Biting Insect Assessment Andranangoo Creek West & Lethbridge Bay West Mining Prospects, Tiwi Islands.


January 2007

Study undertaken on behalf of URS Australia Pty Ltd for Matilda Minerals Ltd

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1.0 Background

A biting insect assessment was conducted at the Andranangoo Creek West and Lethbridge Bay West mining prospects from the 29th September to the 1st of October 2005. This included detailed ground surveys for actual and potential mosquito breeding sites, assessment of aerial photography for potential mosquito and biting midge breeding sites, and initial adult biting insect trapping at both mining prospects.

The report ‘Biting Insect Assessment Andranangoo Creek West & Lethbridge Bay West Mining Prospects, Tiwi Islands (Warchot & Whelan 2005) was produced early upon request by the Environmental Consultants URS Australia Pty Ltd, to allow information from the biting insect investigation to be available for reproduction in the Environmental Impact Statement for this mining project. The detailed report highlighted the findings of the initial assessment, with conclusions and recommendations provided based on the findings (Warchot & Whelan 2005). The early report production meant that information from subsequent peak season adult biting insect trapping in November 2005, and January and May 2006 had to be produced in a separate supplementary report. Therefore some conclusions in the first report were drawn based on field inspections and desktop observations, and not on trap data. The following report highlights the findings of the supplementary trapping, with new conclusions in regards to mosquitoes and biting midges. Trapping conducted for the Andranangoo Creek West and Lethbridge Bay West Biting Insect Assessment Report (Warchot & Whelan 2005) is referred to as ‘initial trapping’ in this supplementary report.

2.0 Methods

Methods for the initial investigation are provided in the initial biting insect assessment report (Warchot & Whelan 2006). Adult biting insect traps for the supplementary trapping were set by Dennis McCamish from Matilda Minerals Ltd on the afternoons one night before the full moon on the nights of November 1st 2005, January 13th 2006 and May 12th 2006, and collected the following mornings. During the supplementary trapping in November 2005 and January and May 2006, two traps were set at each mining prospect, at traps sites utilised during the 29th September to 1st October 2005 initial trapping. The trap sites chosen were:

- Trap Site 1 – Andranangoo Creek West. North edge of Andranangoo Creek West reed swamp, adjacent to NW arm of swamp.
- Trap Site 3 – Andranangoo Creek West. Approximately 50m north of construction camp, in Eucalypt woodland.
- Trap Site 5 – Lethbridge Bay West. In Paperbark forest northwest edge of proposed mining area, adjacent to northwest edge of extensive mudflat.
- Trap Site 7 – Lethbridge Bay West. In Eucalypt open woodland near proposed construction camp.

Only two trap sites from each mining prospect were utilised during the supplementary trapping, instead of the four trap sites that were utilised at each prospect during the initial trapping in late September/early October 2005. This was due to logistical reasons, as the travel time by road between the Andranangoo Creek West and Lethbridge Bay West mining prospects meant that only two traps could effectively be set at each mining prospect on any one night. Therefore the trap sites chosen were those that would best reflect potential biting insect problems in the mining prospects, with one trap set adjacent to the largest potential mosquito breeding sites at each mining prospect, and one trap set adjacent to the construction camp sites at each mining prospect.

Traps were set one night before the full moon in an effort to locate peak monthly abundance of pest biting midge species and monthly mosquito activity.
Dry ice for the biting insect traps was dropped off by MEB to Direct Air at Darwin International Airport in a foam esky, which was then transported to Melville Island via light aircraft. The ice was collected from an airstrip on Melville Island by Dennis McCamish. After collection, trap containers were transported inside an esky to an airstrip for transport back to Darwin, and the esky was placed inside a freezer at Direct Air until collection by MEB. Traps were then processed at the MEB laboratory in Darwin (refer to the Andranangoo Creek West and Lethbridge Bay West Biting Insect Assessment Report for further details).
3.0 Results

3.1 Supplementary biting midge trapping

3.1.1 Species present
Trap locations are shown in Figure 1, with results shown in Tables 1-4. A total of 2,996 female biting midges were collected during trapping in November 2005, and January and May 2006, representing 12 different species (Table 4). The most abundant species was Culicoides ornatus, accounting for 41.4% of all biting midges trapped, followed by Culicoides bundyensis (22.4%), Culicoides narrabeenensis (9.6%), Culicoides marksi (6.8%), Culicoides undescribed sp. No. 6 (6.1%), and Culicoides austropalpalis (6%). Other biting midge species were recorded in very low numbers.

3.1.2 Spatial abundance (Table 4)
Trap Site 7 recorded the most biting midges during the trapping, accounting for 45% of all biting midges trapped, followed by Trap Site 1 (39.6%), Trap Site 5 (11.7%) and Trap Site 3 (3.7%).

Culicoides ornatus was most abundant at Trap Site 1, with a total of 803 females collected during trapping at this site. This was followed by Trap Site 7 (213), Trap Site 5 (109) and Trap Site 3 (16).

Culicoides marksi, Culicoides undescribed sp. No. 6, Culicoides bundyensis, Culicoides austropalpalis and Culicoides narrabeenensis were most abundant at Trap Site 7, with minor numbers at the other trap sites.

3.1.3 Seasonal abundance (Tables 1-3)
The May 2006 trap results revealed significantly higher overall biting midge numbers compared to November 2005 and January 2006. Culicoides ornatus, Culicoides marksi, Culicoides undescribed species No. 6, Culicoides, Culicoides austropalpalis, Culicoides narrabeenensis and Lasiohelia sp. were all recorded in highest numbers in May 2006. Very low numbers of biting midges were recorded in November and January (Tables 1 & 2).

3.2 Supplementary mosquito trapping
Trap locations are shown in Figure 1. Results are shown in Tables 5-8.

3.2.1 Species present

November 2005 (Table 5)
The November trap results revealed extreme numbers of Aedes vigilax at Trap Site 1 (1952 females), with high numbers at Trap Site 5 (807) and Trap Site 7 (634), and minimal numbers at Trap Site 3 (13). Aedes vigilax accounted for 85% of all mosquitoes trapped during November. The next most abundant species in November was Anopheles hilli, with a high of 122 females collected at Trap Site 1, with low numbers collected at Trap Site 5 (54) and minimal numbers collected at Trap Sites 7 (30) and Trap Site 3 (1), which accounted for 5% of all mosquitoes trapped during November.

Culex sitiens was the third most abundant species during November, accounting for 3% of all mosquitoes trapped, with highest numbers at Trap Site 1 (56), followed by Trap Site 5 (51) and Trap Site 7 (16), with nil recorded at Trap Site 3. Culex annulirostris was the fourth most abundant species, accounting for 2.6% of all mosquitoes trapped during November, with highest numbers recorded at Trap Site 1 (44), followed by Trap Site 5 (39), Trap Site 7 (20) and Trap Site 3 (2). This was followed by Anopheles farauti s.l., which accounted for 1.6% of all mosquitoes trapped during November. Highest numbers of An. farauti s.l. were recorded at Trap Site 5 (30), followed by Trap Site 1 (22) and Trap Site 7 (13).
January 2006 (Table 6)
The most abundant mosquito species trapped during the January trapping was *Aedes vigilax*, accounting for 85% of all mosquitoes trapped. Highest numbers of this species was recorded at Trap Site 5 (795), followed by Trap Site 7 (499), Trap Site 1 (331) and Trap Site 3 (275). The next most abundant species was *Anopheles farauti s.l.*, which accounted for 7% of all mosquitoes trapped during January, with highest numbers recorded at Trap Site 1 (68), followed by Trap Site 7 (52), Trap Site 5 (25) and Trap Site 3 (10). *Culex annulirostris* and *Culex sitiens* were the next most abundant species, accounting for 2.9% and 2% respectively of all mosquitoes trapped during January.

May 2006 (Table 7)
The most abundant mosquito species trapped during May was *Mansonia uniformis*, which accounted for 37.3% of all mosquitoes trapped. This was mainly due to very high numbers recorded at Trap Site 1 (1381), with minor numbers recorded at Trap Site 3 (59), Trap Site 7 (12) and Trap Site 5 (10). The next most abundant species was *Anopheles farauti s.l.*, which accounted for 36.8% of all mosquito species trapped, with highest numbers at Trap Site 1 (1273), followed by Trap Site 7 (82), Trap Site 5 (66) and Trap Site 3 (22).

*Culex annulirostris* was the third most abundant species, accounting for 6.3% of all mosquitoes trapped during May, with highest numbers at Trap Site 7 (164), followed by Trap Site 1 (54), Trap Site 5 (26) and Trap Site 3 (5). *Coquillettidia xanthogaster* was the next most abundant species, accounting for 6.2% of all mosquitoes trapped during May, with highest numbers at Trap Site 7 (120), followed by Trap Site 3 (52), Trap Site 1 (43) and Trap Site 5 (28). This was followed by *Anopheles bancroftii*, which accounted for 5.7% of all mosquito species trapped, with highest numbers at Trap Site 1 (151), followed by Trap Site 7 (41) and Trap Site 5 (33). Other mosquito species were recorded in relatively low numbers.

3.2.2 Spatial abundance (Table 8)
Trap Site 1, located adjacent to the large reed swamp associated with Andranangoo Creek, recorded significantly more mosquitoes compared to the other trap sites, recording 57% of all mosquitoes trapped. The next most productive trap site was Trap Site 5, recording 20% of all mosquitoes trapped, followed by Trap Site 7 (18%) and Trap Site 3 (5%).

*Aedes vigilax* was recorded in very high overall numbers at Trap Site 1, although high overall numbers were also recorded at Trap Sites 5 & 7, with moderate numbers at Trap Site 3. *Anopheles farauti s.l.* and *Mansonia uniformis* were both recorded in very high overall numbers at Trap Site 1, with relatively low numbers at the other trap sites. *Anopheles bancroftii* was recorded in highest numbers at Trap Site 1, with minor numbers at the other trap sites, *Cq. xanthogaster* was recorded in highest numbers at Trap Site 7, with minor numbers at the other trap sites, *Cx. sitiens* was recorded in highest numbers at Trap Sites 1 & 5, with very low numbers at the other trap sites. *Anopheles hilli* was recorded in highest numbers at Trap Site 1, with minor numbers at the other trap sites, *Cx. annulirostris* was recorded in highest numbers at Trap Sites 7 & 1, with minor numbers at the other trap sites, and *Verrallina funerea* was recorded in highest numbers at Trap Site 1, with very low numbers at Trap Site 5.

3.2.3 Seasonal abundance (Tables 5-8)
*Aedes vigilax* was most abundant in November, with a total of 3,406 females collected at the four trap sites (Table 5). This was followed by January, with 1,900 females collected at the four trap sites, and May, with 39 females collected at the four trap sites (Tables 6 & 5 respectively).

*Anopheles farauti s.l.* was most abundant in May, with a total of 1,443 females collected at the four trap sites (Table 7). This was followed by January, with 155 females collected at the four trap sites (Table 6). Lowest numbers of this species were recorded in November, with a total of 65 females collected at the four trap sites (Table 5).
Mansonia uniformis was most abundant in May, with a total of 1,462 females collected at the four trap sites. This species was virtually absent during January, with only 3 females collected at the four trap sites (Table 6), and was virtually absent in November, with only 1 female collected at the four trap sites (Table 5).

Other important mosquito species were recorded in relatively low numbers, although still showed seasonal variation. Culex annulirostris was most abundant in May, Anopheles bancroftii was only recorded in May, Anopheles hilli was most abundant in November, Culex sitiens was most abundant in November, and Ve. funerea was most abundant in January.
4.0 Discussion

4.1 Biting midges

4.1.1 Species present

There were three biting midge species collected that were of potential pest significance, *Culicoides ornatus*, *Culicoides marksi* and *Lasiohelia* sp. These species were also collected during initial trapping (Warchot & Whelan 2005). *Culicoides ornatus* was the most important pest biting midge species trapped at the Andranangoo Creek West and Lethbridge Bay West prospects, as *C. ornatus* is a widespread species that has caused major problems throughout coastal areas of northern Australia and along the east coast of Queensland (Shivas and Whelan 2001). *Culicoides marksi* and *Lasiohelia* sp. are also known human biters but have not been implicated as serious pest species in the Northern Territory. For further information on common biting midge species in the NT, please refer to Appendix 1.

4.1.2 Probable breeding sites

Probable breeding sites for *C. ornatus*, *C. marksi* and *Lasiohelia* sp. were described in detail in the initial Biting Insect Assessment report for this mining project. Based on the November 2005, and January and May 2006 trap results, the most important *C. ornatus* breeding site affecting the Andranangoo Creek West prospect will most likely be the upper reaches of small tidal tributaries in Andranangoo Creek (Figure 1), with the upper tidal reaches of the small creek to the west of the Andranangoo Creek West prospect also likely to contain breeding sites for this species. The most important *C. ornatus* breeding site affecting the Lethbridge Bay West prospect is likely to be the upper reaches of the small tidal creek to the east of the prospect area (Figure 2).

*Culicoides marksi* was almost solely recorded at Trap Site 7 in May 2006, which was located at the proposed construction camp site at the Lethbridge Bay West prospect area. This species breeds at the edges of freshwater lakes and streams. The adjacent large brackish swamp, in the upper reaches where seasonal stream flows occur, was the most likely source of this species. Initial trapping results revealed moderate numbers at Trap Site 3, indicating the Andranangoo Creek reed swamp to the east of the Andranangoo Creek West prospect area is also a potential breeding site for this species.

*Lasiohelia* sp. was recorded in very low numbers at all sites, indicating minor breeding sites for this species existed nearby to all trap sites. The breeding sites for most Australian *Lasiohelia* sp. are unknown, although some species are thought to breed in damp, surface-terrestrial environments, which can include patches of tropical rainforest, and general vegetation ranging from wet-sclerophyll forest to open grassland (Debenham 1983). *Lasiohelia* larvae have previously been collected on habitats such as mosses, algae on rocks, soil and wet wood (Debenham 1983). In the NT, *Lasiohelia* sp. have been recorded from monsoon vine forests (Whelan et al 1997c). The development site contains areas of monsoon vine forest, which probably contain small breeding sites for some *Lasiohelia* species.

4.1.3 Spatial abundance and dispersal

*Culicoides ornatus* was recorded in moderate numbers at Trap Site 1, which was located approximately 1km from the nearest areas of significant mangroves associated with Andranangoo Creek (Figure 1). *Culicoides ornatus* are found in highest numbers from 1 to 1.5km from the mangrove margin, with high numbers up to 2km inland from the mangrove margin and dispersal up to 3.5km from the mangrove margin (Shivas and Whelan 2001). Trap Site 3 recorded very low numbers of *C. ornatus*, which reflected the distance of this trap site from the nearest mangrove margin, located approximately 3km to the east and west of this trap site (Figure 1). The trap results revealed that the highest numbers of *C. ornatus* at the Andranangoo Creek West prospect would occur within 1.5km of the mangrove margin, with elevated numbers up to 2km from the mangrove margin.
Trap Site 7, at the Lethbridge Bay West prospect, recorded low numbers of *C. ornatus* during the trapping, with minor numbers recorded at Trap Site 5. The source of this species to Trap Site 7 was most likely the upper tidal reaches of the small mangrove creek located approximately 1.5km to the east of the trap site. The source of this species to Trap Site 5 could have been the same upper tidal reaches of the small tidal creek, located approximately 2.5km to the east of the trap site, with minor breeding sites potentially associated with the mangrove areas at the mouth of the large swamp. The trap results revealed that this species is likely to be present throughout the Lethbridge Bay West mining prospect.

*Culicoides marksi* was mainly recorded at Trap Site 7 during the supplementary trapping, although this species was recorded in moderate numbers at Trap Site 3 during initial trapping. Little information is known about the dispersal characteristics of this species, although initial trapping at the Andranango Creek West prospect area indicates *C. marksi* can disperse at least 1km from their breeding sites. Therefore it can be expected that this species will be most common within at least 1km of the large swamps at both prospects.

*Lasiohelia* sp. was only recorded in very low numbers at all trap sites. Little information is known about the spatial abundance and dispersal characteristics of *Lasiohelia* species in Australia, although Reye (1992) states that the pest range of *Lasiohelia townsvillensis* appears to be around 50 metres unless the breeding area is large and productive, so it is possible that *Lasiohelia* sp. at both prospects will be most abundant within 50m of their breeding sites.

### 4.1.4 Seasonal abundance

Peak season *Culicoides ornatus* abundance generally occurs in the months of August to November (Shivas & Whelan 2001). A smaller peak in abundance also occurs in the early dry season (April and May) (Shivas & Whelan 2001). Lowest numbers are usually encountered in the wet season and mid dry season, due to lower landward dispersal (Shivas & Whelan 2001). In some areas of Darwin Harbour, two peaks in *C. ornatus* numbers occur over a 4 day period during the full and new moons, the first peak resulting from females leaving the mangrove foreshore (*Sonneratia*) breeding sites, and the second peak occurring four days later resulting from females leaving the upper tidal creek breeding sites (Shivas and Whelan 2001). The presence of two waves of dispersing females results in heightened midge levels for at least 6 days in each fortnight (Shivas and Whelan 2001).

The supplementary trap results revealed highest numbers of *C. ornatus* in May, with very low numbers in November and January. The low numbers collected in January was expected, due to lower emergence of *C. ornatus* during the wet season (Shivas 1999).

The low numbers in the month of November were unusual as it was expected that November would record the highest numbers of *C. ornatus* compared to January and May. There was high rainfall in the Darwin area in the week before the trapping, therefore it is possible that high rainfall was also experienced near the proposed mine sites, which may have affected breeding sites and resulted in the low abundance. Shivas (1999) noted that surface sheet flow caused by the first heavy downpours of the wet season was observed to wash away the upper couple of centimetres of mud from an upper tidal creek breeding site, resulting in a loss of *C. ornatus* larval habitat and thus lowering the level of adult emergence.

The reason for the low numbers of *C. ornatus* in November as compared to the highest numbers in May could also have been a result of the timing of trapping. Numbers of this species can vary significantly from one day to another in areas inland of the mangrove margin during the peak fortnightly abundance period (Shivas & Whelan 2001). Peak *C. ornatus* dispersal occurs one day before the full moon in the warmer months (Shivas & Whelan 2001), although it is possible that trapping one day before the full moon missed the dispersal peak for *C. ornatus* in November, as the traps at both prospects were set inland of the mangrove margin. It is possible that the trapping in May was conducted at the time of peak fortnightly abundance, explaining the higher numbers. Alternatively
various unknown environmental factors may have played some kind of role in the low abundance of *C. ornatus* during the November trapping.

However, the May trap results did show that *C. ornatus* will be seasonally present in low numbers at the Lethbridge Bay West Prospect, and in moderate to high numbers at the Andranangoo Creek West Prospect during the late wet season/early dry season. This species is expected to be present in high numbers during the peak season August to November period at the Andranangoo Creek West prospect, and in moderate numbers at the Lethbridge Bay West prospect in these months. Wet season abundance is likely to be relatively low, with lower numbers also expected in the cooler mid dry season months (June/July), as little landward dispersal occurs during these periods of the year (Shivas & Whelan 2001).

Wet season *C. ornatus* abundance is lower than dry season abundance, as breeding from the high productivity creek bank habitat shifts to the less productive *Ceriops* transition zone at the back edge of the creek bank forest, and breeding in the medium productivity *Sonneratia* foreshore areas shifts to the adjacent less productive *Rhizophora* zone (Shivas 1999). Combined with the effects of rainfall on upper tidal tributary breeding sites, this helps to explain the low numbers collected during the January 2006 trapping.

*Culicoides marksi* has been described by Whelan (1998) as being most abundant in the early wet and post wet to mid dry seasons, with low populations in the late dry season. The supplementary trapping located this species in May, with initial trapping also locating this species in late September/early October, indicating *C. marksi* is likely to follow the usual seasonal trend in abundance at both mining prospects.

*Lasiohelia* sp. was most abundant from January to March inclusive during the baseline trapping program at Wickham Point (Warchot and Whelan 2004), and were most abundant from January to May inclusive during the baseline trapping program at Durack (Fairway Waters) (Whelan et al 1998). This indicates that *Lasiohelia* sp. in the Darwin region generally occur in the mid to late wet season and early dry season. Supplementary trapping revealed highest numbers in May, with minimal numbers in January. Based on the supplementary trap results, and the initial trap results, it appears that *Lasiohelia* sp. will be most abundant during January to May.

### 4.1.5 Pest problems and public health

The supplementary trap results revealed that *C. ornatus* is the only biting midge species expected to cause a pest problem at both mining prospects, with the levels recorded at Trap Site 1 in May high enough to cause a moderate-high pest problem to exposed people in the 2 hours either side of sunset and sunrise. The levels recorded at Trap Site 7 in May were high enough to cause a nuisance/low pest problem, and the levels recorded at Trap Site 5 may represent a minor nuisance problem to some people. The very low numbers of *C. ornatus* at Trap Site 3 indicates pest problems are unlikely at that area, due to the distance from the mangroves.

Based on general information on the seasonal abundance of *C. ornatus*, highest pest problems can be expected in the months of August to November at both prospect sites, with greatest pest problems within 1.5km of the mangrove margin, and pest problems likely to be encountered up to 2km from the mangrove margin at both mining prospects. Pest problems will be greatest during a 3-4 day period around the full and new moons, with full moon problems generally twice as large as new moon problems (Shivas & Whelan 2001). High pest problems are expected in the Andranangoo Creek West prospect during these months, while moderate pest problems are likely to be experienced in the Lethbridge Bay West prospect in these months.

Moderate to high pest problems are also likely to be encountered in the late wet/early dry season (April-May) at the Andranangoo Creek West prospect, with low pest problems likely to be experienced at the Lethbridge Bay West prospect in these months. Other periods of the year should have relatively low levels of *C. ornatus*, which should not pose any serious pest problems.
*Culicoides marksi* was only recorded in low numbers during the supplementary trapping at Trap Site 7 in Lethbridge Bay West, although this species was recorded in moderate numbers at the Andranangoo Creek West construction camp during initial trapping. As this species is not considered a serious human pest midge, at most, it is only expected to cause minor nuisance problems at both development sites within 1km of the adjacent large swamps.

The trap results revealed *Lasiohelia* sp. is not expected to cause any pest problems at the development site, although as limited information is available on this genus of biting midges, it is possible that *Lasiohelia* sp. were present at the mining prospects in higher number than what was recorded during trapping. *Lasiohelia* sp. has not been implicated as the cause of any public biting insect complaints in the Darwin Region.

### 4.1.6 Limitations

The supplementary biting midge trap results highlighted the deficiencies with conducting trapping for biting midges on only one night around the full moon. As *C. ornatus* abundance varies greatly from day to day during the peak fortnightly abundance period, trapping on only one of these days during the peak period can lead to an underestimate of peak populations, which appears to have happened for the peak season biting midge trapping during November 2005. Trapping over a 3-4 day period around the full moon would be the best method of sampling peak monthly *C. ornatus* abundance. Monthly trapping for 12-months would also have provided a better indication of seasonal *C. ornatus* abundance.

Trapping once a month for 12-months would have also provided a better indication of the seasonal abundance other biting midges species at both mining prospects.

### 4.2 Mosquitoes

#### 4.2.1 Species present

A total of 31 species of mosquitoes were recorded during supplementary trapping in November 2005 and January and May 2006, representing at total of 10,141 adult female mosquitoes. All of the common pest and disease vector mosquitoes in the Top End of the NT were recorded during trapping. For further information on the mosquito species mentioned in this report, please refer to Appendix 2 and the initial Biting Insect Assessment Report for the Andranangoo Creek West and Lethbridge Bay West mining prospect. The important mosquito species collected are discussed below.

#### 4.2.2 Probable breeding sites

Potential breeding sites for the salt marsh mosquito *Aedes vigilax*, the common banded mosquito *Culex annulirostris*, the North Australian malaria mosquito *Anopheles farauti s.l.*, the golden mosquito *Coquillettidia xanthogaster*, the black malaria mosquito *Anopheles bancroftii*, the saltwater mosquito *Culex sitiens*, the waterlily mosquito *Mansonina uniformis* and the brackish water mosquito *Verrallina funerea* at both mining prospects have been described in the initial Biting Insect Assessment Report for the Andranangoo Creek West and Lethbridge Bay West mining prospect, please refer to this report for further details.

The floodwater mosquito *Aedes normanensis* was another potentially important mosquito species collected during supplementary trapping. This species was collected in very low numbers at Trap Sites 3 and 5. The main breeding sites for this species are poorly draining floodways associated with creeks and rivers, with highest numbers occurring in inland areas. This species only occurs in very low numbers in the Darwin urban area each wet season, reflecting a lack of suitable breeding sites near coastal areas. Very small breeding sites for this species may be present in the poorly draining flowlines in the dune areas at both mining prospects (Figure 1).
The receptacle mosquito *Aedes notoscriptus* was recorded as a single specimen at Trap Site 5. Natural breeding sites for this species are tree holes, although this species will breed in artificial receptacles such as used tyres, drums, pot plant drip trays, bird baths, discarded bottles etc.

The saltwater *Anopheles* species *Anopheles hilli* was recorded in low numbers at both prospects. Probable breeding sites at both prospects will be the tidal/brackish water areas of the large swamps adjacent to both prospects, particularly where *Schoenoplectus* reeds occur.

4.2.3 Spatial abundance and dispersal

*Aedes vigilax*

Trap Site 1, adjacent to the Andranangoo Creek West reed swamp, recorded significantly more *Ae. vigilax* than the other three trap sites. Trap Site 3, at the Andranangoo Creek West construction camp, recorded the lowest overall numbers during the supplementary trapping. The low numbers at the construction camp site compared to the other trap sites may have been due to lights/human activity providing a more attractive source for *Ae. vigilax*, even though the trap was located approximately 50m north of the construction camp site.

Both trap sites at Lethbridge Bay West recorded very high overall numbers of *Ae. vigilax*, with Trap Site 5 being moderately more productive, most likely due to the trap site being located closer to the upper reaches of the adjacent swamp, which is likely to be the most productive area of *Ae. vigilax* breeding as it appears to be vegetated with suitable reed and grass habitats (Figure 1).

*Aedes vigilax* can disperse in pest numbers up to 50km from extensive breeding sites (Whelan 1997a). Due to the dispersal characteristics of this species and the close distance of both mining prospects to extensive breeding sites, *Ae. vigilax* will be present in very high numbers throughout all areas of both mining prospects. Initial trapping also recorded this species in high numbers at the Andranangoo Creek West and Lethbridge Bay West prospects (Warchot & Whelan 2005).

*Culex annulirostris*

*Culex annulirostris* was recorded in highest numbers at Trap Site 7 and Trap Site 1, with relatively low numbers at Trap Sites 3 & 5. Trap Sites 7 & 1 were located closer to potential breeding sites, which explains the higher numbers (Figure 1). With a dispersal range of up to 10km in pest numbers from extensive breeding sites, with highest numbers within 3km of breeding sites (Whelan 1997a), this species can be expected to be widespread throughout both mining prospects.

*Anopheles farauti s.l.*

The North Australian malaria mosquito *Anopheles farauti s.l.* is a species complex that includes three species that are impossible to separate morphologically. The three species in this complex are *Anopheles farauti s.s* (also known as *An. farauti* no. 1), which is a brackish water breeder, and the freshwater breeders *Anopheles hinesorum* (also known as *An. farauti* no. 2) and *Anopheles torresiensis* (also known as *An. farauti* no. 3). Habitat indicators for *An. farauti* are brackish water *Schoenoplectus* and *Eleocharis* reed swamps, and upper reaches of mangrove creeks with freshwater influence, while habitat indicators for *An. hinesorum* and *An. torresiensis* are freshwater reed swamps and vegetated creeks.

*Anopheles farauti s.l.* was recorded in by far the highest numbers at Trap Site 1, adjacent to the Andranangoo Creek West reed swamp, indicating the presence of significant breeding sites for *An. farauti s.l.* Low numbers of this species were recorded at both Trap Sites at Lethbridge Bay West, indicating the adjacent swamp does not contain the extensive breeding sites that are present in the Andranangoo Creek West reed swamp, but still contains significant breeding sites for this species.

The species in the *An. farauti s.l* complex are generally most common up to 1.5km from their breeding sites, therefore the portion of the Andranangoo Creek West prospect within 1.5km of the swamp is
likely to experience the greatest numbers of *An. farauti s.l.*, with low numbers up to 2km from the swamp. Most areas of the Lethbridge Bay West mining prospect are likely to experience low numbers of *An. farauti s.l.*

**Coquillettidia xanthogaster**
This species was recorded in minor numbers at Trap Sites 1, 3 & 5, and low numbers at Trap Site 7. This species disperses widely from breeding sites, generally up to 3-5km, so is likely to be present throughout both mining prospects.

**Mansonina uniformis**
A very large peak in overall numbers was recorded at Trap Site 1, with minimal overall numbers at the other trap sites, indicating the presence of extensive breeding sites in the Andranangoo Creek West swamp, and minimal breeding sites in the Lethbridge Bay West swamp. This species has a limited flight range, and is generally most abundant within 1-2km of breeding sites, indicating the areas of the Andranangoo Creek West mining prospect within 2km of the reed swamp will contain the highest numbers of this species. The apparent absence of extensive *Ma. uniformis* breeding sites at the Lethbridge Bay West swamp indicates that most areas of this prospect is likely to only experience minor numbers of this species.

**Anopheles bancroftii**
This species was recorded in low overall numbers at Trap Site 1, with minor overall numbers at Trap Sites 5 & 7. This species was not recorded at Trap Site 3 during supplementary trapping. *Anopheles bancroftii* generally disperses up to 3km in pest numbers from their breeding sites (Whelan 1997a), therefore is likely to be encountered in low numbers throughout both prospects.

**Verrallina funerea**
This species was most abundant at Trap Site 1 in November 2005, with very low numbers recorded at Trap Site 5 during the same month, and very low numbers recorded at Trap Sites 1 & 5 in January 2006. This species is most common within 500m of breeding sites (Whelan 1997a), which indicates breeding sites exist for this species in the Andranangoo Creek West reed swamp and Lethbridge Bay West swamp, due to the presence of this species in early November 2005. This species is also likely to be present adjacent to any coastal depressions that flood at both mining prospects during the wet season.

**Culex sitiens**
This species was recorded in minor numbers during supplementary trapping, with Trap Sites 1 & 5 being the most productive. This species is generally most common within 2km of breeding sites (Whelan 1997a), therefore will be most abundant at both mining prospects within 2km of the tidal reaches of the adjacent swamps.

**Anopheles hilli**
This species was recorded in low numbers at Trap Site 1, and in minor numbers at Trap Sites 5 & 7. This species is most common within 4km of breeding sites (Whelan 1997a), therefore is likely to be present throughout both prospects.

**Aedes normanensis**
This species was recorded in very low numbers at Trap Sites 3 & 5. This species is generally only encountered in significant numbers in inland areas, therefore it is not expected that this species will be present in any significant numbers at both mining prospects.

**Aedes notoscriptus**
Only a single specimen was recorded at Trap Site 5 during the supplementary trapping. This species can reach low levels in areas with an abundance of artificial receptacles.
4.2.4 Seasonal abundance

*Aedes vigilax*

The supplementary trapping, and initial trapping at both mining prospects, revealed *Ae. vigilax* would follow the usual trend in seasonal abundance of highest numbers in September to January inclusive (Whelan 1997a). High to severe numbers can be expected in the months of September to January inclusive at both mining prospects. Low numbers may also be present at both mining prospects in May if significant late wet season rainfall occurs, which occurred a few weeks before the May 2006 trapping, and low numbers may also be present at both mining prospects in August, in those years when significant high tides occur in August. Moderate to high numbers could also occur in February, if there are extensive interdune areas that flood at both prospects. Elevated numbers will occur for around 1 week in the cooler months, and up to 2 weeks in the high humidity months of November to February inclusive.

*Culex annulirostris*

In the Top End of the NT, *Culex annulirostris* is most abundant from January to August, with highest numbers occurring during the early to mid dry season months of April to August (Whelan 1997a). The supplementary trapping, and initial trapping at both mining prospects, revealed that *Cx.* *annulirostris* would be most abundant at both mining prospects during the dry season months of April to late September/early October.

It is highly likely that the initial trapping and supplementary trapping missed peak season abundance of *Cx. annulirostris*. Only minor numbers of this species were recorded during the peak season months of January and May at both prospects, when levels of this species was expected to be higher. Due to the Andranangoo Creek West swamp in particular containing expansive areas of potential breeding habitat for this species, it is likely that this species will be present in high numbers during the April to August peak abundance period at the Andranangoo Creek West prospect. High numbers are also expected at the Lethbridge Bay West prospect during the April to August peak abundance period, as there appears to be significant habitat for this species in the upper reaches of the Lethbridge Bay West swamp (Figure 2). Low to moderate numbers can be expected at both prospects from January to March and September to early October.

*Anopheles farauti s.l.*

This species occurs in highest numbers in the Top End of the NT from March to June (Whelan 1997a). The supplementary trapping and initial trapping at both mining prospects indicates this species is likely to follow the usual trend in seasonal abundance, as highest numbers were recorded in May. The trapping revealed minor to low numbers of this species are also likely to occur for most other months of the year.

*Coquillettidia xanthogaster*

This species generally peaks in abundance in the months of March to August. Relatively low numbers were recorded at both mining prospects during supplementary trapping and initial trapping, with highest numbers recorded during initial trapping in late September/early October and second highest numbers in May 2006.

Due to the availability of extensive habitat in the Andranangoo Creek West reed swamp, and probably also in the upper reaches of the Lethbridge Bay West swamp, it is likely that higher numbers than what was recorded during trapping will be present at both mining prospects. Therefore, moderate to high numbers of this species are expected to be present at both prospects during the peak season months of March to August, with low numbers expected to be present in September/early October at both prospects.
Mansonia uniformis
This species is generally present in highest numbers from March to June (Whelan 1997a), although in some years in Darwin a peak in abundance also occurs during the mid wet season months of January or February. The supplementary trapping and initial trapping only recorded this species in any significant numbers in May 2006, with most specimens collected from Trap Site 1, adjacent to the Andranangoo Creek West reed swamp. This species is likely to follow the usual trend in seasonal abundance, with highest numbers at the Andranangoo Creek West prospect likely to occur from March to June. Highest numbers of this species will also occur from March to June at the Lethbridge Bay West prospect, although not in the same magnitude as what will be experienced at the Andranangoo Creek West prospect.

Anopheles bancroftii
This species was recorded in relatively low numbers at the Andranangoo Creek West prospect during supplementary and initial trapping, with highest numbers recorded in September 2005 and May 2006. Very low numbers were recorded at Lethbridge Bay West. Highest numbers of this species generally occurs from February to July (Whelan 1997a), which is when the greatest numbers are expected at the mining prospects, although the initial trap results revealed this species will be present until at least September/early October at the Andranangoo Creek West prospect.

Due to the availability of extensive habitat in the Andranangoo Creek West reed swamp, and probably also in the upper reaches of the Lethbridge Bay West swamp, it is likely that higher numbers than what was recorded during trapping will be present at both mining prospects. Therefore moderate to high numbers of this species are expected to be present at the Andranangoo Creek West prospect during the peak season months of March to August, and low to moderate numbers of this species are expected to be present at the Lethbridge Bay West prospect. Low numbers of this species may be present in September/early October, at least at the Andranangoo Creek West prospect.

Culex sitiens
This species was recorded in highest numbers during the initial trapping in late September/early October. The November 2005 supplementary trapping recorded the second highest numbers of this species. In other coastal areas of the NT, this species is generally most abundant during the late dry season and early wet season, and late wet season (Whelan 1997a). The seasonal abundance of Cx. sitiens at both mining prospects is likely to follow this usual trend in peak abundance.

Anopheles hilli
This species is most common during the late wet/early dry season (Whelan 1997a). Highest numbers were recorded in November at both prospects, most likely a result of high tides or early wet season rainfall flooding breeding sites in the large swamps adjacent to both prospects prior to the November trapping. This species is likely to follow the usual trend in abundance as described by Whelan (1997a).

Verrallina funerea
This species is most common from November to March in coastal areas in the NT (Whelan 1997a), when high tides and rainfall flood breeding sites. The seasonal abundance of Ve. funerea at both mining prospects is likely to follow this usual trend in peak abundance.

Aedes normanensis
This species was only recorded in very low numbers in May 2006. Highest abundance in other areas of the NT generally occurs in the months of January to April (Whelan 1997a). The presence of this species in May 2006 would have been a result of the heavy late wet season rainfall in mid April. This species will be most abundant at both mining prospects in the months of January to April in most years, and will be present in May in those years with significant late wet season rainfall.
**Aedes notoscriptus**

This species is most common during the wet season, although can be present in low numbers during the dry season in urban areas. If breeding in artificial receptacles at the construction camp sites is prevented, this species is only likely to be encountered in very low numbers during the wet season at both mining prospects.

**4.2.5 Pest problems**

The most important pest mosquito trapped at both mining prospects was the salt marsh mosquito *Ae. vigilax*. This species will cause widespread high to severe pest problems at both prospects during the months of September to January inclusive. Moderate to high pest problems may also be encountered at both prospects in February, depending on the availability of interdune breeding sites at both prospects. Pest problems will last up to a week during the cooler months, and up to 2 weeks during the warmer humid months of November to February inclusive. Pest problems will occur in shaded areas during the daytime, and throughout the night. Low pest problems may be encountered in May in those years with late wet season rainfall, and in August in those years when significant high tides occur in this month.

*Mansonia uniformis* will cause high to very high pest problems at the Andranangoo Creek West prospect within 2km of the reed swamp during the months of March to June inclusive, and possibly in January or February in some years. No significant pest problems are expected to occur from this species at the Lethbridge Bay West prospect. Pest problems will be noticed mainly at night, although this species will bite in shaded areas near their breeding sites during the daytime.

*Culex annulirostris* is likely to cause moderate to high pest problems at both prospects during the months of April to August, with low to moderate pest problems likely to be experienced in the January to March period and in September/early October. This species bites at night.

*Coquillettidia xanthogaster* is likely to cause moderate to high pest problems in the March to August peak season period at both prospects, with low pest problems continuing until early October at both prospects. This species mainly bites at night, but will also bite in shaded areas during the daytime nearby to their breeding sites.

*Anopheles bancroftii* is likely to cause moderate to high pest problems during the peak season March to August period at the Andranangoo Creek West prospect, and low to moderate pest problems at the Lethbridge Bay West prospect in these months. Low pest problems are likely to continue until late September/early October at the Andranangoo Creek West prospect. This species mainly bites at night, but will also bite in shaded areas during the daytime nearby to their breeding sites.

*Anopheles farauti s.l.* is not as important as a pest mosquito compared to the other species mentioned above, although the very high levels recorded adjacent to the Andranangoo Creek West reed swamp indicates this species will cause at least moderate pest problems from sunset to sunrise at the Andranangoo Creek West prospect within 2km of the adjacent reed swamp, in the months of March to June inclusive, and minor pest problems at the Lethbridge Bay West prospect within 2km of the upper reaches of the adjacent swamp during the same months. No pest problems are expected during other months of the year at both prospects.

Other species trapped are not expected to cause any significant pest problems. *Culex sitiens* may cause low pest problems at night in areas within 2km of the large swamps at both mining prospects, and *An. hilli* may cause low pest problems at night in areas within 4km of the large swamps at both mining prospects. *Verrallina funerea* may cause low pest problems during the daytime in shaded areas nearby to their breeding sites. *Aedes notoscriptus* may cause minor nuisance problems at the construction camps if artificial breeding sites for this species are created. Other mosquito species are not expected to be present in numbers significant to cause any appreciable pest problems.
4.2.6 Public health

*Aedes vigilax* is a known vector of Ross River virus (RRV) disease and Barmah Forest virus (BFV) disease, and will pose a high risk of virus transmission whenever it is present in significant numbers. The greatest potential for disease transmission from this species will occur during the warmer humid months of November to January inclusive, when the longevity of this species is increased and abundance is high. This species will also pose a significant RRV and BFV risk if present in significant numbers at both prospects in February.

*Culex annulirostris* will pose a potentially high risk of RRV and BFV transmission at both prospect areas, with December to June being risk months, and December to March being the peak risk months for virus transmission from this species (Whelan 1997b). This species will also pose a potential seasonal risk for Kunjin virus (KUNV) disease and Murray Valley encephalitis virus (MVEV) disease transmission at both prospect areas, with January to July being the risk period for MVEV, with peak risk from February to May, and December to July being the risk period for KUNV transmission, with peak risk months being February to May (Whelan 1997b).

One of the species in the *Anopheles farauti* s.l. complex will pose a potential risk of local malaria transmission, the brackish water species *Anopheles farauti* s.s. The species *An. farauti* s.s is a known vector of malaria in Vanuatu, Solomon Islands and PNG (Russell & Kay 2004), therefore is regarded as a potential vector of malaria in Australia. The vector competence of *An. hinesorum* and *An. torresiensis* is not known, although it is possible that *An. torresiensis* was/is a potential vector of malaria in Australia, and *An. hinesorum* may be a potential vector in some parts of PNG (N. Beebee pers comm.), therefore these species may be potential vectors in Australia. It is possible that *An. farauti* s.s. was the most common species in the *An. farauti* s.l. complex recorded at both mining prospects, in which case there will be a high risk of potential malaria transmission at both mining prospects in the months of March to June, with a low potential risk of malaria transmission likely to occur for most other months of the year. The risk of potential malaria transmission will occur if a person infected overseas with malaria is exposed to mosquito bites from this species at either mining prospect. *Anopheles hilli* and *Anopheles bancroftii* are also potential vectors of malaria, although due to its short life span, *An. bancroftii* is not considered a significant potential vector (Russell 1987).

*Culex sitiens* will pose a low potential RRV transmission risk when numbers are elevated in November and December, and *Ve. funerea* will pose a low potential RRV and BFV risk when numbers are elevated in November to March. *Aedes normanensis* is a potential vector of RRV, BFV and MVEV, but is unlikely to be present at the mining prospects in numbers high enough to pose a significant risk. *Aedes notoscriptus* is a potential vector of RRV, and will pose a potential virus risk if breeding sites for this species are created in association with the construction camp.

4.2.7 Limitations

It appears that peak season abundance of some important mosquito species, in particular Cx. *annulirostris* and Cq. *xanthogaster*, were missed during the supplementary trapping, as the relatively low numbers of both species was unexpected considering both mining prospects are located adjacent to very large coastal swamps, which were expected to produce high numbers of these mosquito species. Peak season abundance of other mosquito species may also have been missed, however it is likely that peak season *Ae. vigilax*, *An. farauti* s.l. and *Ma. uniformis* were recorded during the trapping.

5.0 Biting insect control and avoidance

5.1 Biting midges

Barrier treatments using the insecticide bifenthrin have been proven successful in controlling adult biting midges in QLD (Standfast et al 2003). The supplementary trap results revealed there may be periods of the year when adult biting midge control is warranted or requested by workers, particularly at the Andranangoo Creek West construction camp. Areas that could be treated with bifenthrin barrier
treatments include under demountables, external floorboards, walls, insect screens and any dense vegetation surrounding the construction camps. If required, dark shade cloth fencing erected around the construction camps treated with bifenthrin will enhance the effectiveness of any barrier treatment.

Additional measures can be taken to reduce biting midge numbers if required. The use of UV or incandescent lights in non personnel areas can act as a diversion for biting midges, although the use of lights alone is not likely to provide a useful or effective buffer (Shivas & Whelan 2001). Personal protection in the 2 hours around sunset and sunrise during full and new moon periods may be required during the dry season. Further information on personal protection from biting midges can be found in Appendix 3.

5.2 Mosquitoes

5.2.1 Mosquito Control and avoidance
Due to the short term nature of both mine sites, larval mosquito control will not be warranted or feasible. However, due to the seasonal very high numbers of potential virus carrying mosquitoes, some form of adult mosquito control is recommended around the construction camps. Bifenthrin barrier treatments as discussed in Section 5.1 are currently the most effective way of controlling adult mosquitoes (Standfast et al 2003). Barrier control of mosquitoes will reduce the potential for mosquito borne disease transmission, and reduce the numbers of bites that can lead to secondary infection from scratching. The salt marsh mosquito *Ae. vigilax* will bite during the daytime at the construction camps, which means this species will be harder to avoid, therefore bifenthrin barrier treatments for this species in particular is recommended. Most other mosquito species can be avoided by preventing exposure after sundown.

Adult mosquito control by fogging may also be required if there are cases of mosquito borne disease and subsequent entomological investigations indicate a further disease transmission risk. Adult mosquito control by ground based operations would only be successful if the mosquitoes were breeding or harbouring in accessible areas relatively close to where they were causing the problem. In this case, the areas to be targeted for fogging will be the extensive swamps located adjacent to both prospect areas, and the areas surrounding the construction camps.

Personal protection and the appropriate screening of accommodation facilities are further measures that can be utilised to minimise the impact of mosquitoes on the workforce, as well as avoiding being exposed to mosquito bites after sunset. Mess facilities should be indoors or screened, to prevent workers being bitten when mosquito numbers are high, and sleeping quarters should have appropriate insect screens to prevent the entry of mosquitoes. Further information on personal protection from mosquitoes can be found in Appendix 4.

5.2.2 Artificial receptacles
Periodic inspections should be conducted around the construction camps during the wet season, to ensure mosquito breeding in artificial receptacles is prevented. This includes inspecting used tyres, drums, rainwater tanks, disused machinery items, and any other receptacle capable of holding water and breeding mosquitoes. Any receptacle holding water should be tipped upside down, stored under cover away from rain, appropriately disposed of at a well-maintained waste disposal facility, or treated with a residual insecticide until it no longer poses a potential mosquito breeding issue. Septic tanks should also be periodically inspected to ensure the lids on the tanks remain fully sealed, and to ensure absorption trenches are operating correctly and are not ponding effluent.

The appropriate management of artificial receptacles is important to prevent the creation of breeding sites for the dengue vector mosquito *Aedes aegypti*, which may be inadvertently transported to the development sites from North Queensland or overseas, and to prevent the creation of mosquito breeding sites for the dengue vector mosquito *Aedes albopictus*, which may be inadvertently transported to the development sites from overseas.
Machinery or equipment sourced from North Queensland should be inspected for the presence of water ponding and mosquito breeding. Potential water holding receptacles includes used tyres, backhoe buckets, excavator tracks, drums, buckets, rainwater tanks and building equipment. Any receptacle sourced from North Queensland that is found to be holding water should be treated with an appropriate chlorine solution or residual insecticide. This is to prevent the introduction of the dengue carrying mosquito *Aedes aegypti* from North Queensland, where it is endemic.

### 6.0 Mosquito breeding and development aspects

The potential for increased mosquito breeding at the mining sites will arise from mining activities that penetrate the ground water table, and the ground water is left to pond within the excavation for periods greater than five consecutive days. The proposed mining method (a form of slot mining) is to include a continuous rehabilitation program occurring close behind the mining face (URS, 2005), so it is unlikely that conditions will be suitable for mosquito breeding in excavated areas. Matilda Minerals have also mentioned that excavations will not be made lower than the groundwater table (Dennis McCamish pers. comm.), which will also limit the potential for surface water ponding and mosquito breeding in excavations during the dry season. However, the suitable rehabilitation of mined areas would be required to prevent the creation of new mosquito breeding sites that would be a detriment to the future use of the surrounding areas.

**Andranangoo Creek West**

Excavations adjacent to the extensive reed swamp have the potential to create further extensive breeding sites for *Ae. vigilax*, *An. farauti s.l.*, *Cx annulirostris*, *An. bancroftii*, *Cx. sitiens*, *Cq. xanthogaster* and *Ma. uniformis*. It is important that mining does not create further mosquito breeding sites, especially as the community of Milikapiti is within flight range of *Ae. vigilax* from the prospect area. Excavations adjacent to the reed swamp should be rectified in a manner that ensures the rehabilitated area has the same topographical level post mining as pre-mining. Rehabilitation works should take into account the likelihood of the backfilled sand consolidating and sinking slightly, potentially creating a low lying area that could become a mosquito breeding site. This situation could be avoided by backfilling the excavations so that the rehabilitated surface is slightly higher than the natural surface level, so that when consolidation and compaction occurs the rehabilitated surface is the same as the natural surface of adjacent undisturbed areas.

It is mentioned in the Notice of Intent Document (URS, 2005) that mining will avoid the *Melaleuca* swamp and associated drainage line where possible, and rehabilitation would be undertaken in a way that reinstates the previous natural pattern of drainage. This rehabilitation work should also include backfilling mined areas as described in the paragraph above, to prevent the expansion of the swamp or creation of new poorly draining areas.

Other areas that are mined should also be rehabilitated in a manner that prevents the creation of low lying areas that could pond water and become mosquito breeding sites, and prevent the creation of areas with impeded drainage.

**Lethbridge Bay West**

The potential for the creation of new mosquito breeding sites will arise from mining activities that occur adjacent to the large tidal mudflat. Any excavations that occur adjacent to the mudflat should be rehabilitated in a manner that re-instates the existing ground level pre-development, to prevent the creation of new areas where tide and rainwater can pond and breed mosquitoes. Other mined areas in the Lethbridge Bay West prospect should also be rehabilitated in a manner that prevents the creation of low lying areas that can pond water, and prevents the creation of areas with impeded surface water flows, especially as the community of Milikapiti is within flight range of *Ae. vigilax* from the prospect area.
7.0 Conclusions

7.1 Biting midges
- *Culicoides ornatus* will be the most important pest biting midge species affecting the Andranangoo Creek West and Lethbridge Bay West prospects.

- *Culicoides ornatus* pest problems are likely to be moderate-high at the Andranangoo Creek West prospect during the late wet season/early dry season (April-May), and low at the Lethbridge Bay West prospect during these months. High pest problems are likely to be experienced at the Andranangoo Creek West prospect during the peak season months of August to November, and low-moderate pest problems are likely to be experienced at the Lethbridge Bay West prospect during these months. Pest problems will be greatest within 1.5km of the mangrove margin, with pest problems likely to occur at least 2km from the mangrove margin. Greatest pest problems will occur 3-4 days around the full and new moons, with full moon problems generally being twice as large as new moon problems.

- Potential breeding sites for *C. ornatus* affecting the Andranangoo Creek West prospect will be the upper high tide mangrove areas of Andranangoo Creek, and the upper tidal creek area to the west of the prospect. The most important potential *C. ornatus* breeding site affecting the Lethbridge Bay West prospect will be the upper tidal reaches of the small creek to the east of the prospect.

- *Culicoides marksi* is only expected to cause at most a minor nuisance problem at both mining prospects. *Lasiohelia* sp. is not expected to cause pest problems at the mining prospects.

- Insecticide barrier treatments may be required, particularly at the Andranangoo Creek West prospect, during periods of high *C. ornatus* activity. Insecticide barrier treatments are unlikely to be required for other pest biting midge species.

7.2 Mosquitoes
- The salt marsh mosquito *Aedes vigilax* will be the most abundant mosquito species at both mining prospects, and will be the most important pest mosquito. This species will reach very high levels throughout all areas of both prospects in the months of September to January inclusive, and will cause serious pest problems. Moderate to high numbers may also be present in February, and low numbers may be present at both mining prospects in May and August in some years. This species is likely to be present in elevated numbers for up to 2 weeks during the warmer, humid months of November to January inclusive, with elevated numbers lasting about 1 week in the cooler months of their peak abundance period. Pest problems will occur in shaded areas during the daytime and at night.

- *Aedes vigilax* will pose a very high Ross River virus (RRV) disease and Barmah Forest virus (BFV) disease risk during September to January inclusive, and possibly February, with the November to February inclusive period being the highest risk months, due to the high temperatures and humidity increasing the longevity of individual females.

- *Anopheles farauti* s.l. will be present in very high numbers at the Andranangoo Creek West prospect during the months of March to June inclusive, causing at least moderate pest problems, and low numbers at the Lethbridge Bay West prospect during these months, causing at least minor pest problems. Minor to low numbers of this species are likely to be present at both prospects during most other months of the year. Highest numbers at both prospects will be encountered within 1.5km of the adjacent swamps, with dispersal up to 2km from their breeding sites. Pest problems will occur at night.
• *Anopheles farauti* s.l. will pose a high risk of malaria transmission at the Andranangoo Creek West prospect during the months of March to June inclusive, and will pose a low risk of malaria transmission for most other months of the year. This species will pose a low risk of malaria transmission at the Lethbridge Bay West prospect during most months of the year. The risk of malaria transmission will only arise if a person with the infectious stages of malaria is bitten by *Anopheles* mosquitoes at either mine site.

• The common banded mosquito *Culex annulirostris* is likely to be present in moderate to high numbers during the peak season April to August period at both prospects, causing moderate to high pest problems. Low to moderate numbers are also expected to occur during the January to March period at both prospects, as well as during September and early October. Pest problems will occur at night.

• *Culex annulirostris* will pose a potential RRV and BFV risk, mainly during the December to June period, a potential Murray Valley encephalitis virus (MVEV) disease risk, with peak risk months for MVEV transmission being January to July, and a potential Kunjin virus (KUNV) disease risk, with peak risk months from KUNV transmission being December to July.

• *Mansonia uniformis* will be present in very high numbers at the Andranangoo Creek West prospect during the March to June inclusive period, causing very high pest problems. Pest problems will be greatest within 2km of the Andranangoo Creek West reed swamp, with pest problems occurring mainly at night, but also in shaded areas near their breeding sites during the daytime. This species does not transmit human disease in Australia. This species is not expected to cause any significant pest problems at the Lethbridge Bay West prospect.

• *Coquillettidia xanthogaster* is likely to be present in moderate to high numbers during the peak season March to August period at both prospects, causing moderate to high pest problems. Low numbers are expected to continue until late September/early October at both prospects. Pest problems will be noticed mainly at night, although this species will bite in shaded areas during the daytime nearby to their breeding sites. This species does not transmit human disease in Australia.

• The black malaria mosquito *Anopheles bancroftii* is likely to be present in moderate to high numbers during the peak season March to August period at the Andranangoo Creek West prospect, causing moderate to high pest problems, and in low to moderate numbers at the Lethbridge Bay West prospect during these months, causing low to moderate pest problems. Low abundance is likely to continue until late September/early October at the Andranangoo Creek West prospect. Pest problems will be noticed mainly at night, although this species will bite in shaded areas during the daytime nearby to their breeding sites. This species has a low potential for malaria transmission.

• Other species that may cause pest problems at both mining prospects include *Culex sitiens* and *Verrallina funerea*. These species are likely to cause low pest problems at both prospects, and will pose a low RRV risk when present. *Verrallina funerea* will also pose a low BFV risk when present. *Anopheles hilli* is likely to cause low pest problems and a low potential malaria risk when present at both prospects.

• There is the potential for the introduction of the dengue mosquito *Aedes aegypti* from North Queensland, if machinery and other equipment capable of ponding water are sourced from this area.

• *Aedes notoscriptus* has the potential to colonise artificial receptacles at the construction camps, and pose a nuisance and potential RRV problem. The dengue mosquito species *Aedes aegypti* and *Ae. albopictus* has the potential to colonise artificial receptacles at the development sites, if these species are inadvertently transported to the development sites.
• Due to the short term nature of both mining sites, larval mosquito control would not be warranted or feasible. Adult mosquito control using a residual barrier insecticide such as bifenthrin will be the best method of reducing adult mosquito populations around the construction camps.

• The mine sites have the potential to create new mosquito breeding sites, if mined areas are not appropriately rectified.
8.0 Recommendations

8.1 Biting midges

- Workers should be advised of a potential biting midge problem at the Andranangoo Creek West and Lethbridge Bay West prospects, with higher pest problems likely to be experienced at the Andranangoo Creek West prospect. Workers should be advised of appropriate personal protection measures, as outlined in Appendix 3.

- If complaints are received about biting midges, barrier insecticide treatments can be used to lower biting midge populations around the construction camp. Areas that can be treated include under demountables, external floorboards, walls, insect screens and any dense vegetation surrounding the construction camps. Shade cloth fencing erected around the construction camp and treated with bifenthrin will also enhance the effectiveness of any barrier treatment.

8.2 Mosquitoes

- All workers should be advised of the high mosquito problems that will occur at both prospect sites, and the high potential for mosquito borne disease transmission at both prospect areas. Workers should be supplied with a copy of the Medical Entomology Branch handout “Personal protection from mosquitoes and biting midges in the NT” (Appendix 4).

- Adult mosquito control around the construction camps using barrier insecticides such as bifenthrin is highly recommended. Areas that can be treated include under demountables, external floorboards, walls, insect screens and any dense vegetation surrounding the construction camps. Dark shade cloth fencing erected around the construction camp and treated with bifenthrin will also enhance the effectiveness of any barrier treatment.

- Equipment sourced from North Queensland, such as used tyres, backhoe buckets, excavator tracks, drums, buckets, rainwater tanks and building equipment, should be inspected for the presence of water ponding, even very small amounts of water, to prevent the introduction of the dengue mosquito *Aedes aegypti* from North Queensland. Any water holding receptacle should be treated with an appropriate chlorine solution or residual insecticide, to kill any mosquito larvae and eggs that may be present.

- Periodic inspections should be conducted around the construction camps, to ensure mosquito breeding in artificial receptacles is prevented, particularly to prevent the creation of potential breeding sites for exotic dengue carrying mosquito species, as well as to prevent the creation of breeding sites for the endemic *Aedes notoscriptus*, which is a potential vector of RRV.

- Any worker returning or sourced from overseas who experiences an onset of fever should be considered as possibly having malaria and be kept indoors away from mosquitoes, until cleared of having malaria or cleared of the infectious stages of malaria by a health care practitioner.

- Rehabilitation of the mining areas should be conducted in a manner that prevents the creation of new mosquito breeding sites, which could affect the future use of the land, or disperse to existing or future development areas on Melville Island. This includes ensuring all mined and disturbed areas are rehabilitated to be free draining.
9.0 Acknowledgements

The MEB would like to thank Dennis McCamish for arranging flights to Melville Island to coincide with biting insect trapping requirements, and Direct Air for storing samples in their freezer until collection by MEB.

Aerial photography used in the Figures was supplied by Julie Marris and James Collins of URS Australia Pty Ltd.
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