Appendix J

Aquatic Ecology Report

NOONAMAH RIDGE

INTRAPAC

Aquatic Ecology Report:

Noonamah Ridge Estate

Prepared for: Intrapac Projects Pty Ltd

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2015

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Executive Summary

Macroinvertebrate biological monitoring was undertaken to provide a baseline assessment of aquatic health, in the vicinity of the proposed Noonamah Ridges Estate (project area). The project area is located predominantly within the upper reaches of the Elizabeth River catchment, which flows into Darwin Harbour. The Elizabeth River is an intermittent system that flows during the wet season and usually ceases to flow by June-July each year, with regular permanent pools. The tributaries of Elizabeth River that flow from the project area are ephemeral, flowing only during the wet season and ceasing to flow early in the dry season (i.e. March/April), either drying completely or contracting to occasional pools during the dry season.

Sampling of macroinvertebrates was undertaken at three sites at the boundary of the project area and downstream in April 2015, in accordance with established AUSRIVAS macroinvertebrate monitoring protocols. Concurrent descriptions of environmental variables (e.g. stream morphology, habitats) and water quality samples were also collected. The downstream sampling site on the Elizabeth River was in the same location monitored previously over a ten year period by the NT Government, so this monitoring also provides an update on the aquatic health of the wider Elizabeth River system.

A total of 32 taxa were identified from the three survey sites, with similar taxonomic richness between survey sites. Macroinvertebrate data were analysed using the Darwin-Daly genus-level AUSRIVAS model, with the two sites at the boundary of the project area having lower than expected taxonomic richness and the downstream Elizabeth River site being similar to reference condition (as determined in previous NT Government monitoring).

As the water quality in streams draining the project area is considered very good and there is no current development within their respective catchments, the relatively poor macroinvertebrate community health could possibly be attributed to relatively poor habitat availability for macroinvertebrate colonisation and/or hydrological conditions associated with their location high in the catchment (i.e. second order streams). Sampled habitats were generally consistent between sites and due to the relatively flashy nature of high flows in this system, stream banks were often scoured with bare substrates and had limited availability of what would be considered ideal macroinvertebrate habitat (e.g. organic matter, trailing root materials, etc.). Another potential explanation is that primary productivity is often reported to increase with increasing stream order, moving down a catchment.

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Acknowledgements

Peter Dostine (NT Dept. of Land and Resource Management) provided details of previous macroinvertebrate monitoring in the Elizabeth River catchment and kindly provided advice on data analysis using the Darwin-Daly AUSRIVAS model.

1 Introduction

1.1 Background

Intrapac Projects Pty Ltd (Intrapac), propose to develop a residential subdivision, Noonamah Ridge Estate, at Noonamah, located approximately 36 km south-east of Darwin – see Figure 1-1. The proposed development is located between the Stuart and Arnhem Highways, and the project area covers approximately 2,800 hectares.

A Notice of Intent was submitted to the Northern Territory Environmental Protection Authority (NTEPA) on 22 December 2013 and it was determined that the proposed development required an Environmental Impact Statement. One of the Terms of Reference for the EIS requires:

> *"a description of the environmental values of the surface waterways on-site and regionally. The description should be based on an accepted method for quantifying river health that is able to (be) compared and repeated in future (i.e. AUSRIVAS)"*.

The 'AUSRIVAS' (Australian River Assessment Scheme) rapid biological assessment system has been widely used to assess the biological health of Australian rivers for many years. To achieve this in the NT, a standardised sampling and assessment protocol has been developed for the sampling of freshwater macroinvertebrate communities (Lamche 2007).

This report summarises the macroinvertebrate biological monitoring undertaken to provide a baseline assessment of aquatic health, both on the site and downstream. It is intended that this report be read in conjunction with the Surface Water Quality Monitoring Report (EcOz 2015) prepared for the EIS.

1.2 Catchment description

1.2.1 Hydrology

The project area falls within two surface water catchments, the majority of which (63 %) is in the upper Elizabeth River catchment, a major tributary of the Darwin Harbour catchment. A relatively small portion of the eastern section of the project area drains into the Adelaide River catchment (Figure 1-1).

The Elizabeth River is an intermittent system that flows during the wet season and usually ceases to flow by June – July each year, with regular permanent pools. The tributaries of Elizabeth River that flow from the project area are ephemeral, flowing only during the wet season and ceasing to flow early in the dry season (i.e. March/April), either drying completely or contracting to occasional pools during the dry season.

1.2.2 Previous biological monitoring

Monitoring of macroinvertebrates in the Elizabeth River catchment was previously undertaken regularly as part of the NT Government's (NTG) monitoring of the Darwin Harbour Catchment. The NTG monitored four sites between 2001 and 2010, with details provided in Table 1-1 and locations shown in Figure 1-1.

Aquatic health according to the AUSRIVAS macroinvertebrate monitoring methodology has generally been Class A (i.e. similar to reference) at most NTG monitoring sites, with the lower freshwater Elizabeth River site (DW40) being Class B (i.e. significantly impaired) during some years (Table 1-1). This indicates that in at least some years, there may be decreased aquatic health as a result of disturbance associated with the existing rural and/or agricultural development within the Elizabeth River catchment.

Table 1-1. Details of NT Government macroinvertebrate monitoring in Elizabeth River catchment

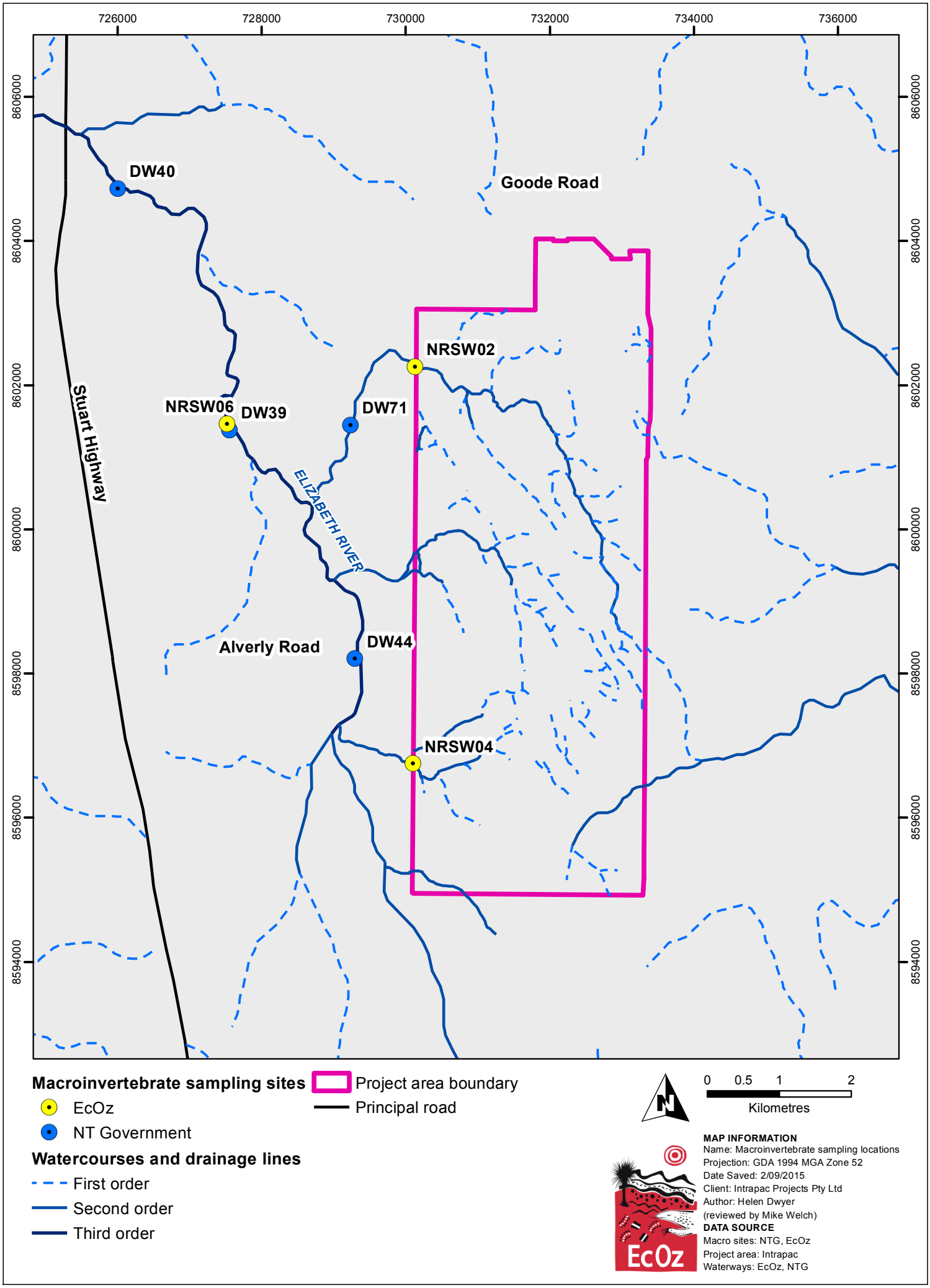
Site	Years sampled and AUSRIVAS model score*						
	2001	2002	2003	2004	2007	2009	2010
DW39	A	A	A	-	-	B	A
DW40	A	B	A	B	B	A	A
DW44	-	A	A	-	-	A	B
DW71	-	-	-	-	-	A	A

** See below for details of scoring categories*

Table 1-2. Details of AUSRIVAS scores

Band	Family level model OE50	Description	O/E Taxa Interpretations
X	> 1.18	More biologically diverse than reference	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
A	0.82 – 1.18	Similar to reference	Expected number of families within the range found at 80% of the reference sites.
B	0.45 – 0.81	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
C	0.07 – 0.44	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
D	< 0.07	Extremely Impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

Source: Lamche (2007)



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ14400 - Noonamah Ridge Estates EIS\01 Project Files\Water Monitoring and SW\Macroinvertebrate sampling locations.mxd

Figure 1-1. Map showing location of study catchment and macroinvertebrate monitoring sites

2 Methodology

2.1 Survey design, locations and timing

Three monitoring sites were sampled, including two sites on Elizabeth River tributaries immediately downstream of the project area boundary, and one site that receives drainage from both the western portion of the project area (i.e. two tributaries sampled and one other) and other tributaries that have varying levels of development. Locations of the sampling sites are shown in Figure 1-1.

Sampling was undertaken on 30 April 2015, which coincided with the recessional flow period, as specified in the *NT AUSRIVAS User Manual* (Lamche 2007). Relatively low rainfall during the 2014/2015 wet season resulted in many sites quickly receding in flow and at the time of sampling, the two tributaries draining the site (i.e. NRSW02 and NRSW04) were flowing at a rate of approximately 10 L/s and the downstream site (NRSW06) was flowing around 50 – 100 L/s (estimated visually).

2.2 Field sampling techniques

2.2.1 Macroinvertebrates

Macroinvertebrate sampling was undertaken in accordance with the *NT AUSRIVAS User Manual* (Lamche 2007). This is a two-person operation, which involves the disturbance of a 5 – 10 m section of stream bank 'edge' habitat with a three-pronged rake by the first person, followed by the second person who passes a 500 µm mesh net (D-shaped opening with 35 cm diameter) through the disturbed water in a sweeping motion.

Following sampling, the net contents are emptied into a bucket of water and the net washed thoroughly, to remove any remaining debris and macroinvertebrates. The organic fraction is separated from the inorganic sediments by stirring the bucket contents and slowly pouring the suspended mixture from the bucket into nested coarse (i.e. 10 mm) and fine (i.e. 500 µm) sieves. The coarse fraction is discarded following an inspection of the sieve contents to check for any invertebrates. The contents of the fine sieve is washed into a 1000 ml plastic wide mouth jar and preserved in the field using ethanol to a concentration of 70 %. The samples are then sorted and identified in the laboratory, as detailed in Section 2.3 below.

2.2.2 Habitat descriptions

In addition to photographs taken at each site, information on habitats sampled and surrounding in-stream and riparian areas were recorded, including the following:

- Stream width (i.e. at water level)
- Bank-full widths and depths (i.e. levy banks)
- Water depth at sample location
- Stream discharge (estimated visually)
- Flow at sample location (estimated visually)
- Dominant substrates at sample location
- Riparian canopy cover (estimated visually)
- Riparian disturbance (i.e. weeds, feral animals, fire).

2.2.3 Water quality

Field parameters (pH, dissolved oxygen [DO], electrical conductivity [EC], turbidity, temperature, total dissolved solids [TDS], and salinity) were measured using hand-held field instruments, calibrated on the day of sampling.

Samples for laboratory analysis were collected using sterile laboratory-supplied sample bottles and submitted to a NATA-accredited laboratory for analysis. Analytes included total suspended solids, dissolved major cations and anions (hydroxide, carbonate, bicarbonate and total alkalinity, sulfate, chlorine, total hardness, Ca, Mg, Na, K), dissolved metals (Al, As, Cd, Cr, Cu, Ni, Pb, Zn, Fe) and nutrients (NH_4, $N0_2$, $N0_3$, TKN, TN, TP, total reactive phosphorus).

2.3 Sample sorting and identification

Samples were sub-sampled so that at a minimum of 200 animals or 10 % of the sample is examined using a sub-sampler as described by Marchant (1989). Where samples were shown to have low abundances the sorting time was limited to a maximum of four hours. At the completion of the sub-sampling, a general scan of the remaining sample was completed and any additional species not initially collected were added to the taxa list. The abundances of the taxa collected from the sub-sample were corrected depending upon the percentage of the subsample that was examined.

Taxonomic resolution followed AUSRIVAS protocols (Lloyd and Cook 2002). The majority of taxa were identified to family level, with some groups identified to class or order (e.g. Mites and worms). Any damaged or immature taxa were identified to the lowest level possible. As per the protocol, micro-crustacea such as Cladocerans, Copeopds and Ostracods were not included in the data analysis.

2.4 Data analysis

Comparisons of abundance and species richness were made between sites, including dominant taxa and where relevant, how this could be influenced by habitat and/or water quality variables observed at a given site.

Macroinvertebrate data were run through the AUSRIVAS Darwin-Daly family-level model, which utilises the following environmental predictor variables:

- Latitude
- Longitude
- Average stream width
- Riparian rainforest areas (km^2) within 500 m of sample site

AUSRIVAS compares the expected (E) number of taxa to the actually observed (O) number of taxa at each site. The AUSRIVAS system only considers taxa that were calculated to have a probability of 50 % or greater of occurring at a test site. The OE50 score is therefore the ratio of the observed to expected number of taxa with a probability of 50 % or greater of occurring. This OE50 score is the major output score used in the NT to assess the health of the macroinvertebrate community at the test site (Lamche 2007).

3 Results and Discussion

3.1 Habitat descriptions

Details of stream habitats sampled and surrounding areas are provided in Table 3-1 and photographs of each sample site are provided in Appendix A. The Elizabeth River tributaries sampled generally flow through Eucalyptus woodland vegetation communities, with a relatively narrow riparian zone that is characterised by species such as *Lophostemon* sp, *Melaleuca* sp. and *Pandanus spiralis*. Sampled habitats were generally consistent between sites and due to the relatively flashy nature of high flows in this system, stream banks were often scoured with bare substrates and had limited availability of what would be considered ideal macroinvertebrate habitat (e.g. organic matter, trailing root materials, etc.). Macrophytes (*Eriocaulon setaceum*) were abundant at sites NRSW02 and NRSW04, with the most notable difference in habitats between sites being that the downstream site (NRSW06) had higher canopy cover and higher stream flows than other sites, associated with the site's location lower in the catchment.

Table 3-1. Stream habitat data

Site/Habitat Variable	NRSW02	NRSW04	NRSW06
Stream Width (m)	3.8	2.3	4.3
Levee Bank Width (m)	7	7	12
Levee Bank Height (m)	2	1.5	2
Water Depth (m)	0.4	0.3	0.2
Stream Discharge (m^3/s)*	0.010	0.010	0.090
Flow at sample location	None	None	Obvious
Dominant Substrate (bank)	Silt/clay	Silt/clay	Sand
Riparian Canopy Cover (%)*	80	10	90
Riparian Disturbance (weeds, fire, feral animals)	Medium density weeds	Medium density weeds	High density weeds
Other observations	Iron floc visible	Iron floc visible	-

** Estimated visually, except discharge at Site NRSW06, taken from nearby DLRM gauge station (G8150018)*

3.2 Water quality

Water quality at all sites was very good at the time of sampling, with field and laboratory data presented in Table 3-2. The following general observations can be made:

- Slightly acidic pH, likely to be attributable to the natural acidity of rainfall in the Darwin region (Ayers et al. 1993; Noller *et al.* 1990).
- EC was low, ranging from 16 – 95 µS/cm. This reflects very low concentrations of dissolved ions in the water, indicating that there is minimal dissolution of minerals within the catchments (i.e. it is essentially pure rainwater).
- Turbidity and suspended solids were low, indicating minimal disturbance and erosion within the catchments.
- Concentrations of dissolved metals were below laboratory detection limits for all metals analysed, except for aluminium and iron.

- Concentrations of nutrients were generally below laboratory detection limits, with slightly elevated organic nitrogen at site NRSW06.

Table 3-2. Water quality data

Parameter	Unit	Lab detection limit	NRSW02	NRSW04	NRSW06
Field					
pH	pH unit	-	5.1	4.99	4.8
DO	%	-	85	99.4	88
EC	uS/cm	-	19	22.5	20.3
TDS	g/L	-	0.0123	0.0146	0.0133
Temperature	°C	-	23.5	23.5	22.3
Turbidity	NTU	-	2.4	1.8	4.1
Laboratory					
Total Suspended Solids	mg/L	*5*	<5	<5	<5
Hydroxide	$CaCO_3$ mg/L	*1*	<1	<1	<1
Carbonate	$CaCO_3$ mg/L	*1*	<1	<1	<1
Bicarbonate	$CaCO_3$ mg/L	*1*	4	10	12
Total Alkalinity	$CaCO_3$ mg/L	*1*	4	10	12
F	mg/L	*0.1*	<0.1	0.1	<0.1
SO_4	mg/L	*1*	<1	<1	<1
Cl	mg/L	*1*	2	2	2
Total Hardness	$CaCO_3$ mg/L	*1*	<1	5	12
Ca	mg/L	*1*	<1	2	3
Mg	mg/L	*1*	<1	<1	1
Na	mg/L	*1*	1	1	1
K	mg/L	*1*	<1	<1	<1
Al (dissolved)	mg/L	*0.01*	<0.01	0.02	0.11
As (dissolved)	mg/L	*0.001*	<0.001	<0.001	<0.001
Cd (dissolved)	mg/L	*0.0001*	<0.0001	<0.0001	<0.0001
Cr (dissolved)	mg/L	*0.001*	<0.0001	<0.0001	<0.0001
Cu (dissolved)	mg/L	*0.001*	<0.001	<0.001	<0.001
Ni (dissolved)	mg/L	*0.001*	<0.0001	<0.0001	<0.0001
Pb (dissolved)	mg/L	*0.001*	<0.001	<0.001	<0.001
Zn (dissolved)	mg/L	*0.005*	<0.005	<0.005	<0.005
Fe (dissolved)	mg/L	*0.05*	<0.05	0.1	0.24
Ammonia	mg/L	*0.01*	0.01	0.04	0.02
Nitrite	mg/L	*0.01*	0.01	0.04	0.02
Nitrate	mg/L	*0.01*	<0.01	<0.01	<0.01
Nitrite+Nitrate	mg/L	*0.01*	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen	mg/L	*0.1*	<0.1	<0.1	0.2
Total Nitrogen	mg/L	*0.1*	<0.1	<0.1	0.2
Total Phosphorus	mg/L	*0.01*	<0.01	<0.01	<0.01
Reactive Phosphorus	mg/L	*0.01*	<0.01	<0.01	<0.01

3.3 Macroinvertebrates

3.3.1 Taxonomic composition

A total of 32 taxa were identified from the three survey sites, with the Class Insecta/Order Diptera having the highest taxonomic richness and abundance (Table 3-3). The three survey sites had similar taxonomic richness, with high abundances of:

- Corixidae (Hemiptera - bugs) and Hydrophilidae (Coleoptera – beetles) at site NRSW02
- Chironominae (Diptera – flies) at site NRSW04
- Palaemonidae (Decopda – prawns) at site NRSW06.

Table 3-3. Macroinvertebrate results

Phylum	Class	Order	Family/Sub-family	Life Stage	AUSRIVAS Code	NRSW02	NRSW04	NRSW06
MOLLUSCA	GASTROPODA		Anclylidae		KG069999	2	2	12
ANNELIDA	OLIGOCHAETA		*Oligochaeta*		LO999999	26	18	24
ARTHROPODA	CRUSTACEA	Ostracoda				0	4	0
		Cladocera				4	0	2
		Copeopoda				6	6	0
		Decapoda	Parathelphusidae			1	6	2
			Atyidae		OT019999	0	0	8
			Palaemonidae		OT029999	0	1	38
	INSECTA	Ephemeroptera	Baetidae	N	QE029999	6	14	8
			Caenidae	N	QE089999	24	12	8
		Odonata	Coenagrionidae	L	QO029997	14	4	0
			Anisoptera (imm)	L	QO999998	0	0	2
			Hemicordulidae	L	QO999998	0	2	2
			Libellulidae	L	QO999998	8	0	0
		Hemiptera	Corixidae	A/N	QH659999	48	16	8
			Notonectidae	A/N	QH679999	8	2	0
			Pleidae	A/N	QH689999	0	2	0
			Veliidae	A/N	QH569999	2	0	0
		Coleoptera	Dytiscidae	A	QC099999	0	4	1
			Elmidae	L	QC349999	0	0	2
			Hydraenidae	A	QC139999	2	0	0
			Hydrophilidae	A	QC119999	2	2	0
			Hydrophilidae	L	QC119999	42	0	0
			Hydrochidae	A	QCAO9999	0	8	2
		Diptera	Cecidomyiidae	L		2	0	0
			Chironomidae	P		6	18	6
			Tanypodinae	L	QDAE9999	44	48	30
			Orthocladiinae	L	QDAF9999	0	14	14
			Chironominae	L	QDAJ9999	60	132	38
			Ceratopogonidae	L	QD099999	8	4	2
			Culicidae	L	QD079999	6	0	0
		Trichoptera	Ecnomidae	L	QT089999	2	4	4
			Leptoceridae	L	QT259999	2	0	2
					Total abundance	325	323	215
					Total richness	22	22	21

3.3.2 AUSRIVAS modelling

Outputs from the Darwin-Daly family-level AUSRIVAS model are presented in Table 3-4, which indicates that site NRSW02 has lower than expected taxonomic richness, either as a result of water quality and/or habitat quality. Both of the other sites were classified as similar to reference, noting that site NRSW04 was only just classified as Band A (i.e. OE50 for Band A is 0.82-1.18).

As the water quality at sites NRSW02 and NRSW04 is considered very good and there is no current development within their respective catchments, the relatively poor macroinvertebrate community health could possibly be attributed to relatively poor habitat availability for macroinvertebrate colonisation and/or hydrological conditions associated with their location high in the catchment (i.e. second order streams). Sampled habitats were generally consistent between sites and due to the relatively flashy nature of high flows in this system, stream banks were often scoured with bare substrates and had limited availability of what would be considered ideal macroinvertebrate habitat (e.g. organic matter, trailing root materials, etc.). Another potential explanation is that primary productivity is often reported to increase with increasing stream order, moving down a catchment (e.g. Allan and Castillo 2007).

Table 3-4. Output from the Darwin-Daly family-level AUSRIVAS model

Site	OE50	Band	Description
NRSW02	0.79	B	Significantly impaired
NRSW04	0.83	A	Similar to reference
NRSW06	1.03	A	Similar to reference

4 Acronyms and References

4.1 Acronyms

AUSRIVAS	Australian Rivers Assessment Scheme
DLRM	Department of Land Resource Management
DO	Dissolved oxygen
EC	Electrical conductivity
NTG	Northern Territory Government
NTEPA	Northern Territory Environmental Projection Authority
TDS	Total dissolved solids

4.2 References

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Appendix A – Site Photographs

NRSW02 upstream

NRSW02 downstream

NRSW04 upstream

NRSW04 downstream

NRSW06 upstream

NRSW06 downstream