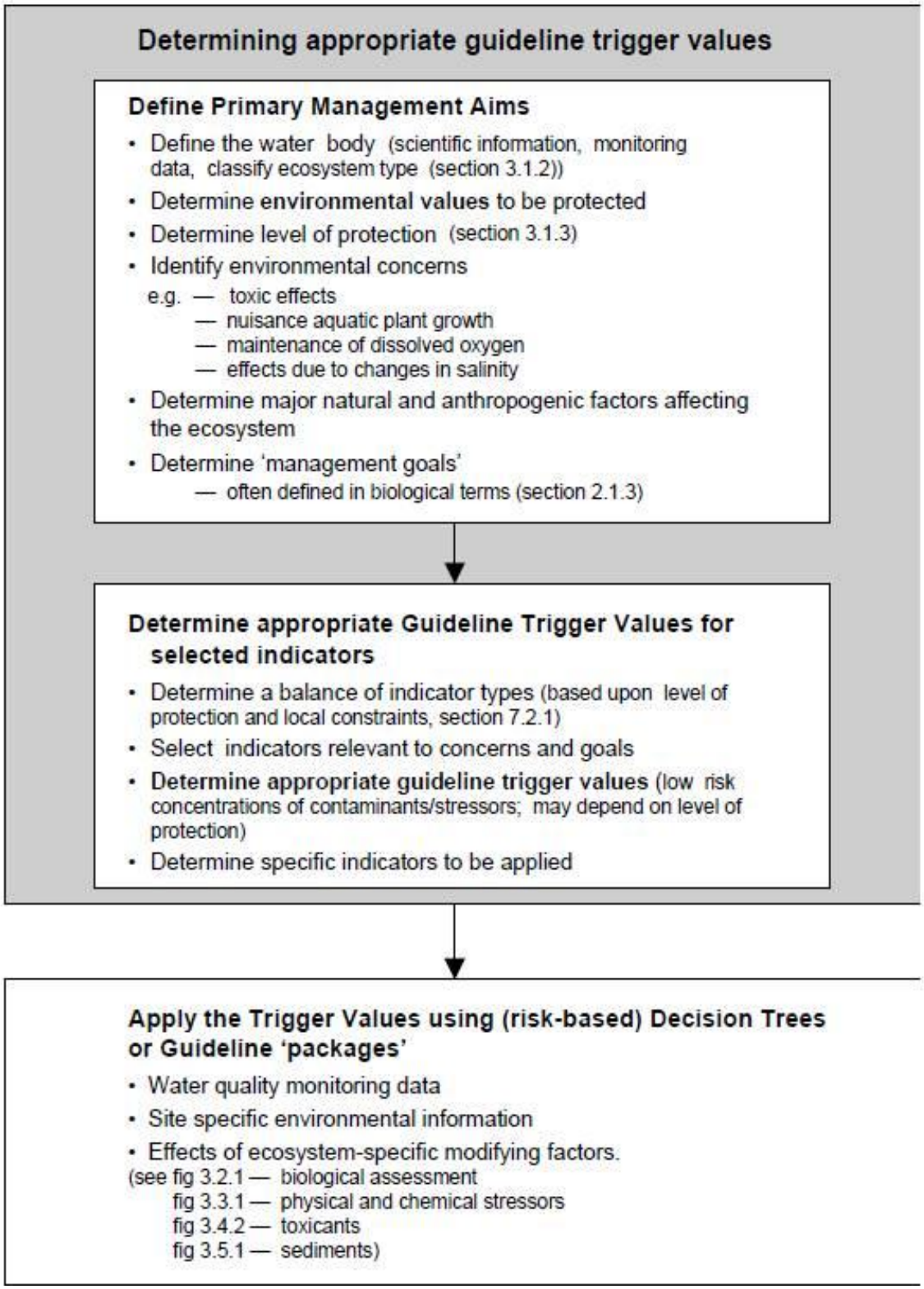

Figure 2-1: Flow chart of the steps involved in applying the guidelines for protection of aquatic ecosystems (*ANZECC/ARMCANZ* 2000, page 3.1-4). *Figure references in the diagram refer to ANZECC/ARMCANZ (2000).*

3 Upper Georges River catchment

(NWQG process step to - ***Define the water body*** - Refer to Figure 2.1)
The Upper Georges River catchment is a combination of Mittagong Formation-based soils and shale-based soils that comprise the sub-catchments and the complex inter-related surface and groundwater hydrological regimes.

The channel of the upper Georges River lies in a sandstone gorge and is gently sloping between Cataract Scout Camp and Lysaghts Crossing to the north of Appin Village. The river is characterised by pools separated by sandstone rock bars. Over this reach the channel gradually widens from 6 m to 20 m and deepens from 0.2 m to 2 m. The banks of the channel are mostly soft sediment although they are sometimes exposed and subject to slumping. The upper Georges River catchment contains native vegetation and pockets of urban and rural development. Generally, a complete band of vegetation lines the channel in the upper Georges River, but breaks occur where fire trails cross the river and residential properties of Appin township front the river (The Ecology Lab 2002a, 2004f).

Brennans Creek dam (BCD) is used as the main water storage and recycling facility for West Cliff Colliery process water. When the dam inflows (catchment inflows and treated process water) exceed process requirements and evaporation, excess water is discharged into the Upper Georges River via Environmental Protection Licence 2504 Point 10 or Point 1 (spillway).

In the absence of water discharges from BCD, Upper Georges River water quality is between 100µS/cm in high flow conditions to 1350 µS/cm during dry periods. The higher salinities can be ascribed to the presence of a number of naturally saline springs related to the local geomorphology and outcropping lithology whose presence would dominate pool water chemistry, particularly during prolonged dry periods (Cardno Ecology Lab & Ecoengineers Pty Ltd 2010).

Further definition can be found in Appendix B: West Cliff Mine - Assessment of potential ecotoxicants - Brennans Creek Dam Discharge (Ecoengineers Pty Ltd)

3.1 Water system definition

Cardno Ecology Lab & Ecoengineers Pty Ltd (2010) defined the upper catchment of the Georges River, which includes Brennans Creek and sections upstream and downstream of the confluence with the creek as a s*lightly to moderately disturbed system.* This section of the catchment contains:

- cleared land for rural, residential and industrial purposes;
- riparian water rights for rural lots; and
- West Cliff Mine and Brennans Creek dam.

A *slightly to moderately* disturbed system is defined as an ecosystem in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained.

4 ENVIRONMENTAL VALUES

(NWQG process step to – ***Determine environmental values*** - Refer to Figure 2.1)
The upper catchment of the Georges River, which includes Brennans Creek and sections upstream and downstream of the confluence with the creek, contains two types of land uses with water quality and river flow objectives described in Table 4.1.

Table 4.1: Land Use Type and Water Quality and River Flow Objectives within the Upper Georges River catchment

Land Use Type: "Mainly forested areas", which have streams running through state forests, national parks, nature reserves and other forested areas	Land Use Type: "Uncontrolled streams" are waterways that have flow patterns that are largely natural but may have been altered in some way
Water Quality Objectives:	**Water Quality Objectives:**
aquatic ecosystems	aquatic ecosystems
visual amenity	visual amenity
secondary contact recreation	secondary contact recreation
primary contact recreation	primary contact recreation
	livestock water supply
	irrigation water supply
	homestead water supply
aquatic foods (cooked)	aquatic foods (cooked)
River Flow Objectives:	**River Flow Objectives:**
protection of pools in dry times	protection of pools in dry times
protection of natural low flows	protection of natural low flows
maintenance of wetland and floodplain inundation	maintenance of wetland and floodplain inundation
maintenance of natural flow variability	maintenance of natural flow variability
minimisation of the effects of weirs and other structures	minimisation of the effects of weirs and other structures
	Minimise effects of dams on water quality

The Georges River Combined Councils' Committee (GRCCC) supported all of the Water Quality Objectives (WQO) and River Flow Objectives (RFO), with emphasis on healthy aquatic ecology; safe swimming and water looking pleasant and clean (DECC 2006). Many community members supported a whole-of-catchment approach.

The water quality and river flow objectives that can be potentially impacted or enhanced by the discharge of water from Brennans Creek Dam include; the protection of aquatic ecosystems,

pools in dry times, natural low flows and effect of dams on water quality (Cardno Ecology lab Pty Ltd and Ecoengineers Pty Ltd, 2010). The relevant WQO and RFO recognised by the GRCCC and Cardno Ecology Lab and Ecoengineers Pty Ltd, 2010 are discussed in the following sections.

4.1 Primary and Secondary Contact - Recreational use

The NWQG state that water used for primary contact activities, such as swimming, should be sufficiently free from faecal contamination, pathogenic organisms and other hazards (e.g. toxic chemicals) to protect the health and safety of the user. The NWQG for secondary activities including boating and fishing are modelled on amenity guidelines.

The analytes tested at EPL 2504 Point 12, approximately 50 metres downstream of the Brennans Creek Georges River confluence are generally at or below the primary (and therefore secondary) contact guidelines with the exception of aluminium as shown in Table 4.2 and Table 4.3.

Table 4.2: Microbiological water quality from Brennans Creek dam

Indicator	Recommended maximum "median" for Primary contact	Average (2011) Brennans Creek Dam
Faecal coliforms	Median maximum 150/100mL 90% of samples < 600/100mL	34/100mL
Enterococci organisms	Median maximum 35/100mL Maximum 100/100mL	26/100mL

Table 4.3 Chemical analysis from Brennans Creek dam

Analyte	Recommended guideline – General for Primary contact (Eg swimming)	Average total concentration at EPL2504 Point 12 – 2004 to 2012
pH	6.5 to 9.0	8.0 to 9.0
Aluminium	200 µg/L	780 µg/L
Arsenic	50 µg/L	6 µg/L
Chloride	400,000 µg/L	150,000 µg/L
Copper	1000 µg/L	4 µg/L
Lead	50 µg/L	2 µg/L
Manganese	100 µg/L	38 µg/L
Nickel	100 µg/L	102 µg/L
Sulfate	400,000 µg/L	23,000 µg/L
Zinc	5000 µg/L	29 µg/L

4.2 Visual amenity

Visual amenity was one of the key WQO identified by the community during consultation process for the Georges River (DECC 2006). The water released from EPL 2504 enhances the visual amenity of ephemeral sections of the Upper Georges River, see Figure 4-1 - The water quality meets the visual amenity guidelines:

- Free from floating debris and oil, grease;
- No undesirable odour, taste or foaming or colour, except after large storm events; and
- No algal blooms.

Figure 4-1: View of the Georges River at West Cliff at the confluence of the Georges River with Brennans Creek Courtesy of The Ecology Lab (2006).

4.3 Protect pools in dry time

During dry times, some streams stop flowing and form pools, which provide refuges for aquatic plants and animals. Similarly, protection of natural low flows is seen as another key RFO in the study area. Brennans Creek Dam controlled water releases from the catchment of Brennans Creek provide the opportunity to contribute to flows in the Georges River consistent with its RFOs.

Large reductions in releases from Brennans Creek dam would have adverse consequences on the aquatic ecology in the Georges River (Cardno Ecology Lab & Ecoengineers Pty Ltd 2010).

4.4 Protect natural low flows

The construction of Brennans Creek dam and the West Cliff Mine Coalwash Emplacement area has significantly altered the natural ephemeral flow of Brennans Creek and as a result the upper Georges River flows.

In terms of river flows, DECC (2006) states that flow patterns in many rivers have been significantly altered and will not return to natural flow regimes. The NSW Government is not attempting to restore completely natural flow patterns where the community benefits significantly from altered flow patterns.

4.5 Livestock supply

Although no formal water licences are in place within the Upper Georges River catchment, riparian rights for rural properties are in place and the water quality discharged is suitable for livestock water supply. Table 4.4 shows a comparison between water quality at EPL 2504 Point 12 and the NWQG recommended levels for livestock water supply.

Table 4.4: Comparison of NWQG recommended levels for livestock water supply with average concentration at Point 12

Analyte	Recommended guideline – Livestock water supply	Average total concentration at EPL2504 Point 12 – 2004 to 2012
Aluminium	5000 µg/L	780 µg/L
Arsenic	500 µg/L	6 µg/L
Copper	400 µg/L (sheep)	4 µg/L
Lead	100 µg/L	2 µg/L
Nickel	1000 µg/L	102 µg/L
Zinc	20,000 µg/L	29 µg/L

4.6 Irrigation supply

Although no formal water licences are in place within the Upper Georges River catchment, riparian rights for rural properties are in place and the water quality discharged is suitable for many crops. **Table 4.5** shows a comparison between water quality at EPL 2504 Point 12 and the NWQG recommended levels for irrigation of crops.

Table 4.5: Comparison of NWQG recommended levels for irrigation of crops with average concentration at Point 12

Analyte	Recommended guideline – Irrigation	Average total concentration at EPL2504 Point 12 – 2004 to 2012
pH	6.0 to 9.0	8.0 to 9.0
Aluminium	5000 µg/L	780 µg/L
Arsenic	100 µg/L	6 µg/L
Chloride	<175,000 µg/L (chloride sensitive)	150,000 µg/L
Copper	200 µg/L	4 µg/L
Lead	2000 µg/L	2 µg/L
Manganese	200 µg/L	38 µg/L
Nickel	200 µg/L	102 µg/L
Zinc	2000 µg/L	29 µg/L
Salinity (moderately tolerant). Suitable for the following crops – most grains, peaches, olives, pastures including couch, wheatgrass and fescue, vegetables including zucchini and broccoli.		

4.7 Minimise effects of dams on water quality

In the WQO, DECC 2006, noted that many dams release water from the bottom of reservoirs, where temperatures and dissolved oxygen are lower, and nutrient concentrations are higher.

Brennans Creek dam controlled water releases are from the bottom of the dam as an outcome of PRP 7 in 2006. Further water quality studies would be required to determine any impact on water quality within the Georges River.

4.8 Aquatic ecosystem

The NWQG detail default trigger values provide a starting point to determine toxicants that need assessment using the decision tree methodology. The triggers are designed to be conservative in order that risks are adequately assessed.

Discharge water quality data for the period 2004 to 2012 was compare against the 95% NWQG default trigger values as shown in Table 4.6.

Table 4.6: Comparison of discharge water quality against default 90% and 95% NWQG trigger values for the period 2004 to 2012 at EPL2504 Point 10

Analyte	Default trigger value for freshwater level of protection species [1]		BCD analyte concentrations (2004 to 2012)	Default trigger value for freshwater level of species reached	
Metals and Metalloids:	**90%**	**95%**		**90%**	**95%**
Aluminum (pH > 6.5)	80	55 µg/L	670 ± 310 µg/L (52)	Yes	Yes
Arsenic As (III) As (VI)	 94 µg/L 42 µg/L	 24 µg/L 13 µg/L	10 ± 3 µg/L (52)	No	No
Cadmium	0.4 µg/L	0.2 µg/L	<0.1 µg/L [2]	No	No
Cobalt	90 µg/L		8 – 9 µg/L[3]	No	No
Copper	1.8 µg/L	1.4 µg/L	5 ±2 µg/L (52)	Yes	Yes
Lead	5.6 µg/L	3.4 µg/L	2 ±1 µg/L (52)	No	Yes
Manganese	2500 µg/L	1900 µg/L	25 ±25 µg/L (52)	No	No
Nickel	13 µg/L	11 µg/L	150 ±46 µg/L (52)	Yes	Yes
Zinc	15 µg/L	8 µg/L	39 ±1 µg/L (52)	Yes	Yes
Non-metallic inorganics:					
Ammonia	pH 8.5 - 400 µg/L pH 9.0 - 180 µg/L		160 ± 120 µg/L (46)	Yes, depending upon pH.	
Nitrate	3400 µg/L	700 µg/L	890 ±450 µg/L (46)	No	Yes
Salinity / Electrical conductivity: Upland rivers Lowland rivers	350 µS/cm 2200 µS/cm		2348 ±502 µg/L (96)	Yes Yes	

Analytes; arsenic, cadmium, cobalt and manganese were all below the 95% NWQG default trigger level and therefore it can be expected that the 95% of aquatic species will be protected. Analytes; aluminum, copper, lead, nickel, zinc, ammonia, nitrate and salinity have the potential to be above the NWQG default trigger values and further analysis was undertaken in the Section 8.

[1] Number in brackets is the number of samples analysed during the period.

[2] Cadmium result from limited number of samples from OEH 2012.

[3] Cobalt result from limited number of samples from OEH 2012.

5 LEVEL OF PROTECTION

(NWQG process step to – ***Determine level of protection*** - Refer to Figure 2.1)
Cardno Ecology Lab & Ecoengineers Pty Ltd (2010) defined the upper catchment of the Georges River, which includes Brennans Creek and sections upstream and downstream of the confluence with the creek as a s*lightly to moderately disturbed system.* This section of the catchment contains:

- cleared land for rural, residential and industrial purposes;
- riparian water rights for rural lots; and
- West Cliff Mine and Brennans Creek dam.

A *slightly to moderately* disturbed system is defined as an ecosystem in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained.

Previous studies by OEH (2012) and Cardno Ecology Lab & Ecoengineers Pty Ltd (2010) used the 95% NWQG default protection level trigger due to the catchment being defined as *slightly to moderately* disturbed system. Due to the variety of environmental values, a lower level of species protection, say 90% may be considered appropriate and acceptable to the community and government agencies in order balance other environmental values including:

- protection of pools during dry periods;
- visual amenity;
- irrigation and livestock water supply; and
- Recreational purposes.

Therefore both the 90% and 95% levels of species protection have been assessed.

6 ENVIRONMENTAL ISSUES

(NWQG process step to – ***Identify environmental concerns*** - Refer to Figure 2.1)
Environmental issues that may have an adverse impact upon the health of the Upper Georges River catchment were identified by DECC (2006) and GRCCC during consultation with local communities. These included the following anthropogenic concerns:

- Sediment and erosion;
- Pollution from rural runoff;
- Inadequate on-site effluent management in rural residential properties;
- Inadequate management of leachate from existing and former landfill areas;
- The environmental effects of longwall mining on river flows and water quality.
- Urban encroachment;
- Pest animals;
- Weed invasion
- Litter; and
- Inappropriate recreational activities (eg. 4WD's, trail bikes, illegal fishing activities, etc).

Other environmental concerns related to ecotoxic effects are detailed in Section 0.

7 MANAGEMENT GOALS

(NWQG process step to – ***Determine 'management goals'*** - Refer to Figure 2.1)

Many of the Upper Georges River water quality and river flow objectives are not influenced by West Cliff Colliery's operations, however those that can be influenced by the operations include:

- Protection of pools during dry times for amenity and aquatic ecology;
- Nutrient levels and temperature;
- Water available for irrigation and livestock water supply;
- Low or no observable ecotoxicity (acute and chronic) at an agreed mixing zone (downstream of the confluence of Brennans Creek and the Georges River);
- Minimise land disturbance, in line with the West Cliff Emplacement Management Plan.

8 DECISION FRAMEWORK

(NWQG process step to – ***Determine appropriate trigger values*** - Refer to Figure 2.1)
Through the NWQG decision framework, the potential pollutant concentration was compared with the guideline trigger value. If the default trigger value is not exceeded, the risk of an impact is low and no further action is required. Where the default trigger value was exceeded further work including ecotoxicity testing and metals speciation work was conducted.
The water quality guidelines for the Upper Georges River were determined in accordance with **Figure 8-1**.

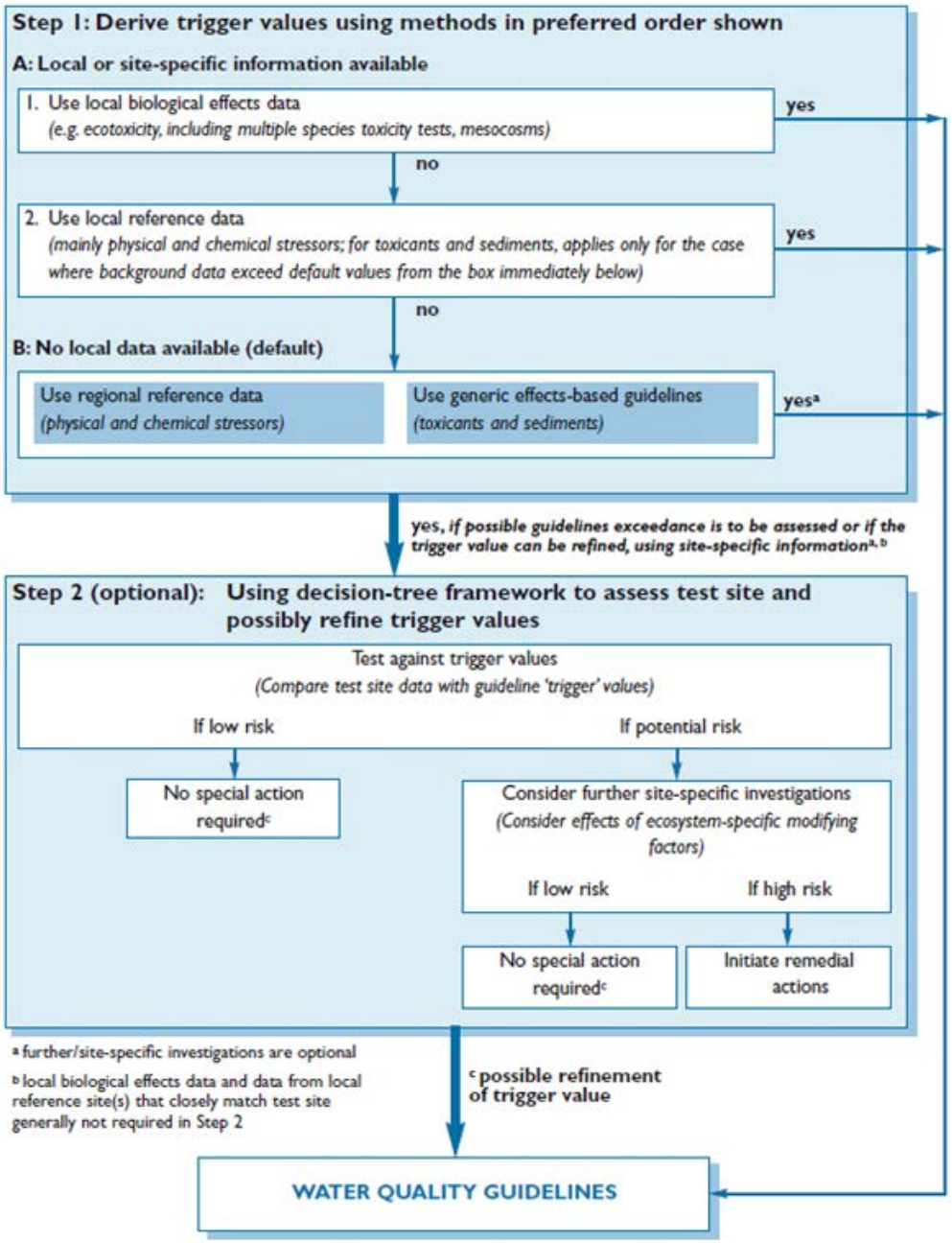

Figure 8-1: Shows the NWQG procedures for deriving and refining water quality guidelines. (ANZECC / ARMCANZ 2000 Introduction page 12).

8.1 Local or site specific information available

Studies were undertaken in 2004 and 2005 by the Ecology Lab and Ecoengineers to determine if there was an ecologically significant impact on surface waters from treated mine waters in Brennans Creek and the Georges River. The studies found that the waterways were slightly to moderately impaired using the Ausrivas methodology due to the treated mine water. Control locations were found to have no impairment or were slightly impaired.

Another study was conducted in 2006 to determine if there was an ecologically significant impact on surface waters from treated mine waters in Brennans Creek and the Georges River. The study showed no indication that macroinvertebrates were impoverished and that taxon richness and abundance was not statistically different to the control locations. The study recommended that consideration be given to developing appropriate water quality criteria rather than the NWQG default trigger values.

Further studies on in-stream ecological effects, laboratory ecotoxicity testing, chemical composition, shrimp translocation study and a literature review (salinity limits and gradients) were conducted in 2009 to assist with the establishment of a salinity limit for dry weather discharge. The Cardno Ecology Lab and Ecoengineers study (2010) determined that:

- Water quality in the upper Georges River is characterized by naturally variable electrical conductivity (EC; a measure of salinity) which ranges from 100 µS/cm in high flow conditions to at least 1350 µS/cm during dry periods - even in the absence of mine water discharges.
- Since the introduction of the West Cliff Water Management System (in August 2004) the mean EC of the LDP10 discharge to Brennans Creek had been relatively constant at ~2574 µS/cm which is slightly above the default trigger value for lowland rivers for south eastern Australia.
- Chemical speciation modelling indicated that the concentrations and chemical species of As, Ni and Zn in water discharged from the mine are not likely to be ecotoxicologically significant.
- Freshwater invertebrates exhibit a wide range of tolerance to elevated salinity, with the majority of taxa surviving at conductivities as high as 3000 to 12500 µS/cm. Even the most sensitive taxa can be found at around 1250 µS/cm.
- Notwithstanding this, the literature clearly indicates that salinity has adverse effects on freshwater biota.
- Tolerances appear to be correlated with the maximum salinities at which species are found in the field.
- Microalgae, particularly diatoms, appear to be more responsive to salinity than macroinvertebrates.
- Surveys of aquatic macroinvertebrates of the Upper Georges River in 1997 had indicated that while the river may have been impacted in the stretches above and below Brennans Creek, it still supported a healthy macroinvertebrate community.

- More recent studies of the upper Georges River for PRP10.1 had indicated that aquatic biota may be less affected by salinity than might be expected from the ANZECC/ARMCANZ (2000) National Water Quality (NWQG) guidelines.
- EC (salinity) correlates only weakly with abundance and composition of macroinvertebrates although it should be noted that regionally, outside of Georges River, gradients of salinity were very weak.
- Ecotoxicological studies elsewhere indicate that invertebrate taxa commonly found in the Georges River, such as mayfly larvae and glass shrimps (*Paratya*), survive in mine water with conductivities ranging from 2000 to 3000 µS/cm. Even the most sensitive test species, the water flea (*Ceriodaphnia*), survived up to 1500 µS/cm.
- However, field translocation experiments showed mortality of glass shrimps (*Paratya*) up to 2300 µS/cm in Brennans Creek. Statistical modelling of these field data suggest that bicarbonate, total suspended solids and possibly residues of Magnasol 572, rather than electrical conductivity, may account for the observed mortality.
- EC (salinity) may not, therefore, be a particularly good indicator of potential toxicity, except where extreme values are encountered.
- Abundant and diverse assemblages of macroinvertebrates can be found in streams with relatively high conductivity, including those receiving mine water discharges. This suggests that the current ANZECC/ARMCANZ (2000) guidelines are overly conservative, at least as applied to Georges River and that there is a need to establish more relevant site-specific trigger values for conductivity.

A summary of results from the PRP work has been compiled in Table 8.1 Summary of Ecological, ecotoxicity and water quality analysis from 2004 to 2012. In addition EPL 2504 – A summary of Pollution Reduction Programs.

Table 8.1: Summary of Ecological, ecotoxicity and water quality analysis from 2004 to 2012

PRP Study	Macroinvertebrate studies		Field samples (Georges River)			Mine site discharge										
	Ausrivas Band	Total biodiversity	EC (µS/cm)	pH	Turbidity	As (mg/L)	EC (µS/cm)	Cu (mg/L)	Ni (mg/L)	Zn (mg/L)	Fe (mg/L)	Pb (mg/L)	pH	Al (mg/L)	TSS (mg/L)	Co [4](mg/L)
WC PRP6 (Jun 2004)	B		820	8.1	3.2	0.011	-	0.018	0.187	0.108	1.82		8.45		14	
Surface	B		845	8.2	1.2											
Mine discharge Aug 2004	B		831	8.2	3.4											
WC PRP9 (Feb 2006)	C		1070	9.0	15	0.008	2650	0.004	0.155	0.033	2.43	-	8.0	0.55	3	
Autumn 2005				9.3	21	0.010		0.011	0.159	0.066	2.26	-	8.3	0.86		
Surface				9.2	22	0.008		0.01	0.141	0.046	2.83	-	8.2	0.88		
	C		1755				2640								9	
	B		1677				2650								4	
WC PRP9 (Feb 2006)	B		2305	8.8	214	0.008	2560	0.011	0.165	0.053	1.86	-	8.5	0.66	12	
Spring 2005 Surface	B		1632	8.7	125	0.007	2540	0.008	0.16	0.048	1.74	-	8.2	0.5	10	
	B		1628	8.7	195	0.008	2750	0.008	0.158	0.049	1.24	-	8.3	0.58	44	
PRP 10: Expt 1	Shrimp relocation definition		2680			0.011	2708	0.004	0.196	0.043	0.85	0.004	8.5	2.03	19	
PRP 10: Expt 2	Shrimp relocation definition		2200			0.010	2466	0.01	0.196	0.086	1.39	0.007	8.8	1.03	8	
PRP11: Point 10	Acute ecotoxicity definition		1860 ± 52	8.6 ± 0.1	19 ± 1			-	0.105 ± 0.011	0.45 ± 0.0	-	-	-	0.33 ± 0.01	5 ± 1.4	
OEH Study: Acute Upstream Georges	Acute ecotoxicity definition		150 - 249	7.0 –8.0		0.009		0.0008	0.004	0.009	-	-		0.18 (<0.04 – 0.18)	-	0.0006
OEH Study: Chronic Upstream Georges	Chronic ecotoxicity definition		150 - 249	7.0 –8.0		0.009		0.0008	0.004	0.009	-	-		0.18 (<0.04 – 0.18)	-	0.0006
OEH Study: Acute Point 10	Acute ecotoxicity definition		1700 - 1960	8.6 –9.3		0.009		0.0065	0.110	0.040	-	-	-	0.46	-	0.009
OEH Study: Chronic Point 10	Chronic ecotoxicity definition		1700 - 1960	8.6 –9.3		0.009		0.0065	0.110	0.040	-	-	-	0.46	-	0.009
OEH Study: Acute Downstream Georges	Acute ecotoxicity definition		673 - 1301	8.4 – 9.0		0.005		0.0077	0.060	0.030	-	-	-	0.35	-	0.008
OEH Study: Chronic Downstream Georges	Chronic ecotoxicity definition		673 - 1301	8.4 – 9.0		0.005		0.0077	0.060	0.030	-	-	-	0.35	-	0.008
OEH Study: Acute BCD	Acute ecotoxicity definition		1552 - 1800	8.8 – 8.9		0.009		0.0060	0.090	0.040	-	-	-	0.72	-	0.012
OEH Study: Chronic BCD	Chronic ecotoxicity definition		1552 - 1800	8.8 – 8.9		0.009		0.0060	0.090	0.040	-	-	-	0.72	-	0.012

AUSrivas Bands: X or A = Richer or equivalent invertebrate assemblage than reference condition, B = Sites below reference condition (ie significantly impaired), C = Sites well below reference condition (ie severely impaired), D = Impoverished.

Key:			
Shrimp relocation study	11% mortality to *Paratya* in Brennans Creek. <5% mortality to *Paratya* in Brennans Creek.	30% mortality to *Paratya* in Brennans Creek 0-30% mortality to *Paratya* in Brennans Creek	N/A
Acute ecotoxicity testing	No significant adverse impact relative to control.	Larval fish only impacted on last day of exposure. Slight reduction in bacterial growth.	N/A
Chronic ecotoxicity testing	No observed effect	<50% reduction in reproduction	>50% reduction in reproduction
Total biodiversity (number of taxa)	No significant variation between test and control sites.	N/A	N/A

[4] Co – EPA used low reliability trigger value, not statistically derived 95 % protection of species.

8.2 Comparison of potential pollutants with default trigger values

The default trigger values for aquatic ecology have the potential to be exceeded at EPL 2504 Point 10 for aluminium, copper, lead, nickel, zinc, ammonia, nitrate and salinity.

Refer to the modelling report attached as Appendix B: West Cliff Mine - Assessment of potential ecotoxicants - Brennans Creek Dam Discharge (Ecoengineers Pty Ltd).

8.2.1 Metals, speciation and sorption modeling

Modeling of metal speciation of aluminium, copper, lead, nickel and zinc was performed by Ecoengineers using both the Swedish Visual MINTEQ (version 3.0) model and the American PHREEQC version 2 model. Based on this modelling with PHREEQC, it is unlikely that the metals in the water would exert any ecotoxic effect. It should be noted that the protective effect in respect of metals is a combination of adsorption onto particles, complexation of metals by organic matter (NOM), and complexation by inorganic ligands (chiefly carbonate). (Ecoengineers 2012 b). The cationic metal concentrations calculated by the speciation modelling are shown in Table 8.2 . The modelling report is attached as Appendix B: West Cliff Mine - Assessment of potential ecotoxicants - Brennans Creek Dam Discharge (Ecoengineers Pty Ltd).

Table 8.2: Total cationic metal concentrations calculated by speciation modelling

Metal	PHREEQC Total cationic species (with HFO adsorption) (mg/L)	Visual MINTEQ Total cationic species (without HFO adsorption) (mg/L)	NWQG Default trigger value (mg/L)
Al	0.000056	0.000052	0.055
Cu	0.0000061	0.0000021	0.0018
Ni	0.0039	0.041	0.011
Pb	0.00000097	0.0000045	0.0034
Zn	0.00092	0.0106	0.008

8.2.2 Ammonia

The NWQG default trigger value for ammonia is based upon the free (un-ionised) ammonia and considers speciation at different pH values. Further analysis undertaken in preparation for this licence variation has revealed a need to study the ecotoxic effects of ammonia within the dam and discharge. We recommend that this study is included in a subsequent pollution reduction program for the purpose of determining the need or otherwise for a pollutant limit for EPL 2504.

8.2.3 Nitrate

The NWQG default trigger value for ammonia is based upon the free (un-ionised) ammonia and considers speciation at different pH values. Further analysis undertaken in preparation for this licence variation has revealed a need to study the ecotoxic effects of nitrate within the dam and discharge. We recommend that this study is included in a subsequent pollution reduction program for the purpose of determining the need or otherwise for a pollutant limit for EPL 2504.

8.2.4 Salinity

Freshwater invertebrates exhibit a wide range of tolerance to elevated salinity, with the majority of taxa surviving at conductivities as high as 3,000 up to 12,500 µS/cm. Even the most sensitive taxa can be found at around 1,250 µS/cm

Results from pollution reduction program studies showed the following:

- No statistically observable difference between control sites and the Georges River containing mine discharge for total biodiversity (number of taxa);
- There was no decrease in shrimp mortality at salinity levels <2466µS/cm;
- At salinity levels <2500µS/cm, macroinvertebrate assemblages were impaired, but not severely impaired or impoverished.

Ecotoxicity data for bicarbonate is discussed further in Section 4 of Appendix B.

8.2.5 Other Potential Pollutants

Other potential pollutants including chemical oxygen demand (COD), total dissolved solids (TDS), manganese, cobalt and cadmium are discussed further in Appendix B.

8.3 Ecotoxicity study

In July 2012 a program to test whole effluent ecotoxicity of Brennans Creek dam water and water discharged at EPL 2504 Point 10 was completed as part of Pollution Reduction Program 11. The key findings from the ecotoxicity tests for water discharged from EPL 2504 Point 10 into Brennans Creek can be summarised as follows:

- No observable acute ecotoxicity (within experimental error) to the water flea (48 hr test) and the green alga (72 hr test);
- No observable acute ecotoxicity (within experimental error) to the glass shrimp (96 hr test) and the Rainbow Fish (96 hr test) using a solution renewal protocol which was used to maintain pH control during the longer duration tests.

In August 2012, OEH published the “Chemical and ecotoxicology assessment of discharge water from West Cliff Mine.” The key findings from the acute ecotoxicity tests were generally aligned with those conducted in July 2012 as part of PRP11. In addition to the acute ecotoxicity testing, OEH conducted reproductive impairment tests on the water flea. All locations tested showed some reduction in reproduction throughout the testing cycle.

8.4 Proposed pollutants and concentration limits

The proposed EPL 2504 variations for pollutants and concentration limits have been determined using the NWQG and the site specific trigger values developed in this supporting material. The analytes have been summarised in Table 8.3: Summary proposed EPL2504 pollutants, concentration limits and rationale.

Table 8.3: Summary proposed EPL2504 pollutants, concentration limits and rationale

Analyte	Proposed 90 percentile	NWQG default and site specific trigger (Level of protection)	Speciation modelling (bioavailability) Refer to Appendix B		Summary of ecological studies and chemical analysis that support the rationale for the proposed pollutants and their concentration limits.
			PHREEQC Total cationic species (with adsorption)	Visual MINTEQ Total cationic species (without adsorption)	
Salinity	<2500µS/cm ≥2500µS/cm (≤1.5ML/day)	**NWQG default** <2200 µS/cm (lowland) <350 µS/cm (upland) **NWQG site specific** <2200 µS/cm	n/a	n/a	At proposed limit ≤2500 µS/cm (No volume limit): • No statistically observable difference between control sites and Georges River sites containing mine discharge. for total biodiversity (number of taxa). • Shrimp relocation studies – 11% shrimp mortality in Brennans Creek and <5% in Georges River. • Ausrivas Band B at all sites (significantly impaired, but not severely impaired of impoverished). At proposed limit >2500 µS/cm ≤5000 µS/cm (Volume discharge limit 1.5ML/day): • Reduction in salt load to account for a reduction in flows in the Georges River. • Dry period between 2002 to 2003 – 3 to 5 times dilution. • Ausrivas Band C at 2 of 4 sites with >2600 µS/cm; • Shrimp relocation studies – 30% shrimp mortality in Brennans Creek and 0-30% in Georges River at >2600 µS/cm. • Refer to Appendix C – Summary of NPI pollutant loads.
Al (filterable)	1 mg/L	**NWQG default** 0.055 mg/L (95%) 0.080 mg/L (90%) **NWQG site specific** 0.72 mg/L	0.000056mg/L	0.000052mg/L	At proposed limit: • No statistically observable difference between control sites and Georges River sites containing mine discharge for total biodiversity (number of taxa). • Ausrivas Band B at all sites (significantly impaired, but not severely impaired of impoverished); • No acute ecotoxic effect in PRP11 at 0.72 mg/L Metal speciation modelling: • Modelling suggests that Al is not bioavalable at levels above the trigger values. • The lack of ecotoxicity suggests that most of the filtered Al is in a colloidal form or occurs as $Al(OH)_4^-$, neither of which are appreciably ecotoxic.
As III (filterable)	0.02 mg/L	**NWQG default** 0.013 mg/L (95%) 0.094 mg/L (90%) **NWQG site specific** 0.013 mg/L	n/a	n/a	At proposed limit: • Accounts for mixing zone in the Georges River; • Trigger default level for As rounded up to 2 significant figures.
Cd (filterable)	Recommend a PRP	**NWQG default** 0.0002 mg/L (95%) 0.0004 mg/L (90%)			Further work needed to establish Cd site specific trigger level and licence limit (if applicable) as limited data set available. EPA data set: Cd <0.0001 to 0.0001 mg/L (below trigger value).
COD	50 mg/L (interim) Recommend a PRP	N/A			Chemical Oxygen Demand (COD) concentrations from Annual Return data used from 2007 and 2008 to establish proposed 90 percentile limit Recommend a PRP to establish a licence limit for COD after Water Efficiency Project is completed. Chemical Oxygen Demand (COD) has been included as a pollutant to encompass all organic matter by indirect measurement.
Co (filterable)	Recommend a PRP	Statistically derived trigger 0.090mg/L (95%)			Further work needed to establish Co site specific trigger level and licence limit (if applicable) as limited data set available. EPA data set: • Co 0.008 to 0.012 mg/L (well below trigger value).
Cu (filterable)	0.01 mg/L	**NWQG default** 0.0014 mg/L (95%) 0.0018 mg/L (90%) **NWQG site specific** 0.009 mg/L	0.0000061mg/L	0.0000021mg/L	At proposed limit: • No observable impact to total biodiversity. • Ausrivas Band B.
Mn (filterable)	Recommend a PRP	**NWQG default** 1.9 mg/L (95%) 2.5 mg/L (90%)			Further work needed to establish Mn site specific trigger level and licence limit (if applicable) as limited data set available.

Analyte	Proposed 90 percentile	NWQG default and site specific trigger (Level of protection)	Speciation modelling (bioavailability) Refer to Appendix B		Summary of ecological studies and chemical analysis that support the rationale for the proposed pollutants and their concentration limits.
			PHREEQC Total cationic species (with adsorption)	Visual MINTEQ Total cationic species (without adsorption)	
NH3-N (ammonia)	Recommend a PRP	pH 8.5 – 0.4 mg/L pH8.7 – 0.29 mg/L	n/a	n/a	Further work needed to establish NH3 site specific trigger level and licence limit (if applicable) as limited data set available.
Ni (filterable)	0.2 mg/L	**NWQG default** 0.011 mg/L (95%) 0.013 mg/L (90%) **NWQG site specific** 0.196 mg/L	0.0039 mg/L	0.041 mg/L	At proposed limit: • No statistically observable difference between control sites and Georges River sites containing mine discharge for total biodiversity (number of taxa). • Ausrivas Band B at all sites (significantly impaired, but not severely impaired of impoverished); • No acute ecotoxic effect in PRP11 at 0.196 mg/L. Metal speciation modelling: • Adsorption modelling suggests that Ni is not bioavalable. • Speciation calculations using a filterable Ni concentration of 0.160 mg/L indicate that DOM complexation plays only a minor role in Ni speciation (0.010 mg/L). • Ni complexation was dominated by the uncharged $NiCO_3$ species (0.133 mg/L). However, the combined concentration of inorganic cationic Ni species was calculated as only 0.0039 mg/L, which is well below the trigger value of 0.011 mg/L.
Pb (filterable)	0.016 mg/L	**NWQG default** 0.0034 mg/L (95%) 0.0056 mg/L (90%) **NWQG site specific** 0.008 mg/L	0.00000097 mg/L	0.0106 mg/L	At proposed limit: • Accounts for mixing zone in the Georges River; • Trigger default level for Pb multiplied by 2.
Total Dissolved Solids (TDS)	<1425 mg/L ≥1425 mg/L (≤1.5ML/day)	N/A			EC: TDS ratio and salinity limit used to establish proposed 90 percentile limit. TDS <1425 mg/L (No volume limit) TDS ≥1425 (≤1.5ML/day). TDS has been included to encompass cations and anions together with some minor dissolved species such as silicate, nitrate/nitrite and fluoride etc.
Zn (filterable)	0.1 mg/L	**NWQG default** 0.008 mg/L (95%) 0.015 mg/L (90% **NWQG site specific** 0.07 mg/L	0.0009 mg/L	0.0106 mg/L	At proposed limit: • No statistically observable difference between control sites and Georges River sites containing mine discharge for total biodiversity (number of taxa). • Ausrivas Band B at all sites (significantly impaired, but not severely impaired of impoverished) between 0.033 mg/L and 0.108 mg/L. Average used for site specific trigger; • No acute ecotoxic effect in PRP11 at 0.04 mg/L. Metal speciation modelling: • Adsorption modelling suggests that Zn is not bioavalable. • Calculations using a filterable concentration of 0.09 mg/L Zn indicated Zn speciation also was dominated by carbonate species (0.068 mg/L). • The calculated sum of inorganic, positively charged Zn species other than Zn carbonate species (including the potentially most ecotoxic free ion Zn^{2+} species) is 0.0009 mg/L, well below the NWQG default trigger value.
pH	6.5 to 9.0	As per existing licence			
TSS	50 mg/L	As per existing licence			
O&G	10 mg/L	As per existing licence			

Table 8.4: Summary of salinity and proposed volume limits on discharge

Volume (ML)	Salinity (µS/cm)	Total Dissolved Solids (TDS) (mg/L)
No defined limit – discharges used to manage River Flow Objectives (RFOs)	≤2500µS/cm	≤1425 mg/L
≤ 1.5ML/day	>2500µS/cm ≤5000µS/cm	

9 PRACTICAL MEASURES

Recommended practical improvement measures to meet WQO and RFOs fall into short, medium and long term timeframes and are summarised as follows:

1. Complete the Water Efficiency project that is currently under construction at the West Cliff Coal Preparation Plant. The expected improvements include a reduction in aluminium and salinity.

2. Complete a formal review of the soon to be published Tippler et al. (2012) study findings to determine other potential drivers of ecotoxicity in the Georges River.

3. Complete proposed pollution reduction programmes to assess the potential ecotoxicity of ammonia, cobalt, manganese, cadmium and any other relevant ecotoxicants identified from Tippler et al (2012) to determine site specific trigger values and potential licence limits, as required.

4. West Cliff Mine underground operations are scheduled for completion in 2016. This operational change may present further opportunities to reconfigure the surface water management system and further improve water discharge quality. These studies and further works will be addressed in accordance with the Bulli Seam Operations Project development consent (Application 08_0150) Schedule 4, Condition 16 - BSO Surface Water Management Plan 5, 7 and 10 year commitments.

10 MONITORING

The Management goals listed for the Upper Georges River in Section 6 can be monitored via the following processes:

- Flow regimes and water quality monitoring can be conducted in line with the requirements of EPL 2504 Point 10 and Extraction Plan monitoring requirements;
- Pollution Reduction Programmes established in accordance with Schedule 4, Condition 16 of the Bulli Seam Operations Project development consent.

11 CONCLUSION

In conclusion, surveys of aquatic macroinvertebrates of the Upper Georges River in 1997 have indicated that while the river may have been impacted in the stretches above and below Brennans Creek, it still supported a healthy macroinvertebrate community.

Studies of the upper Georges River conducted for PRP10.1 have indicated that aquatic biota may be less affected by salinity than might be expected from the NWQG.

Ecotoxicological studies elsewhere indicate that invertebrate taxa commonly found in the Georges River, such as mayfly larvae and glass shrimps, survive in mine water with conductivities ranging from 2000 to 3000 µS/cm. Even the most sensitive test species, the water flea, survived up to 1500 µS/cm.

Recently completed PRP11 concluded there was no observable acute ecotoxicity to selected sensitive macroninvertebrates namely the water flea, green alga, glass shrimp and rainbow fish larvae.

The application to vary EPL 2504 recommends new pollutants and concentration limits, monitoring requirements and proposed practical measures that are expected to continue to contribute to the management goals of the Upper Georges River for water quality and river flow.

These include management goals are:

1. Protection of pools during dry times for amenity and aquatic ecology;
2. Nutrient levels and temperature;
3. Water available for irrigation and livestock water supply;
4. Low or no observable ecotoxicity (acute and chronic) at an agreed mixing zone (downstream of the confluence of Brennans Creek and the Georges River);
5. Minimise land disturbance, in line with the West Cliff Emplacement Management Plan.

The proposed additional pollutants and concentration limits have been determined using the National Water Quality Guideline methodologies. This work has involved detailed analysis and modelling using the latest scientific techniques and an extensive scientific dataset from a series of Pollution Reduction Programmes completed during the last 10 years.

12 REFERENCES

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APPENDIX A: EPL 2504 – A summary of Pollution Reduction Programs

EPL2504 PRP	Licence Requirement (Summary)	Status	Summary of findings
PRP 4 & 6	Determine if there is an ecologically significant impact on the surface waters from treated mine waters into Brennans Creek and the Georges River	Completed in 2004, and 2005 by The Ecology Lab and Ecoengineers	The studies showed slightly or moderately impairment from treated minewater. The control locations were considered to have no impairment or slightly impaired.
PRP 7	A trial was undertaken to minimise the frequency of rain induced releases over the dam spillway. Aim was to optimise the salinity and pH of discharge.	Trial completed in 2006 and then implemented.	Led to reduced variation in pH, salinity and suspended solids. Control processes are still in place today.
PRP 9	Determine if there is an ecologically significant impact on the surface waters from treated mine waters into Brennans Creek and the Georges River	Completed in 2006 by The Ecology Lab and Ecoengineers	Study showed no indication that the macroinvertebrates were impoverished and that taxon richness and abundances were very similar to those at the control sites. Recommendation: Modification of the current mine water discharges is not required at present. Consideration could, however, be given to the development of water quality criteria that are more appropriate to the local conditions than the current ANZECC default trigger values for upland rivers.
PRP 10.1	Determination of a salinity limit for the dry weather discharge including: • in-stream ecological effects, ecotoxicity, chemical composition, salt concentration and load, • relevant scientific literature on the impact of comparable salinity on ecosystem health; • NSW Water Quality and River Flow Objectives for the Georges River	Studies completed in March and April 2009	The mortality of shrimp was generally low at all sites, although mortality was significantly greater at Brennans Creek and generally decreased with distance downstream the Georges River in both experiments. Experiment 1 –Mortality rate – 30% in Brennans Creek and 0-30% in the Georges River. Experiment 2 –Mortality rate – 11% in Brennans Creek and <5% in the Georges River. The outcomes of Experiment 2 suggested the methodology and associated magnitude of use of the coagulant Magnasol 572 within West Cliff Colliery site should be reviewed.

EPL2504 PRP	Licence Requirement (Summary)	Status	Summary of findings
PRP 10.2	Investigation of Strategies, Technologies or Works to Achieve the Salinity Discharge Limit	Studies not undertaken, due to inconclusive PRP 10.1.	West Cliff Water Efficiency Project currently under construction. Expected benefits include a reduction in aluminium and salinity.
N/A	West Cliff Water Efficiency Project. Reduction in Magnasol and minor reduction in salinity.	PRC Approval.	13/04/2011 – letter sent to EPA requesting that PRP 10.2 and further ecotoxicity work be delayed until the implementation of the *West Cliff Water Efficiency Project.*
PRP 11	Undertake a program to test the whole effluent toxicity of water from Brennans Creek dam and from the West Cliff coal preparation plant water treatment plant.	Due 26th July	No observable acute ecotoxicity (within experimental error) to the water flea (48 hr test) and the green alga (72 hr test); No observable acute ecotoxicity (within experimental error) to the glass shrimp (96 hr test) and the Rainbow Fish (96 hr test) using a solution renewal protocol which was used to maintain pH control during the longer duration tests in line with US EPA methodology.

APPENDIX B: West Cliff Mine - Assessment of potential ecotoxicants - Brennans Creek Dam Discharge (Ecoengineers Pty Ltd)

APPENDIX C: Summary of NPI Substances FY11 and FY12

	Volume discharged (ML)	Al	As	Cu	Pb	Mn	Ni	Zn
FY11 Concentration (mg/L)	1,222	0.888	0.010	0.006	0.002	0.021	0.131	0.032
FY11 Load (kg)	1,222	1,086	12.4	7.0	2.7	26	160.6	38.9
FY12 Concentration (mg/L)	2,103	0.926	0.0084	0.0051	0.002	0.019	0.11	0.047
FY12 Load (kg)	2,103	1,948	17.7	10.7	4.2	40.0	231.3	98.8