Northern Territory Government
DEPARTMENT OF LAND RESOURCE MANAGEMENT

Dry season water quality and macroinvertebrate assemblages in Rapid Creek: an urban stream in the monsoonal tropics of northern Australia

Report number 01/2014D

This report can be cited as:

Dostine, P.L. (2014). Dry season water quality and macroinvertebrate assemblages in Rapid Creek: an urban stream in the monsoonal tropics of northern Australia. Aquatic Health Unit, Water Resources Division, Department of Land Resource Management. Report number 01/2014D. Palmerston, Northern Territory.

Report number 01/2014D

ISBN: 978-1-74350-048-4

Executive summary

- Rapid Creek is a small, seasonally flowing, coastal stream in the Darwin urban area. The catchment of Rapid Creek has been intensively modified by urban residential and industrial development. This change in land use can stress natural stream systems by hydrological change, i.e. by increased run-off from impervious surfaces and increased volume of stream flows, and by the transport of increased levels of toxicants to aquatic systems.
- Water quality at sites in the freshwater reach of Rapid Creek was measured throughout the dry season from early June to late September in 2013. Macroinvertebrate community structure and composition at these sites was measured in the early dry season in 2012 and 2013. The condition of macroinvertebrate communities within Rapid Creek was assessed using outputs from predictive models, and by comparison with assemblages from reference sites.
- Water quality deteriorated throughout the dry season in accord with the diminution and cessation of flow within the stream. By mid-September saturated dissolved oxygen declined to <40%, while concentrations of nutrients including total nitrogen, total phosphorous and ammonia exceeded local or national water quality trigger values. This is likely to be a natural phenomenon.
- Macroinvertebrate communities were consistently scored as below reference condition. This may imply ecological degradation, or may be due to the fact there are few analogues of this type of stream in the reference data, and that models misrepresent expected taxa richness. The macroinvertebrate communities of Rapid Creek are species poor relative to reference streams within the Darwin-Daly region.
- There is no evidence of marked ongoing deterioration in the ecological health of Rapid Creek, as assessed by indices of macroinvertebrate community composition. Water quality in Rapid Creek varies markedly within the dry season, and is linked to flow. Despite the presumably annual, intra-seasonal decline in water quality, Rapid Creek provides habitat for a depauperate macroinvertebrate fauna, as well as a small assemblage (approximately 10) of native fish species.

Contents

1. Introduction

Rapid Creek is a freshwater stream within the urban area of Darwin in the monsoonal tropics of northern Australia. The creek system includes a tidal section fringed by mangroves in the lower third, a freshwater stream fringed by monsoon forest vegetation in the middle reaches, and a paperbark swamp in the upper section. Most of the catchment of Rapid Creek has been modified from the natural condition.

Residential and other development within the catchment has increased the area of impervious hard surfaces, leading to an overall increase in run-off volume (and concomitantly a potential decrease in groundwater recharge). Increase in run-off volume will change the hydrology of the stream, resulting in more frequent flow events. Pollutant loads to streams draining urban catchments are elevated relative to rural and undisturbed catchments (Skinner *et al*. 2009). Consequently, there are at least two types of stressors acting on Rapid Creek: increased wet season flows, and increased levels of contaminants in wet season run-off. Increased wet-season flows can reduce within-stream habitat diversity and scour benthic sediments; while elevated contaminants may have toxic effects on aquatic biota. These stressors, especially hydrologic ones, would be expected to have an impact on the composition of biological communities in Rapid Creek.

This report presents results of an assessment of ecological condition based on data from 2012 and 2013, and the comparison of test site data in Rapid Creek with a large dataset from reference sites in the Darwin-Daly region. The report describes intra-seasonal variation in water quality parameters but does not attempt to identify or quantify potential contaminants in either run-off waters or within the stream.

2. Methods

2.1 Study sites

Water quality parameters were measured, and water and macroinvertebrate samples were collected at three sites in the freshwater reach of Rapid Creek in the dry season of 2013 (Figure 1). These sites are referred to as G8150127 (weir site); G8155182 (middle site); and G1855142 (Yankee pool). Macroinvertebrate samples were previously collected at these sites in 2012, and at one site (G8150127, weir site) in most years since 2001.

Figure 1. Map showing three sample sites and catchment boundary of Rapid Creek.

2.2 Water quality

Water quality variables were measured at three sites in Rapid Creek at weekly intervals on 16 occasions throughout the dry season of 2013 from 7th June to 25th September, mostly within a four hour period from 10 am. Four parameters (temperature, pH, conductivity, dissolved oxygen) were measured at each site using a Quanta water quality meter; turbidity was measured at each site using a Hach (model 2100P) turbidity meter. Water samples were collected from site G8150127 for laboratory analysis of chlorophyll *a*, nitrate, nitrite, total nitrogen, phosphate, total phosphorous and ammonia. Diurnal variation in dissolved oxygen concentration was measured using Hydrolab data loggers deployed at the same site over a 29 hour period from 10 am on 26th June 2013.

2.3 Macroinvertebrates

Macroinvertebrates were collected from three sites in Rapid Creek in the early dry season in 2012 and 2013. Samples were collected on 26/4/2012 and 7/6/2013 using methods prescribed by protocols for the Northern Territory AusRivAS models. Samples of macroinvertebrates were collected from edge habitats using a triangular pond net and a three-pronged rake within a 10m section of the stream edge. The rake was used to disturb the substrate in advance of the collecting net. The contents of the net were rinsed on a 500 µm sieve in the field and preserved in 70% ethanol. In the laboratory samples were rinsed on a 500 µm sieve and placed in a 100 cell box sub-sampler. The contents of randomly selected cells were extracted and macroinvertebrates were sorted using a channelled sorting tray until tallies for a sample exceeded 200 individuals, and the cell was completely sorted. Most non-chironomid macroinvertebrates were identified in the laboratory using a Wild binocular microscope. Chironomid specimens were mounted on glass slides in the mounting fluid Hoyer's solution, and examined using an Olympus compound microscope. Generally, most taxa were identified to genus using regional taxonomic keys. Not all hydacarinids were identified to genus in 2012 and 2013.

The early dry edge genus level AusRivAS model was used to score the extent of potential ecological impairment at a site. Model outputs (NTE50, NTP50, NTC50 and OE50) are defined in Table 1. The parameter OE50 is the ratio of the number of invertebrate taxa observed at a site (NTC50) to the sum of the probabilities of all the taxa predicted to occur with a greater than 50% probability of occurrence (NTE50). OE50 provides a measure of biological impairment at the test site.

Parameter	Description
NTE50	The number of invertebrate taxa expected with greater than a 50% probability of occurrence, NTE50, is the sum of the probabilities of all the taxa predicted with greater than a 50% probability of occurrence.
NTP50	NTP50 is a count of the number of invertebrate taxa predicted with greater than a 50% probability of occurrence.
NTC50	The invertebrate taxa that were predicted above the threshold probability of 50% and which were also collected at the test site are counted to form the observed (collected) value, NTC50.
OE50	The Observed to Expected ratio, OE50, is the ratio of the number of invertebrate taxa observed at a site (NTC50) to the number of taxa expected (NTE50) at that site.

Table 1. Description of outputs from AusRivAS models.

Macroinvertebrate community patterns in samples from Rapid Creek were examined in relation to a larger dataset of macroinvertebrate community structure from reference sites within the Darwin-Daly region. Ordination methods were used to display community patterns and to examine the temporal trajectory of community structure at one site. The taxon richness (number of taxa identified) in 13 samples from Rapid Creek and from 114 sites on streams in the Darwin-Daly region was compared graphically. Data from reference sites included 192 taxa, mostly at the level of genus.

3. Results and Discussion

3.1 Water quality

In 2013, dry season flow at G8150127 declined steadily from the end of the wet season and ceased flowing on 4th September (Figure 2.)

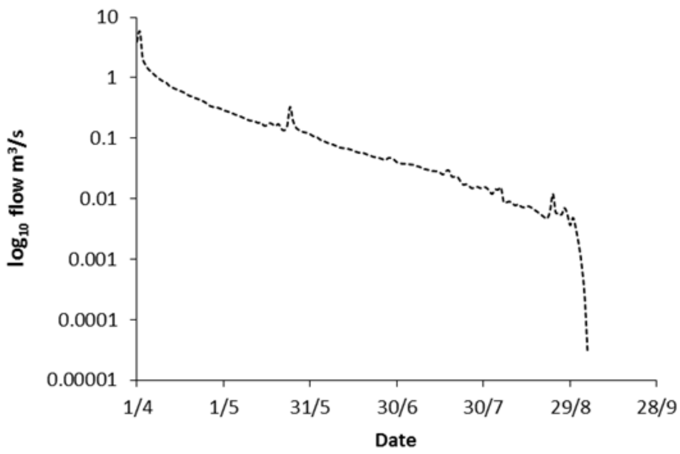

Figure 2. Mean daily flow (m^3/s) at G8150127 from April to September 2013.

Water quality at three sites on Rapid Creek varied consistently among sites (Figure 3). Electrical conductivity and turbidity increased slightly throughout the dry season but remained low, whilst pH declined. There was a marked decline in dissolved oxygen to extremely low levels in the late dry season. Nutrient concentrations at site G8150127 were relatively invariable until after the cessation of flow in early September (Figure 4). Thereafter, concentrations increased to levels which exceed either or both local and national water quality objectives (Table 2). Similar trends in water quality were observed in the 2005 dry season (Aquatic Health Unit, 2006).

Parameter	Unit of measurement	ANZECC trigger value	Darwin Harbour catchment water quality objective[1]
Chlorophyll a	µg/L	5	2
Nitrate	mg/L	0.01	NA
Ammonia	mg/L	0.01	NA
Total nitrogen	mg/L	0.3	0.23
Total phosphorous	mg/L	0.01	0.01

[1] Source: Fortune (2010)

Table 2. Local and national water quality objectives for nutrients.

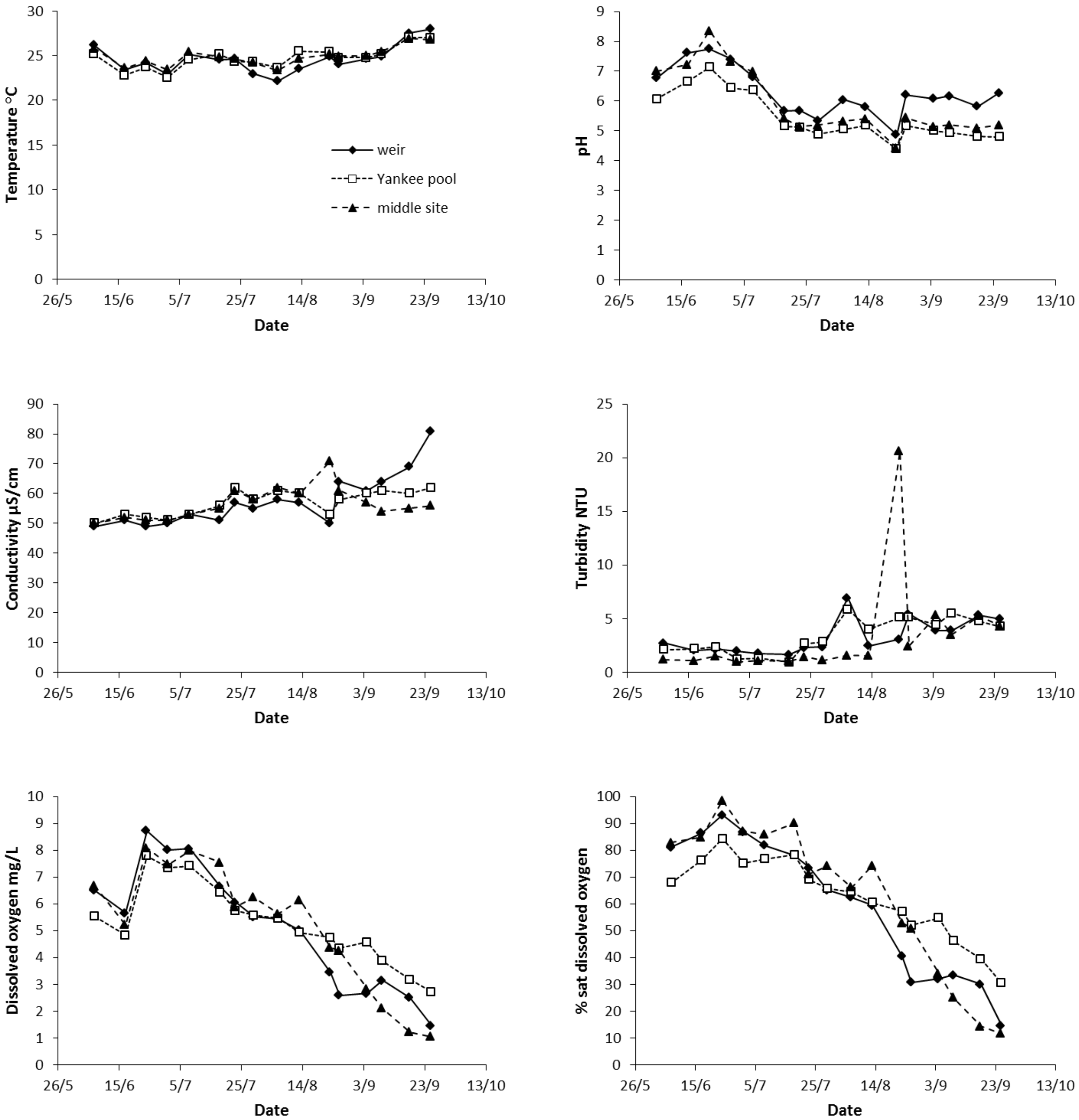

Figure 3. Temporal variation in water quality parameters measured at three sites in Rapid Creek from 7th June to 25th September 2013.

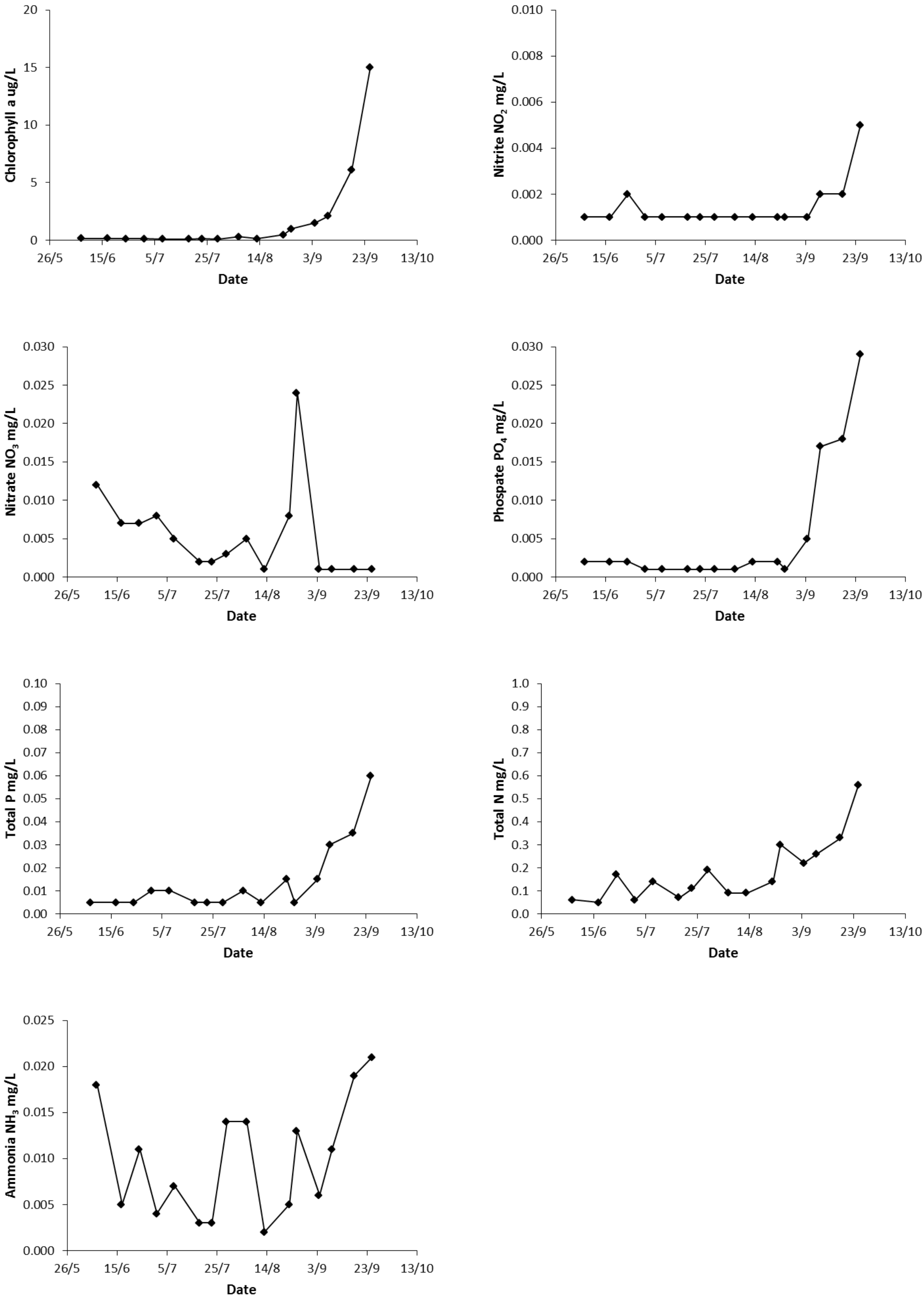

Figure 4. Temporal variation in measurements of chlorophyll and nutrients nitrite, nitrate, phosphate, total phosphorous, total nitrogen and ammonia from site 8150127 in Rapid Creek from 7th June to 25th September 2013. Nutrient concentrations expressed as elemental N or P.

Dissolved oxygen concentrations ranged from 5.6 to 6.9 mg/L (Hydrolab serial number 37117), and from 5.8 to 6.7 mg/L (Hydrolab serial number 37145) (Figure 5), and had an uncharacteristic diurnal pattern that may be due to shading effects and groundwater inputs. The low diurnal range indicates low rates of primary production within Rapid Creek in the early dry season, as expected in a small well-shaded stream. High chlorophyll concentrations later in the dry season (Figure 4), however, suggest much higher primary production.

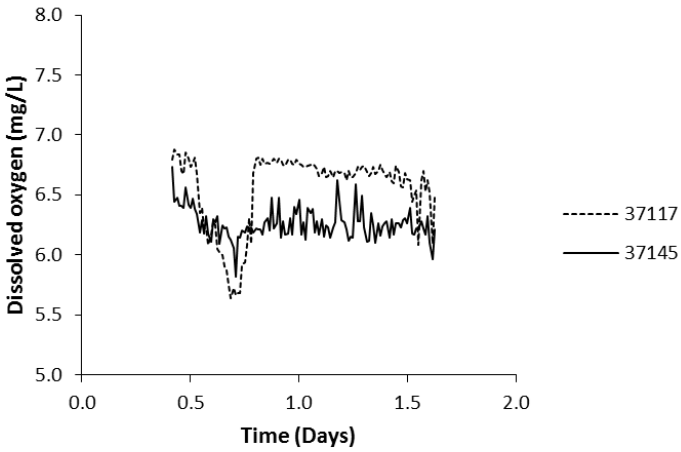

Figure 5. Dissolved oxygen concentration measured at 15 minute intervals from 10 am 26th June 2013 by two Hydrolab data loggers (identified by serial numbers) at the same site in Rapid Creek.

3.2 Macroinvertebrates

Macroinvertebrate communities sampled at three sites in 2012 and 2013 included 52 model taxa (Table 3). AusRivAS OE50 scores ranged from 0.49 to 0.70, and were graded as B, i.e. showing evidence of significant ecological impairment. Samples featured large numbers of limnesiid water mites. Chironomid larva, especially the genus *Tanytarsus* were moderately abundant, whilst Coleoptera, Ephemeroptera and Trichoptera were sparsely represented. Examination of the model outputs showed that 13 taxa predicted to occur with a probability of occurrence of greater than 50% at these types of sites, but were absent in either or both years. Three taxa (*Djalmabatista*, *Nanocladius* and *Wundacaenis*) were absent in both years (Table 4). These taxa commonly occur in similar habitats at stream sites throughout the region.

Differences in community composition are implied by an ordination scatter-plot of Rapid Creek and reference samples. Rapid Creek samples cluster separately from reference sites. There was no consistent temporal trend in community structure in samples from site G8150127 (Figure 6).

The taxon richness of 13 samples from Rapid Creek was markedly less than that of reference sites from throughout the Darwin-Daly region (Figure 7). Taxon richness per sample ranged from 12 to 32 (mean 24.6) in Rapid Creek samples. Taxon richness per site ranged from 22 to 61 (mean 38.4) in the reference sites. A total of 70 taxa were recorded from 13 samples from Rapid Creek. Most taxa present in Rapid Creek samples commonly occur in samples from throughout the region.

There are caveats that need to be borne in mind when interpreting these results. There are several explanations for the observed biological patterns, as follows,

(i) Low taxon richness may be the natural condition for these sites. Rapid Creek is a relatively small system, with a uniform channel and low within-stream habitat diversity.

(ii) Results may be due to poor model performance and the lack of suitable analogue sites within the reference data set used to predict assemblage composition.

(iii) Elevated catchment run-off from impervious surfaces may result in greater scouring flows and loss of benthic habitats, and consequent impoverishment of benthic fauna.

(iv) Rapid Creek is isolated from similar patches of stream habitat, hence the probability of recolonisation by dispersing aerial adults is low.

In summary, Rapid Creek contains a less diverse macroinvertebrate fauna than other streams in the region. There is no evidence of marked ongoing deterioration in the ecological health of Rapid Creek, as assessed by indices of macroinvertebrate community composition. Water quality in Rapid Creek varies markedly within the dry season, and is linked to flow. Despite the presumably annual, intra-seasonal decline in water quality, Rapid Creek provides habitat for a depauperate macroinvertebrate fauna, as well as a small assemblage (approximately 10) of native fish species.

			2012			2013				
Order	**Family**	**Model taxon**	**W**	**YP**	**MS**	**W**	**YP**	**MS**	**Total**	**% tot**
Coleoptera	Dytiscidae	*Laccophilus*	1						1	0.1
Coleoptera	Elmidae	*Austrolimnius*		1					1	0.1
Coleoptera	Hydraenidae	*Hydraena*				2			2	0.2
Coleoptera	Hydrophilidae	*Helochares*					1		1	0.1
Collembola		Collembola	1	2	1	8	2		14	1.1
Decapoda	Atyidae	*Caridina*	15			4			19	1.5
Decapoda	Palaemonidae	*Macrobrachium*		2	3	1	1	3	10	0.8
Diptera	Ceratopogonidae	Ceratopogoninae		2		1	2		5	0.4
Diptera	Chironomidae	?*Stictochironomus*		1	1				2	0.2
Diptera	Chironomidae	?T*elmatopelopia*		6				1	7	0.6
Diptera	Chironomidae	*Ablabesmyia*	1			1	1		3	0.2
Diptera	Chironomidae	*Cladotanytarsus*				10	1	1	12	0.9
Diptera	Chironomidae	*Corynoneura*	5			3	1	1	10	0.8
Diptera	Chironomidae	*Dicrotendipes*		1		27	3		31	2.4
Diptera	Chironomidae	*Fittkauimyia*				1			1	0.1
Diptera	Chironomidae	*Larsia*		2	1			1	4	0.3
Diptera	Chironomidae	*Paramerina*	3		7	29	17	22	78	6.1
Diptera	Chironomidae	*Paratendipes*	1	2	7		7	2	19	1.5
Diptera	Chironomidae	*Polypedilum*	5	4	11	34	25	17	96	7.6
Diptera	Chironomidae	*Procladius*	1		1			1	3	0.2
Diptera	Chironomidae	*Rheotanytarsus*			34	3	10	18	65	5.1
Diptera	Chironomidae	*Robackia*					1		1	0.1
Diptera	Chironomidae	*Stenochironomus*						1	1	0.1
Diptera	Chironomidae	*Tanytarsus*	8	16	40	9	34	53	160	12.6
Diptera	Chironomidae	Unk genus ? (Cranston)		1	1				2	0.2
Diptera	Chironomidae	Unk genus D1	4	2	4	1	2	2	15	1.2
Diptera	Empididae	Empididae			5		1		6	0.5
Diptera	Psychodidae	Psychodidae		1					1	0.1
Diptera	Tipulidae	Tipulidae			1				1	0.1
Ephemeroptera	Baetidae	*Cloeon*	5	1	1	3			10	0.8
Ephemeroptera	Baetidae	*Pseudocloeon*		2				3	5	0.4
Ephemeroptera	Caenidae	*Tasmanocoenis*					3		3	0.2
Hemiptera	Corixidae	Corixidae	4	2					6	0.5
Hemiptera	Gerridae	Gerridae				1			1	0.1
Hemiptera	Mesoveliidae	Mesoveliidae						1	1	0.1
Hemiptera	Veliidae	Veliidae				1			1	0.1
Hydracarina	Hydrodromidae	*Hydrodroma*	3	81	2		28	1	115	9.1
Hydracarina	Limnesiidae	*Limnesia*	138	39	43	118	53	56	447	35.2
Hydracarina	Oxidae	*Oxus*	7	3	3				13	1.0
Mollusca	Planorbidae	*Gyraulus*			1				1	0.1
Nematoda		Nematoda			1		2	1	4	0.3
Odonata		Anisoptera	1		3	1	4	4	13	1.0
Odonata		Zygoptera	1			1		2	4	0.3
Oligochaeta		Oligochaeta	2	15		6	1	4	28	2.2
Oribatida		Oribatida	1			1			2	0.2
Trichoptera	Ecnomidae	*Ecnomus*		6	16			1	23	1.8
Trichoptera	Hydroptilidae	*Hellyethira*		6	2		1		9	0.7
Trichoptera	Hydroptilidae	*Hydroptila*		3	3		1		7	0.6
Trichoptera	Leptoceridae	*Oecetis*					1		1	0.1
Trichoptera	Leptoceridae	*Triaenodes*			1	1			2	0.2
Trichoptera	Leptoceridae	*Triplectides*						1	1	0.1
Trichoptera	Philopotamidae	*Chimarra*						1	1	0.1
		Total	207	201	193	267	203	198	1269	
		NTE50	21.03	20.5	20.5	21.47	22.46	21.47		
		NTP50	30	29	29	31	30	31		
		NTC50	12	12	11	15	11	13		
		OE50	0.57	0.59	0.54	0.70	0.49	0.61		
		Score	B	B	B	B	B	B		

Table 3. Model taxa recorded in samples from three sites on Rapid Creek in 2012 and 2103. W = weir; YP = Yankee pool; MS = middle site.

Order	Family	Genus	Year 2012	2013
Coleoptera	Elmidae	*Austrolimnius*		x
Coleoptera	Hydraenidae	*Hydraena*	x	
Coleoptera	Hydrochidae	*Hydrochus*	x	
Diptera	Chironomidae	*Djalmabatista*	x	x
Diptera	Chironomidae	*Nanocladius*	x	x
Diptera	Chironomidae	*Stempellina*		x
Diptera	Chironomidae	*Cladotanytarsus*	x	
Diptera	Chironomidae	*Paratanytarsus*	x	
Ephemeroptera	Caenidae	*Wundacaenis*	x	x
Ephemeroptera	Caenidae	*Tasmanocoenis*	x	
Trichoptera	Hydroptilidae	*Orthotrichia*		x
Trichoptera	Leptoceridae	*Oecetis*	x	
Trichoptera	Leptoceridae	*Triplectides*	x	

Table 4. Macroinvertebrate taxa predicted to occur with a probability of > 50%, but which were not collected at all three sites in Rapid Creek in either 2012 or 2013. Three taxa were absent in both 2012 and 2013.

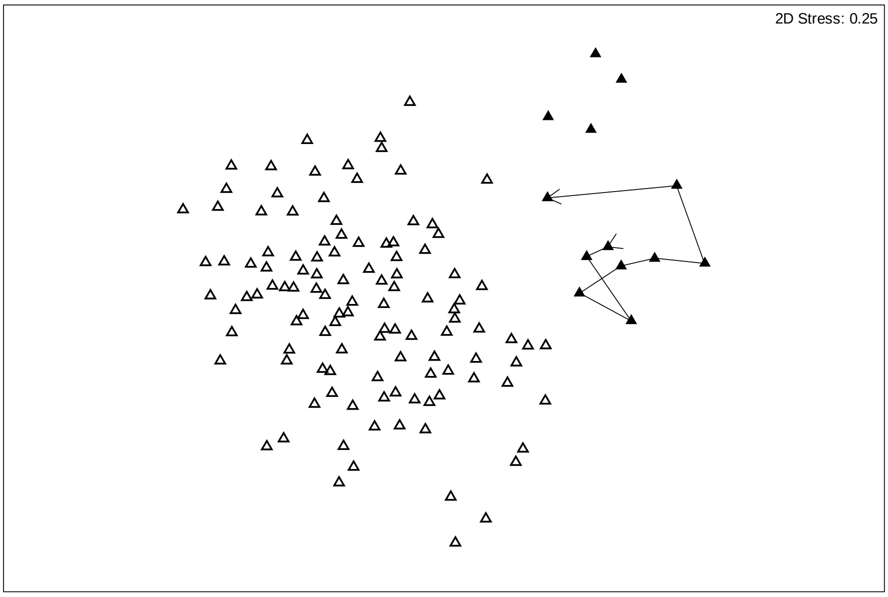

Figure 6. Scatter-plot of MDS ordinations of macroinvertebrate communities from 114 reference sites from streams in the Darwin-Daly region (hollow symbols) and 13 samples from three sites in Rapid Creek (solid symbols). The temporal trajectory of community composition in ordination space is shown for site G8150127, which was sampled on nine occasions between 2001 to 2013.

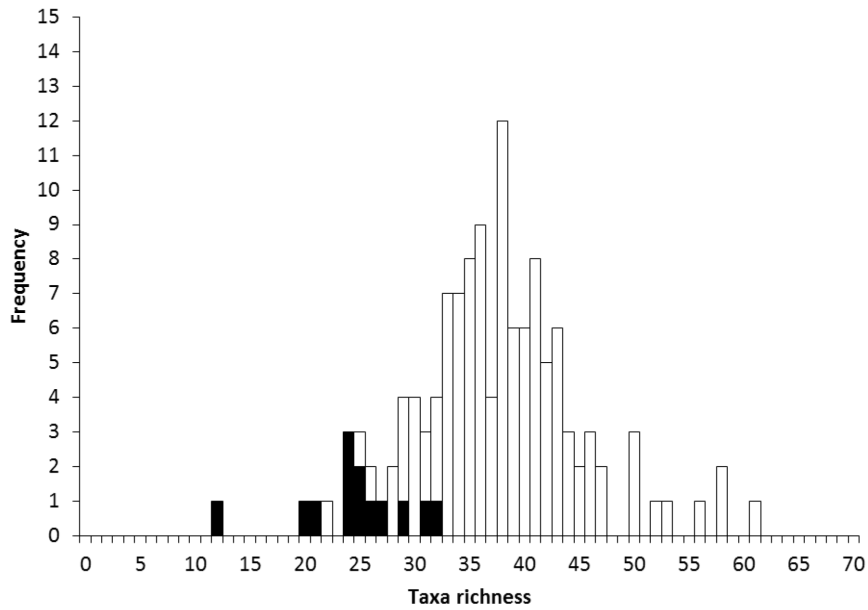

Figure 7. Frequency histogram of macroinvertebrate taxa richness in 114 reference sites from streams in the Darwin-Daly region and 13 samples from three sites in Rapid Creek.

4. Acknowledgements

Technical staff of the Aquatic Health Unit collected field samples, and Simon Townsend provided useful comments on the draft report.

5. References

Aquatic Health Unit (2006). Monitoring for aquatic ecosystem protection in Rapid Creek. Report 19/2006D. Environmental Protection Agency Program, Department of Natural Resources, Environments and the Arts, Darwin.

Fortune, J. (2010). Water Quality Objectives for the Darwin Harbour Region - Background Document. Department of Natural Resources, Environment, The Arts and Sport, Palmerston

Skinner, L., Townsend, S. and Fortune, J. (2009). The impact of urban land-use on the total pollutant loads entering Darwin Harbour. Report 06/2008D. Department of Natural Resources, Environment, The Arts and Sport, Darwin.