MAUD CREEK GOLD MINE
KATHERINE
Aquatic Ecology Assessment

Freshwater Fishes and Aquatic Macroinvertebrates

Final Report

Prepared for
URS Australia/Terra Gold Mining Ltd
July 2007






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Maud Creek Gold Project: Aquatic Ecology Assessment 2007

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This report was prepared in June - July 2007 and is based on data reviewed and information compiled during field surveys undertaken during May 2007. Ecological Management Services Pty Ltd disclaims any responsibility for any changes that have occurred after this time.

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Contents

1. Introduction **1**

1.1. Objectives and Scope 1

2. Methods **1**

2.1. Study Area and Local Catchments 1

2.2. Field Survey Methods 3

2.3. Data Analysis 5

2.4. Existing Data Review 6

2.5. Site Selection and Habitats 6

2.6. Seasonality & Climatic Conditions 7

3. Survey Results **8**

3.1. Water Quality Parameter Results 8

3.2. Freshwater Fishes 9

3.3. Aquatic Macroinvertebrates 10

3.4. Aquatic Macrophytes 16

3.5. Other Semi-aquatic Vertebrates 16

4. Discussion **17**

5. References **19**

Figure 1-1 Aquatic Survey Sites

Figure 3-1 Selected surface water quality parameters

Figure 3-2 Macroinvertebrate Species Diversity (Shannon Index)

Figure 3-3 Group average Bray-Curtis Similarity based on macroinvertebrate communities

Figure 3-4 MDS plot based on group average Bray-Curtis Similarity of macroinvertebrate communities

Figure 3-5 Observed/Expected (O/E50) Taxa Scores: AUSRIVAS Darwin – Daly Early Edge Model

Appendix 1 Site photos

Appendix 2 Aquatic Site Habitat Data

Appendix 3 Laboratory Water Quality Analysis Results

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Dr Gisella Lamche, EPA/NRETA: Comments on AUSRIVAS sampling protocols and methods, RIP500 data

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Keith Martin: Comments on previous aquatic surveys of the Maud Creek study area, comments on the distribution of the freshwater sawfish in the Katherine-Daly system

MAUD CREEK GOLD MINE, KATHERINE

Aquatic Ecology Assessment

Final Report

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1. Introduction

Ecological Management Services Pty Ltd was commissioned by URS Australia Pty Ltd (URS) to prepare a report documenting the aquatic ecology of the Maud Creek study area, including Gold Creek and adjacent/downstream areas on Maud Creek. The study area is located within the Maud Creek Station and downstream areas, 275 km south-east of Darwin and 20 km east of Katherine. The main surveys were conducted within mineral tenements on Gold Creek and adjacent and downstream sections of Maud Creek (Figure 1-1). The Maud Creek Gold Project proposal is documented in URS (2006).

1.1. Objectives and Scope

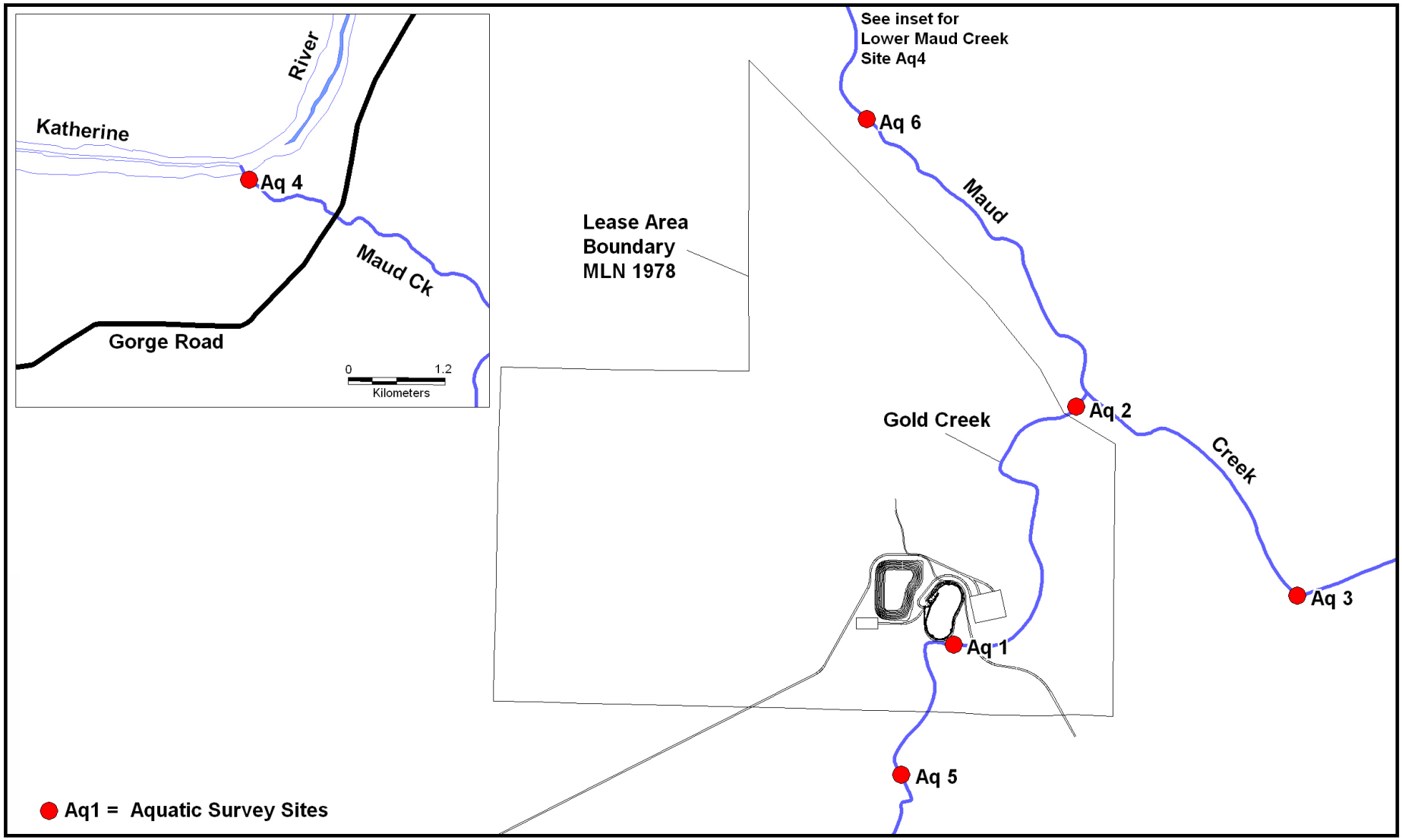
The objectives of the aquatic fauna study were to:

- Review and update existing aquatic ecology data for the local area and previous assessments conducted within the Maud Creek Gold Mine study area;
- Describe the aquatic habitats, freshwater fishes and aquatic macroinvertebrates of the Maud Creek catchment area;
- Conduct aquatic macroinvertebrate sampling following AUSRIVAS survey protocols;
- Identify the occurrence or expected occurrence of any species or species groups of high conservation value and the habitats or areas in which they are present; and
- Assess the status of introduced aquatic species in the area.

2. Methods

2.1. Study Area and Local Catchments

In this report the “lease area” refers to MLN 1978 and the “study area” refers to the lease areas and adjacent and downstream areas on Gold Creek and Maud Creek (Figure 1-1). The study area is located within the catchment of Gold Creek, a minor tributary of Maud Creek. Gold Creek is a small seasonal stream that is reduced to small waterholes or is completely dry in the late dry season, and subject to occasional strong flows and flooding during the wet season. The confluence of Gold Creek and Maud Creek is adjacent to the northern boundary of the lease area.



Plan Note:
Base mapping provided by URS Australia
Site locations are approximate.

Project:
Maud Creek Gold Project
Aquatic Ecology Assessment 2007

Title:
Aquatic Survey Sites

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Figure 1-1

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The upper catchment of Maud Creek rises in the stony country to the south of Nitmiluk National Park and flows into the Katherine River about 20 km upstream from Katherine (Martin 1996). During the dry season, Maud Creek ceases to flow and in the lower reaches dries to a series of pools. Martin (1996) conducted a helicopter survey of the Maud Creek catchment late in the dry season. During this survey Maud Creek was found to be virtually dry for most of its lower length, apart from permanent pools near the mouth and at a small gorge downstream of the lease area, and the upper reaches supported numerous large, permanent waterholes (Martin 1996). Some of these pools were up to 1 km in length and at least 2 m deep. These pools are likely to support a variety of freshwater life which would colonise the entire system, including Gold Creek, during the wet season (Martin 1996).

2.2. Field Survey Methods

The aquatic surveys were undertaken between 7 May and 12 May 2007. The surveys were timed to comply with the sampling period suitable for the early dry season Darwin – Daly AUSRIVAS model (Lamche 2007) and to allow the system to recover from the effects of wet season flood events. Six aquatic survey sites were sampled, including 3 sites on Gold Creek and 3 sites on Maud Creek. Standard biological survey techniques were used during the aquatic surveys, including a number of capture/release netting techniques. Records were also compiled using observational methods and incidental observations. The survey focussed on aquatic vertebrate and macroinvertebrate taxa, however observational records of semi-aquatic vertebrates were also compiled. A summary of the sample methods applied at each site is included in Table 2-1.

In the field, aquatic sampling sites were chosen at representative locations in the stream systems draining components of the lease area and downstream/upstream reference sites were also established on both Maud Creek and Gold Creek. Sites were selected where pool habitats suitable for sampling using the Darwin – Daly AUSRIVAS edge model were present. A minor tributary draining the northern section of the lease area was not sampled as no suitable sites were located on this tributary. Site photos (Appendix 1) and environmental data was collected at each site, including physical habitat descriptions (Appendix 2) and water quality parameters (Appendix 3). Water quality sampling was conducted following protocols outlined by Lamche (2007), with laboratory analysis undertaken by Northern Territory Environmental Laboratories (NTEL), Darwin. Field parameters including Water Temperature, Dissolved Oxygen (DO), pH, Turbidity (NTU) and Electrical Conductivity (EC) were sampled using a Horiba U10 multi-probe. Laboratory parameters included Nitrate (NO3), Nitrite (NO2), Ammonia (NH3), Total Kjedahl Nitrogen (TKN), Total Phosphorous (TP), Dissolved Reactive Phosphorous (DRP), Alkalinity, Electrical Conductivity (EC) and pH. Additional parameters included CO3, HCO3, OH, NO2-N and NO3-N. Results of the laboratory analysis are included in Appendix 3.

Aquatic macroinvertebrates were sampled following the methodology described in the Draft NT Darwin – Daly AUSRIVAS sampling manual (Lamche 2007). Aquatic macroinvertebrates were sampled using a 250µm mesh triangular net with aperture 300 x 350 x 300 mm. Two 5 metre edge habitat samples were collected at each site (total 10m per site) following the method described in Lamche (2007). This method involves agitating the edge substrate and root matter with a three pronged rake, while sweeping the net through the water column to capture dislodged material over the length of the sample. All samples were obtained from pool edge habitats to retain consistency with the model (Lamche 2007) and between sites. Macroinvertebrate samples were preserved in 90% alcohol in the field for laboratory sorting. Samples were sorted to family level following the methodology described in Lamche (2007). This involved removing and sorting sub-samples from the main sample until 200 organisms were removed, counting each organism from

each subsample and continuing to count all organisms in the last subsample. In cases where a sample contained small numbers of organisms a cut-off limit of four hours for picking the sample was applied if the 200 organism count could not be reached in this time period (Lamche 2007). As required by Lamche (2007) microcrustacea (e.g. Cladocera, Ostracoda etc) were excluded from the model analysis. As the main focus of the analysis was the identification to family/sub-family level for analysis using the Darwin – Daly early edge model it was not necessary to allocate additional resources to identify all organisms in samples to lower taxonomic levels than those required by the model. However macroinvertebrates were identified to lower taxonomic levels or species types where this did not require allocation of additional identification time or resources. For most macroinvertebrate groups an estimate of the diversity of species/types was made, however this assessment is likely to underestimate the numbers of species of some groups present in samples, particularly smaller and more difficult to identify species such as chironomids. Macroinvertebrate taxa were identified by Paul Barden using appropriate taxonomic keys.

Additional macroinvertebrate samples were obtained at most sites from “Gansel” bait and opera house fish traps, fine mesh seine sweeps and by hand collecting.

The survey of freshwater fishes was undertaken under DPIFM Special Permit No. 2006-2007/S17/2270. Freshwater fishes were sampled at all sites using cast nets and a fine mesh seine net (8 m long x 1.5 m drop with 1 mm mesh). At each site a minimum of one fine mesh seine drag and 5 net casts were undertaken. A large gill net (30m x 30mm knot to knot, 2m drop) was deployed at one site on Maud Creek, however at most sites the habitat was not sufficiently wide or deep to allow this sampling method to be applied. Traps of two different sizes were set at all sites. These were fine meshed (2 mm) Gansel bait traps (40 cm x 25 cm with a 3 cm opening) and medium mesh (18 mm) “opera house” traps. Four Gansel bait traps and two opera traps were set for a standard period of time (1 hour) at each site and were baited with a commercial fish attractant. These traps were used to sample fishes, crustaceans and freshwater turtles. Bankside observations of fishes and other species were compiled during the day and at night with the aid of a spotlight. Lure casting and baited hook and line were used as additional methods at three deeper sites on Maud Creek.

Table 2-1
Sampling Effort at Aquatic Sites

Method	Aq1	Aq2	Aq3	Aq4	Aq5	Aq6
Water Quality/Habitat Parameters	Yes	Yes	Yes	Yes	Yes	Yes
Macroinvertebrate Samples (5m Sweep)	2	2	2	2	2	2
Gansel Bait Traps (1 hour set)	4	4	4	4	4	4
Opera House Traps (1 hour set)	2	2	2	2	2	2
Fine Mesh Seine Net Drags	1	1	1	1	1	2
30m Gill Net (1 hour set)						Yes
Cast Net Casts	5	5	5	5	5	5
Hook and line/Lure Casts			Yes	Yes		Yes
General Observations	Yes	Yes	Yes	Yes	Yes	Yes

2.3. Data Analysis

Macroinvertebrate data was analysed using the NT Darwin - Daly AUSRIVAS early edge family model. Required variables for this model include site latitude, longitude, area of riparian rainforest within a radius of 500m of the site (RIP500) and mean stream width within the sampled reach. RIP500 measurements for the Maud Creek study sites were provided by G. Lamche, NT Environmental Protection Agency, NRETA. The AUStralian RIVer ASsessment System (AUSRIVAS) system is a standardised national system for assessment of river condition using instream macroinvertebrates (Davies 2000). AUSRIVAS models predict the aquatic macroinvertebrate fauna that would be expected to occur at a site in the absence of environmental stress such as pollution, habitat degradation or flow regulation. A comparison of the macroinvertebrates expected to occur at the test site with those actually collected (O/E ratio) provides a site specific measure of the biological impairment of a site. The Darwin - Daly AUSRIVAS model has been specifically developed for the catchments in the Darwin area and Daly - Katherine River catchments.

Additional analysis of the macroinvertebrate data was undertaken using PRIMER (Clarke & Gorley 2007). PRIMER (Plymouth Routines In Multivariate Ecological Research) is a statistical analysis program that includes a wide range of univariate, graphical and multivariate routines for analysing species-by-samples data from community ecology (Clarke & Gorley 2007). PRIMER is well suited to the analysis of macroinvertebrate community data (Lamche 2007).

Macroinvertebrate community structure was examined among sites with multivariate ordination of group average Bray - Curtis similarity. This analysis was selected as it is a standard method in reporting for macroinvertebrate studies and is a recommended component of reporting under the Darwin – Daly AUSRIVAS model (Lamche 2007). Analysis of Bray - Curtis Similarity was also included in previous macroinvertebrate studies undertaken on Maud Creek (Martin 1996).

A dendrogram and MDS (non-metric multidimensional scaling) plot of the group average Bray - Curtis similarity data was produced. Prior to analysis of similarity the data was transformed to down-weight the contributions of quantitatively dominant species to the similarities calculated between sites (overall square root transformation, Clarke & Gorley 2007). Pre-treatment (transformation) of assemblage data is desirable to reduce the dominant contributions of abundant species to Bray-Curtis similarities, as this resemblance measure does not incorporate any form of scaling of each species by its total or maximum across all samples (Clarke & Gorley 2007). The transformation of data allows the analysis to take more notice of less abundant species in determining the community similarity matrix (Clarke & Gorley 2007).

Martin (1996) also assessed species diversity using the Shannon diversity index. This analysis was repeated for the current assessment using PRIMER, calculated as:

$$H' = - \Sigma P_i \log (P_i) \text{ log base e}$$

where P_i is the fraction of individuals belonging to the *i*-th species.

2.4. Existing Data Review

Existing data on the aqautic fauna of the Maud Creek study area was obtained from a number of sources. These included:

- Dry season aquatic ecology surveys (freshwater fishes and aquatic macroinvertebrates) of the Maud Creek study area, including sites on Maud Creek down and upstream of the Gold Creek confluence (Dames & Moore 1994; Martin 1996).
- Freshwater fishes recorded in the Donkey Camp section of the Katherine River (Martin 1989; Midgley 1980; Dames & Moore 1991);
- Macroinvertebrate data from a site sampled on Maud Creek at the confluence of Dorothy Creek (Dostine 2000);
- An EPBC Act protected matters report with a centre-point located on the study area (DEWR 2007);
- Existing reports and data from surveys in the Katherine – Daly system (Faulks 1998; Katherine Region Waterwatch 2002, 2003); and
- Freshwater fishes listed in the Nitmiluk National Park management plan (Parks & Wildlife Commission of the Northern Territory 2002).

2.5. Site Selection and Habitats

Six systematic aquatic sample sites were selected within the study area (Figure 1-1, Appendices 1 & 2). Plates depicting each of the sites during the sampling period are presented in Appendix 1 and a summary of site habitat data is included in Appendix 2. Three sites were selected along Gold Creek, including one site within the mine area (Aq1), one site upstream of the mine area (Aq5) and one site downstream of the mine area upstream of the confluence with Maud Creek (Aq2) (Table 2-2). These sites were not sampled during previous surveys of the study area as they did not support surface water (K. Martin pers comm., 2007). Three additional sites were located on Maud Creek, including one site upstream of the Gold Creek confluence (Aq3) and one site downstream of the Gold Creek confluence (Aq6). An additional site (Aq4) was located on the lower section of Maud Creek downstream of the Nitmiluk Park Road, to sample a site previously assessed by Martin (1996). A number of other sites sampled by Martin (1996) could not be re-sampled during the current survey as they were not accessible without the use of a helicopter (K. Martin pers comm. 2007).

Table 2-2
Aquatic Sampling Site Locations and Characteristics

Site	Catchment	Location	Site Characteristics
Aq1	Gold Creek	Adjacent to existing pit.	Upstream from an existing culvert, adjacent to existing pit. Moderate to high level of impact from swamp buffalo and past mining activity.
Aq2	Gold Creek	100m upstream of the Maud Creek confluence on Gold Creek. Downstream of mine area.	Characterised by high steep banks and moderate to high level of impact from swamp buffalo. Adjacent to track crossing.
Aq3	Maud Creek	Maud Creek approx. 1400 m upstream of the Gold Creek confluence.	Bank erosion and open areas denuded of riparian vegetation. A minor tributary enters the stream upstream of the site.
Aq4	Maud Creek	Lower section of Maud Creek approx. 300m upstream of the Katherine River.	Wide deep pool located within a high rocky gorge. Signs of significant flood damage and sediment deposition from previous wet season flows.
Aq5	Gold Creek	Approx 350m upstream of the mine area on Gold Creek.	High level of impact from swamp buffalo, with high levels of turbidity and bank erosion.
Aq6	Maud Creek	Maud Creek approx. 1500 m downstream of the Gold Creek confluence.	Good quality riparian vegetation and relatively good instream conditions. Little evidence of impacts from feral pig, cattle or swamp buffalo.

Pools on Gold Creek were generally turbid, due primarily to disturbance from swamp buffaloes. Aquatic vegetation was absent at most sites with the exception of small patches of sedges and rushes and beds of charophytes (*Chara* spp) at one site (Aq1). Riparian vegetation at all sites was dominated by a similar range of canopy species, including *Melaleuca spp, Lophostemon grandiflorus, Terminalia spp* and *Pandanus spiralis*. The surrounding vegetation is predominantly grassy open woodland. The two lower sites on Maud Creek (Aq4 and Aq6) represent the only sites that are likely to support permanent water between the lease areas and the Katherine River (Martin 1996). Site Aq4 supports the most significant permanent freshwater habitat, with a large deep pool present in a narrow rocky gorge connected to the Katherine River.

2.6. Seasonality & Climatic Conditions

Previous surveys of the Maud Creek study area were undertaken during seasonally dry conditions, with no surface water present on Gold Creek and surface water on Maud Creek restricted to a series of refuge pools (K. Martin pers comm. 2007; Martin 1996). During the current survey Gold Creek supported flowing water throughout its length within the study area and sampling was undertaken at three long pools on this tributary. Maud Creek was also flowing and larger refuge pools were connected by a series of riffles. No rainfall was recorded in the local area in the month prior to the sampling, however prior to this the catchment received in excess of 130mm between the 22 and 25 March 2007, causing local flooding and requiring the closure of the Nitmiluk Park Road at the Maud Creek crossing. Signs of flooding were still evident on the sections of Maud and Gold Creek sampled during the current survey (May 2007).

3. Survey Results

3.1. Water Quality Parameter Results

Water quality parameter results are displayed in Appendix 2 and 3 and Figure 3-1. Surface water conditions within the local area are generally alkaline with relatively high pH levels recorded at some sites. During the survey period the pH of surface water ranged from 7.7 (Aq3) to 8.5 (Aq2). Total alkalinity ($CaCO_3$) and alkalinity as bicarbonate (HCO_3) readings were highest at sites on Gold Creek (up to 445 mg/L) and lower on sites on Maud Creek (80 – 123 mg/L) (Figure 3-1).

It is likely that the high alkalinity results on Gold Creek during the surveys are influenced by bank storage (water stored in saturated soil on the creek banks), which contributes to the elevated pH levels during the wet season (URS pers comm.). Inflows of bank storage can be high in calcium bicarbonate and are characterised by alkaline, high pH conditions. These conditions were noted during sampling at a number of sites during previous surveys (Martin 1996). Sites on Gold Creek recorded poorer results for some parameters than sites sampled on Maud Creek, particularly electrical conductivity (Figure 3-1). The site with the most obvious impacts related to swamp buffalo disturbance (Aq5) had the highest turbidity (NTU 231) readings (Figure 3-1). Other parameters, including Total Kjeldhal Nitrogen (TKN), Total Phosphate and Filterable Reactive Phosphorus, did not vary significantly across the sites.

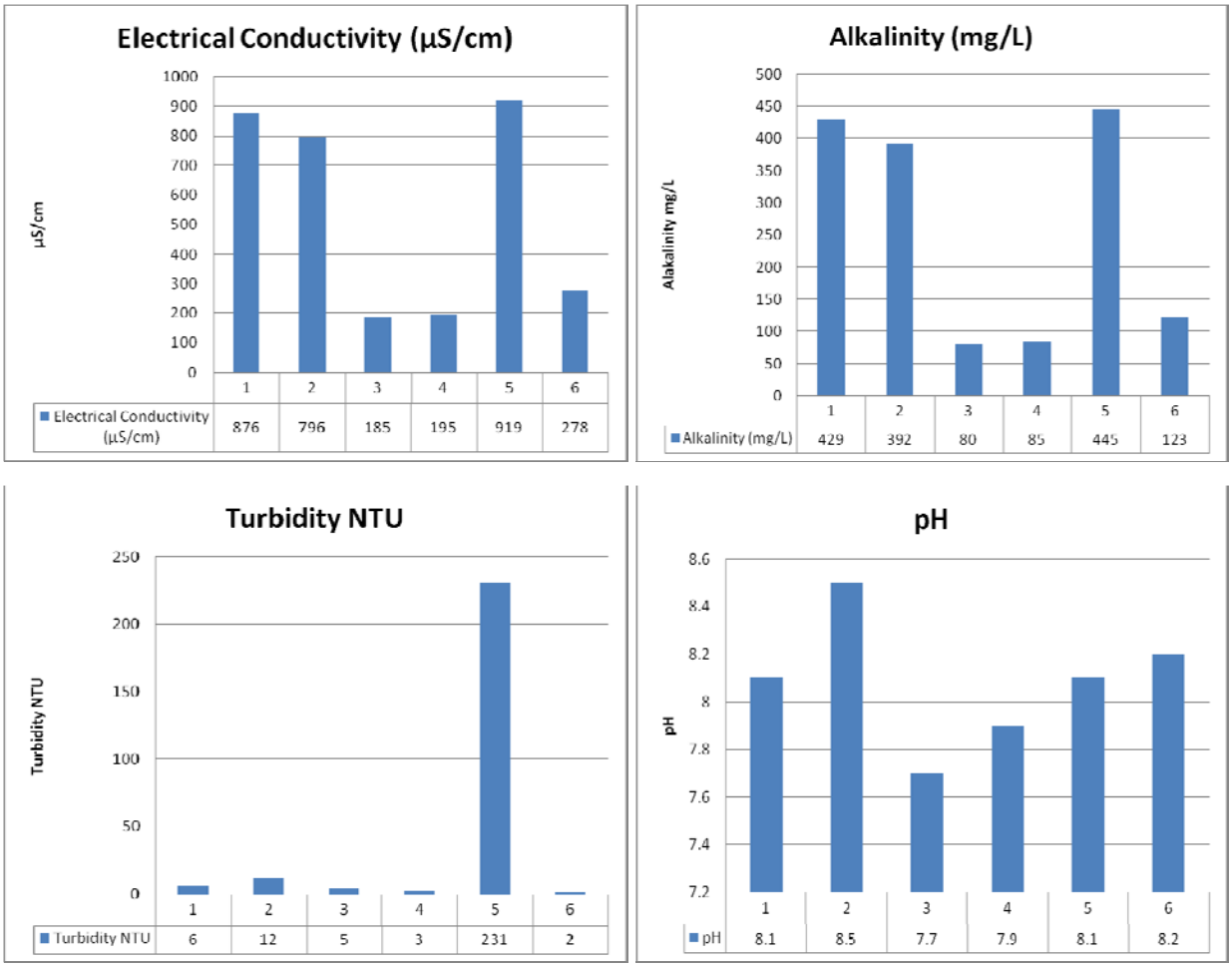

Figure 3-1. Selected surface water quality parameters

3.2. Freshwater Fishes

Fifteen species of freshwater fishes were recorded in Gold Creek and Maud Creek during the survey (Table 3-1). The western rainbowfish (*Melanotaenia australis*) was the most abundant species in samples and was the only species present at all sites. Other common species included the banded grunter (*Amniataba percoides*), spangled grunter (*Leiopotherapon unicolor*) and northern trout gudgeon (*Mogurnda mogurnda*).

Sites with larger expanses of permanent water, including Aq4 and Aq6, supported the highest diversity of fish species during the survey. These results are similar to those obtained by Martin (1996). Site Aq4 (M4 in Martin 1996) is close to the Maud Creek - Katherine River confluence, and this site supported the highest number of species of the sites sampled (nine of the fifteen species). Martin (1996) recorded eleven species at this site. Sites on Gold Creek supported a lower variety of species than those sampled on Maud Creek, however this tributary is largely dry during the dry season. Five species, including the western rainbowfish, sailfin glassfish (*Ambassis agrammus*), spangled grunter, northern trout gudgeon and sleepy cod (*Oxyeleotris lineolata*) were recorded in Gold Creek. Sites in the upper reaches of Gold Creek supported fewer species, with only 2 species detected at site Aq5.

Survey results are similar to those obtained during previous surveys undertaken in Maud Creek. Martin (1996) recorded a similar range of species with the addition of the oxeye herring (*Megalops cyprinoides*) and the blue catfish (*Arius graeffei*). Midgley (1980) reported seventeen species near the Maud Creek junction and eighteen species were recorded in the Donkey Camp reach on the Katherine River by Martin (1989). Results of these studies indicate a total of six additional species occurring in the Katherine River which have not yet been collected in Maud Creek, including barramundi (*Lates calcarifer*), toothless catfish (*Anodontiglanis dahli*), shovelnose catfish (*Arius midgleyi*), salmon catfish (*Arius leptaspis*), sharp-nosed grunter (*Syncomistes butleri*) and strawman (*Quirichthys stramineus*).

Table 3-1
Freshwater Fishes, Maud Creek & Gold Creek: May 2007

Common Name	Scientific Name	Aq1	Aq2	Aq3	Aq4	Aq5	Aq6
Bony Bream	*Nematolosa erebi*				x		
Yellow-finned Catfish	*Neosilurus hyrtlii*			2	1		
Western Rainbowfish	*Melanotaenia australis*	23	6	89	1	4	52
Freshwater Longtom	*Strongylura krefftii*				x		
Fly-specked Hardyhead	*Craterocephalus stercusmuscarum*				x		
Sailfin Glassfish	*Ambassis agrammus*	1					
Banded Grunter	*Amniataba percoides*			4	4		16
Spangled Grunter	*Leiopotherapon unicolor*		1	4		1	
Sooty Grunter	*Hephaestus fuliginosus*				x		x
Mouth Almighty	*Glossamia aprion*				1		1
Seven-spot Archerfish	*Toxotes chatareus*				x		
Flathead Goby	*Glossogobius giurus*			1			6
Northern Trout Gudgeon	*Mogurnda mogurnda*	5	1				x
Sleepy Cod	*Oxyeleotris lineolata*		2				1
Giant Gudgeon	*Oxyeleotris selheimi*			1			
Total	**15**	**3**	**4**	**6**	**9**	**2**	**7**
Total No Individuals		**29**	**10**	**101**	**7**	**5**	**76**

Numbers = number of individuals captured in combined methods at sites including cast net, traps and fine mesh seine. X = observed at site.

3.3. Aquatic Macroinvertebrates

A total of 58 taxa of macroinvertebrates with representatives of 30 families/orders were recorded during the survey (Table 3-2). Two additional freshwater macroinvertebrate species were recorded at sites during trapping and netting for freshwater fishes. The freshwater crab *Austrothelphusa transversa* (Parathelphusidae) was captured in bait traps at Aq5 and Aq2 in Gold Creek. A species of freshwater mussel (*Velesunio* sp, Hydriidae) was present at Aq6 on Maud Creek. The number of taxa identified is likely to underestimate true species numbers, particularly for smaller groups such as the Ceratopoginidae and Chironomidae. For example the current study (May 2007) recorded seven types of chironomid while Dostine (2000) recorded fourteen chironomid taxa at one site on Maud Creek.

Table 3-2

Aquatic Macroinvertebrates, Maud Creek & Gold Creek: 2007

Family	Species/Type	Common Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6
Ancylidae	*Ferrissia spp*	Limpet Snail			4	4		
Planorbidae	*Gyraulus spp*	Freshwater Snail	1					36
Corbiculudae	Corbiculudae sp 1	Bivalve Mollusc				1		
Oligochaeta	Oligochaeta	Segmented Worm						4
Acarina	Acarina sp 1	Water Mites	1	1	2	3	1	1
Acarina	Acarina sp 2	Water Mite			1	2		
Acarina	Acarina sp 3	Water Mite				1		2
Acarina	Acarina sp 4	Water Mite			1	2		2
Atyidae	*Caridina* sp 1	Freshwater Shrimp				3		13
Palaemonidae	*Macrobrachium* sp 1	Freshwater Prawn		1				2
Dytiscidae	*Batrachomatus wingii*	Predacious Diving Beetle				1		
Dytiscidae	sp 2	Predacious Diving Beetle		8		3		
Dytiscidae	sp 3	Predacious Diving Beetle				7		
Dytiscidae	*Hydroglyphus spp*	Predacious Diving Beetle	10					
Dytiscidae	sp 5	Predacious Diving Beetle		1				
Dytiscidae	*Necterosoma spp*	Predacious Diving Beetle					2	
Dytiscidae	*Laccophilus spp*	Predacious Diving Beetle					3	
Dytiscidae	Larvae *Tiporus spp*	Predacious Diving Beetle		2		1		2
Gyrinidae	Gyrinidae sp 1	Whirligig Beetle				1		
Hydrophilidae	larvae *Georissus spp*	Scavenger Water Beetle			1			
Hydrophilidae	larvae sp 2	Scavenger Water Beetle					1	
Hydraenidae	Hydraenidae sp 1	Minute Rove Beetle	3					
Elmidae	*Austrolimnius spp*	Riffle Beetle				1		2
Elmidae	Elmidae sp 2	Riffle Beetle				1		2
Elmidae	Elmidae sp 3	Riffle Beetle						1
Elmidae	Elmidae Larvae	Riffle Beetle			1		1	1
Culicidae	Culicidae sp 1 larvae	Mosquito				1		
Culicidae	larvae *Anopheles spp*	Mosquito					1	
Ceratopogonidae	Ceratopogonidae	Biting Midge	35	17	4	12	47	3
Sciomyzidae	Sciomyzidae type 1	Marsh Fly				1		
Tanypodinae	Tanypodinae type 1	Non-biting Midge	27	5	7	18	5	7
Orthocladiinae	Orthocladiinae type 1	Non-biting Midge	22	14	47	24	32	10
Orthocladiinae	Orthocladiinae type 2	Non-biting Midge				1		

Family	Species/Type	Common Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6
Chironominae	Chironominae type 1	Non-biting Midge	30	32	23	18	18	15
Chironominae	Chironominae type 2	Non-biting Midge	15	9	3	8	9	1
Chironominae	Chironominae type 3	Non-biting Midge		1				
Chironomidae	Chironomidae pupae	Non-biting Midge	4	2	1	2	5	5
Baetidae	*Cloeon* sp 1	Mayfly	15	43	39	31	34	49
Baetidae	Baetidae sp 2	Mayfly	17		4		1	1
Caenidae	*Tasmanocoensis spp*	Mayfly	15	53	48	50	43	19
Caenidae	*Wundacaensis dostini*	Mayfly			20		4	5
Gerridae	Gerridae sp 1	Water Strider				1		
Gerridae	Gerridae sp 2	Water Strider		1				
Corixidae	*Micronecta* sp	Water Boatman	3	5	6	11	4	
Notonectidae	Notonectidae sp 1	Back Swimmer						1
Pleidae	Pleidae sp 1	Pygmy Back Swimmer	1	1				
Pyralidae	Pyralidae larval sp 1	Moth (aquatic larvae)						1
Isostictidae	*Eyrysticta* sp 1	Damselfly						1
Protoneuridae	*Nososcticta* sp 1	Damselfly						2
Gomphidae	*Austrogomphus spp*	Dragonfly				15		
Gomphidae	Gomphidae sp 2	Dragonfly			1			1
Libellulidae	*Potamarcha congener*	Dragonfly				1		3
Libellulidae	Libellulidae sp 2	Dragonfly		6	1			1
Libellulidae	*Brachydiplax spp*	Dragonfly		4	1			
Hydroptilidae	*Hellyethira* sp 1	Caddis Fly			1			1
Leptoceridae	*Oecetis* sp 1	Caddis Fly	2	1	3	6		6
Leptoceridae	*Triaenodes* sp 1	Caddis Fly						11
Leptoceridae	*Triplectides* sp1	Caddis Fly						1
Total Number			201	207	219	231	211	212
Number of Species/Types	58		16	20	22	30	17	33

Diversity and Abundance of Macroinvertebrates

Diversity of macroinvertebrate taxa (Shannon index) was highest at the three sites located on Maud Creek (Figure 3-2). This is to be expected, as the sites sampled on Gold Creek would be dry or reduced to small pools during the late dry season and sites on Gold Creek also appear to be subjected to higher levels of disturbance and stock impacts. The highest diversity of aquatic macroinvertebrates was recorded at Aq6 on Maud Creek downstream of the Gold Creek confluence. Based on general qualitative observations during the survey period this site displayed lower levels of disturbance from cattle and swamp buffalo when compared to other sites in the vicinity of the lease area. Site Aq6 also displayed less flood damage than the site located lower in the Maud Creek system (Aq4). The two sites that displayed the least amount of disturbance by swamp buffalo and stock during the surveys (Aq4 and Aq6) and had corresponding low levels of turbidity (NTU 2-3) and recorded the highest macroinvertebrate diversity. Lowest diversity of macroinvertebrates was recorded at Aq5 and Aq1 on Gold Creek (Figure 3-2). The site with the most significant impacts related to swamp buffalo disturbance (Aq5) recorded the lowest macroinvertebrate diversity. Across the sites the aquatic Diptera (true flies) and Coleoptera (aquatic beetles) were the richest groups in samples.

Abundances of macroinvertebrates within samples were low to moderate and in most cases a high percentage or all subsamples had to be sorted to obtain 200 specimens. Martin (1996) also reported low abundances of macroinvertebrates in samples collected in Maud Creek. Very low numbers of water mites (Acarina) were present in samples. Insect groups dominated the macroinvertebrate fauna at all sites and the Diptera (true flies) and Ephemeroptera (mayflies) were numerically abundant in samples. The mayflies of the family Caenidae (*Tasmanocoensis*) were common at most of the sites sampled. Aquatic dipteran taxa in the families Chironomidae and Ceratopogonidae were also relatively numerically abundant in samples.

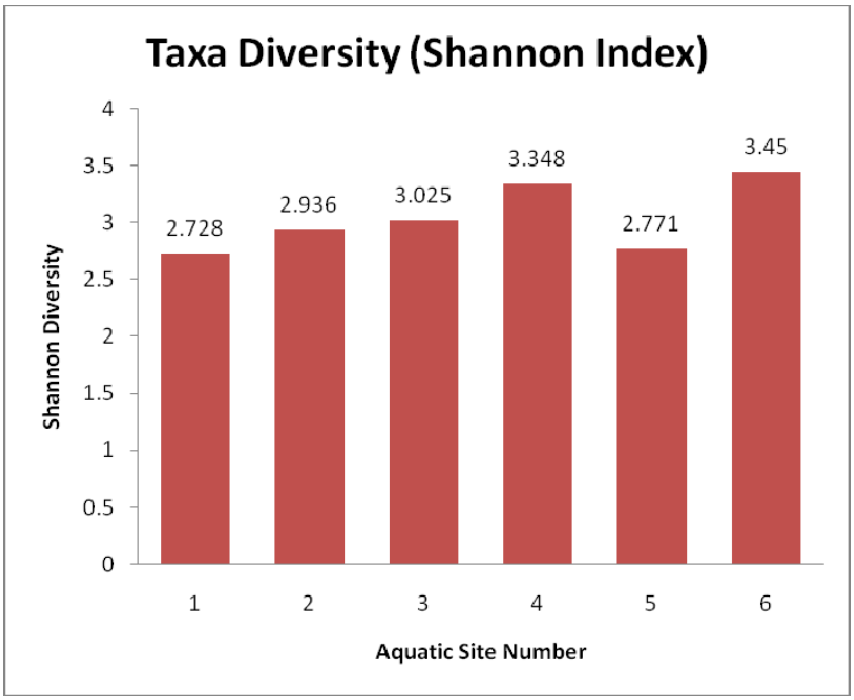

Figure 3-2. Macroinvertebrate Taxa Diversity (Shannon Index)

Community Similarity

Macroinvertebrate community similarity was determined using Bray – Curtis group average similarity (Figure 3-3). An MDS plot of this data is presented in Figure 3-4: a smaller distance between sites in the plot indicates a greater level of community similarity. All sites had relatively high levels of macroinvertebrate community similarity, with greater than 50% overlap in taxa composition based on Bray – Curtis group average similarity. Sites on Gold Creek (Aq1, Aq2 and Aq5) and the most significantly stock impacted site on Maud Creek (Aq3) also displayed relatively high levels of community similarity (>65%) (Figure 3-3).

Site Aq1 and Aq2 are located within areas of the study area that have been subjected to past disturbance and are impacted by the presence of swamp buffalo and other stock, and are typical of the mid to lower section of Gold Creek. These two sites supported relatively similar macroinvertebrate communities based on Bray – Curtis similarity (>65% similarity) (Figure 3-3). The macroinvertebrate community recorded at Aq3 on Maud Creek was most similar to that recorded at Aq5 based (~70% similarity) (Figure 3-3). Site Aq5 and Aq3 showed the highest level of impacts from stock of any of the sites sampled. Sites located on the lower reaches of Maud Creek (Aq4, Aq6) displayed lower levels of community similarity with the sites located in the vicinity of the lease, and each other, as indicated by the MDS plot of the similarity data (Figure 3-4).

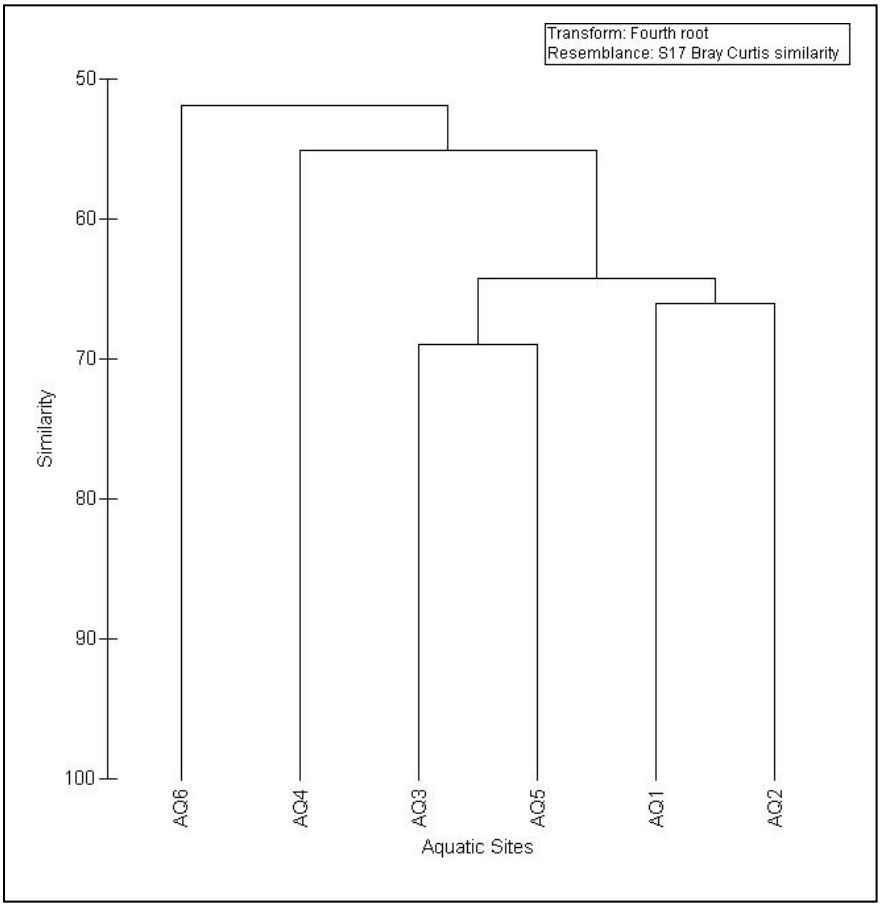

Figure 3-3. Group average Bray-Curtis Similarity based on macroinvertebrate communities

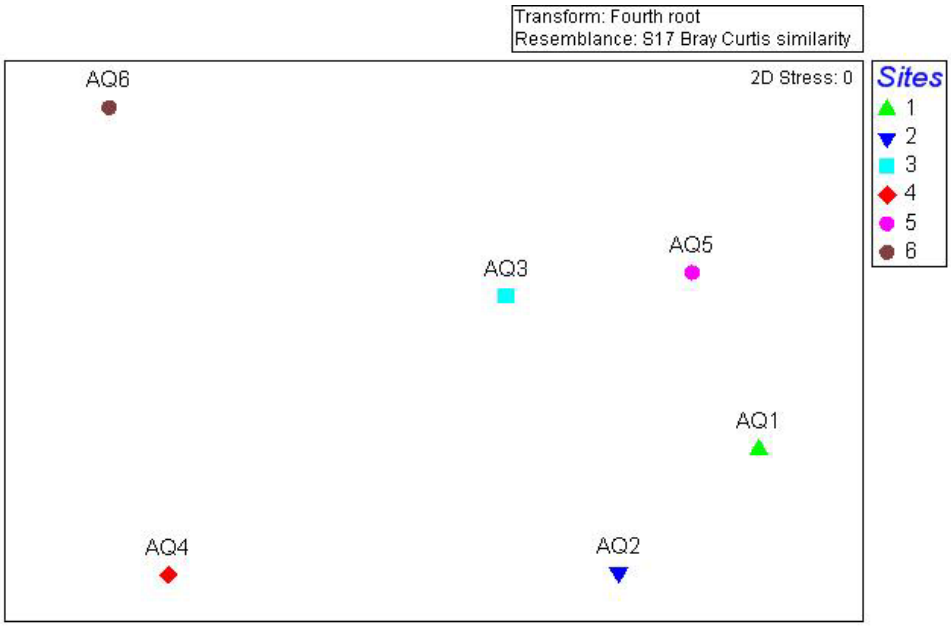

Figure 3-4. MDS plot based on group average Bray-Curtis Similarity of macroinvertebrate communities

AUSRIVAS Model Results

The AUSRIVAS banding scheme is included in Table 3.3. Results from the AUSRIVAS Darwin – Daly early edge model for the sample sites are presented in Table 3-4 and Figure 3-5. In general the ratio of observed to expected taxa (O/E) and band width results indicate that the majority of the sites sampled are ‘’significantly impaired”. Only one site (Aq6 on Maud Creek) fell within the A bandwidth (O/E = 1.03) indicating that this site is similar to reference condition. The impaired instream conditions in the vicinity of the mining lease and adjacent areas are likely to be related to impacts from stock (particularly swamp buffalo) and other disturbance associated with past land use. The impaired conditions at Aq4 on lower Maud Creek are likely to be related to recent flooding events, and it is expected that in the absence of other factors this site could recover with time and regain reference condition (band A).

Site Aq1 and Aq2 are located within areas of the study area that have been subjected to past disturbance and are impacted by the presence of swamp buffalo and other stock. Site Aq1 is adjacent to an existing mine pit. These sites are typical of the central and downstream component of Gold Creek within the study area. Macroinvertebrate results reflect the poor instream conditions at these sites relative to reference sites, with a number of expected taxa absent. The results fall within the “significantly impaired” B bandwidth (O/E = 0.79 at Aq1, O/E = 0.74 at Aq2) in the AUSRIVAS model (Table 3-3) indicating that these sites have index values below the 10^{th} percentile of reference sites.

Site Aq3 is located on Maud Creek upstream of the Gold Creek confluence. This site displayed significant disturbance from swamp buffalo and cattle, with large areas of bankside erosion and loss of fringing riparian vegetation. The results for Aq3 fall within the “significantly impaired” B bandwidth (O/E = 0.79) in the AUSRIVAS model (Table 3-3).

Site Aq4 is located on Maud Creek upstream of the Katherine River confluence. This site displayed low levels of disturbance from stock and human activity, however the results for this site fall within the “significantly impaired” B bandwidth (O/E = 0.75) in the AUSRIVAS model (Table 3-3). The poor result at this site may be partly influenced by diffuse sources higher in the catchment (e.g. land clearing for agricultural development), however it is more likely that this band score is related to the significant degree of flood damage and sediment deposition from wet season flooding events. The position of this site at the lowest end of the Maud Creek catchment suggest that the damage to macroinvertebrate communities and habitats from flooding and sediment inflows is more severe than for sites higher in the catchment, requiring a longer recovery period.

Site Aq5 is located on Gold Creek upstream of the existing pit area. The low O/E taxa score (Figure 3-5) at this site indicates poor instream conditions relative to reference sites. The results for Aq5 fall within the “significantly impaired” B bandwidth (O/E = 0.74) in the AUSRIVAS model (Table 3-3). Significant numbers of swamp buffalo were observed in the vicinity of this site, and damage associated with their wallowing behavior is extensive on this section of Gold Creek.

Site Aq6 is located on Maud Creek downstream of the confluence with Gold Creek. During the survey this site was characterised by intact riparian vegetation and low levels of impact from stock. The results for macroinvertebrates fall within the “similar to reference” A bandwidth (O/E = 1.03) in the AUSRIVAS model (Table 3-3) indicating that the site expected/observed taxa score is within the range of the central 80% of reference sites. This site had the highest O/E taxa score of any site sampled during the survey (Figure 3-5).

Table 3-3

The AUSRIVAS Banding Scheme (Lamche 2007)

Band	Description	O/E Taxa	O/E Taxa Interpretations
X	More biologically diverse than reference	O/E Greater than 90th percentile of reference sites used to create the model	More families than expected. Potential biodiversity "hotspot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream
A	Similar to Reference	O/E within the range of central 80% of the reference sites used to create the model	Expected number of families within the range found at 80% of the reference sites
B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact either on water and/or habitat quality resulting in a loss of families
C	Severely Impaired	O/E below band B. Same width as Band A	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality
D	Extremely Impaired	O/E below band C down to zero	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

Table 3-4

AUSRIVAS Macroinvertebrate Band and O/E Taxa Results, Darwin - Daly Early Edge Model

Site	O/E Taxa Score	Overall Site Assessment Band	Band Description	O/E Taxa	O/E Taxa Description
Aq1 Gold Ck adjacent to existing pit	0.79	B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact on water and/or habitat quality resulting in a loss of macroinvertebrate families
Aq2 Gold Ck upstream of the Maud Ck confluence	0.74	B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact on water and/or habitat quality resulting in a loss of macroinvertebrate families
Aq3 Maud Ck approx. 1400 m upstream of the Gold Creek confluence	0.79	B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact on water and/or habitat quality resulting in a loss of macroinvertebrate families
Aq4 Maud Ck lower section approx. 300m upstream of the Katherine River	0.75	B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact on water and/or habitat quality resulting in a loss of macroinvertebrate families
Aq5 Gold Ck approx. 350m upstream of the mine area on Gold Creek	0.74	B	Significantly Impaired	O/E below the 10th percentile used to create the model	Potential impact on water and/or habitat quality resulting in a loss of macroinvertebrate families
Aq6 Maud Ck approx. 1500 m downstream of the Gold Creek confluence	1.03	A	Similar to reference	O/E within the range of central 80% of reference sites used to create the model	Expected number of families within the range found at 80% of the reference sites

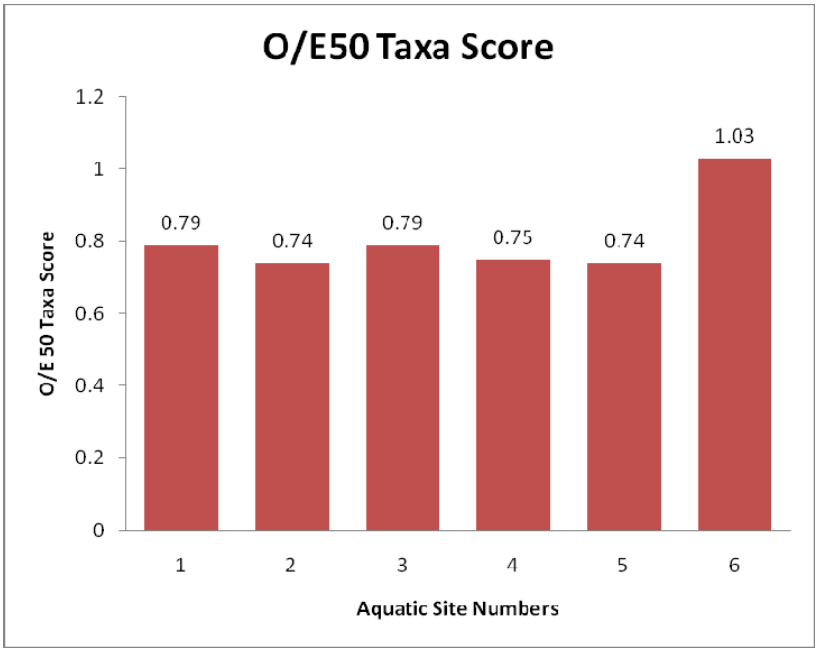

Figure 3-5. Observed/Expected (O/E50) Taxa Scores: AUSRIVAS Darwin – Daly Early Edge Model

3.4. Aquatic Macrophytes

Aquatic vegetation was absent at most sites with the exception of small patches of sedges and beds of charophytes (*Chara spp*) on sections of Gold Creek within the lease area. A small area of rushes (*Juncus spp*) was located at the upstream end of the reach sampled at Aq5. The ephemeral nature the local drainage systems, in combination with significant wet season flooding and sediment deposition, has created conditions that are not conducive to the development of stable beds supporting dense instream macrophytes.

3.5. Other Semi-aquatic Vertebrates

Only small numbers of semi-aquatic vertebrates were observed during the survey. Freshwater crocodiles (*Crocodylus johnstoni*) are common in the Katherine River system and this species was identified at permanent waterholes on Maud Creek during helicopter surveys (Martin 1996). Signs indicating the presence of freshwater crocodiles were identified at two sites on Maud Creek (Aq3 and Aq6). Habitats on Maud Creek are less suitable for estuarine crocodiles (*Crocodylus porosus*) however this species potentially occurs in the lower reaches of the Maud Creek system.

Freshwater turtles have also been reported to occur in Maud Creek (Martin 1996) however none were sighted during the current survey. The absence of large expanses of permanent water in Maud Creek near the lease area and on Gold Creek suggests that aquatic reptiles such as turtles and crocodiles would only be expected to occasionally enter the lease area during the wet season (Martin 1996). Water rats (*Hydromys chrysogaster*) were observed on Gold Creek during the survey period and signs and tracks of this species were recorded on the margins of Maud Creek and Gold Creek at several locations.

4. Discussion

The freshwater fishes recorded during the current and previous surveys (Martin 1996) are not listed as threatened in legislation. The species occurring in Maud Creek are all common and widespread forms that are well adapted to the variable instream conditions that characterise the system (Martin 1996). A search of the EPBC protected matters data base for the Katherine region (URS 2006) returned a record for freshwater sawfish (*Pristis microdon*), a species that is listed as threatened under the Commonwealth *EPBC Act 1999*. Suitable habitat for this species is unlikely to occur within the study area and the presence of this species in adjacent areas of the Katherine River has not been confirmed, although it has been recorded in the Daly River (K. Martin pers comm. 2007 from D. Thorburn).

Analysis of the results of biological sampling within Maud Creek and Gold Creek at six sites indicate that only one site (Aq6) is similar to reference conditions based on AUSRIVAS O/E taxa bandwidth for the Darwin – Daly early edge model. All other sites indicate a level of significant biological impairment in comparison to reference sites. The main identifiable source of disturbance in relation to the sites in the vicinity of the lease area is swamp buffalo and other stock, particularly the wallowing behaviour and disturbance to riparian vegetation by swamp buffalo.

Results from sampling conducted on Gold Creek within the study area indicate that habitats in this system are 'significantly impaired' based on the AUSRIVAS Darwin – Daly early edge model. Disturbance from swamp buffalo, and to a lesser degree feral donkey, feral pig and cattle, appears to be a significant factor in the impairment of this stream. Increased turbidity, loss of riparian vegetation and bankside erosion were evident in areas where swamp buffalo congregate in significant numbers. It is also possible that past land use practices have contributed to the poor instream habitat quality on Gold Creek. There are no areas of this creek investigated during the current survey that would be considered to support high quality or significant instream habitat.

The principle ecological value of Maud Creek and Gold Creek in the vicinity of the lease area to aquatic fauna (e.g. freshwater fishes) is as a temporary feeding and growing habitat and a migration corridor through the wet season (Martin 1996). There are no introduced species of aquatic fauna known from Maud Creek or the Katherine River (Martin 1996), and a single introduced semi-aquatic species, the cane toad, occurs in the local area.

The proposed mining impacts will be limited to a relatively small area of the Gold Creek catchment and ore processing and other related activities will be undertaken off-site, indicating that overall impacts on local surface water habitats are likely to be localised. Local surface water quality in the Gold Creek catchment may improve in the medium term if sedimentation and erosion are controlled during the construction and operational phases and stock (particularly swamp buffalo) are removed from the lease area.

General management recommendations include:

- Results from the macroinvertebrate assessment indicate that the majority of the aquatic sites assessed on Gold Creek and Maud Creek in the vicinity of the lease area are significantly impaired. Where possible further impacts on these systems should be minimised to avoid further deterioration of their biological condition.
- Complete works activities associated with Gold Creek and undertake stabilisation works prior to the onset of the wet season;
- Maintain buffers to riparian vegetation where possible and establish measures to manage storm water and minimise erosion and sedimentation in works areas;
- Remove stock, particularly swamp buffalo, from the site to enable the recovery and regeneration of riparian areas and improve local surface water quality.

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Appendix 1 Site Photos

Site Area Gold Creek, adjacent to Maud Creek Mine	**Site Number** AQ1

Site Area Gold Creek Upstream of the Maud Creek Confluence	**Site Number** AQ2

Site Area Maud Creek Upstream of the Gold Creek Confluence	**Site Number** AQ3

Site Area Maud Creek Upstream of the Katherine River Confluence	**Site Number** AQ4

Site Area Gold Creek Upstream	**Site Number** AQ5

Site Area Maud Creek Downstream of the Gold Creek Confluence	**Site Number** AQ6

Appendix 2 Aquatic Site Habitat Data

Summary of habitat data collected using standard data collection protocol for the Draft Darwin – Daly AUSRIVAS model (Appendix 1 in Lamche 2007). A detailed description of the habitat and other parameters recorded during field sampling is included in Lamche (2007). All data refers to a 100m reach established at each sample location. Highlighted rows indicate predictor variables for the AUSRIVAS Darwin – Daly Early/Edge Family Model.

Site Code	**AQ1**	**AQ2**	**AQ3**	**AQ4**	**AQ5**	**AQ6**
Tributary	Gold Creek	Gold Creek	Maud Creek	Maud Creek	Gold Creek	Maud Creek
Site Description						
Site, disturbance & Impacts	Moderate disturbance, stock impacts and mining activities. Vehicle tracks, fencing and soil sample pits. Road culvert downstream of reach.	Gold Creek near confluence of Maud Creek. Moderate disturbance and stock impacts.	Maud Creek upstream of Gold Creek confluence. Significant impacts from stock, including bank erosion and loss of riparian vegetation.	Little disturbance from stock. Significant impacts from wet season flooding.	Gold Creek upstream. Significant impacts from swamp buffalo, bank erosion and loss of riparian vegetation.	Maud Creek downstream of Gold Creek confluence. Minimal impacts from stock.
Site history and comments	Semi-natural creek. Site flows may be influenced by downstream culvert.	Deeply incised gully associated with cattle/buffalo access to the creek. Track crossing and clearing near reach.	Natural reach on Maud Creek. Side tributary upstream of reach.	Natural reach on lower Maud Creek. Very little intrusion by cattle.	Semi-natural creek. Significant buffalo impacts.	Natural reach of Maud Creek.
UTM Co-ordinates (MGA 94)	53 225456E 8401434N	53 225947E 8402476N	53 226919E 8401662N	53 220142E 8409004N	53 225228E 8400906N	53 225042E 8403692N
Water Quality Parameters						
Date & Time	07 May 2007 0915 hrs	08 May 2007 1115 hrs	08 May 2007 1455 hrs	09 May 2007 0900 hrs	09 May 2007 1500hrs	12 May 2007 1100hrs
pH	8.1	8.5	7.7	7.9	8.1	8.2
Electrical Conductivity (µScm)	876	796	185	195	919	278
Dissolved Oxygen (mg/L) (Field)	4.2	6.5	3.4	6.07	3.85	5.52
Turbidity NTU (Field)	6	12	5	3	231	3
Alkalinity (mg/L)	429	392	80	85	445	123
CO^3 (mg/L)	12	26	<1	<1	7	<1
TKN (mg/L)	0.39	0.27	0.29	0.16	0.46	0.24
Total P (mg/L)	0.015	0.015	0.015	0.01	0.025	0.015

Site Code	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6
Tributary	Gold Creek	Gold Creek	Maud Creek	Maud Creek	Gold Creek	Maud Creek
Water Temp (°C) (Field)	23.5	24.4	29.9	22.9	31.5	24.3
Physical Characteristics						
Macroinvertebrate Sampling Edge Habitat Macroinvertebrate Sample Site (10m length sampled)	10m length sampled, 0.30m sampling depth, 20% fine organics, mud, muck, 10% coarse organics, sticks, leaves.	10m length sampled, 0.30m sampling depth, 2% fine organics, mud, muck, 8% coarse organics, sticks, leaves.	10m length sampled, 0.30m sampling depth, 5% fine organics, mud, muck 2% coarse organics, sticks, leaves.	10m length sampled, 0.30m sampling depth, 2% fine organics, mud, muck, 2% coarse organics, sticks, leaves.	10m length sampled, 0.30m sampling depth, 15% fine organics, mud, muck, 5% coarse organics, sticks, leaves.	10m length sampled, 0.30m sampling depth, 2% fine organics, mud, muck, 5% coarse organics, sticks, leaves.
Substrate	50% sand, 50% silt/clay.	10% pebbles/gravel, 80% sand, 10% silt/clay.	5% Cobbles, 10% pebbles/gravel, 50% sand, 35% silt/clay.	3% Cobbles, 5% pebbles/gravel, 90% sand, 2% silt/clay.	5% pebbles/gravel, 55% sand, 40% silt/clay.	20% cobbles, 20% pebbles, 40% sand, 20% silt/clay.
Percentage coverage Riparian vegetation and macrophytes	10-35% algal cover, 10-35% overhanging vegetation, 10-35% trailing root vegetation.	35-65% overhanging vegetation.	10-35% overhanging vegetation.	35-65% overhanging vegetation.	35-65% overhanging vegetation.	35-65% overhanging vegetation.
Edge Description	Angled 45 - 90^{o}	Angled 45 - 90^{o}	Angled 45 - 90^{o}	Angled 45 - 90^{o}	Angled 45 - 90^{o}	Angled 45 - 90^{o}
Habitat Features						
Flow Velocity	No detectable flow	90cm/min	No detectable flow	15cm/min	10cm/min	110cm/min
Stream Width (m) At water level: Three measurements upstream and three measurements downstream of the macroinvertebrate sampling site	10.8, 9.9, 13.6. 10.8, 9.7, 7.9	6.6, 7.5, 8.8, 6.2, 6.6, 7.3.	9.6, 14.2, 15.9, 17.5, 8.3, 5.6.	25.6, 14.6, 12.6, 16.4, 18.3, 23.8.	2.2, 5.5, 3.2, 3.2, 2.1, 4.5.	14.4, 13.1, 11.4, 14.0, 9.4, 16.6
Habitats within 100m reach (Estimated % habitat components looking from above)	90% sand/silt bed, 5% snags, 4% macrophytes, 1% gravel/rock bed	90% sand/silt bed, 5% snags, 5% gravel/rock bed.	90% sand/silt bed, 5% snags, 5% gravel/rock bed.	95% sand/silt bed, 3% snags, 2% gravel/rock bed.	90% sand/silt bed, 5% snags, 5% gravel/rock bed.	90% sand/silt bed, 8% snags, 2% gravel/rock bed.
RIP 500 Values (Riparian Rainforest in a 500m Radius)	0	0	0	0.025456753	0	0
Habitat (Riffle, Run or Pool) % of total area of 100m reach	100% pool	70% pool and 30% riffle	100% pool	100% pool	100% pool	100% pool
Width between top of levee banks (Bankfull width)	14.5m	12.9m	38.5m	37.6m	24m	39.1m

Site Code	**AQ1**	**AQ2**	**AQ3**	**AQ4**	**AQ5**	**AQ6**
Tributary	Gold Creek	Gold Creek	Maud Creek	Maud Creek	Gold Creek	Maud Creek
Width between immediate stream banks (if different from bankfull width)	11.8m	10.8m	27.5m	29.3m	10m	17.7m
Height of Levee Bank from water surface	1.4m	4.6m	6.5m	7m	4.2m	9.1m
Riparian Zone Width (Left Bank) Facing Downstream	19.3m	11.8m	12.9m	16.4m	5.5m	7.7m
Riparian Zone Width (Right Bank) Facing Downstream	14.0m	12.6m	13.5m	18.0m	6.7m	16.8m
Flow Level (Relative to normal dry season flow, if known. Normal inundation level marked by limit of terrestrial grass or by eroded area, or boundary in bank sediment types). Low, Moderate, High, Flood	low	low	low	low	low	low
Riparian Vegetation						
Vegetation cover of river (Estimation of shade on river at midday, average values for left and right banks)	26-50% vegetation cover of river, 25% *Lophostemon grandiflorus* >10m, 25% *Melaleuca* <10m, 80% pasture grass & spear grass. 95% native vegetation, 5% exotic vegetation.	26-50% vegetation cover of river, 15% *Lophostemon grandiflorus* >10m, 15% trees <10m, 45% shrubs/vines, 45% grasses/ferns/sedges. 80% native vegetation, 20% exotic vegetation. Weeds: *Hyptis suaveolens*, *Calotropis procera* and *Senna obtusifolia*	6-25% vegetation cover of river, 5% *Lophostemon grandiflorus* >10m, 2% *Ficus spp* <10m, 10% juvenile *Lophostemon grandiflorus.* 95% native vegetation, 5% exotic vegetation. Weeds: *Hyptis suaveolens, Echinochloa colona*	6-25% vegetation cover of river, 5% Eucalyptus, Melaleuca >10m, 5% *Lophostemon grandiflorus* , Melaleuca <10m, 1% Melaleuca. 100% native vegetation.	26-50% vegetation cover of river, 5% *Lophostemon grandiflorus* >10m, 25% *Lophostemon grandiflorus* <10m, 2 % juvenile *Lophostemon grandiflorus* , 5% *Juncus spp* 100% native vegetation.	51-75% vegetation cover of river, 40% *Melaleuca spp, Lophostemon grandiflorus* >10m, 10% *Lophostemon grandiflorus, Melaleuca spp, Pandanus spp* <10m, 5 % juvenile *Lophostemon grandiflorus* , 5% *Juncus spp* 100% native vegetation.
Erosion in riparian zone	Bare ground above water mark on left and right banks, tree roots exposed on left and right banks, low local catchment erosion.	Bare ground above water mark on left and right banks, tree roots exposed on left and right banks, gully erosion on left and right banks, slumping banks on left bank and on right bank where cattle/buffalo have accessed creek, low to moderate local catchment erosion.	Bare ground above water mark on left and right banks, tree roots exposed on left and right banks. Wide areas of erosion on banks in reach area.	Bare ground above water mark on left and right banks, tree roots exposed on left and right banks, little local catchment erosion. Flood damage and significant sediment deposition from wet season floods.	Bare ground above water mark on left and right banks, tree roots exposed on left and right banks, gully erosion on both banks, moderate local catchment erosion.	Few signs of erosion in riparian zone.

Site Code	**AQ1**	**AQ2**	**AQ3**	**AQ4**	**AQ5**	**AQ6**
Tributary	Gold Creek	Gold Creek	Maud Creek	Maud Creek	Gold Creek	Maud Creek
Land use Left Bank (Facing Downstream)	grazing, mining (mine pit)	grazing	grazing	native woodland	grazing	National Park
Land use Right Bank (Facing Downstream)	grazing, mining	grazing	grazing	native woodland	grazing	National Park
Observations						
Water Odour (Normal, Sewage, Petrol/chem., Other)	Normal	Normal	Normal	Normal	Normal	Normal
Water Oils (None, Sheen, Slick, Globs, Other)	None	None	None	None	None	None
Foam/Scum (None, Pollen/Leaves, Algal Scum, Foam, Other)	None	None	None	None	None	None
Plume (Little, Some, Lots)	Little	Little	Little	Little	Little	Little
Sediment Oils (Absent, Light, Moderate, Profuse)	Absent	Absent	Absent	Absent	Absent	Absent
Sediment Odours (Normal, Sewage, Petrol/Chem., Anaerobic, Other)	Normal	Normal	Normal	Normal	Normal	Normal
Evidence of human impact (e.g. Litter, pipes, drains, concrete structures, damaged vegetation, campfires, boat and vehicle access)	Culvert downstream of reach. Adjacent to existing mine pit.	Track crossing upstream of site.	Track parallel with creek.	None recorded	None recorded	Old cattle yards ~150 m from site.

Appendix 3 Laboratory Water Quality Analysis Results

Parameter	pH	EC	Alkalinity	CO3	HCO3	OH	NO2_N	NO2	NO3_N	NO3	PO4_P	Total P	NH3_N	TKN
Units	units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
AQ1	8.1	876	429	12	417	<1	<0.005	<0.02	0.005	0.02	0.02	0.015	<0.005	0.39
AQ2	8.5	796	392	26	366	<1	<0.005	<0.02	<0.005	<0.02	0.015	0.015	<0.005	0.27
AQ3	7.7	185	80	<1	80	<1	<0.005	<0.02	<0.005	<0.02	0.01	0.015	0.005	0.29
AQ4	7.9	195	85	<1	85	<1	<0.005	<0.02	0.005	0.02	0.01	0.01	0.01	0.16
AQ5	8.1	919	445	7	438	<1	0.005	0.02	<0.005	<0.02	0.025	0.025	0.08	0.46
AQ6	8.2	278	123	<1	123	<1	<0.005	<0.02	<0.005	<0.02	0.01	0.015	<0.005	0.24