Biodiversity

Metropolitan Coal's biodiversity monitoring program has been developed to monitor impacts of the Project on aquatic and terrestrial flora and fauna, with a specific focus on swamps.

The biodiversity monitoring program includes monitoring of:

- upland swamp vegetation and groundwater;
- riparian vegetation;
- aquatic biota and their habitats; and
- amphibians.

The monitoring results are described below.

Upland Swamps Vegetation Monitoring

Eight upland swamps, namely Swamps 16, 17, 18, 20, 23, 24, 25 and 26 have been mapped above or immediately adjacent to Longwalls 20-22 (Figure 1). A swamp substrate characterisation study has also been conducted to contribute to Metropolitan Coal's understanding of the ecological, hydrological and geomorphic processes of swamps over Longwalls 20-22.

With the exception of in-valley Swamp 20, which supports tea tree thicket, all swamps over Longwalls 20-22 are small valley-side swamps and comprise restioid heath, with intergrades with banksia thicket. Transitions between restioid heath and banksia thicket are thought to be driven by fire frequency.

Three swamps (Swamps 16, 17 and 23), although showing seepage are more akin to sandstone heath woodland with low tree densities. The vegetation contains species found in upland swamps, mixed with a range of non-swamp species.

Swamps 101, 111a and 125 have been selected as control sites for monitoring of the restioid heath/banksia thicket valley-side swamps (Figure 1) and Swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp have been selected as sites for monitoring of the tea tree thicket vegetation of Swamp 20 (Figure 2).

The upland swamp vegetation monitoring program includes visual monitoring, transect/quadrat monitoring and monitoring of indicator species, as described below.

Visual Inspections

Visual inspections of the swamps overlying and immediately adjacent to Longwalls 20-22 and at the control swamps have been conducted in spring 2011 and autumn 2012 at the same time as the vegetation surveys.

Traverses covering the majority of the extent of the swamp were conducted to record observations such as cracking of exposed bedrock areas and/or swamp sediments, areas of increased erosion, changes in water colour, changes in vegetation condition and the amount of seepage.

No cracking of exposed bedrock areas or swamp sediments was observed in either longwall or control swamps, other than what has been reported previously in baseline surveys in Swamps 17 and 23, and the rock displacement in Swamp 24.

Small areas of minor increased erosion were observed in the bare areas of longwall Swamp 17 in addition to areas previously identified. Also, rill and gully erosion was observed in the table drains adjacent to longwall Swamps 16 and 17. Minor sheet-wash erosion was observed in longwall Swamp 24 and along walking trail 9J adjacent to longwall Swamp 26 and the drainage line downstream of longwall Swamp 20, and minor bank scour was observed within the drainage channel which runs through control Swamp 125. The observed erosion was thought to be the result of heavy rainfall events in late summer.

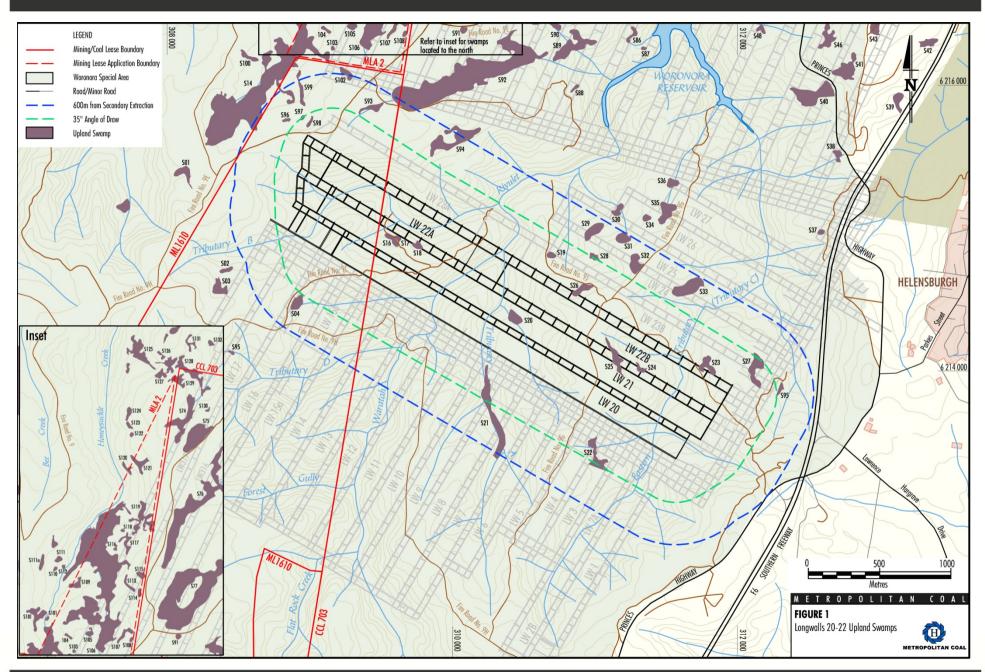
No changes in water colour were observed in either longwall or control swamps; and no new areas of water ponding.

Small areas of iron staining in saturated sediments, and associated metallic sheens to water surfaces were observed in seepage areas at several sites including longwall Swamp 20; and control Swamps 101 and 125. The amount and extent was the same for both longwall and control sites and is likely to be a natural occurrence as a result of the above average period of rainfall during 2011 and 2012, raising iron containing groundwater. The water colour under the areas of metallic surface sheens was found to be clear.

In general, vegetation of both longwall and control swamps was found to be in good condition. Sites containing previously recorded small patches of vegetation senescence (longwall Swamps 17, 18 and 23) were re-inspected during autumn 2012. No further senescence was found in these areas, and in some instances adjacent vegetation was found to be opportunistically encroaching into these areas.

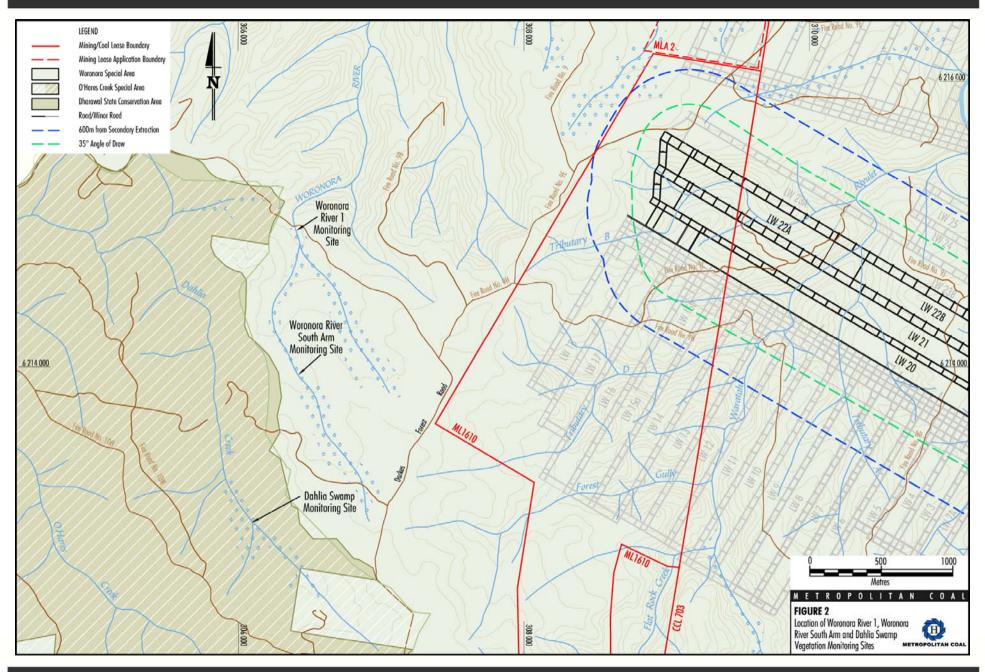
















Minor dieback of scattered individuals such as *Banksia ericifolia* subsp. *ericifolia*, *Petrophile pulchella* and *Hakea teretifolia* were observed in both longwall and control swamps (for example within longwall Swamps 18 and 25, and control Swamps 101 and 125). Some of these have been recorded during previous surveys.

Seepage areas were commonly observed across terminal steps and other rocky areas throughout longwall and control sites. In both longwall and control sites, soil sediments were generally damp to saturated, and areas of standing water were common. The amount of water observed within the swamps is most likely attributable to the above average rainfalls of the preceding months.

No weed species were observed within any of the upland swamps inspected.

Transect/Quadrat Monitoring

Transect and quadrat monitoring has been conducted in spring 2011 and autumn 2012 of:

- restioid heath vegetation Swamps 16, 17, 18, 24 and 25 overlying Longwalls 20-22, and in control swamps 101, 111a and 125 (Figure 1); and
- tea tree thicket vegetation Swamp 20 overlying Longwalls 20-22, and in control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp (Figures 1 and 2).

Swamps 16 and 17 (restioid heath/sandstone heath woodland) were also added to the vegetation monitoring program in autumn 2010 (Figure 1). Each swamp has been monitored with three transects, with the exception of tea tree thicket control Swamps Woronora River 1, Woronora River South Arm and Dahila Swamp, where only a single transect has been established owing to the much larger size of the control swamps.

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and
- condition/health rating for each species in the quadrat.

In summary, the results of the surveys indicate the following:

- Generally, vegetation at all sites was in a healthy condition throughout the survey period.
- Fluctuations in species cover and vegetation condition were recorded across all sites.
- The vegetation structure, dominant species and estimated cover and abundance for each stratum in autumn 2012 was relatively consistent with that observed in spring 2011 suggesting that the trend of increased height and percentage cover, which was observed in spring 2011, may have slowed. This data is supported by observational data which only noted increased vegetation height and density at control Swamp 101.
- Fluctuations in species richness were similar between longwall sites and control sites over the survey period, with no consistent patterns between seasons or across sites for the restioid heath sites.
- Species richness was variable in autumn 2012 when compared to spring 2011.
- Decreases in species richness were recorded at all valley side control swamps (Swamps 101, 111a, 125) between spring 2011 to autumn 2012 while small increases and decreases were recorded at longwall swamps. Over all seasons, there does not appear to be any increasing or decreasing trends in species richness for valley side swamps between seasons or between survey periods.
- Within the tea tree thicket sites, similar patterns of species richness have occurred at control swamps across all previous seasons. However, at longwall Swamp 20, a notable decrease in species richness was recorded in autumn 2012. A total of 30 species was recorded compared to 41 in spring 2011. From the data however, species richness in Swamp 20 generally tends to be lower in the autumn survey periods when compared to the spring surveys, possibly representing seasonal differences. Species not recorded during autumn 2012 included more cryptic species such as *Drosera peltata*, *Drosera binata*, *Utricularia* sp. and *Selaginella uliginosum*.
- The changes in species composition, cover and condition reflect normal population variation and cycles in response to seasonal variations and plant growth.
- No weeds were recorded within any of the sites.

Transect and quadrat monitoring will be conducted bi-annually in autumn and spring.





Indicator Species

Population monitoring of indicator species has also been conducted in spring 2011 and autumn 2012.

Twenty tagged individuals of *Epacris obtusifolia*, *Sprengelia incarnata* and *Pultenaea* aristata have been monitored in each of the following valley side swamps, commencing spring 2009:

- Epacris obtusifolia longwall Swamps 18, 24 and 25 and control Swamps 101, 111a and 125.
- Sprengelia incarnata longwall Swamp 24 and control Swamps 101 and 125.
- Pultenaea aristata longwall Swamps 18, 24 and 25 and control Swamps 101 and 111a. Note, survey of Pultenaea aristata in Swamp 24 commenced in autumn 2010.

Twenty tagged individuals of *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* have also been monitored in longwall Swamp 20 and at the associated control sites (Woronora River 1, Woronora River South Arm and Dahlia Swamp).

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant.

The following provides a summary of the results of indicator species monitoring:

- Within both the side valley swamps and tea tree thicket swamps the condition of tagged indicator species has progressively declined since 2009, and continued to decline in autumn 2012. This can be seen by the increase in the number of plants with some level of dieback and a subsequent decrease in the number of tagged plants in a healthy condition.
- The continued decrease in the proportion of healthy plants at valley side swamps occurred at both longwall and control sites and thus is considered to represent natural declines in response to climatic conditions, ageing plants and natural disturbances such as inclement weather conditions. The observed declines are not considered to be related to mining of Longwalls 20-22.

Within the valley side swamps, Sprengelia incarnata has undergone the largest decrease in overall condition at both longwall and control sites, followed to a lesser degree by Pultenaea aristata with Epacris obtusifolia having the most tagged plants scoring a healthy condition rating (Condition 5). The decline in condition for Sprengelia incarnata is often due to individuals presenting with leaf dieback on the lower stems. As noted above, this species is typically found with this habit throughout all sites and probably reflects the normal growth form of this species.

Six dead individuals of the tagged valley side swamp indicator species were recorded during autumn 2012 and had been recorded in previous seasons, including:

- Tag J17 Pultenaea aristata in longwall Swamp 18;
- Tag J6 Pultenaea aristata in Swamp 18;
- Tags K52 and K58 Sprengelia incarnata in Swamp 24;
- Tags J86 Pultenaea aristata in Swamp 24; and
- Tag K26 Sprengelia incarnata in control Swamp 101.

Two individuals observed to be dead in spring 2011 (Tag J28 Pultenaea aristata in control swamp 101 and Tag J98 Pultenaea aristata in longwall Swamp 24) were observed to be in good condition in autumn 2012 having re-sprouted.

Of the three monitored species within tea tree thickets, Leptospermum juniperinum and Banksia robur in longwall Swamp 20 underwent the greatest decline in overall condition. The decline in condition for tea tree thicket indicator species was generally associated with some level of leaf herbivory (commonly Banksia robur), leaf discolouration (commonly Callistemon citrinus) or some loss of leaves (commonly Leptospermum juniperinum). These causes for recorded declines in condition were common to both longwall and control sites.

No further dead individuals were recorded in tea tree thicket sites in autumn 2012 (Tag A64 Banksia robur in control swamp Dahlia Swamp was recorded as dead in spring 2010).

Monitoring of indicator species will be conducted bi-annually in autumn and spring.





Upland Swamps Groundwater Monitoring

Piezometers were installed in the following upland swamps in July 2010 to monitor groundwater levels (Figure 3):

- Valley side Swamps 16/17 overlying Longwalls 20-22 (sandstone piezometer to a depth of 10 metres [m]).
- Valley side Swamp 25 overlying Longwalls 20-22 (swamp substrate piezometer to a depth of 0.9 m and sandstone piezometer to a depth of 10 m).
- Valley side Swamp 101 (control swamp substrate piezometer to a depth of 0.9 m and sandstone piezometer to a depth of 10 m).
- In-valley Swamp 20 overlying Longwalls 20-22 (swamp substrate piezometer to a depth of 0.9 m and sandstone piezometers to depths of 4 and 10 m).
- Headwater Swamp Woronora River 1 (WRSWAMP1) (control swamp substrate piezometer to a depth of 0.9 m and sandstone piezometers to depths of 4 and 10 m).

Longer-term groundwater level data for upland swamps has been acquired with single swamp substrate piezometers at sites SWAMP1, SWAMP2 and SWAMP3, and paired piezometers at site SWAMP4 and SWGW1 (Figure 3).

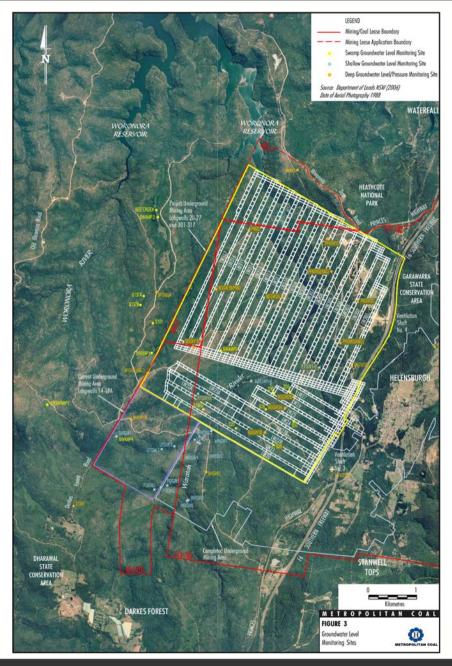






Chart 1 shows that the perched groundwater levels at SWAMP1, SWAMP2 and SWAMP3 have a highly dynamic behaviour that is characterised by an immediate response to rainfall events, followed by fairly rapid recessions as water is lost by evaporation and evapotranspiration. The monitored sites are far from current mining, and there is no evidence of any change in behaviour due to mining.

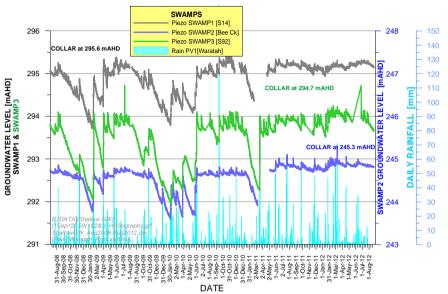


Chart 1 Perched Groundwater Hydrographs in SWAMP1, SWAMP2 AND SWAMP3

The groundwater levels in the paired piezometers at SWAMP4 and SWGW1 and their correlations to rainfall are shown on Chart 2. The groundwater levels at SWAMP4 are perched and hydraulically isolated from a deeper perched water table (or the regional water table) in the underlying sandstone aquifer (measured by site SWGW1).

SWAMP4 is considered to be characteristic of headwater upland swamps in that they typically obtain most of their moisture from direct rainfall infiltration. The water tables at SWAMP4 are greater than 3 m apart. There is a strong correlation between swamp and sandstone water level fluctuations which suggests either direct leakage from the swamp to the underlying sandstone, and/or direct rain recharge to adjacent sandstone with lateral groundwater flow to the sandstone beneath the swamp.

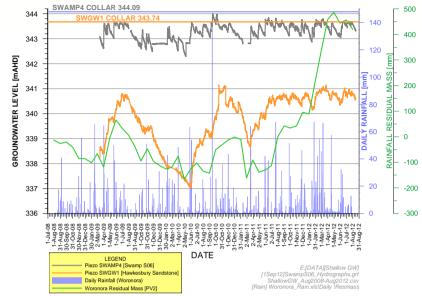


Chart 2 Separation of Water Tables at SWAMP 4

The residual mass curves are indicators of rainfall trends. In previous years as the residual mass trends agreed well with observed groundwater level trends, rainfall is inferred to be the primary driving force. During the review period, rainfall conditions have been wetter than normal. This has resulted in groundwater levels staying close to their maximum observed levels, indicating close to full saturation in the swamp.

The hydrographs at the two control swamps (SWAMP 101 and WRSWAMP1 [Figure 3]) are displayed in Chart 3 and Chart 4. Both sites show a pronounced drop in groundwater levels in February 2011, associated with a rainfall deficit, but there have been mixed responses during the review period. At SWAMP 101, the water tables are always separated, usually by 0.5 m, and groundwater flow direction is downwards. Water levels have remained close to full saturation levels during the review period. At site WRSWAMP1, the water level in the swamp (piezometer at 1 m depth) is always lower than the potentiometric level in the deeper sandstone piezometers. This suggests that the swamp is being recharged by groundwater from below and possibly from the sides. The swamp piezometer and the 4 m sandstone piezometer show good connectivity across the swamp/sandstone interface (except during January-March 2012), with separation from the groundwater head at the 10 m sandstone piezometer which reported rises in water level consistent with wetter conditions during the review period.



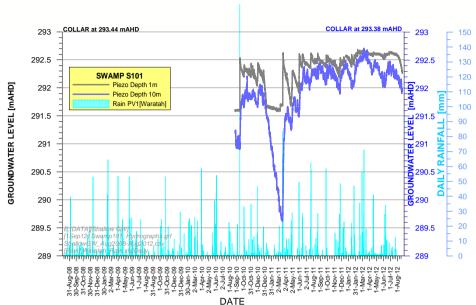


Chart 3 Groundwater Hydrographs at SWAMP 101

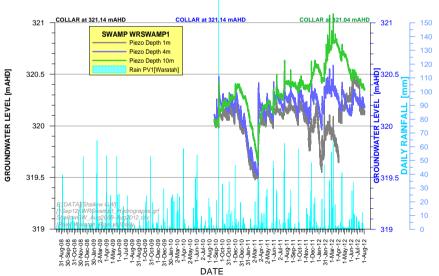


Chart 4 Groundwater Hydrographs at WRSWAMP1

Hydrographic responses for the recently monitored swamps overlying or adjacent to Longwalls 20-22 (Swamp 16/17, Swamp 20 and Swamp 25) are displayed in Charts 5 to 7. All sites show a pronounced drop in groundwater levels in February 2011, associated with a rainfall deficit but there have been responses during the review period that are inconsistent with a climatic effect. Longwall 21 extraction passed Swamp 16, 17 and 20 in November 2011, December 2011 and April 2012 respectively. Clear mining effects are inferred in the sandstone peizometer at Swamp 16 and 20, but no immediate effect was observed at Swamp 17.

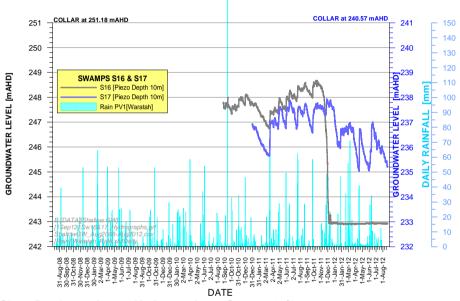


Chart 5 Groundwater Hydrographs at Swamp 16/17





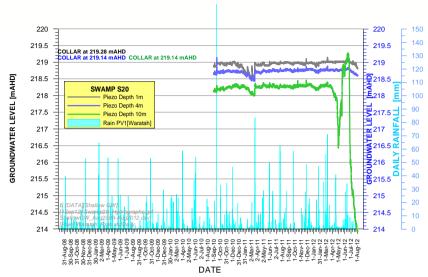


Chart 6 Groundwater Hydrographs Swamp 20

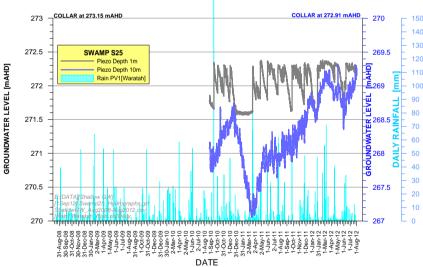


Chart 7 Groundwater Hydrographs at Swamp 25

At Swamp 20, water appears to be infiltrating downwards to a series of perched water tables monitored by sandstone piezometers at 4 m depth and 10 m depth. The sandstone water levels remained stable during the review period until April 2012. The upper two piezometers showed no effect but there is evidence of a slight decline in the final month of the review period. It cannot be confirmed whether this is due to a climatic or a mining effect.

Swamp 25 maintains a consistent separation between swamp water levels and the water table level in sandstone at depth 10 m, water is likely to be infiltrating downwards from the swamp. During the review period, the deeper water table has risen in response to generally wetter conditions.

Swamp 17 sandstone water levels were unaffected by passage of the Longwall 21 front. However, there is a downward trend from January to July 2012 which is inconsistent with climatic trends. This is possibly a post-mining effect.

The piezometer at Swamp 16 is located in weathered Hawksbury Sandstone at a 10 m depth. The water table at Swamp 16 dropped 5.2 m, commencing when the Longwall 21 face was approximately 600 m west of the piezometer. The water level reached a stable minimum as the Longwall 21 was directly below the piezometer and has maintained the new equilibrium for a period of eight months. Despite the decline the piezometer has not been drained.

Riparian Vegetation Monitoring

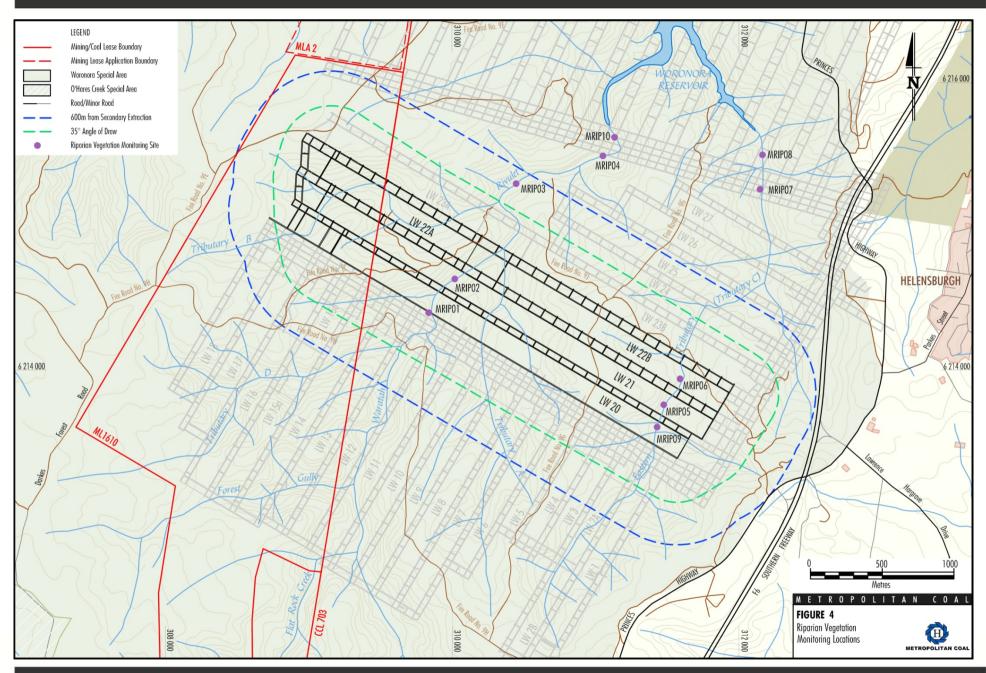
The riparian vegetation monitoring program includes visual, quadrat, transect and indicator species monitoring of riparian vegetation on the Waratah Rivulet and Eastern Tributary, as described below.

Visual Inspections

Visual inspections of riparian areas have been conducted in spring 2011 and autumn 2012 in locations adjacent to riparian vegetation monitoring sites (longwall sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09, and control sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10, Figure 4), and areas traversed whilst accessing the monitoring sites.









The following provides a summary of the results of visual inspections:

- Cracking of streamside rocky areas was observed during the autumn 2012 survey between sites MRIP01 and MRIP02. Several short and fine cracks were observed on the eastern bank above the water level (at the time of inspection).
 No dieback vegetation was observed in areas adjacent to the cracked bedrock.
- No other cracking of streamside rocky areas or rock displacement was observed within either longwall or control sites.
- No cracking of non-sandy streamside sediments observed within either longwall or control sites.
- No new areas of water ponding observed within either longwall or control sites.
- Flood impacted and senescing vegetation was recorded at all sites, including evidence of further flooding since the spring 2011 survey. Most sites were found to have flood-swept vegetation, and with varying degrees of mechanical damage to bark and branches. Woody debris and litter dams were common, and in some areas, soils surfaces were stripped of litter, small shrubs and groundcovers and in others sediments were deposited. In general vegetation appears to be recovering from consecutive flood impacts excluding those areas where vegetation has been buried by woody debris, litter or sediments.
- Some creek bank areas also displayed signs of erosion and scouring of sediments, for example, along the Eastern Tributary between sites MRIP05 and MRIP09 and along Waratah Rivulet at sites MRIP04 and MRIP10. The Eastern Tributary appears to have been more impacted by recent flooding as demonstrated by debris movement, bank scouring and the extent of flood swept vegetation.

Visual inspections of riparian vegetation will be conducted bi-annually in autumn and spring at the time of the vegetation surveys.

Quadrat/Transect Monitoring

Quadrat and transect monitoring has been conducted in spring 2011 and autumn 2012.

A permanent quadrat (20 m x 2 m) has been used to monitor riparian vegetation on the Waratah Rivulet and Eastern Tributary at sites MRIP01, MRIP02, MRIP05 and MRIP06 (overlying Longwalls 20-22) and at sites MRIP03, MRIP04, MRIP07 and MRIP08 (downstream of Longwalls 20-22) (Figure 4).

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics:
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and
- condition/health rating for each species in the quadrat.

A permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) has also been used to monitor riparian vegetation at sites MRIP01 to MRIP08. The data collected along each transect includes the occurrence of weed species (species and location) and a condition/health rating for each plant along the transect.

Permanent photo points have been established for each quadrat and along each transect.

In summary, the results of the surveys indicate the following:

- Riparian vegetation at all sites was found to be flood impacted as a results of successive flooding including further floods between spring 2011 and autumn 2012 surveys. Results from autumn 2012 were similar to autumn 2011, and riparian vegetation continues to improve in condition despite being impacted by consecutive floods.
- The only sites where a discernible pattern could be observed were at control sites MRIP07 and MRIP08 where a reduction in cover was recorded across all-structural layers from autumn 2011 to spring 2011. At both these sites flood-impacted vegetation was still common and recovery appeared to be slower than that observed at other sites. At site MRIP08 in particular, the scouring and deposition of sediments has impacted heavily on the ground layer vegetation.
- Despite the damage to vegetation and the flood-swept appearance, many individuals at the time of survey were still alive, and/or recovering.

Quadrat and transect monitoring will be conducted bi-annually, in autumn and spring.





Species Richness

Species richness at all riparian sites increased in autumn 2012 compared to spring 2011 with the exception of site MRIP02 which remained unchanged. The increases in species richness were small with the exception of site MRIP07 where a larger increase in species richness was observed in autumn 2012.

- Site MRIP06 was the most floristically diverse site while MRIP08 was the least diverse, where the ground layer comprised a combination of boulders and sparse vegetation cover dominated by *Lomandra fluviatilis*.
- The longwall sites were generally more floristically diverse compared to the control sites. The differences in floristic diversity can be attributed to the nature of the habitats at these sites. All four longwall sites are generally shrubbier, and have little exposed bedrock present. Control sites MRIP03 and MRIP07 are also relatively shrubby, however sites MRIP04 and MRIP08 are characterised by extensive rock and boulders, sediments, and less vegetative cover in comparison.

Indicator Species

Twenty tagged individuals of *Prostanthera linearis*, *Schoenis melanostachys* and *Lomatia myricoides* have been monitored at sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 (overlying Longwalls 20-22) and at sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10 (downstream of Longwalls 20-22) (Figure 4). Note, only 10 individuals of *Prostanthera linearis* were available for tagging at site MRIP08.

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant.

Monitoring of indicator species will be conducted bi-annually in autumn and spring.

In summary, the results of the surveys of indicator species indicate the following:

- Many of the tagged plants within the riparian sites have been severely flood impacted, with some individuals unable to be located in spring 2011 and again in autumn 2012 due to burial under vegetation, sediments and woody debris.
 Those plants unable to be relocated have been replaced with new individuals. In several instances, plants missing and/or buried in spring 2011 were relocated in autumn 2012, being uncovered after subsequent flooding.
- In autumn 2012 all tagged plants were located with the exception of one individual, Tag H63 Prostanthera linearis at longwall site MRIP05. If not located in spring 2012 surveys it will be replaced by another individual within the monitoring site.
- The condition scores for Prostanthera linearis and Schoenus melanostachys have declined since spring 2010, with an increase in the number of plants with some level of dieback and a subsequent decrease in the number of tagged plants in a healthy condition. This decline continued marginally in spring 2011 and autumn 2012 at both longwall and control sites with the number of plants in healthy condition only slightly below that recorded in autumn 2011. Exceptions to this in autumn 2012 were Prostanthera linearis and Schoenus melanostachys at control sites.
- Given that the declines have been recorded at both longwall and control sites, the
 results are considered to represent natural fluctuations in response to climatic
 conditions, ageing plants and, in particular, to natural disturbances including
 floods.
- Of the three indicator species, Lomatia myricoides has been the least impacted by flooding largely in part to its robust habit and deep root zone. One additional dead Lomatia myricodes was observed in autumn 2012.
- Prostanthera linearis and Schoenus melanostachys were most impacted by flooding in spring 2011 and autumn 2012 with many individuals of Prostanthera linearis found flood-swept and uprooted, whilst many Schoenus melanostachys were buried under sediment and woody debris. A greater proportion of Prostanthera linearis and Schoenus melanostachys also had some level of dieback.





Aquatic Biota and their Habitats

The aquatic ecology monitoring program for Longwalls 20-22 has been designed to:

- monitor subsidence-induced impacts on aquatic ecology (referred to as stream monitoring); and
- monitor the response of aquatic ecosystems to the implementation of stream remediation works (referred to as pool monitoring).

The design of the monitoring programs uses a "Beyond BACI" experimental design and focuses on representative sampling within streams and pools in the Longwalls 20-22 mining area and in suitable control streams and pools not subject to mine subsidence.

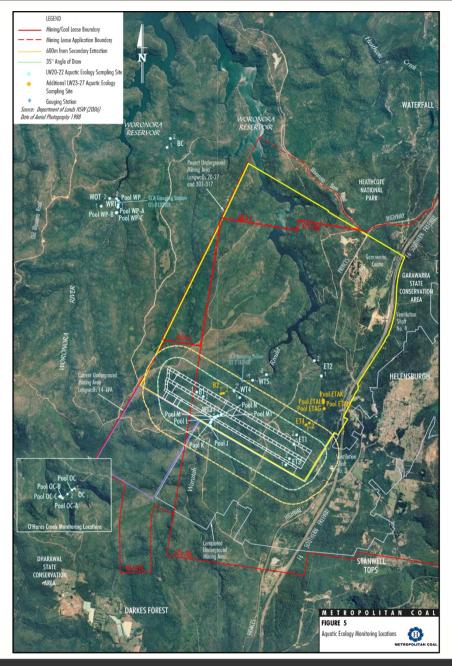
Stream Monitoring

The stream monitoring program includes the monitoring of aquatic habitat characteristics, water quality, aquatic macroinvertebrates and aquatic macrophytes. Baseline monitoring has been conducted in spring 2008, autumn 2009, spring 2009, autumn 2010 and spring 2010. Surveys have been carried out in spring 2010, autumn 2011, spring 2011 and autumn 2012 since the commencement of Longwall 20.

Monitoring has been conducted at two sampling sites (approximately 100 m long) at the following stream sampling locations:

- Locations WT3 on Waratah Rivulet, ET1 and ET3 on the Eastern Tributary and B1 on Tributary B, overlying Longwalls 20-22.
- Locations WT4 and WT5 on Waratah Rivulet and ET2 on the Eastern Tributary, downstream of Longwalls 20-22.
- Control locations: WR1 on Woronora River; OC on O'Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

The approximate locations of the sampling sites are shown on Figure 5.







The methods used to survey aquatic biota and their habitats at each site are:

- Stream characteristics are recorded in accordance with the Australian River
 Assessment System (AUSRIVAS) protocol (visual assessment of stream width
 and depth, composition of the substratum, riparian conditions, signs of
 disturbance, water quality and percentage cover of the substratum by algae).
- Water quality sampling is conducted for electrical conductivity, dissolved oxygen, pH, temperature, turbidity, oxygen reduction potential, alkalinity, total phosphorous and total nitrogen to provide information relevant to water quality at the time of sampling.
- Aquatic macroinvertebrate sampling is conducted using the AUSRIVAS protocol, as well as quantitative sampling where three replicate macroinvertebrate samples are collected within each site using timed sweeps.
- The distribution of submerged and emergent (occurring in-stream and in the riparian zone) aquatic macrophytes are estimated along each sampling location by assigning a cover class to each species. The cover classes are: (1) one plant or small patch (i.e. few), (2) not common, growing in a few places (i.e. scattered), and (3) widespread (i.e. common). In addition, an assessment of the in-stream (i.e. submerged and emergent) aquatic vegetation is made within each site by estimating the relative abundance (i.e. percentage cover) of aquatic macrophytes within five haphazardly placed 0.25 square metre quadrats, using a stratified sampling technique.

Table 1 presents the AUSRIVAS Band results for each site.

Charts 1a to 4h present the mean abundance of macroinvertebrates, mean diversity of macroinvertebrates, mean percentage cover of macrophytes and mean diversity of macrophytes at each sampling location, respectively, using the quantitative sampling data.

Monitoring of the sampling sites will be conducted bi-annually, in autumn and spring.

Table 1
AUSRIVAS Band Results

Stream	Site				AUSRIV	AS Band			
		sp-08	aut-09	sp-09	aut-10	sp-10	aut-11	sp-11	aut-12
Waratah	WT3-1	В	В	В	В	В	С	В	В
Rivulet	WT3-2	В	В	В	С	В	С	В	В
	WT4-1	D	С	С	С	В	С	С	Α
	WT4-2	В	С	С	В	В	С	В	Α
	WT5-1	В	С	С	С	С	В	Α	В
	WT5-2	D	С	С	С	С	С	С	В
Tributary C	C1-1	D	С	В	В	С	С	В	В
Note: also	C1-2	D	С	С	В	В	В	С	Α
referred to as Eastern	C2-1	D	В	В	С	С	В	С	С
Tributary	C2-2	D	С	В	С	С	С	D	В
(ET)	C3-1	-	-	В	С	С	С	В	В
	C3-2	-	-	D	С	С	С	С	С
Tributary B	B1-1	В	С	С	С	С	С	В	С
	B1-2	С	В	С	В	С	С	С	В
Bee Creek	BC1	D	С	С	В	С	С	D	С
	BC2	С	В	D	В	С	В	В	В
Woronora	WOT1	С	В	_*	В	С	С	В	С
Tributary	WOT2	С	С	D	С	С	С	С	В
Woronora River	WR1	D	В	С	В	С	С	С	С
	WR2	С	С	С	В	С	С	С	С
O'Hares Creek	OC1	В	В	В	Α	В	В	Α	Α
O. CO.	OC2	D	В	В	В	В	В	В	С

⁻ Survey of Sites ET3-1 and ET3-2 commenced in spring 2009.





^{-*} Insufficient water habitat available to sample

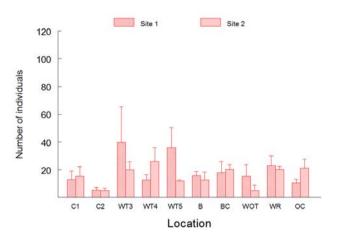


Chart 1a Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Spring 2008

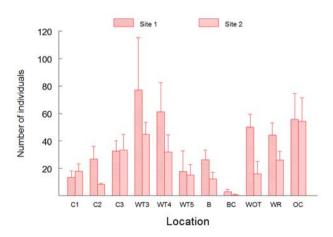


Chart 1c Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Spring 2009

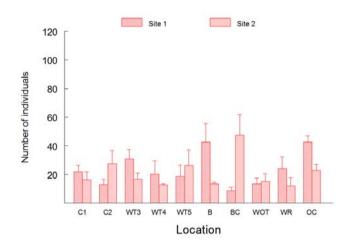


Chart 1b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Autumn 2009

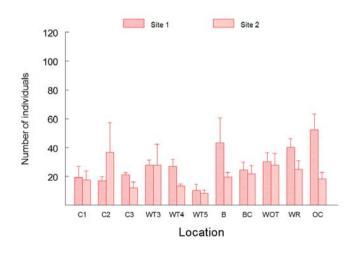


Chart 1d Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Autumn 2010





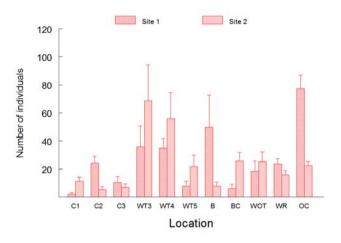


Chart 1e Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Spring 2010

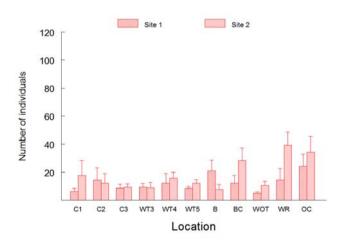


Chart 1g Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Spring 2011

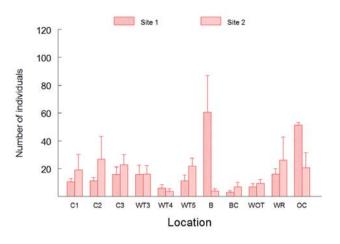


Chart 1f Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring, Autumn 2011

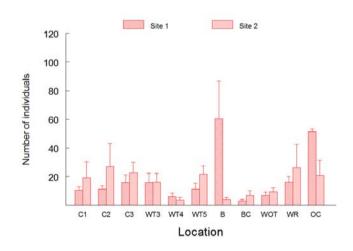


Chart 1h Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Autumn 2012





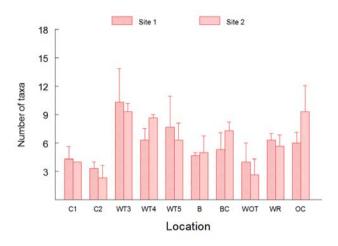


Chart 2a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Spring 2008

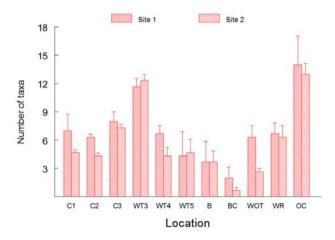


Chart 2c Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Spring 2009

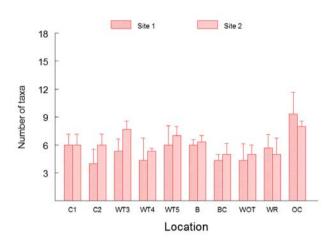


Chart 2b Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Autumn 2009

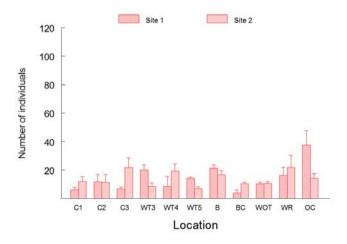


Chart 2d Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Autumn 2010





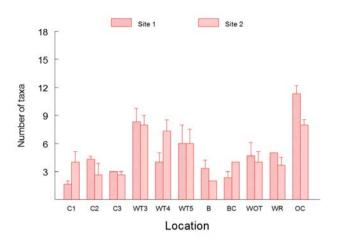


Chart 2e Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Spring 2010

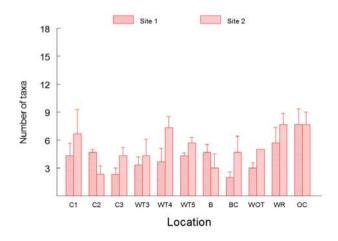


Chart 2g Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Spring 2011

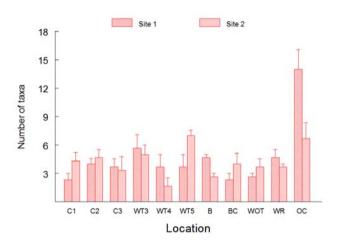


Chart 2f Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Autumn 2011

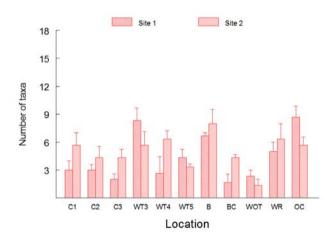


Chart 2h Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring, Autumn 2012





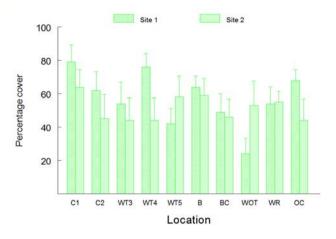


Chart 3a Mean (+SE) Macrophyte Percentage Cover, Stream Monitoring, Spring 2008

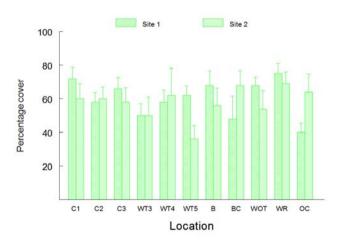


Chart 3c Mean (+SE) Macrophyte Percentage Cover, Steam Monitoring, Spring 2009

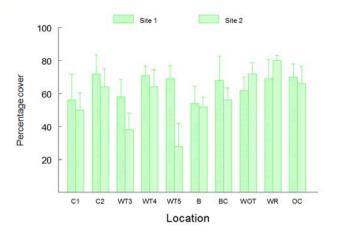


Chart 3b Mean (+SE) Macrophyte Percentage Cover, Stream Monitoring, Autumn 2009

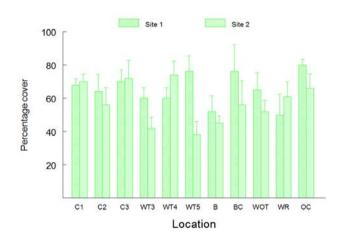


Chart 3d Mean (+SE) Macrophyte Percentage Cover, Stream Monitoring, Autumn 2010



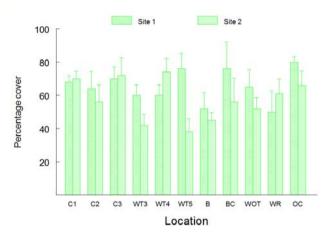


Chart 3e Mean (+SE) Macrophyte Percentage Cover, Steam Monitoring, Spring 2010

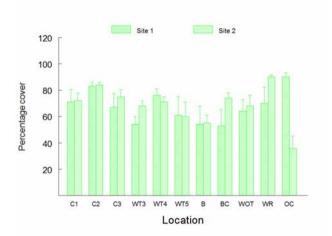


Chart 3g Mean (+SE) Macrophyte Percentage Cover, Steam Monitoring, Spring 2011

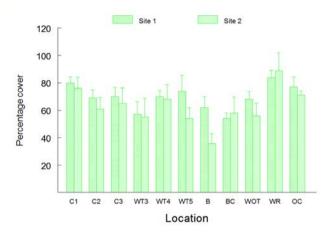


Chart 3f Mean (+SE) Macrophyte Percentage Cover, Stream Monitoring, Autumn 2011

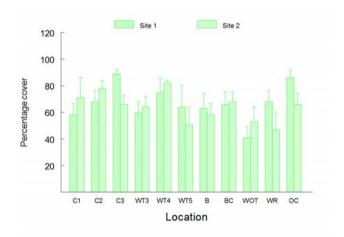


Chart 3h Mean (+SE) Macrophyte Percentage Cover, Stream Monitoring, Autumn 2012



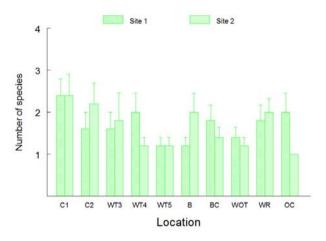


Chart 4a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Spring 2008

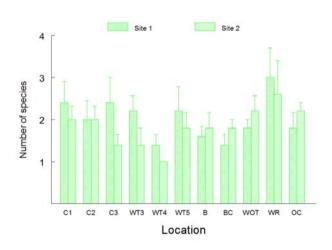


Chart 4c Mean (+SE) Macrophyte Diversity, Stream Monitoring, Spring 2009

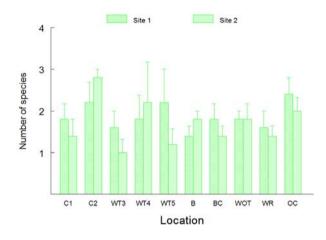


Chart 4b Mean (+SE) Macrophyte Diversity, Stream Monitoring, Autumn 2009

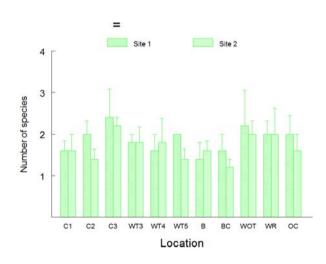


Chart 4d Mean (+SE) Macrophyte Diversity, Stream Monitoring, Autumn 2010



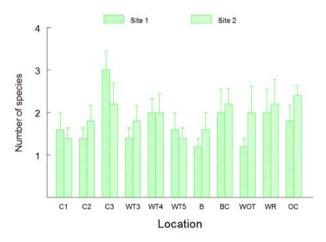


Chart 4e Mean (+SE) Macrophyte Diversity, Stream Monitoring, Spring 2010

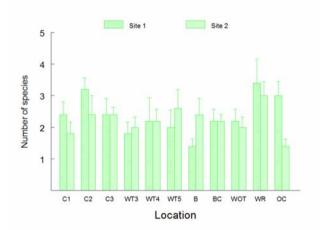


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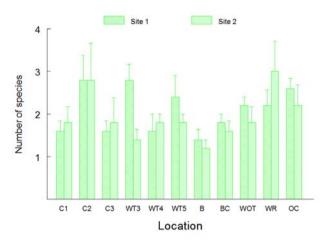


Chart 4f Mean (+SE) Macrophyte Diversity, Stream Monitoring, Autumn 2011

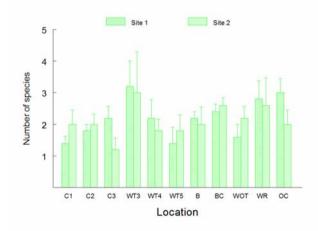


Chart 4h Mean (+SE) Macrophyte Diversity, Stream Monitoring, Autumn 2012



Pool Monitoring

Baseline monitoring of pools on Waratah Rivulet has been conducted since spring 2008¹ to assess the response of aquatic ecosystems to the implementation of future stream remediation works, namely:

- Larger pools, J, M1 and N on Waratah Rivulet overlying Longwalls 20-22.
- Smaller pools K, L and M on Waratah Rivulet overlying Longwalls 20-22.
- One larger control pool on Woronora River (Pool WP) and one larger control pool on O'Hares Creek (Pool OC).
- Three smaller control pools on Woronora River (Pool WP-A, WP-B and WP-C) and three smaller control pools on O'Hares Creek (Pool OC-A, OC-B and OC-C).

The approximate locations of the sampling sites are shown on Figure 5.

Sampling is conducted at two random sites within the larger pools and at one site within the smaller pools.

Within each site in each pool, aquatic macroinvertebrates and macrophytes are sampled using the same quantitative techniques described for stream monitoring above. The AUSRIVAS sampling technique is not used for macroinvertebrate sampling in the pool monitoring.

Quantitative estimates of aquatic macrophytes (i.e. emergent, floating attached and/or submerged species of aquatic plants) are collected at one site at each small pool and at two sites at each large pool. In addition, the spatial distribution of floating attached and/or submerged macrophytes (e.g. *Myriophyllum penduculatum* and *Triglochin procerum*) is also mapped in each pool, to provide a visual comparison of their distribution through time.

Charts 5a to 8h present the mean abundance of macroinvertebrates, mean diversity of macroinvertebrates, mean percentage cover of macrophytes and mean diversity of macrophytes at the larger pools, respectively, using the quantitative sampling data.

Charts 9a to 12f present the mean abundance of macroinvertebrates, mean diversity of macroinvertebrates, mean percentage cover of macrophytes and mean diversity of macrophytes at the smaller pools, respectively, using the quantitative sampling data.

The baseline monitoring data provides a benchmark against which aquatic biota and their habitats can be measured before and after stream remediation works.

Monitoring of the sampling sites will be conducted bi-annually, in autumn and spring.

Pools monitored since spring 2009: larger pools - Pools J and M1 on Waratah Rivulet; smaller pools: Pools K, L and M on Waratah Rivulet, Pools WP-A, WP-B, WP-C on Woronora River and Pools OC-A, OC-B, OC-C on O'Hares Creek.





Pools monitored since spring 2008: larger pools - Pool N on Waratah Rivulet, Pool WP on Woronora River and Pool OC on O'Hares Creek.

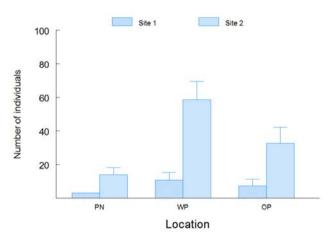


Chart 5a Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Spring 2008

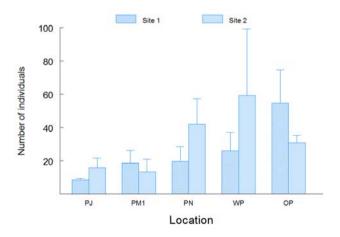


Chart 5c Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Spring 2009

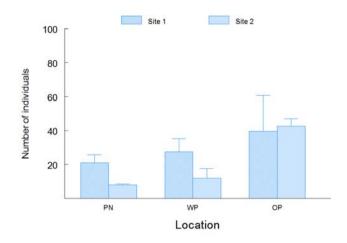


Chart 5b Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Autumn 2009

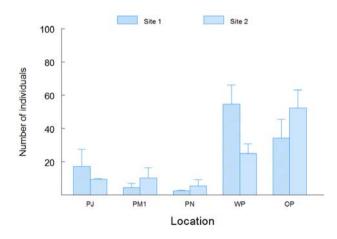


Chart 5d Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Autumn 2010





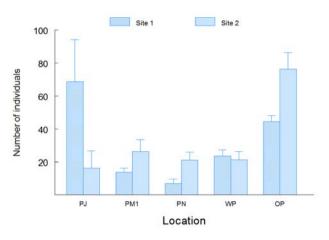


Chart 5e Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Spring 2010

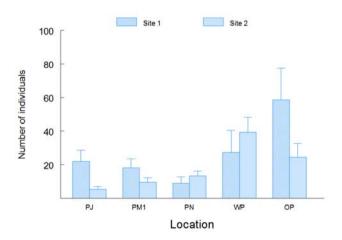


Chart 5g Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Spring 2011

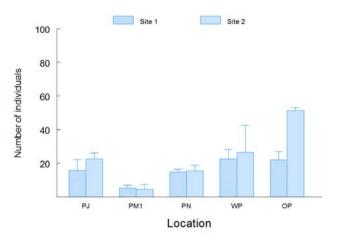


Chart 5f Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Autumn 2011

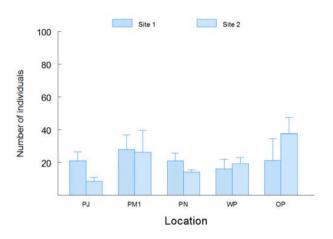


Chart 5h Mean (+SE) Macroinvertebrate Abundance, Larger Pools, Autumn 2012





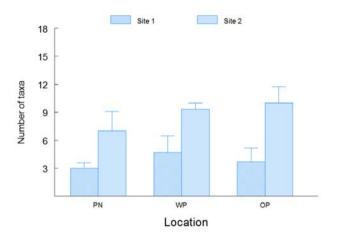


Chart 6a Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Spring 2008

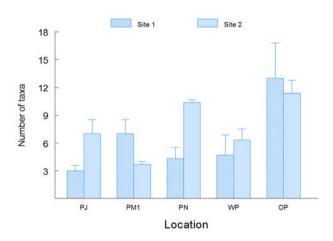


Chart 6c Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Spring 2009

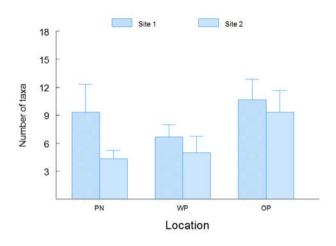


Chart 6b Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Autumn 2009

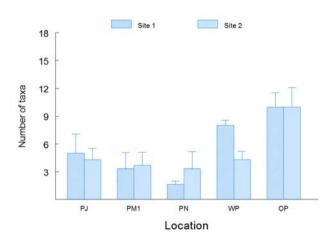


Chart 6d Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Autumn 2010





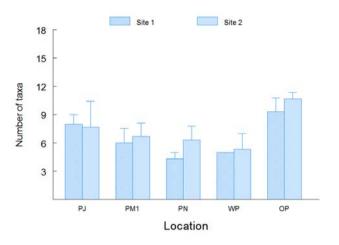


Chart 6e Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Spring 2010

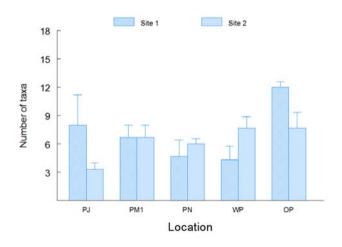


Chart 6g Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Spring 2011

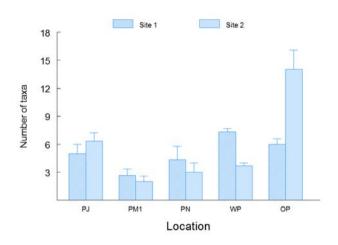


Chart 6f Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Autumn 2011

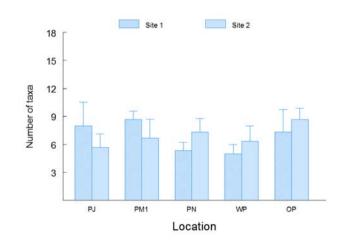


Chart 6h Mean (+SE) Macroinvertebrate Diversity, Larger Pools, Autumn 2012





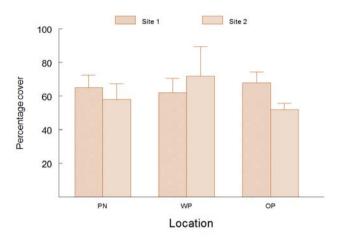


Chart 7a Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Spring 2008

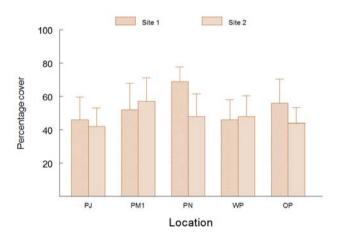


Chart 7c Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Spring 2009

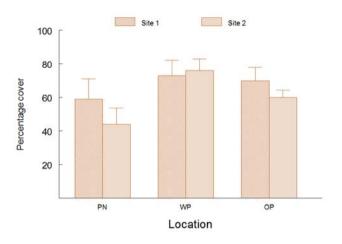


Chart 7b Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Autumn 2009

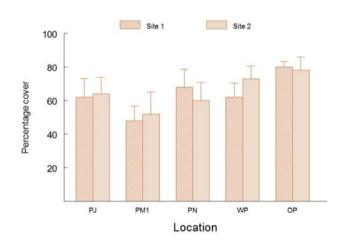


Chart 7d Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Autumn 2010





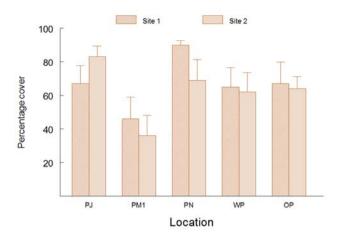


Chart 7e Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Spring 2010

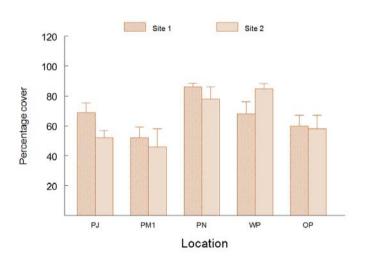


Chart 7g Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Spring 2011

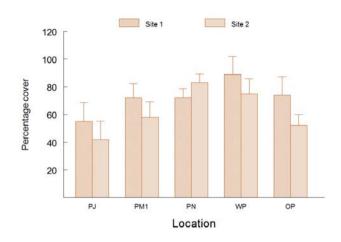


Chart 7f Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Autumn 2011

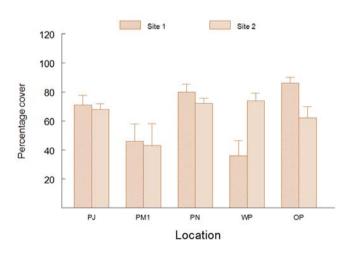


Chart 7h Mean (+SE) Macrophyte Percentage Cover, Larger Pools, Autumn 2012





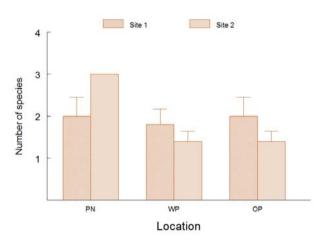


Chart 8a Mean (+SE) Macrophyte Diversity, Larger Pools, Spring 2008

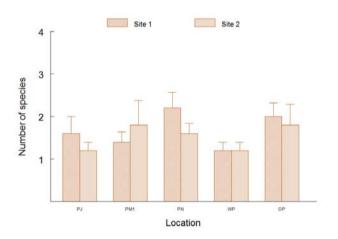


Chart 8c Mean (+SE) Macrophyte Diversity, Larger Pools, Spring 2009

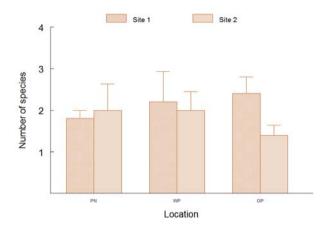


Chart 8b Mean (+SE) Macrophyte Diversity, Larger Pools, Autumn 2009

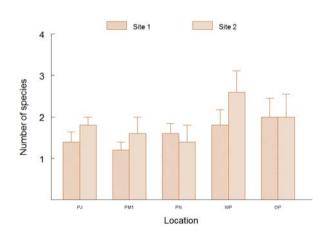


Chart 8d Mean (+SE) Macrophyte Diversity, Larger Pools, Autumn 2010





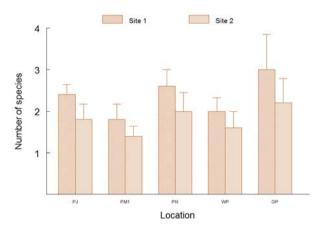


Chart 8e Mean (+SE) Macrophyte Diversity, Larger Pools, Spring 2010

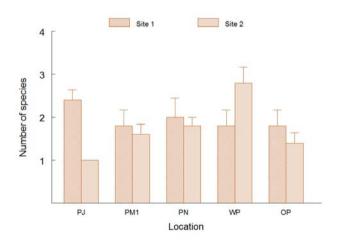


Chart 8g Mean (+SE) Macrophyte Diversity, Larger Pools, Spring 2011



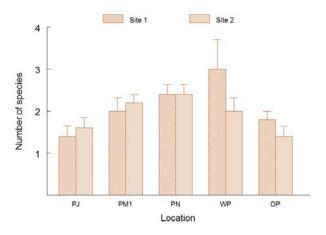


Chart 8f Mean (+SE) Macrophyte Diversity, Larger Pools, Autumn 2011

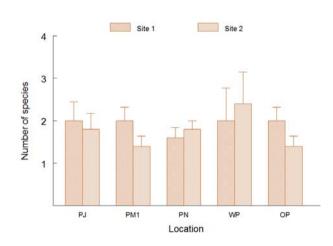


Chart 8h Mean (+SE) Macrophyte Diversity, Larger Pools, Autumn 2012





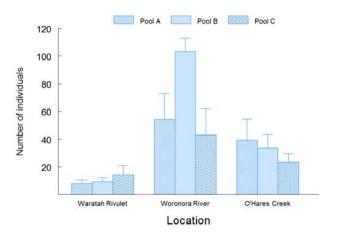


Chart 9a Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Spring 2009

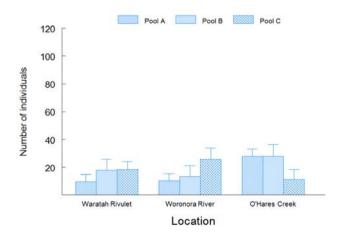


Chart 9c Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Spring 2010

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (n = 3).

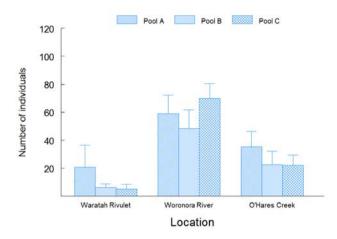


Chart 9b Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Autumn 2010

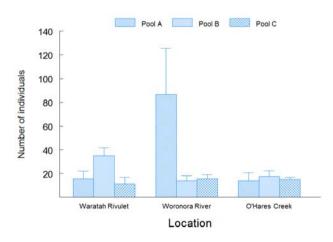


Chart 9d Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Autumn 2011





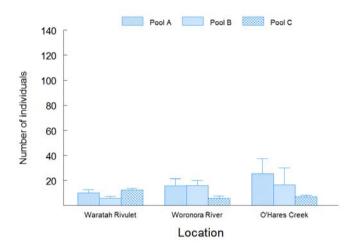


Chart 9e Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Spring 2011

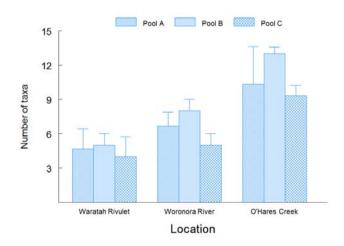


Chart 10a Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Spring 2009

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (*n* = 3).

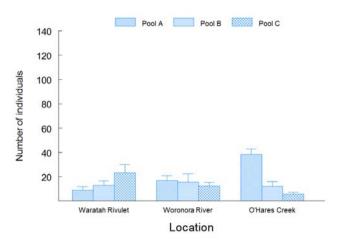


Chart 9f Mean (+SE) Macroinvertebrate Abundance, Smaller Pools, Autumn 2012

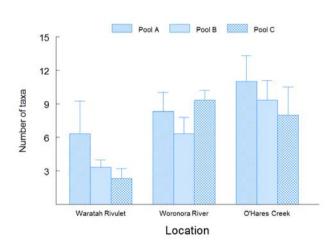


Chart 10b Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Autumn 2010





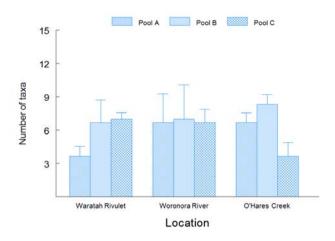


Chart 10c Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Spring 2010

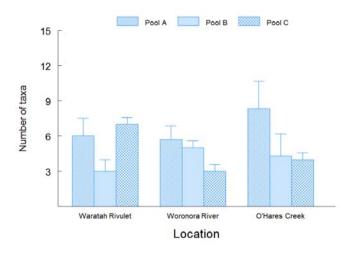


Chart 10e Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Spring 2011

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (n = 3).

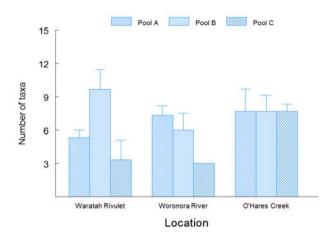


Chart 10d Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Autumn 2011

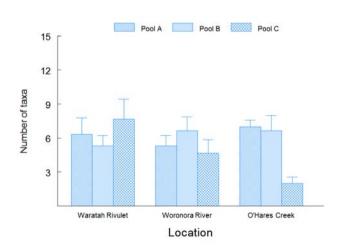


Chart 10f Mean (+SE) Macroinvertebrate Diversity, Smaller Pools, Autumn 2012





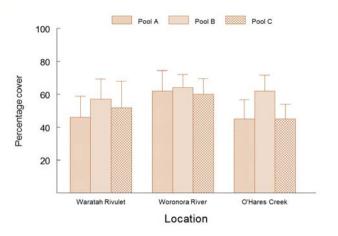


Chart 11a Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Spring 2009

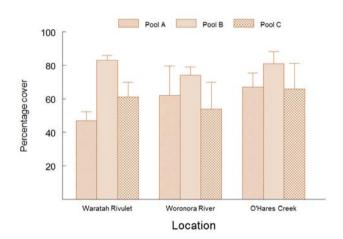


Chart 11c Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Spring 2010

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (n = 5).

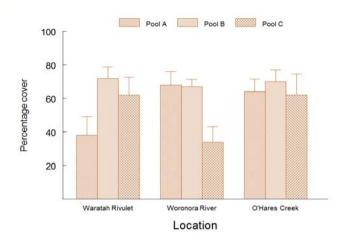


Chart 11b Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Autumn 2010

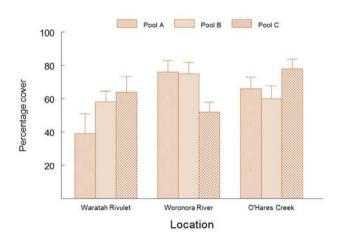


Chart 11d Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Autumn 2011



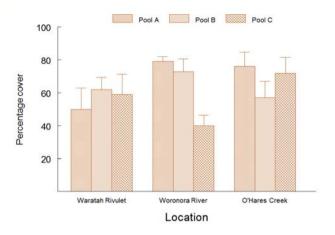


Chart 11e Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Spring 2011

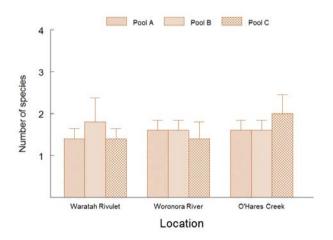


Chart 12a Mean (+SE) Macrophyte Diversity, Smaller Pools, Spring 2009

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (n = 5).

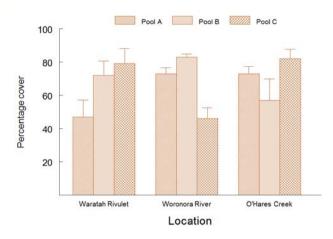


Chart 11f Mean (+SE) Macrophyte Percentage Cover, Smaller Pools, Autumn 2012

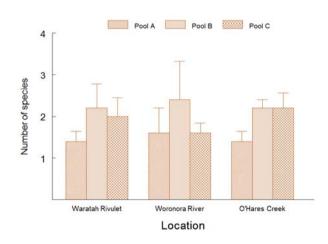


Chart 12b Mean (+SE) Macrophyte Diversity, Smaller Pools, Autumn 2010





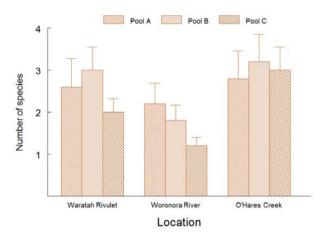


Chart 12c Mean (+SE) Macrophyte Diversity, Smaller Pools, Spring 2010

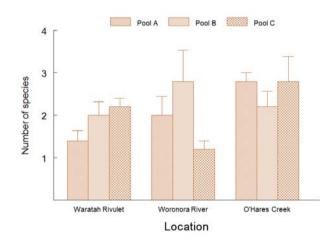


Chart 12e Mean (+SE) Macrophyte Diversity, Smaller Pools, Spring 2011

Note: Pools A, B and C on Waratah Rivulet represent Pools K, L and M, respectively (n = 5).

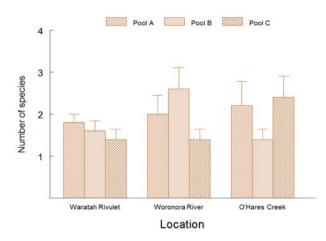


Chart 12d Mean (+SE) Macrophyte Diversity, Smaller Pools, Autumn 2011

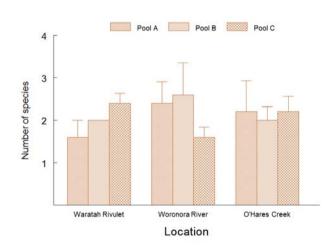


Chart 12f Mean (+SE) Macrophyte Diversity, Smaller Pools, Autumn 2012





Amphibian Surveys

A monitoring program has been developed for Longwalls 20-22 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog (*Heleioporus australiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) associated with tributaries. Baseline monitoring has been conducted in spring/summer 2009 and spring/summer 2010.

Six sites overlying Longwalls 20-22 and six control sites will be surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. The approximate locations of the sampling sites are shown on Figure 6. Each site is surveyed once during a standard one hour general area day search (early morning and late afternoon) supplemented by an evening 60 minute search/playback session using hand held spotlights and head lamps.

Species are assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- UC = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (>40 individuals), adult or tadpole stage.

The results of the three surveys to date (2009, 2010 and 2011) are presented in Table 2.

Adult Red-crowned Toadlets were observed at three test sites (sites 2 to 4) in spring/summer 2009, five test sites (sites 2 to 6) in 2010 and four test sites (sites 2 to 5) in 2011 (Table 2). At the control sites, adult Red-crowned Toadlets were observed at three sites in 2009 (sites 7, 9 and 10), three sites in 2010 (sites 10 to 12), and at no sites in 2011. Evidence of breeding for the Red-crowned Toadlet in test sites was observed at site 3 in 2011. Evidence of breeding at control sites was observed at sites 8 and 10 in 2011 (Table 2).

Only one adult Giant Burrowing Frog has been recorded (at test site 4 in 2011). Evidence of breeding has been observed at two control sites (site 10 in 2009 and site 7 in 2011).

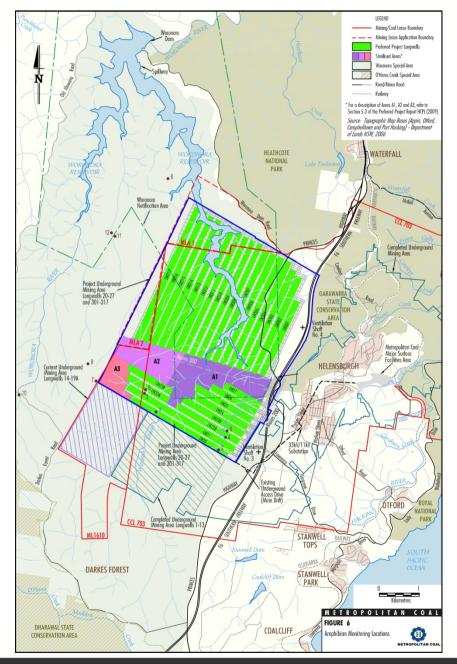




Table 2
Amphibian Species Diversity and Abundance, Spring/Summer 2009, 2010 and 2011

Scientific Name	Common Name	Survey		Sites	Above Lo	ongwalls	s 20-22				Contr	ol Sites			Te	otal	Relative Abundance ²	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Myobatrachidae				•	•	•												
Crinia signifera	Common	2009	1 ¹	1	1	>10	2	1	1	0	0	5	0	0	>16	6	MC	UC
	Eastern Froglet		0	0	0	0	0	0	0	0	0	>10	0	0	0	>10	MC	MC
		2010	3	4	3	2	3	5	4	3	0	4	1	2	20	14	MC	MC
			0	0	c100	0	0	0	0	0	0	30	27	6	c100	c233	Α	Α
		2011	3	9	7	3	7	0	10	4	3	8	0	0	29	25	С	С
			0	0	0	0	0	0	0	10	0	c100	0	0	0	c110	0	Α
Heleiporus	Giant Burrowing	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
australiiacus	Frog ^{v, v}		0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0
			0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	UC
Limnodynastes peronii	Brown-striped	2009	0	0	0	1	1	1	0	0	0	2	0	0	3	2	UC	UC
	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	53	0	76	0	0	0	0	0	0	0	129	0	Α	0
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	c100	0	0	0	0	0	c100	0	Α
Limnodynastes	Spotted Grass	2009	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
tasmaniensis	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	1	0	3	0	0	0	0	0	0	0	4	0	UC	0
			0	0	0	0	0	0	0	c100	0	0	0	0	0	c100	0	Α
Pseudophryne	Red-crowned	2009	0	1	2	2	0	0	1	0	1	1	0	0	5	3	UC	UC
australis	Toadlet ^v		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	1	7	1	6	9	0	0	0	1	1	2	24	4	С	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	1	1	3	4	0	0	0	0	0	0	0	9	0	UC	0
			0	0	10	0	0	0	0	5	0	c100	0	0	10	c105	UC	Α

Table 2 (Continued) Amphibian Species Diversity and Abundance, Spring/Summer 2009, 2010 and 2011

Scientific Name	Common Name	Survey		Sites	Above L	ongwall	s 20-22				Contro	ol Sites			Т	otal	Relative Abundance ²	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Myobatrachidae ((Cont.)																	
Uperoleia	Smooth Toadlet	2009	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1
laevigata			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	2	2	0	0	0	0	0	0	0	0	0	4	0	UC	0
			0	0	10	0	0	0	0	0	0	0	0	0	10	0	UC	0
		2011	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	UC
			0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	UC
Hylidae																		
Litoria citropa	Blue Mountains	2009	0	1	0	1	0	1	0	0	0	0	0	0	3	0	UC	0
	Tree Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	4	0	3	0	2	0	0	0	0	1	0	0	9	1	UC	1
			0	0	4	0	0	0	0	0	0	0	0	0	4	0	UC	0
		2011	0	0	0	0	2	0	0	0	0	0	0	0	2	0	UC	0
			0	0	2	0	0	0	0	0	0	0	0	0	2	0	UC	0
Litoria dentata	Bleating Tree	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	3	3	0	0	6	0	UC
			0	0	0	0	0	0	0	0	0	0	15	0	0	15	0	MC
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litoria freycineti	Southern Rocket	2009	0	0	0	0	5	1	0	0	0	2	0	0	6	2	UC	UC
	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	3	1	2	0	0	0	1	0	0	4	0	1	6	6	UC	UC
			0	8	0	0	0	0	0	c1000	0	38	0	3	8	c1041	UC	Α
		2011	0	0	0	0	0	0	6	1	6	0	0	0	0	13	0	MC
			0	0	30	0	0	0	0	c200	40	1	0	0	30	c241	С	Α
Litoria	Broad-palmed	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
latopalmata	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	c500	0	0	0	c500	0	0	c1000	0	Α
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Table 2 (Continued) Amphibian Species Diversity and Abundance, Spring/Summer 2009, 2010 and 2011

Scientific Name	Common Name	Survey		Sites /	Above L	ongwall	s 20-22				Contro	ol Sites	Total		Relative Abundance ²			
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Hylidae (Cont.)																		
LItoria lesueurii	Lesueur's Frog	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	2	0	2	0	4	0	0	0	0	0	0	8	0	UC	0
			42	0	10	0	0	0	0	0	0	0	0	0	52	0	Α	0
		2011	2	2	0	3	0	1	0	0	0	2	0	0	8	2	UC	UC
			0	0	4	0	0	0	0	0	0	5	0	0	4	5	UC	UC
Litoria wilcoxii	Stony Creek	2009	0	10	0	0	3	0	0	0	0	4	0	0	13	4	MC	UC
	Frog		0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	UC
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litoria peronii	Peron's Tree	2009	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0
	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	3	0	0	2	0	2	0	7	0	UC
			0	0	0	0	0	0	c1000	0	0	0	0	0	0	c1000	0	Α
		2011	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
			0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Litoria	Green Stream	2009	0	0	0	2	1	>5	0	0	0	0	0	0	>8	0	UC	0
phyllochroa	Frog		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Table 2 (Continued) Amphibian Species Diversity and Abundance, Spring/Summer 2009, 2010 and 2011

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22								Contro	ol Sites		Total		Relative Abundance ²		
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Species Diversity at Each Site		2009	1	5	2	6	5	5	3	0	1	7	0	0				
		2010	4	5	7	3	4	3	4	2	0	6	4	4				
		2011	3	3	6	4	4	1	3	6	3	5	0	0				
Species Diversity	in all Control	2009													9	8		
and all Test sites		2010													7	7		
		2011													7	9		
Species Diversity	across the	2009													11			
survey site		2010														10		
		2011													,	10		

¹ First line of data refers to the presence or absence of adults, while the second line of data refers to absence or presence of tadpoles.





Relative Abundance of adult and tadpole stage assessed independently: 0 – no sightings, 1 – One sighting, UC – Uncommon, 2 to 10 individuals, MC – Moderately common, 11 to 20 individuals, C – Common, 21 to 40 individuals, A – Abundant, >40 individuals, c1000 = approximately 1,000 animals estimated.

V, V Listed as vulnerable under the TSC Act and EPBC Act.

V Listed as vulnerable under the TSC Act.

Chart 13 shows the number of amphibian species recorded at each site in 2009 to 2011.

These data reflect an expected variability across sites and years. A portion of the variability is likely associated with survey weather conditions at the time or in the weeks preceding the surveys. The year 2009 was a very dry year, whereas 2010 was a much wetter year and more free surface water and damp micro-habitat areas were present across the survey area than in 2009. Daytime and night time temperatures were depressed in 2011 although rainfall was above average. Lower than average night time temperatures likely depressed frog calling behaviour. Based on the results of the surveys of longwall and control sites to date, amphibian species diversity and abundance are consistent with expected population variations and cycles in response to seasonal variations.

In summary, the amphibian surveys identified the following:

- Six test sites are located above Longwalls 20-22, with three (sites 1, 2 and 3)
 having been undermined at the time of the spring/summer 2011 survey.
- Eleven amphibian species were located across the survey area in 2009 and 10 species in years 2010 and 2011.
- Species diversity at individual test sites varied between one to seven, and in control sites in spring/summer 2011.
- Seven species were located across all test sites and nine species across all control sites in spring/summer 2011.
- Breeding events were identified for six species located in test sites during 2009-2011, including one event for the Red-crowned Toadlet. At control sites, breeding events have been identified for 10 species, including two events for the Red-crowned Toadlet both in 2011, and two breeding events for the Giant Burrowing Frog.
- The amphibian species diversity and abundance data are consistent with expected population variations and cycles in response to seasonal variations.

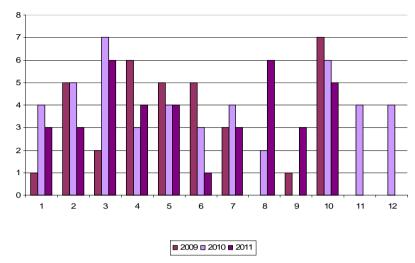


Chart 13 Amphibian Species Diversity, 2009, 2010 and 2011



