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re: GRCCC Community River Health Monitoring Project – Autumn 2011 Technical Summary

Dear Brad and Alex,

The attached technical report accompanies the GRCCC Community River Health Monitoring Program Autumn 2011 Report Card and provides detailed results for Wollondilly Shire Council monitoring sites.

The autumn 2011 report card will be released to councils on 30 September 2011 and to the public on 7 October 2011 however technical summaries for each LGA will remain confidential.

If you would like to discuss the results further Alison Hanlon, GRCCC Program Manager and I are available to come and meet with you and your team.

Kind Regards

Carl Tippler

GRCCC Community River Health Coordinator

GRCCC River Health Monitoring Project

Introduction

As part of the GRCCC River Health Monitoring Program, six freshwater monitoring sites were chosen within the Wollondilly Shire Council area for ecological assessment on a six monthly basis from spring 2009 to autumn 2011. Four sites along the Georges River (Upper Georges River at Kings Falls Bridge, 50 m downstream of the Brennan's Creek confluence and Kennedy Grove at Appin) are monitored as part of the program in conjunction with Brennan's Creek, Illuka Creek and Cobbong Creek. Due to the minimal disturbance to the catchment areas of Upper Georges River at Kings Fall Bridge, Illuka and Cobbong Creeks, these monitoring sites have been classified as 'clean' reference sites and are used to formulate the guideline values upon which report grades are calculated.

Data is collected in the field by GRCCC staff with the assistance of members from the local community, trained in scientific rapid ecological assessment methods.

The ecological condition of waterways throughout the catchment was assessed by measuring a combination of biotic and chemical factors. These include water quality (pH, electrical conductivity (EC), dissolved oxygen (DO), turbidity (NTU), total phosphorous (TP) and total nitrogen (TN)), riparian vegetation (using the Rapid Appraisal of Riparian Condition or RARC (Jensen *et al*, 2005)) and macroinvertebrates following the SIGNAL2 methodology (Chessman 2003) which uses a simple index to indicate water quality based on the tolerance of macroinvertebrates to various pollutants. When combined with macroinvertebrate abundance and richness, the SIGNAL score provides a general indication of the condition of the waterway. In addition, macroinvertebrate richness at order level was assessed and the Shannon Weiner Biodiversity Index (H), which measures the evenness of the distribution of taxa throughout the macroinvertebrate assemblage, was applied as part of the assessment.

The SIGNAL methodology allows for a rapid assessment of the condition of waterways by matching SIGNAL scores with macroinvertebrate richness at the taxonomic level or order. Order level identification has been proven to be sufficient for the detection of broad scale change (Wright *et al*, 1995).

Results from each round of sampling are displayed in a report card format where a grade from A+ to F- is awarded to each biotic index (table 1) dependant on a comparison with ecosystem guideline values. Index grades are then averaged and an overall grade awarded to each site.

Table 1. River Health grade with corresponding condition.

Grade	Condition
A+	Excellent
A – B+	Good
B – C-	Fair
D+ - F-	Poor

This report accompanies the autumn 2011 report card and discusses results from that monitoring period. Autumn 2011 saw the final round of four sampling periods completed for this current round of funding. Monitoring activities as part of the next round of Federal funding will commence in July 2011.

Rainfall

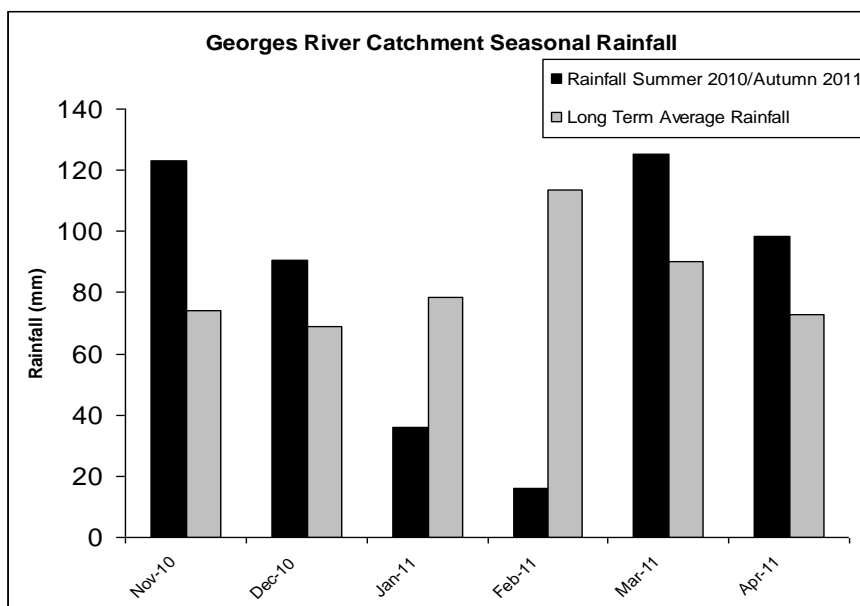


Figure 1: Average monthly rainfall across the Georges River catchment (14 B.O.M monitoring stations)

During the 6 months since the spring 2010 monitoring period (November 2010 to April 2011) rainfall across the catchment was above average for November and December (fig. 1). A particularly dry summer occurred with rainfall well below average for January and February. The dry spell came to end as autumn rains for March and April were above across the catchment.

Monitoring Site Locations

Six River Health monitoring sites fall within Wollondilly Shire Council area. Indicative locations of these sites can be seen on the map (figure 2) while coordinates and elevation are found below (Google Earth, 2011).

Freshwater monitoring sites:

Site 1 – Upper Georges River - 34°12'39"S, 150°47'46"E elevation: 240 m

Site 2 – Brennan's Creek - 34°12'15"S, 150°47'58"E elevation: 244 m

Site 3 – Georges River Downstream of Brennan's Creek (GRDBC) - 34°12'14"S, 150°47'54"E elevation: 244 m

Site 4 – Georges River at Appin (GRA) - 34°11'44"S, 150°47'32"E elevation: 232 m

Site 5 – Illuka Creek - 34°14'29"S, 150°43'15"E elevation: 372 m

Site 6 — Cobbong Creek - 34°10'35"S, 150°50'24"E elevation: 215 m

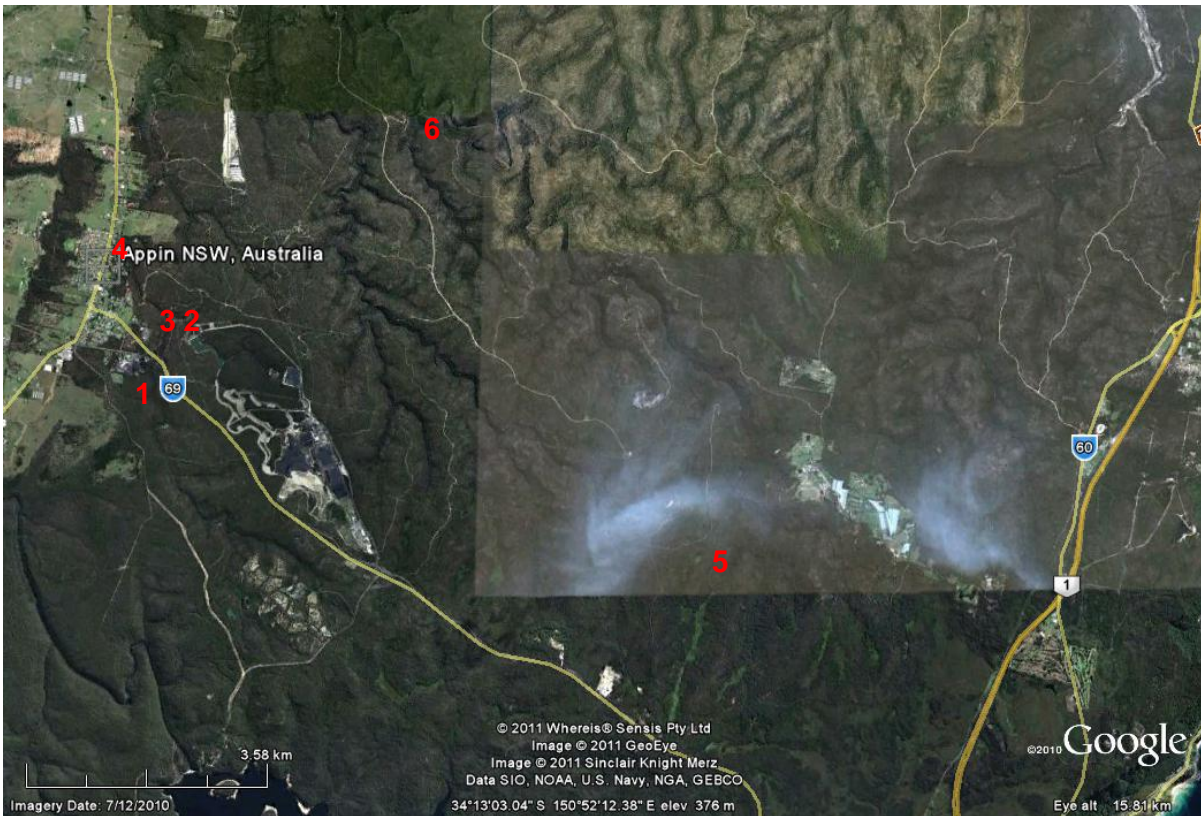


Figure 2: River Health monitoring sites within Wollondilly Shire Council area.

Results

Overall Summary

Table 2: Overall grades of Wollondilly River Health sites

	Autumn 2011	Spring 2010	Autumn 2010	Spring 2009
Upper Georges River	A	A+	A	A+
Brennan's Creek	C-	C-	C-	C+
GRDBC	C+	B	C	B-
GRA	B	B-	B-	B-
Cobbong Creek	A+	A+	A+	A+
Illuka Creek	A+	A-	A-	A-

The overall grade recorded for Upper Georges River during autumn 2011 was A. This result continues the slightly fluctuating pattern observed in previous monitoring periods (table 2) and indicates good ecological condition.

No change to the overall grade was recorded for Brennan's Creek with the grade of C- remaining, indicating fair ecological condition.

The overall grade for GRDBC in autumn 2011 was C+ which represents fair ecological condition. A slight yet non significant increase in the overall grade from B- in spring 2010 to B in autumn 2011 was recorded for GRA. This result does not reflect a change in the ecological condition which has remained fair since 2009.

Excellent ecological conditions persist at Cobbong Creek as indicated by the consistent record of the grade of A+ since spring 2009. In addition the grade of A+ was recorded for Illuka Creek in autumn 2011 representing a slight increase in grade when compared with previous results and indicating excellent ecological condition.

Macroinvertebrate summary

Table 3: Macroinvertebrate grades for Wollondilly monitoring sites

	Autumn 2011	Spring 2010	Autumn 2010	Spring 2009
Upper Georges River	A+	A+	A+	A+
Brennan's Creek	D-	E+	F+	C-
GRDBC	D+	C-	E	C
GRA	A	A-	B	B
Cobbong Creek	A+	A+	A	A
Illuka Creek	A+	A+	A-	A-

Macroinvertebrates are commonly used as indicators of water quality. They show a wide range of sensitivities to various pollutants with some taxa being highly sensitive to pollution and disturbance while others show a high degree of tolerance. The macroinvertebrate assemblage found within each site during monitoring enables a broad scale assessment of the upstream aquatic environment and with repeated monitoring macroinvertebrates will provide an accurate assessment to detect changes in the health of the aquatic ecosystem.

No change to the macroinvertebrate grade for the Upper Georges River, Cobbong and Illuka Creeks were recorded during autumn 2011 with the grade of A+ remaining constant (table 3).

These grades indicate that macroinvertebrate communities at these sites are rich in both diversity and sensitive species which reflect the excellent ecological conditions of these sites.

The macroinvertebrate grade recorded for Brennan's Creek during autumn 2011 was D-. This result continues the trend of increasing macroinvertebrate grades since autumn 2010 however this result does not reflect a change in the ecological condition which has remained poor since autumn 2010.

The macroinvertebrate grade for GRDBC during autumn 2011 was D+. This result represents a slight decline in grade when compared to spring 2010 and continues the trend of fluctuating grades, indicating the condition of the macroinvertebrate community varies from fair to poor.

The gradual increase in macroinvertebrate grades continued at GRA with the grade of A recorded in autumn 2011. This result indicates the condition of the macroinvertebrate community has improved from fair to good since the commencement of monitoring in 2009.

Table 4. Shannon Index, SIGNAL score and Order level richness for six Wollondilly monitoring sites from spring 2009 through autumn 2011.

	Shannon Index (H)				Richness				SIGNAL Score			
	Autumn 11	Spring 10	Autumn 10	Spring 09	Autumn 11	Spring 10	Autumn 10	Spring 09	Autumn 11	Spring 10	Autumn 10	Spring 09
Upper Georges River	2.15	2.13	2.22	2.14	14	14	13	12	5.25	4.91	4.80	4.60
Brennan's Creek	1.23	1.29	1.38	1.56	6	7	6	8	4.96	3.58	3.80	4.73
GRDBC	0.87	0.94	1.43	1.70	9	8	6	7	4.17	4.84	4.26	4.70
GRA	1.53	1.56	1.78	1.90	12	9	9	10	4.55	4.70	5.30	4.24
Cobbong Creek	2.15	2.04	1.98	1.96	11	10	10	11	5.75	5.52	5.28	5.35
Illuka Creek	1.83	1.86	2.00	2.01	12	10	9	9	5.26	5.70	6.46	5.08

Shannon Index values (H) for Upper Georges River, remained relatively unchanged from previous results with H = 2.15 recorded during autumn 2011 (table 4). In addition Cobbong Creek and Illuka Creek recorded H = 2.15 and H = 1.83 respectively during autumn 2011 indicating no significant change when compared to previous results. These results indicate that there is excellent diversity within macroinvertebrate communities at these sites.

When compared to previous results no significant changes in richness were recorded for Upper Georges River, Cobbong Creek and Illuka Creek with 14, 11 and 12 macroinvertebrate orders observed respectively during autumn 2011 monitoring. Again these results indicate excellent levels of species richness amongst macroinvertebrate communities at these sites.

No significant change to the Shannon index was recorded for Brennan's Creek in autumn 2011 with H = 1.23. This result is significantly below the mean Shannon Weiner Index value for clean reference sites (n=9) of H = 1.88 +/- 0.19 indicating macroinvertebrate biodiversity in Brennan's Creek is depauperate when compared to reference condition. This is further evidenced by a richness of six orders recorded during autumn 2011, which is significantly below the mean reference condition of 11 +/- 2 orders.

When compared to spring 2010 no significant change to the Shannon Index was recorded for GRDBC in autumn 2011 with H = 0.87. Nevertheless this result represents a significant decline in biodiversity when compared to longer term results. In addition this result is significantly lower than reference condition (H = 1.88 +/- 0.19) indicating macroinvertebrate biodiversity is poorer at GRDBC than in reference streams. Macroinvertebrate richness at GRDBC was slightly higher in autumn 2011 with nine orders recorded. This result is comparable with mean richness of clean reference sites (11 +/- 2 orders). Although there was an increase in richness during autumn 2011 no improvement in biodiversity was recorded at GRDBC (as indicated by the Shannon index), this was due to the high abundance of two pollution tolerant taxa resulting in uneven distribution of taxa throughout the macroinvertebrate assemblage which can be seen in Appendix 1.

When compared to spring 2010 no significant change to the Shannon Index was recorded for GRA during autumn 2011 with H = 1.53. This result continues the declining trend in biodiversity recorded at this site since 2009. When compared to reference condition (H = 1.88 +/- 0.19) indicates macroinvertebrate biodiversity at this site is poorer than that of reference streams. Macroinvertebrate richness was comparable with reference condition during autumn 2011 with 12 macroinvertebrate orders recorded. This result did not affect biodiversity (as indicated by the Shannon Index) as the distribution of taxa within the macroinvertebrate assemblage was uneven and dominated by a high abundance of a small number of taxa (Appendix 1).

The SIGNAL methodology allows for a rapid assessment of the condition of waterways by matching SIGNAL scores with macroinvertebrate richness at the taxonomic level or order. Order level identification has been proven to be sufficient for the detection of broad scale change (Wright et al, 1995).

For the Georges River catchment a SIGNAL score of greater than 4.50 combined with macroinvertebrate richness of 9 orders or more is indicative of waterways with favourable habitat and natural water quality conditions.

SIGNAL scores for Upper Georges River, Cobbong Creek and Illuka Creek were 5.25, 5.75 and 5.26 respectively during autumn 2011 (fig. 4). When combined with macroinvertebrate richness of 14, 11 and 12 orders respectively, the SIGNAL method indicates that favourable habitat and chemically dilute conditions are found at these sites.

In contrast SIGNAL scores were lower for Brennan's Creek, GRDBC and GRA with 4.96, 4.17 and 4.55 recorded respectively, with the exception of Brennan's Creek these results were marginally below the mean SIGNAL score for clean reference sites of (n=9) is 5.07 +/- 0.50.

When SIGNAL scores for Brennan's Creek and GRDBS are combined with richness of 6 and 9 orders respectively, results indicate that toxic pollution or harsh physical conditions affect the macroinvertebrate community of Brennan's Creek. It is likely that high levels of salinity and/or nutrients from an urban or industrial source affect the macroinvertebrate community at GRDBC. In addition the combination of a SIGNAL score of 4.55 and richness of 12 orders recorded for GRA in autumn 2011 indicates is also beginning to be impacted by high salinity and/or nutrients.

It is evident from the results of macroinvertebrate monitoring that the macroinvertebrate communities of Brennan's Creek, GRDBC and GRA vary significantly from the reference sites of Upper Georges River, Cobbong Creek and Illuka Creek. A comparison of the macroinvertebrate results from Upper Georges River, Brennan's Creek and GRDBC clearly shows a decline in the macroinvertebrate community at Brennan's Creek and GRDBC. As macroinvertebrates are reliable indicators of ecosystem condition this result shows the aquatic ecosystem of both Brennan's Creek and GRDBC are degraded, the most probable cause being discharge to Brennan's Creek for the Westcliff Colliery.

Water Quality Summary

Table 5: Water Quality grades for Wollondilly monitoring sites

	Autumn 2011	Spring 2010	Autumn 2010	Spring 2009
Upper Georges River	B+	A+	B+	A+
Brennan's Creek	E+	E	D	D
Georges River Downstream of Brennan's Creek	C-	B	D	D
GRA	C-	C-	C-	C+
Cobbong Creek	A	A+	A	A+
Illuka Creek	A-	B+	A+	A+

The seasonal fluctuation in water quality grade continued at Upper Georges River with B+ recorded in autumn 2011 (table 5). This result was slightly lower than spring 2010, yet equivalent to autumn 2010 and indicates good water quality conditions.

The water quality grade of E+ was recorded in autumn 2011 for Brennan's Creek. No significant change to water quality grade has occurred since 2009 with the condition of water quality remaining poor.

The water quality grade of C- was recorded for GRDBC and GRA in autumn 2011, indicating fair water quality conditions for both sites. When compared to spring 2010 this result represents a slight reduction in grade for GRDBC and no change for GRA.

Water quality grades of A and A- were recorded for Cobbong Creek and Illuka Creek respectively in autumn 2011 indicating good water quality conditions.

For the purpose of assessment, ANZECC guideline limits for upland rivers (>150m ASL) are applied to all Wollondilly monitoring sites. However due to the naturally acidic conditions of waterways in the upper catchment, often with low levels of dissolved oxygen, the GRCCC will be recommending the development of regional water quality guidelines that are specific to the natural conditions of the Georges River Catchment. This will be discussed with councils in the near future.

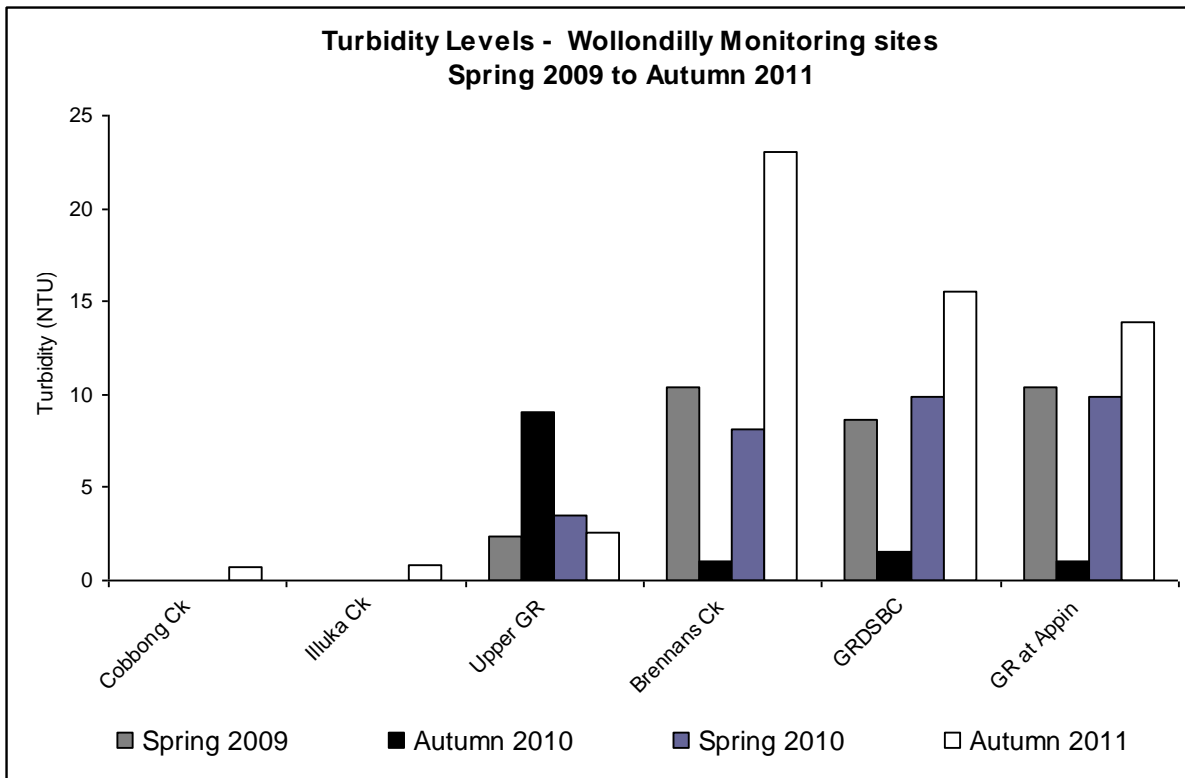


Figure 3. Comparison of turbidity levels of Wollondilly monitoring sites from spring 2009 through autumn 2011.

Results from water quality monitoring during autumn 2011 show turbidity at all Wollondilly monitoring sites was compliant with the ANZECC guideline limit for upland rivers of 25 NTU. Turbidity in Cobbong Creek, Illuka Creek and Upper Georges River was 0.7, 0.8 and 2.6 NTU respectively in autumn 2011 (fig.3). In addition 23, 15.5 and 13.9 NTU was recorded at Brennan's Creek, GRDBC and GRA respectively. Although turbidity levels at Brennan's Creek, GRDBC and GRA were compliant with the ANZECC guideline, these results are excessive of the mean turbidity for clean reference sites (n=9) is 3.6 +/- 8.7 NTU and show that increased turbidity in Brennan's Creek affects turbidity levels of downstream Georges River sites.

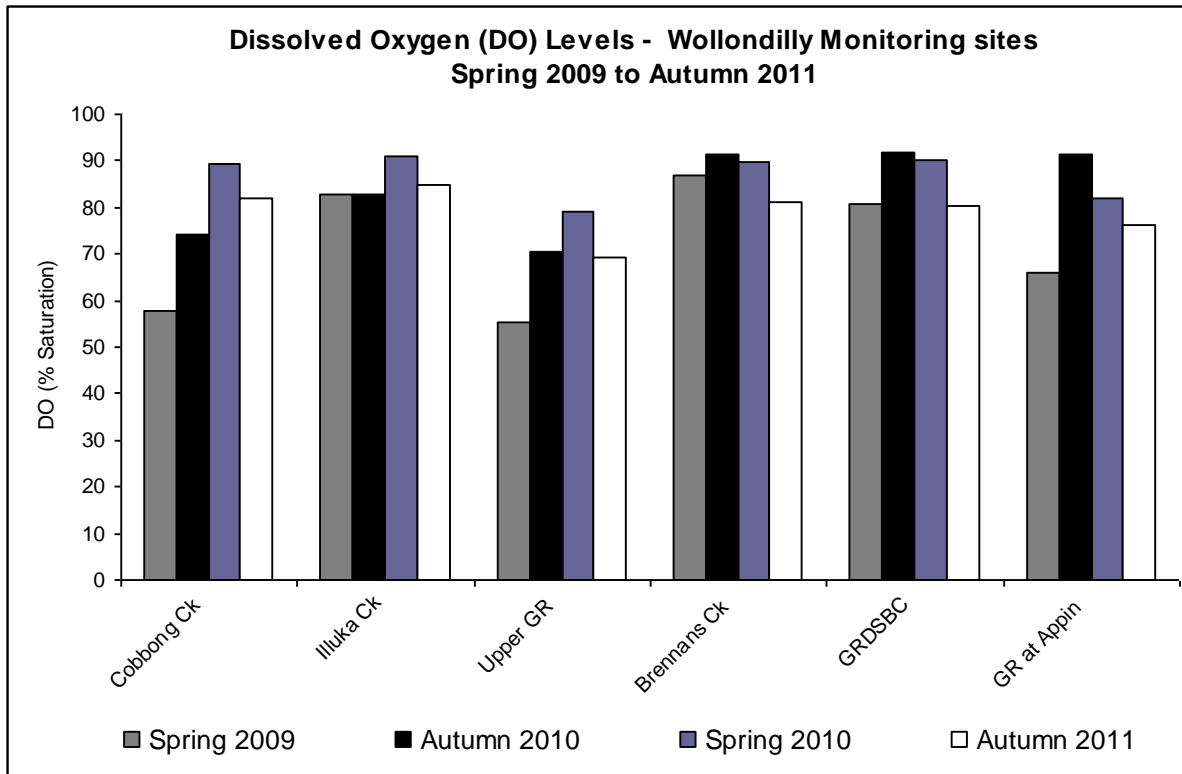


Figure 4. Comparison of dissolved oxygen levels of Wollondilly monitoring sites from spring 2009 through autumn 2011.

The ANZECC guideline for dissolved oxygen for upland rivers is 90 – 110% saturation however DO levels at a number of clean reference sites within the upper Georges River catchment are often naturally below guideline values.

Dissolved oxygen (DO) levels at all Wollondilly monitoring sites were within guideline limits during autumn 2011 monitoring. DO remained relatively constant when compared to results from previous monitoring periods with Cobbong Creek, Illuka Creek, Upper Georges River recording DO levels of 81.8 %, 84.7 % and 69.2 % respectively (fig. 4). In addition DO recorded at Brennan’s Creek, GRDBSBC and GRA was 81.0 %, 80.2 % and 76.4% respectively. With the exception of Upper Georges River, DO levels measured at all sites are well within the boundary of the mean DO level for clean reference sites (n=9) of 86.5% +/- 13.4% saturation.

The Upper Georges River monitoring site is located on the downstream end of a deep pool, with characteristically low DO levels. Although DO during autumn 2011 was outside mean reference condition, this site is classified as a reference site due to low catchment disturbance and therefore such low DO levels should be considered as normal condition.

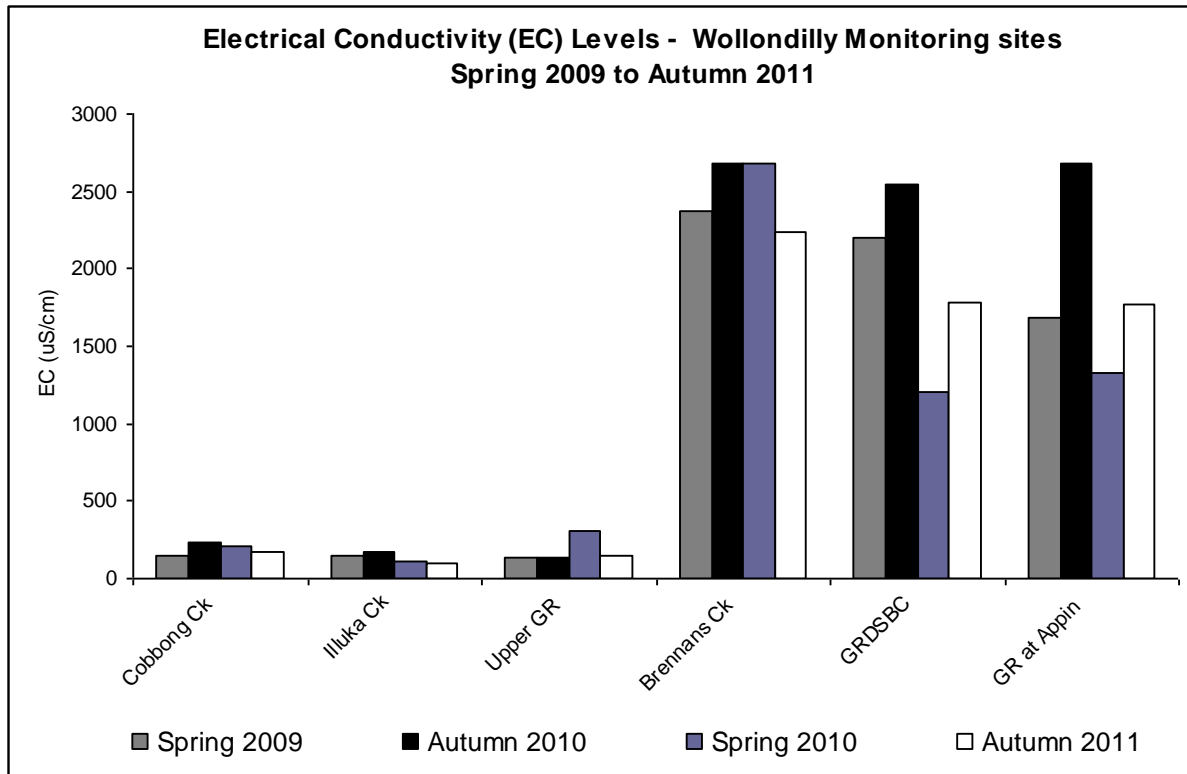


Figure 5. Comparison of conductivity (EC) levels of Wollondilly monitoring sites from spring 2009 through autumn 2011.

During autumn 2011 monitoring, conductivity (EC) at, Cobbong Creek, Illuka Creek and Upper Georges River was 168 $\mu\text{S}/\text{cm}$, 93 $\mu\text{S}/\text{cm}$ and 147 $\mu\text{S}/\text{cm}$ respectively (fig. 5), satisfying the ANZECC guideline for upland rivers of 30 - 350 $\mu\text{S}/\text{cm}$. These results were consistent with those from previous monitoring periods.

Brennan's Creek Dam continues to discharge highly saline water to Brennan's Creek and ultimately to the Georges River causing degradation to water quality. The conductivity of Brennan's Creek during autumn 2011 was 2233 $\mu\text{S}/\text{cm}$, similar to results from previous monitoring periods and 6.3 times in excess of ANZECC limits and 15 times the mean conductivity of clean reference sites within the catchment ($n=9$) of 146 \pm 74 $\mu\text{S}/\text{cm}$.

In addition EC at GRDBBC and GRA was 1783 $\mu\text{S}/\text{cm}$ and 1775 $\mu\text{S}/\text{cm}$ respectively, slightly higher than results from spring 2010, however still in excess of both ANZECC limits and reference condition.

It is evident from these results that highly saline discharge from Brennan's Creek Dam, adjacent to the West Cliff Colliery is degrading water quality in Brennan's Creek and downstream Georges River sites. Elevated EC's are detected as far downstream as The Woolwash in the Campbelltown LGA, however due to the diluting ability of O'Hare's and Punchbowl Creeks elevated EC levels are not detected any further downstream than the Woolwash in the Campbelltown LGA.

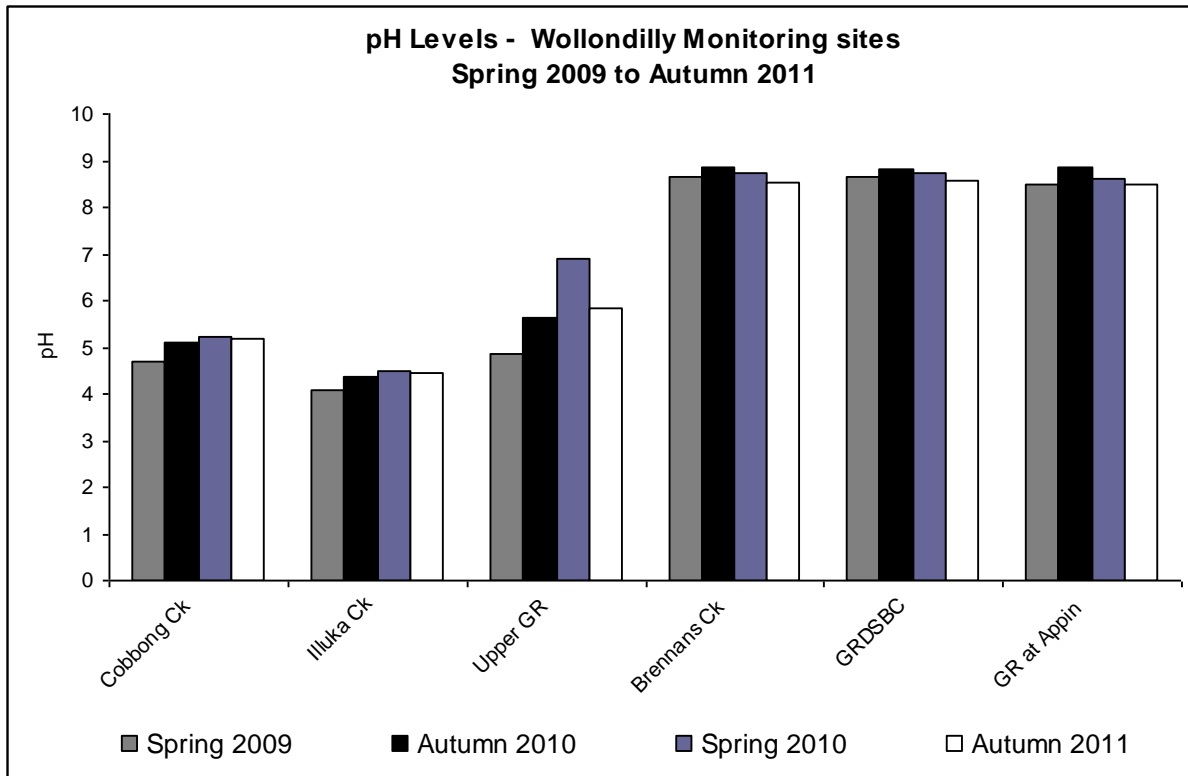


Figure 6. Comparison of pH levels of Wollondilly monitoring sites from spring 2009 through autumn 2011.

The ANZECC guideline for upland rivers is 6.50 – 7.50 however, due to the acidic nature of surface waters within the upper Georges River catchment, it is normal for pH levels to be below 6.50. For the purpose of assessment and as recommended in the ANZECC guidelines, data collected in this study has been used to formulate a region specific guideline for pH in upland rivers to accommodate these acidic conditions. As a result the regional guideline for pH in upland rivers of the Georges River Catchment is 3.00 – 7.50.

During autumn 2011 monitoring Cobbong Creek, Illuka Creek and Upper Georges River recorded pH levels of 5.19, 4.46 and 5.85 respectively. While falling below the ANZECC guideline limits the recorded levels comply with the guideline range of 3.00 – 7.50 (fig 6), and are typical of acid conditions found in undisturbed sub-catchments of the Georges River catchment.

In contrast Brennan’s Creek, GRDBSBC and GRA recorded pH levels 8.54, 8.58 and 8.48 respectively consistent with results from previous monitoring periods. The pH levels at these sites continue to be above ANZECC guideline values and are also significantly above the mean pH for clean reference sites (n=9) of 6.12 +/- 1.07.

When compared with results from the Upper Georges River, where conditions are found to be slightly acidic, pH levels in Brennan’s Creek and downstream Georges River sites indicate a shift to mildly alkaline conditions, emphasising the negative effect that industrial waste water discharge is having on the water quality of the Brennan’s Creek and the Georges River downstream as far as The Woolwash in the Campbelltown LGA.

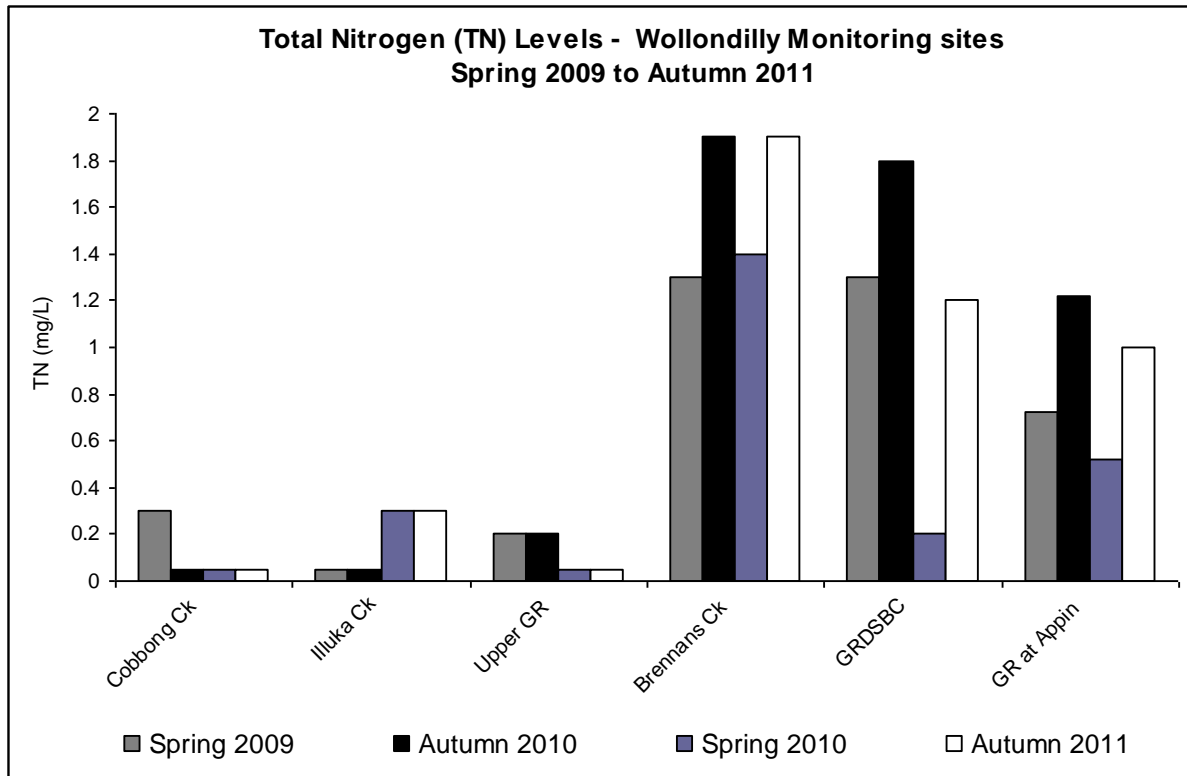


Figure 7: Comparison of total nitrogen (TN) data for Wollondilly between spring 2009 through autumn 2011.

During autumn 2011, total nitrogen (TN) levels at Cobbong Creek and Upper Georges River were below laboratory detection limits (< 0.10 mg/L) and therefore within the ANZECC guideline for upland rivers of 0.25 mg/L (fig. 7).

Total nitrogen in Illuka Creek during autumn 2011 was 0.30 mg/L, in excess of the ANZECC guideline limit. However as this site is classified as a reference site, the TN level detected is considered as natural condition and is likely the result of the decay of materials high in organic content within the headwater swamp of Illuka Creek.

In contrast, 1.90 mg/L was recorded at Brennan's Creek; slightly higher than spring 2011 results, and 7.6 times the ANZECC limit and 9.5 times the mean TN level of reference condition streams of 0.2 ± 0.1 mg/L.

Elevated TN levels were detected at GRDBC and GRA during autumn 2011 with 1.2 mg/L and 1.0 mg/L recorded respectively, excessive of both the ANZECC guideline and reference condition.

These results indicate that discharge into Brennan's Creek from Brennan's Creek Dam adjacent to the West Cliff Colliery is causing elevated nitrogen concentration in Brennan's Creek and at downstream Georges River sites.

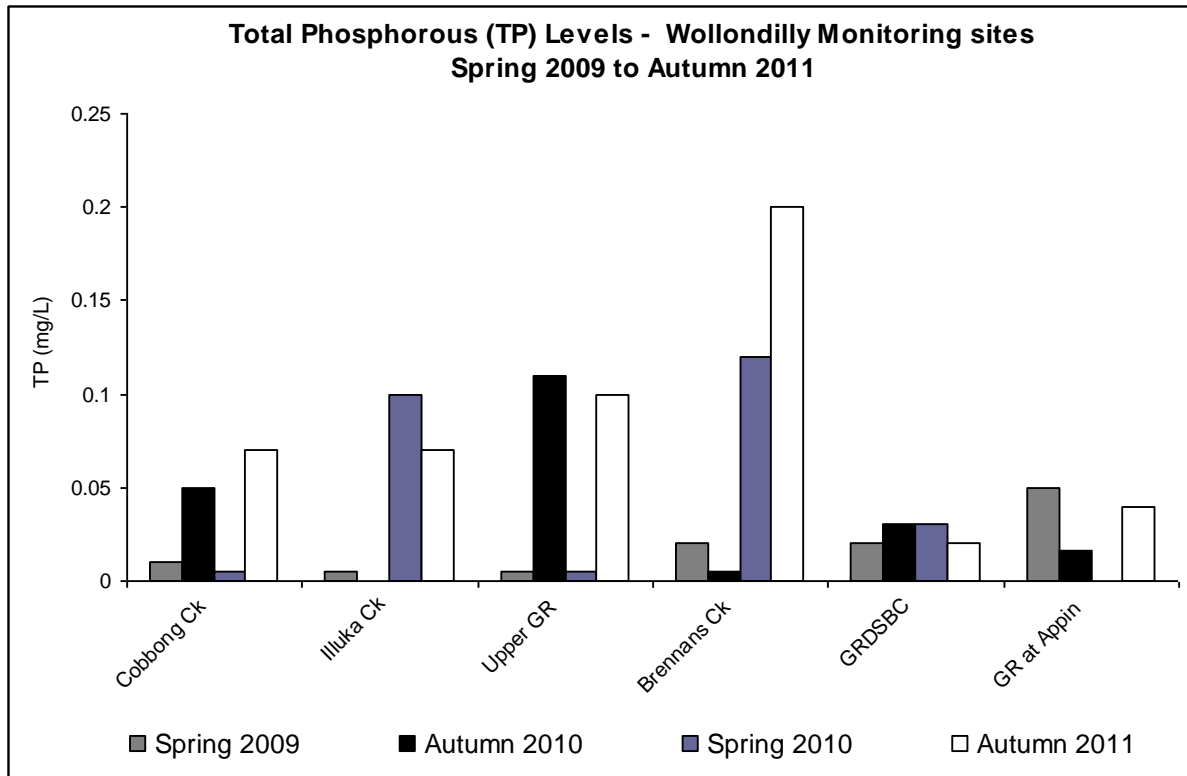


Figure 8: Comparison of total phosphorous (TP) data for Wollondilly between spring 2009 through autumn 2011.

During autumn 2011, total phosphorous (TP) levels at Cobbong Creek and Illuka Creek were 0.07 mg/L (fig. 8) which is in excess of the ANZECC guideline for upland rivers of 0.02 mg/L. However due to the near pristine nature of these waterways these results should be considered normal and likely to be the result of decaying organic materials within the headwater swamps and deep pools of both Creeks. In addition 0.1 mg/L of TP was recorded for Upper Georges River, above ANZECC guidelines yet also consistent with natural conditions as described for r Illuka and Cobbong Creeks.

In contrast, 0.2 mg/L was recorded for Brennan's Creek; the highest TP level recorded for this site since 2009. This result is 10 times above the ANZECC limit and 6.6 times the mean TP concentration of clean reference sites (n=9) of 0.03 mg/L +/- 0.04 mg/L.

Elevated TP levels were not detected at GRDBC or GRA during autumn 2011 with 0.02 mg/L and 0.04 recorded respectively. These results were significantly lower than levels in Brennan's Creek and it is likely to be a reflection of the diluting capability of increased flows, low in TP, originating from the upper Georges River during the monitoring period.

Vegetation Summary

Vegetation surveys were conducted during spring 2009 monitoring and will be repeated in 2013 or if a significant change is observed at a particular site, such as mass revegetation or clearing, in which case a new survey will be performed and reported.

Table 6: Vegetation grades for Wollondilly monitoring sites

	Spring 2009
Upper Georges River	A+
Brennan's Creek	A+
GRDBC	A+
GRA	B
Cobbong Creek	A+
Illuka Creek	B+

The vegetation grade for Cobbong Creek was A+ indicating excellent riparian condition. This site has a complex canopy structure providing good habitat with an intact riparian vegetation community that showed no evidence of disturbance or invasive weed species reflecting the pristine condition of this site.

The riparian vegetation community at Illuka Creek showed good condition as reflected by the vegetation grade of B+. Although located in a pristine catchment, the riparian vegetation here is dominated by heath and understorey species. Therefore comparison with other sites with a higher degree of canopy structure resulted in a slightly lower grade than would be expected in such a catchment.

A small degree of bushland has been cleared at the Upper Georges River site, primarily understorey which has led to the colonisation of some invasive species. However this has not caused a significant impact on the riparian zone which is reflected by the vegetation grade of A+. It would be of great benefit to this site if some weed control was performed and understorey species re-established to maintain the integrity of this section of the upper Georges River

An excellent riparian vegetation community was recorded at both Brennan's Creek and GRDBC, reflected by vegetation grades of A+. Both sites had complex canopy structure, little evidence of invasive species and good habitat potential.

In contrast the vegetation grade for Georges River at Appin was recorded as B. Vegetation on the eastern side of the Georges River at this point remains in good condition. However, housing built close to the river bank and clearing of adjacent bushland has heavily altered the riparian zone. At the time of sampling it was evident that local residents are continuing to clear riparian vegetation and cut large trees on neighbouring land for fire wood. The habitat value of this site would be greatly enhanced if riparian vegetation was replanted and indiscriminate clearing of bushland was halted.

Conclusion

The results of water quality testing since the spring 2009 provide evidence of the detrimental effects of discharge originating from the West Cliff Colliery to Brennan's Creek and ultimately to the Georges River. Elevated conductivity, pH, TN and TP levels are consistently recorded in Brennan's Creek and at sites downstream of the Brennan's Creek/Georges River confluence, with evidence of these impacts recorded as far downstream as the Woolwash in Campbelltown. Water quality improves after fresh flows from O'Hare's and Punchbowl Creeks enters the Georges River. These findings are further supported by the reduction in macroinvertebrate diversity and SIGNAL scores as discussed in the previous macroinvertebrate summary.

It has become evident through continued sampling that TN and TP levels recorded at clean reference sites in the upper catchment are often outside recommendations of the ANZECC guidelines. Ongoing collection of water quality data will enable the formulation of regionally specific guidelines for TN and TP, as is case with DO and pH, for the accurate assessment of these parameters.

Recommendations

It is recommended that Wollondilly Shire Council consider the following actions to investigate sources of water quality degradation and allow amelioration of ecosystem integrity.

- In conjunction with Campbelltown City Council, commence routine water quality (monthly) and macroinvertebrate monitoring (with identification to family level or higher) above, in and below Brennan's Creek to investigate the level of degradation mine waste water discharge has on the waters of the Upper Georges River.
- Commence routine water quality (monthly) and macroinvertebrate monitoring (with identification to family level or higher) at Kennedy Grove in Appin to investigate the effects of sewage on the aquatic ecosystem.
- To provide comparative data, routing monitoring of a clean reference site must accompany monitoring of degraded sites.
- Restore riparian vegetation near the Georges River Appin site and investigate and revegetate clearing that is occurring near housing for firewood.

References

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Appendix 1

Macroinvertebrate richness and abundance of Wollondilly River Health monitoring sites, spring 2009 to autumn 2011.

*season 1 = spring 2009, season 2 = autumn 2010, season 3 = spring 2010, season 4 = autumn 2011

Season	SITE	Plecoptera	Mecoptera	Ephemeroptera	Tricoptera	Megaloptera	Acarina	Nematomorpha	Coleoptera	Decopoda	Amphipoda	Bivalvia	Diptera	Odonata	Arachnida	Hemiptera	Isopoda	Lepidoptera	Oligochaeta	Turbellaria	Gastropoda	Hirudinea	Total Specimens	Richness (Order)
1	Brennan's Creek	0	0	11	9	0	1	0	37	0	0	0	50	4	0	50	0	0	0	0	1	0	163	8
1	Cobbong Ck	0	0	31	26	0	10	1	13	50	0	0	10	20	0	21	0	0	0	0	0	0	182	9
1	GR Kings Fall Bridge	0	0	31	31	2	2	0	20	23	0	50	24	24	0	28	0	0	1	1	0	0	237	12
1	GRA	0	0	9	0	0	5	0	9	0	0	0	21	22	2	50	0	0	0	0	7	1	126	9
1	GRDBC	0	0	36	13	0	0	0	50	0	0	0	22	11	0	50	0	0	0	0	3	0	185	7
1	Illuka Ck	2	0	23	12	0	23	0	4	3	1	0	17	5	1	17	0	0	0	0	0	0	108	11
2	Brennan's Creek	0	0	0	8	0	0	0	19	0	0	0	50	8	1	50	0	0	0	0	0	0	136	6
2	Cobbong Ck	4	0	21	49	0	17	0	15	50	0	0	8	9	2	25	0	0	0	0	0	0	200	10
2	GR Kings Fall Bridge	0	0	23	23	5	6	0	18	21	0	50	21	27	1	7	0	0	4	2	0	0	208	13
2	GRA	0	0	50	50	6	0	0	11	0	0	0	13	44	1	30	0	0	0	0	0	1	206	9
2	GRDBC	0	0	1	12	0	0	0	11	0	0	0	12	41	0	50	0	0	0	0	0	0	127	6
2	Illuka Ck	7	0	38	24	0	21	0	14	3	0	0	15	13	0	40	0	0	0	0	0	0	175	9
3	Brennan's Creek	0	0	2	0	0	0	0	53	0	0	0	50	14	2	19	0	0	0	2	0	0	142	7
3	Cobbong Ck	12	0	50	34	0	10	0	25	50	0	0	14	9	1	26	0	0	0	0	0	0	231	10
3	GR Kings Fall Bridge	3	0	50	36	1	4	0	14	50	0	50	24	19	3	5	0	0	2	3	0	0	264	14
3	GRA	0	0	40	17	0	50	0	16	0	0	0	50	50	0	50	0	0	0	0	4	1	278	9
3	GRDBC	0	0	28	5	14	0	0	37	0	0	50	0	21	1	50	0	0	0	0	0	0	206	8
3	Illuka Ck	8	0	50	17	0	43	0	15	3	0	0	23	3	1	10	0	0	0	0	0	0	173	10
4	Brennan's Creek	0	0	6	33	0	0	0	17	0	0	0	37	49	0	50	0	0	0	0	0	0	192	6
4	Cobbong Ck	23	0	27	50	0	23	0	23	50	0	0	18	22	2	25	0	0	2	0	0	0	265	11
4	GR Kings Fall Bridge	5	0	50	31	6	4	0	31	27	0	15	24	14	0	2	1	0	2	0	0	1	213	14
4	GRA	0	0	19	50	2	50	0	14	1	0	0	50	40	1	50	0	0	0	0	2	1	280	12
4	GRDBC	1	0	4	5	0	0	0	22	12	0	0	50	9	9	50	0	0	0	0	3	0	165	9
4	Illuka Ck	45	0	1	15	1	22	0	3	1	0	0	27	12	1	24	0	0	2	0	0	0	154	12