Northern Territory Government
Department of Health and Community Services

Biting Insect Assessment Princess Louise and North Point Mine Sites

January 2007

Study undertaken on behalf of URS Australia Pty Ltd for Burnside Operations Pty Ltd

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1.0 Introduction

Burnside Operations Pty Ltd plan to commence mining at the North Point and Princess Louise mine sites, located in the East Burnside Project Area approximately 130km south-east of Darwin. The mining method will be open cut, with ore to be transported to Union Reefs Gold Mine for processing. Workers are to be housed at the mine camp at Cosmo Village.

Mine sites have the potential to create or exacerbate mosquito breeding, potentially from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge, waste water disposal, as well as the construction of roads and mine waste dumps. Mine sites also have the potential to introduce new mosquito species into the Northern Territory, such as the dengue mosquito *Aedes aegypti* from North Queensland, if equipment was to be sourced from this area. As part of the environmental process, all major development in the NT is required to consider mosquitoes during the preparation of Environmental Impact Statements or Public Environmental reports, to ensure new development does not create new mosquito breeding sites, and also to protect the health of workers.

Previous baseline trapping has been conducted at the Brocks Creek Project Area (Brocks Creek Gold Project Baseline Mosquito Monitoring Report, Montgomery et al 1996a and Brocks Creek Gold Project Baseline Extension Mosquito Monitoring Report, Montgomery et al 1999b) and Cosmo Project Area (Northern Gold/Burnside Project Baseline Mosquito Monitoring Report, Montgomery et al 1999a), located to the west of the proposed Princess Louise and North Point mine sites. Trapping at these mine sites revealed pest and disease carrying mosquito species, and also identified several new mosquito breeding sites created by mine activities. As the proposed Princess Louise and North Point mine sites are located over 5km from the Brocks Creek Project area, and over 15km from the Cosmo Project area, information on mosquito abundance from the previous baseline trapping could not be directly applied to this project. However, information on mosquito species diversity could be applied to this project, and an examination of topographical maps and aerial photography of the project site in conjunction with previous baseline information could be conducted to predict mosquito problems that may occur at the proposed mine sites.

2.0 Aims

The aims of the biting insect assessment are to assess the information from the baseline biting insect investigations at the Brocks Creek and Cosmo Project areas, and apply any relevant information from these investigations to the Princess Louise and North Point mine sites, as well as examine topographical maps and aerial photography for the presence of potential mosquito breeding habitat, and examine development processes for the potential to create or exacerbate mosquito breeding.

Conclusions and recommendations will be provided based on the findings of the desktop assessment, which will include avoidance and control of pest and disease carrying mosquito species, preventing the creation or exacerbation of mosquito breeding, preventing the reintroduction of malaria into the NT, preventing the introduction of the dengue mosquito *Aedes aegypti* from North Queensland (if equipment was to be sourced from this area), and recommendations on the rehabilitation of mined areas to ensure actual and potentially significant mosquito breeding sites do not remain upon cessation of mining operations.

3.0 Methods

Two previous Baseline Biting Insect Assessments were examined to provide information on the potential diversity of mosquito species in the proposed Princess Louise and North Point mines sites. The Biting Insect Assessments were conducted at the Brocks Creek Project Area (Montgomery et al 1996a and 1999b) and the Cosmo Project Area (Montgomery et al 1999a). The Brocks Creek Project Area was located over 5km to the west of the proposed mine sites, with the Cosmo Project Area located over 15km to the west of the proposed mine sites, therefore information on species abundance from these Biting Insect Assessments could not be accurately applied to the proposed Princess Louise and North Point mine sites. Therefore topographical maps were examined to predict likely populations of various pest and disease carrying mosquito species affecting the proposed mine sites.

Development processes were also evaluated to determine the potential for mining activities to create new mosquito breeding sites or exacerbate existing mosquito breeding sites.

4.0 Results

The results of the initial baseline mosquito trapping at the Brocks Creek Project Area (Montgomery et al 1996a) and the results of the baseline mosquito trapping at the Cosmo Project Area have been provided in this section. Results from the baseline extension mosquito monitoring program at the Brocks Creek Project Area have not been provided, as the information from the extension trapping was similar to the initial baseline program, with the exception of *Aedes vigilax*, although this will be discussed further into the report.

4.1 Brocks Creek Project Area Baseline Mosquito Trapping September 1995 to November 1996

The results from the baseline mosquito trapping at the Brocks Creek Project Area are displayed in Tables 1-7. Trap locations are displayed in Figure 3. A total of five trap locations were utilised in the Brocks Creek Project Area.

4.1.1 Species present

Thirty four (34) species of mosquito were collected in the base line monitoring program. This included eight (8) *Anopheles* species, fourteen (14) *Aedes* species and six (6) *Culex* species. The domestic pest species *Cx. quinquefasciatus* that is associated with polluted water was not recorded. Similarly, the vector of Dengue Fever (*Ae. aegypti*) which has been previously eliminated from the NT was not recorded.

4.1.2 Relative Numbers

A total of 12,247 female mosquitoes were trapped over the 15 month period. The most predominant species trapped was *Ae. normanensis* (36.21 %), followed by *Cx. annulirostris* (30.75 %), *An. annulipes* (7.99 %), and *Coquillettidia xanthogaster* (5.48 %). Table 7 presents the complete list of species trapped.

Site 1 (26 species, total number trapped 2,554). *Aedes normanensis* was the most common species trapped (57.6 %), followed by *Cx. annulirostris* (22.55 %), *An. annulipes* (7.2 %) and *Cq. xanthogaster* (4.86 %) (see Table 1).

Site 2 (10 species, total number trapped 179). *Aedes normanensis* was the most common species trapped (47.49 %), followed by *Ae. elchoensis* (21.79 %) and *Culex annulirostris* (10.61 %) (see Table 2). Due to the brevity of the monitoring period this site will not be considered further in this document.

Site 3 (24 species, total number trapped 3,945). *Culex annulirostris* was the most common species trapped (33.43 %), followed by *Ae. normanensis* (26.64 %), *An. annulipes* (10.06 %) and *An. meraukensis* (5.4 %) (see Table 3).

Site 4 (24 species, total number trapped 2,983). The most common species trapped was *Ae. normanensis* (34.13 %), followed by *Cx. annulirostris* (18.97 %). Less common species were *An. annulipes* (10.69 %), *An. meraukensis* (7.41 %), *Ae. lineatopennis* (8.82 %) and *Cq. xanthogaster* (6.67 %) (see Table 4).

Site 5 (24 species, total number trapped 2,765). *Culex annulirostris* was the most common species trapped (47.2 %), followed by *Ae. normanensis* (32.37 %) and *An. annulipes* (2.82 %) (see Table 5). Please note that the monitoring period at site 5 was 3 months shorter than at sites 1, 3 and 4.

4.1.3 Seasonal abundance

The highest numbers of mosquitoes (3,052) were collected on 28 November 1996 (see Table 6). Total numbers were also relatively high in January, March, April and 1 November 1996.

The number of *Ae. normanensis* reached a very high peak on 28 November 1996, with secondary peaks occurring in March 1996, April 1996 and November 1995.

The maximum numbers of *Cx. annulirostris* were recorded on 1 November 1996. Smaller peaks occurred in December 1995, January 1996 and July 1996.

The number of *An. annulipes* peaked in May 1996. Similarly high peaks occurred in April 1996 and 1 November 1996.

The number of *An. farauti* reached significant numbers in March 1996.

The number of *Cq. xanthogaster* reached a peak in July 1996, with a secondary peak occurring in March 1996.

Aedes vigilax was recorded in low numbers and reached its highest level on 28 November 1996.

4.1.4 Spatial Distribution

The highest total number of mosquitoes was trapped at site 3 (Table 7). The highest numbers of *Cx. annulirostris* were trapped at site 3 and 5 (the monitoring period at site 5 was 3 months shorter than site 1, 3 and 4).

The highest numbers of *Ae. normanensis* were trapped at site 1 (Wetland filter) although numbers at all sites were high on a seasonal basis.

The highest number of *An. annulipes* was collected at site 3, although numbers were also high at site 4.

Significant numbers of *An. farauti* were trapped at similar levels at site 3 and site 4.

The highest number of *Cq. xanthogaster* was trapped at site 5.

Aedes vigilax was collected in low numbers throughout the monitoring period, with highest numbers at sites 3 and 4.

4.2 Cosmo Project Area (Northern Gold/Burnside Project Area) Baseline Mosquito Trapping March 1996 – March 1997

The results from the baseline mosquito trapping at the Brocks Creek Project Area are displayed in Tables 8 - 10. Trap locations are displayed in Figure 4. A total of two trap locations were utilised in the Cosmo Project Area.

4.2.1 Species Present

A total of thirty three (33) species of mosquito were collected during the base line monitoring program. This included seven (7) *Anopheles* species, thirteen (13) *Aedes* species and nine (9) *Culex* species (Table 10).

The domestic pest species *Cx. quinquefasciatus* that is often associated with polluted water was not recorded. The vector of Dengue Fever (*Ae. aegypti*), which has been previously eliminated from the NT, was also not recorded.

4.2.2 Relative Numbers

A total of 8,380 female mosquitoes were trapped over the 13 month period. The predominant species trapped was *Cx. annulirostris* (34.76 %), followed by *Coquillettidia xanthogaster* (20.70 %) and *Ae.*

normanensis (16.59 %). Less common species were *Ae. reesi* (6.86 %) and *Mansonia uniformis* (6.22 %). Table 10 presents the complete list of species.

"Billabong" - site 1 (26 species, total number trapped 4,246). *Coquillettidia xanthogaster* was the most common species trapped (27.53 %), followed by *Cx. annulirostris* (25.20 %), *Ae. normanensis* (15.19 %) and *Ae. reesi* (10.60 %) (see Table 8).

"Wetland filter" - site 2 (30 species, total number trapped 4,134). *Culex annulirostris* was the most common species trapped (44.58 %), followed by *Ae. normanensis* (18.02 %), *Cq. xanthogaster* (13.69 %) and *Ma. uniformis* (11.66 %) (see Table 9).

4.2.3 Seasonal abundance

The highest numbers of mosquitoes were collected in June 1996 (see Table 10). Total numbers were also relatively high in July 1996, November 1996 and January 1997.

The peak in June 1996 was comprised primarily of *Cq. xanthogaster*, *Ma. uniformis* and *Cx. annulirostris*. The maximum number of *Cq. xanthogaster* was recorded in June 1996. Smaller peaks occurred in July and August 1996.

The July 1996 peak was comprised primarily of *Cx. annulirostris* and *Cq. xanthogaster*. The maximum number of *Cx. annulirostris* was recorded in July 1996. Smaller peaks occurred in June, August, October, January and March 1997.

The November 1996 peak was comprised primarily of a large peak in *Ae. normanensis*. A much smaller peak was detected in March 1997. The January 1997 peak was comprised primarily of *Cx. annulirostris* and *Ae. reesi*.

A number of *Anopheles* species were recorded in significant numbers. *Anopheles annulipes* reached a peak of 48 in May 1996 and remained at significant levels until September 1996. It was recorded at significant levels again in January and February 1997. *Anopheles meraukensis* reached a peak of 117 in April 1996, with secondary peaks in May 1996 (32) and February 1997 (34). *Anopheles farauti* reached a peak of 17 in April 1996.

4.2.4 Spatial Distribution

The highest numbers of *Cq. xanthogaster, An. annulipes, An. farauti, An. meraukensis* and *Ae. reesi* were collected at site 1 (Billabong) (Table 8).

The highest numbers of *Cx. annulirostris*, *Ae. normanensis* and *Ma. uniformis* were trapped at site 2 (Wetland filter) (Table 9).

4.3 Desktop Assessment

The major natural mosquito breeding sites affecting the proposed mine sites are expected to be the ephemeral creek lines associated with Howley Creek and the Margaret River, and the seasonally flooded areas associated with the Margaret River (Figures 1 & 2). The Margaret River and seasonally flooded areas associated with this river are likely to be the major natural sources of mosquitoes to the Princess Louise and North Point mine sites.

These ephemeral creek lines and associated seasonally flooded areas are not expected to be sources of very high numbers of mosquitoes for extended periods, but are probable sources of low to high numbers of mosquitoes during certain periods of the wet season and early dry season. Important mosquito species likely to breed in these areas include *Aedes normanensis, Culex annulirostris, Coquillettidia xanthogaster, Anopheles farauti s.l.* and *Anopheles annulipes s.l.*

The major breeding sites will be areas in ephemeral creek lines fringed with grass or containing semi-aquatic reeds, while the seasonally flooded areas associated with the Margaret River are likely to be major breeding sites (figures 1 & 2). Those breeding sites within 4 - 5km of the proposed mine sites are likely to contribute to mosquito abundance of some mosquito species such as *Cx. annulirostris, Cq. xanthogaster* and *Ae. normanensis*, which are known to disperse widely from major breeding sites, although breeding sites within 2km of the proposed mine sites will be the major source of mosquitoes.

The Fountain Head mine is located within approximately 3km of the proposed North Point Mine, and within approximately 5km of the Princess Louise mine (Figures 1 & 2). If significant mosquito breeding is currently occurring within the disturbed areas associated with this existing mine, then there may be some minor dispersal of species such as *Cx. annulirostris, Cq. xanthogaster* and *Ae. normanensis* to the North Point mine, and potentially the Princess Louise mine. This would occur if very productive or extensive mosquito breeding sites exist at the Fountain Head mine.

There are some existing dams and pits located approximately 3-5km to the south and south west of the Princess Louise mine site. If these dams and pits contain significant breeding sites, they may be sources of *Cx. annulirostris* and *Cq. xanthogaster* to the Princess Louise mine site. They are probably too far from the North Point mine to be a significant source. The major potential breeding sites in these dams will be any shallow vegetated upstream reaches and shallow vegetated edges, while in the pits the major potential mosquito breeding sites will be any shallow vegetated edges.

The existing pits nearby to the North Point and Princess Louise mine sites could be sources of *Cx. annulirostris, Cq. xanthogaster, An. annulipes s.l.* and *An. farauti s.l.* to the Princess Louise and North Point mine sites, if significant mosquito breeding habitat is associated with these pits.

The salt marsh mosquito *Aedes vigilax* can fly in pest numbers up to 50km from their tidal breeding sites. This species was recorded at the Brocks Creek Project Area (Montgomery et al 1996a, 1999b) and Cosmo Project Area (Montgomery et al 1999a), most likely dispersing from the tidally influenced areas of the Adelaide River and Daly River, and is likely to be seasonally present at the Princess Louise and North Point mine sites. Peak season months for this species in the Top End of the NT are the months of September to January inclusive (Whelan 1997a).

The presence of water dams, dry season water discharge into drainage lines, impoundment of natural drainage lines, wetland filters, borrow pits, depressions and inappropriate effluent disposal have the potential to be sources of mosquitoes to the Princess Louise and North Point mine sites and the Cosmo Village.

5.0 Discussion

5.1 Species present

The most common mosquito species recorded at the Brocks Creek Project Area and Cosmo Project Area were relatively similar. *Aedes normanensis, Culex annulirostris, Coquillettidia xanthogaster* and *Anopheles annulipes s.l.* were among the most common mosquito species recorded during baseline mosquito trapping at the Brocks Creek and Cosmo Project Areas (Montgomery et al 1996a, Montgomery et al 1999a & 1999b). *Aedes vigilax* was also recorded from the Brocks Creek and Cosmo Project Areas (Montgomery et al 1996a, Montgomery et al 1999a & 1999b). Other species of potential importance recorded at both the Brocks Creek and Cosmo Project Areas were *Anopheles farauti s.l.* and *Mansonia uniformis.*

Due to all of the above mentioned species being recorded at both the Brocks Creek and Cosmo Project Areas, which are located over 5km and over 15km to the west of the proposed Princess Louise and North Point mine sites, it is likely that these mosquito species will also be present at the Princess Louise and North Point mine sites, due to the presence of similar natural habitats. The more important mosquito species are discussed in further detail below. Potential breeding sites are highlighted in Figures 1 & 2.

5.1.1 *Culex annulirostris (common banded mosquito)*

<u>Breeding sites</u>

Culex annulirostris generally breeds in freshwater and brackish water swamps with emergent vegetation such as grasses and semi-aquatic reeds, freshwater streams with vegetation, as well as temporary flooded grasslands, sewage ponds with vegetation and semi-polluted stormwater drains (Whelan 1997a, Appendix 1).

The Baseline Mosquito Assessment for the Brocks Creek Project revealed this species was most likely breeding in flooded ground depressions and ephemeral creek lines, as well as a ‘billabong’ created as the result of a road with inappropriate culvert provisions being constructed over an ephemeral creek line (Montgomery et al 1996a). Extremely high *Cx. annulirostris* breeding was also created at the mine staff accommodation area at the Cosmo Howley Village as a result of the inappropriate disposal of excess effluent into a nearby creek (Montgomery et al 1996a). Vegetated dam margins were also potential breeding sites for this species at the Brocks Creek Project Area (Montgomery et al 1996a).

The Baseline Mosquito Assessment at the Cosmo Project Area revealed this species was most likely breeding in the un-formalised wetland filter, flooded ground depressions and ephemeral creek lines or shallow flooded areas downstream of the constructed wetland filter, and potentially grassy margins of dams and silt retention structures (Montgomery et al 1999a).

Natural breeding sites for this species at the Princess Louise and North Point mine sites are likely to be vegetated margins of ephemeral creek lines and flooded ground depressions (Figure 1). Artificial breeding sites could include the existing pits adjacent to the North Point and Princess Louise mine sites, and the dams and pits located within 4km to the south and south west of the Princess Louise mine, if the margins of these pits and dams contain grasses and/or semi aquatic reed growth.

If there are seasonally flooded disturbed areas at the Fountain Head mine, these areas could be potential breeding sites for *Cx. annulirostris.*

<u>Seasonal abundance</u>

Culex annulirostris is generally most common in the months of January to August inclusive in the Top End of the NT (Whelan 1997a). The months of peak abundance would depend on the type of nearby habitat. Montgomery et al (1996a) concluded that the ephemeral creek lines within and adjacent to the Brocks Creek Project Area were not likely to contain significant mosquito breeding sites in the mid and late dry season, either as they would be dry or contain only defined pools, with bare margins and numerous aquatic predators of mosquito larvae. It is probable that the ephemeral creek lines and associated low lying areas adjacent to the Princess Louise and North Point mines are similar in nature, therefore this species can be expected to originate from ephemeral creek lines and associated low lying areas adjacent the project area in the early wet season when initial flooding occurs (December and January), and in the late wet/early dry season months of March to early June when vegetation growth is at a maximum and water levels begin to recede, leaving behind vegetated areas with restricted access for mosquito larvae predators.

Any presence of water dams with vegetated margins, wetland filters, and dry season discharge of water into dams, wetland filters or creek lines, has the potential to create productive and extended breeding for this species into the late dry season. This was particularly evident during baseline mosquito trapping at the Cosmo Project Area, which had low populations of *Cx. annulirostris* throughout the dry season months (Montgomery et al 1999a).

Culex annulirostris was most abundant during the months of January, June to August and October at the Cosmo Project Area (Montgomery et al 1999a), with the late dry season abundance attributed to breeding in artificial sites, while abundance in other months was likely to be due to breeding in both natural sites and artificial sites.

Culex annulirostris was most abundant during the months of November to January inclusive, March to May inclusive and July at the Brocks Creek Project Area (Montgomery et al 1996a), and was probably abundant in June, although traps were not set in this month. Breeding in artificial sites was probably the main contributor of dry season *Cx. annulirostris* abundance at the Brocks Creek Project Area (Montgomery et al 1996a).

<u>Dispersal</u>
Culex annulirostris can disperse up to 10km from extensive breeding sites, although are most common within 4km of breeding sites (Whelan 1997a), and there is usually a significant drop in *Cx. annulirostris* numbers up to 2km away from significant breeding sites (Whelan 2004). If no new breeding sites for this species are created by mining activity, most *Cx. annulirostris* will be encountered within 2km of ephemeral creek lines and associated low lying areas. If the mine sites create new breeding sites for this species, *Cx. annulirostris* will also be encountered within 2km of those newly created sites. If the existing pits adjacent to the North Point and Princess Louise mine sites (Figure 1) contain significant breeding sites for *Cx. annulirostris*, this species will disperse to both the North Point and Princess Louise mine sites from these pits.

If the existing dams and pits located to the south and south west of the Princess Louise mine site contain significant *Cx. annulirostris* breeding habitat, they may be a source of this species to the Princess Louise mine site.

If there are significant seasonally flooded disturbed areas located at the Fountain Head mine site, these may be sources of *Cx. annulirostris* to the North Point mine, and potentially to the Princess Louise mine if there are extensive *Cx. annulirostris* breeding sites at the Fountain Head mine site.

<u>Pest numbers</u>
Culex annulirostris reaches pest levels when there are more than 100 per CO2 baited EVS trap per night, for those traps set away from residential areas (Whelan 1997a). This pest threshold was exceeded during certain months at all trap sites during baseline mosquito trapping at the Brocks Creek Project Area, although usually not to any great extent, except for Trap Site 3 in November 1996a, which recorded numbers 6 times the pest threshold (Table 3). For most other occasions when *Cx. annulirostris* numbers exceeded the pest threshold at the Brocks Creek Project area, numbers were generally not much above 2 times the pest threshold. This indicated that a potential low to moderate pest problem existed at the Brocks Creek Project Area.

At the Cosmo Project Area, pest thresholds were exceeded by up to 3 times at the ‘Billabong’ trap site during certain months, and by up to 5 times during certain months at the ‘wetland filter’ trap site. This indicated a potential low to moderate pest problem.

Culex annulirostris only bites at night, and is less persistent in the presence of lights, personal protective clothing and repellents (Whelan et al 2001), therefore will only pose a pest problem to unprotected workers at night. Low to moderate pest problems may occur at the Princess Louise and North Point mine sites within 2km of breeding sites in the early wet season months of December and January, and the early dry season months of April to June. If artificial breeding sites for this species are created at the Princess Louise and North Point mine sites, peak season pest problems could be high, and pest problems could occur throughout the dry season months, until the breeding sites are rectified.

Seasonal low to moderate pest problems at the Cosmo Village are likely to be encountered, sourced from potential breeding sites highlighted by Montgomery et al (1999a). If artificial breeding sites at the Cosmo Project Area have not been rectified or maintained, then seasonally high pest problems could be encountered in areas nearby to those artificial breeding sites.

Disease significance
Culex annulirostris is the most important vector of arboviruses in the NT (Whelan & Weir 1993). It is recognised as a good vector of Murray Valley encephalitis virus (MVEV), Kunjin virus (KUNV), RRV and BFV (Merianos et al 1992, Whelan et al 1993). Many other arboviruses have been isolated from this species (Whelan & Weir 1993). *Culex annulirostris* will pose a potential disease risk when it is present at the mine sites, especially when this species is present during the main risk months for the various arboviruses (Appendix 2), and when it is present in the warmer, humid months of November to March, when the longevity of this species will be increased, increasing the chance of this species obtaining a virus from a vertebrate host and passing it on to a human.

5.1.2 *Aedes vigilax (salt marsh mosquito)*

Potential breeding sites
The salt marsh mosquito breeds in tidal and brackish water in coastal areas, such as salt marshes, brackish water reed swamps and upper reaches of tidal creeks (Whelan 1997a). There will be no breeding sites for this species at or nearby to the Princess Louise and North Point mine sites. Breeding sites for this species affecting the mine sites will either be the tidal reaches of the Adelaide River or Daly River, depending on wind direction.

Seasonal abundance
Aedes vigilax is most abundant around coastal areas of the NT in the months of September to January inclusive, with adults dispersing from their breeding sites around 9 days after significant tides or rainfall in these months. During the less humid months in coastal areas, *Ae. vigilax* abundance usually lasts for one week, while in the more humid months of November to January inclusive, abundance lasts up to two weeks. Low numbers can be encountered in coastal areas in May and June in some years depending on late wet season rainfall or significant high tides, while this species is virtually absent during other months.

Baseline mosquito trapping at the Brocks Creek and Cosmo Project areas (Montgomery et al 1996a & 1999a) revealed highest numbers of this species in the month of November, with low abundance in December at the Brocks Creek Project area. Further mosquito trapping at the Brocks Creek Project Area in 1997 revealed highest numbers in November (Montgomery et al 1999b).

Dispersal
Aedes vigilax can disperse in pest numbers up to 50km from extensive tidal breeding sites with favourable winds. This dispersal characteristic would ensure that this species is seasonally present at the Princess Louise and North Point mine sites. This species is likely to appear at the mine sites

around 14 - 15 days after monthly high tides or significant rainfall over the tidal areas of the Adelaide or Daly River in the months of September to January inclusive.

Pest numbers

Generally 50 or more *Ae. vigilax* females in a CO2 baited EVS trap set outside of residential areas indicates a pest problem. This species is a painful and persistent biter, and will bite during the day in shaded areas and during the night (Whelan 1997a, Appendix 1). The persistent and day biting habits of this species make *Ae. vigilax* probably the most important pest mosquito in coastal areas of the NT.

Aedes vigilax was encountered in low numbers at the Brocks Creek and Cosmo Project Areas during baseline trapping (Montgomery et al 1996a, Montgomery et al 1999a), and in high numbers at the Brocks Creek Project Area during extension trapping in 1997 (Montgomery et al 1999b), indicating in some years with favourable winds, moderate to high pest problems are likely to be encountered at the Princess Louise and North Point mine sites and Cosmo Village.

Disease significance

Aedes vigilax is a vector of RRV in the Top End of the NT (Tai et al 1993, Whelan & Weir 1993). This species is also a vector of BFV (Merianos et al 1992, Whelan et al 1993). The greatest potential for virus transmission from this species is in November to January inclusive, when this species occurs in peak numbers, and the humid conditions in these months increases the longevity of mosquitoes, increasing the chance of an individual *Ae. vigilax* obtaining a virus from a vertebrate host and passing it onto a human.

5.1.3 *Aedes normanensis (floodwater mosquito)*

Breeding sites

This mosquito species generally breeds in broad, flat sub-coastal drainage floors of minor and major creeks (Whelan 1997a, Appendix 1). Drought resistant eggs from this species are laid in drying mud, and hatch after subsequent inundation with rainwater.

The ephemeral creek lines adjacent to the Princess Louise and North Point mine sites are likely to be breeding sites for this species, but do not appear to contain extensive areas of broad, flat drainage floors, therefore are not expected to be sources of very high numbers of this species. The ephemeral creek lines within 5km of the proposed mine sites appear mostly relatively narrow and well defined, although there appears to be some significant flat drainage areas that could be productive breeding sites (Figure 1). Therefore at least moderate, and potentially high numbers of this species are expected to originate from nearby ephemeral creek lines and associated poorly draining areas, with the North Point mine site located close to numerous ephemeral creek lines, therefore is likely to experience greater numbers of this species.

The Fountain Head mine could contain breeding sites for this species, if there are disturbed areas capable of ponding rain water for periods greater than five consecutive days.

Moderate to high numbers of *Ae. normanensis* were recorded at Sites 3 & 4 at the Brocks Creek Project Area, which were located nearby to relatively large areas of ephemeral creek lines (Montgomery et al 1996a). This species was recorded in very high numbers at Site 1 at the Brocks Creek Project Area, due to breeding in a cleared wetland filter site after first flooding (Montgomery et al 1996a), indicating this species also breeds in seasonally flooded disturbed areas. Minor depressions in an uncleared wetland filter site were also considered as breeding sites for this species (Montgomery et al 1996a).

High numbers of *Ae. normanensis* were recorded at the Cosmo Project Area at both trap sites, with ephemeral creek lines, small retention dams and borrow pits, and shallow edges of larger dams being considered the sources of this species (Montgomery et al 1999a).

Seasonal abundance

Aedes normanensis breeds in the wet season, with January to April being the peak months (Whelan 1997a, Appendix 1), although this species will also breed in October, November and May in those years when significant rainfall occurs in these months. Eggs hatch upon inundation with rainwater and pest problems generally begin 9 days after the flooding rain and last for up to 2 weeks.

Aedes normanensis was most abundant in the months of October to April during baseline trapping at the Brocks Creek and Cosmo Project Areas, and absent during the other months (Montgomery et al 1996a & 1999a).

Dispersal

Aedes normanensis is most common within 2km of breeding sites, although can disperse up to 5km in pest numbers (Whelan 1997a, Appendix 1). Both mine sites are located within 2km of ephemeral creek lines, with the North Point mine located within 2km of numerous ephemeral creek lines, therefore is likely to be subject to greater dispersal of *Ae. normanensis* compared to the Princess Louise mine.

The North Point mine may also be subject to dispersal from the Fountain Head mine, if breeding sites for this species are present in the disturbed areas associated with the Fountain Head mine. The Fountain Head mine is located approximately 3km from the North Point mine and approximately 5km from the Princess Louise mine, therefore the North Point mine will be the most affected by any dispersal that may occur from the Fountain Head mine area.

Pest problems

Aedes normanensis is considered a major pest species, and readily bites humans, mainly in the evening and at night although this species has been known to bite in shaded areas during the daytime. Generally 50 or more of this species in a CO2 baited EVS monitoring trap set close to residential areas indicates a likely pest problem (Whelan 1997a). This threshold was greatly exceeded at the Brocks Creek and Cosmo Project Areas during baseline mosquito trapping (Montgomery et al 1996a & 1999a), indicating there is a high probability that this species will also cause seasonal pest problems at the Princess Louise and North Point mine sites. It is probable that seasonally moderate pest problems may occur at the Princess Louise and North Point mine sites, although seasonally high pest problems may occur if significant breeding habitat is located within 2km of the proposed mine sites, or if new breeding sites for this species are created by development. Pest problems are likely to occur in the months of January to April, and also in October to December in those years when significant rainfall flooding occurs in these months.

Seasonal pest problems at the Cosmo Village are likely to be encountered, sourced from potential breeding sites highlighted by Montgomery et al (1999a). If the wetland filters at the Cosmo Project Area have not been rectified or maintained, then high to very high pest problems are likely to be encountered in areas nearby to the wetland filters, which may include the mine camp.

Disease significance

Aedes normanensis is a potential vector of Ross River virus (RRV) and Barmah Forest virus (BFV) (Whelan & Weir 1993), and a potential vector of Murray Valley encephalitis virus (Whelan 1997a).
Aedes normanensis it is not considered as important as *Culex annulirostris* and *Aedes vigilax* as a potential RRV vector, but depending on region and conditions this species can be involved in RRV transmission (Russell 2002). This species is also not considered a principal vector or MVEV and BFV (Russel & Kay 2002).

The main risk for RRV transmission in the NT is the months of December to June, with peak risk months being January to March (Whelan 1997b, Appendix 2). The main risk period for BFV transmission in the NT is the months of October to July, with the peak risk months being January to March (Whelan 1997b, Appendix 2). The main risk period for MVEV transmission is the months of January to July, with March to May being the peak risk period (Whelan 1997b, Appendix 2).

The potential for virus transmission from this species will occur during the wet season months starting 9 days after significant rainfall floods breeding sites, with the potential virus risk lasting around 2 weeks. The potential for virus transmission will affect unprotected workers in the evenings and at night, and in shaded areas during the daytime.

5.1.4 *Anopheles annulipes s.l. (Common Australian Anopheles mosquito)*

Potential breeding sites

This species mainly breeds in freshwater streams and vegetated swamps, and also breeds in some receptacles (Whelan 1997a). Breeding sites for this species at the Brock Creek Project Area were probably along the vegetated margins of the ephemeral creeks and flooded ground depressions, as well as a 'billabong' caused by an embanked creek line (Montgomery et al 1996a). Breeding sites for this species at the Cosmo Project Area were probably the vegetated margins of the alluvial dams, ephemeral creeks and flooded ground depressions (Montgomery et al 1999a).

Natural breeding sites for *An. annulipes s.l.* at the Princess Louise and North Point mine sites are likely to be along the vegetated margins of ephemeral creek lines and flooded ground depressions. Artificial breeding sites could include the existing pits adjacent to the North Point and Princess Louise mine sites (Figure 1), if the pits contain areas of shallow, vegetated margins.

Seasonal abundance

This species is generally most abundant during the wet season and post wet season, depending on the availability of surface water in the post wet season (Whelan 1997a). At the Brocks Creek Project Area, *An. annulipes s.l.* was most abundant in the early wet season months of November and December, and in the post wet season months of April and May (Montgomery et al 1996a). There were constant levels of this species at one trap site at the Brocks Creek Project Area for the majority of the year, possibly associated with the 'billabong' caused by the embanked creek line (Montgomery et al 1996a).

At the Cosmo Project Area, highest numbers of this species was trapped in the months of February to May, although a relatively constant level of this species was recorded for much of the year, probably due to breeding in the vegetated margins of the alluvial dams (Montgomery et al 1999a).

Dispersal

Anopheles annulipes s.l. are most common within 2km of breeding sites, therefore those areas of the proposed mine sites within 2km of ephemeral creek lines will experience the greatest problems from this species. If the existing pits adjacent to the Princess Louise and North Point mine sites contain breeding sites for this species, there will be dispersal to the mine sites from these pits. If artificial breeding sites for this species are created at the mine sites, then this species will also be encountered within 2km of these sites.

At the Cosmo Village, *An. annulipes s.l.* will be most common within 2km of potential breeding sites such at ephemeral creek lines and any un-maintained or un-rectified artificial water impoundments.

Pest numbers

Anopheles annulipes s.l. is not as significant as a pest mosquito compared to the above mentioned species. This species bites at night, particularly around dawn and dusk, therefore only exposed people after sundown within 2km of breeding sites are likely to experience pest problems from this species.

Seasonal minor to low pest problems at the Cosmo Village are likely to be encountered, sourced from potential breeding sites highlighted by Montgomery et al (1999a).

Disease significance

Anopheles annulipes s.l. is considered a potential vector of malaria (Russell & Kay 2004). The *Anopheles annulipes s.l.* species complex is known to include at least 10 sibling species, although nothing is known of the vector competence of each sibling species (Russell & Kay 2004). The risk for potential malaria transmission at the Princess Louise and North Point mine sites will occur if a person with the infectious stages of malaria is bitten by an *An. annulipes s.l.* female at the development site. The risk threshold for *Anopheles* species in a CO2 baited EVS trap is regarded as 10 females per trap per trap night. This number was exceeded at both the Brocks Creek Project Area and Cosmo Project Area (Montgomery et al 1996a, 1999a). It is likely that *An. annulipes s.l.* will reach levels above the risk threshold at the Princess Louise and North Point mine sites, particularly during the wet season months and post wet season months.

Malaria is not endemic to Australia, so a risk will only arise if a person returning from overseas with the infectious stages of malaria is exposed to *An. annulipes s.l.* at the proposed mine sites. Therefore all personnel sourced or returning from overseas who suddenly becomes ill with high fever should be considered as possibly having malaria, and be kept indoors away from mosquito bites until cleared of having malaria, or cleared of the infectious stages of malaria by a health care practitioner.

5.1.5 *Anopheles farauti s.l. (North Australian malaria mosquito)*

<u>Breeding sites</u>

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 hinesorum and *Anopheles torresiensis* are likely to be the only two species in the *An. farauti s.l.* species complex present at the Princess Louise and North Point mine sites. Potential breeding sites will be the vegetated margins of nearby ephemeral creek lines and flooded ground depressions, as well as the existing pits adjacent to the Princess Louise and North Point mine sites if the pits contain shallow, vegetated margins (Figure 1). At the Brocks Creek Project Area, this species was potentially breeding in the vegetated margins of ephemeral creeks and flooded ground depressions (Montgomery et al 1996a).

<u>Seasonal abundance</u>

Anopheles farauti s.l. is generally most abundant in the late wet season and early dry season months of March to June (Whelan 1997a, Appendix 1). In these months semi-aquatic vegetation growth is at its maximum, and receding water levels combine to create suitable breeding habitat for this species.

Highest numbers of *An. farauti s.l.* were recorded in March at the Brocks Creek Project Area (Montgomery et al 1996a), and in February to April at the Cosmo Project Area (Montgomery et al 1999a).

<u>Dispersal</u>

Anopheles farauti s.l. can disperse up to 3km, although they are most common within 1.5km of breeding sites (Whelan 1997a, Appendix 3). Therefore the majority of *An. farauti s.l.* at the mine sites and mine camp will be noticed within 1.5km of ephemeral creek lines, flooded ground depressions and un-maintained artificial water impoundments.

<u>Pest numbers</u>

Pest numbers of this species in a CO_2 trap is generally regarded to be 50 per trap per trap night (Whelan 1997a, Appendix 3). However, this species is a more timid biter compared to *Ae. vigilax, Ae. normanensis* and *Cx. annulirostris*, therefore will be of lower pest significance. *Anopheles farauti s.l.* females only bite after sundown. Pest numbers were not recorded during the trapping at the Brocks Creek and Cosmo Project Areas, however it is possible that minor to low pest numbers may be present in the months of February to May at the proposed mine sites and mine camp.

Disease significance

The species *An. farautis.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. The risk threshold for malaria transmission from *An. farauti s.l.* per trap is generally regarded to be 10 females per trap per trap night. This threshold was exceeded in April at one site during baseline mosquito trapping at the Cosmo Project Area (Montgomery et al 1999a), and in the month of March at two sites during baseline trapping at the Brocks Creek Project Area (Montgomery et al 1996a). It is possible that *An. farauti s.l.* will be present in levels above the risk threshold at the Princess Louise and North Point mine sites, in the months of February to May.

Malaria is not endemic to Australia, so a risk will only arise if a person returning from overseas with the infectious stages of malaria is exposed to *An. farauti s.l.* at the prospect area. Therefore all personnel sourced or returning from overseas who suddenly becomes ill with high fever should be considered as possibly having malaria, and be kept indoors away from mosquito bites until cleared of having malaria, or cleared of the infectious stages of malaria by a health care practitioner.

5.1.6 Other pest species

Mosquito species of pest significance only were also trapped during baseline mosquito monitoring at the Brocks Creek Project Area and Cosmo Project Area. This included the golden mosquito *Coquillettidia xanthogaster* and the water lily mosquito *Mansonia uniformis.* Further information on these species can be found in Appendix 1.

At the Brocks Creek Project Area, *Cq. xanthogaster* was recorded in low numbers at all sites, with the months of January, March, July and September being the most productive. The wetland filter was a potential breeding site for this species (Montgomery et al 1996a). At the Cosmo Project Area, this species was recorded in high numbers at the 'billabong' trap site, and low to moderate numbers at the 'Wetland filter' trap site. Peak abundance was in June to August. Potential breeding sites for this species were the wetland filters, flooded ground depressions and creek lines (Montgomery et al 1999a).

At the proposed mine sites, potential breeding sites for *Cq. xanthogaster* includes vegetated creek lines and flooded ground pools, the existing pits adjacent to the Princess Louise and North Point mine sites if vegetated with margin vegetation, and the dams and pits to the south of the Princess Louise mine site (Figure 1). This species is likely to be encountered in low to moderate numbers at the proposed mine sites, and potentially high numbers if artificial breeding sites for this species are created. Numbers of this species are likely to be similar at the Cosmo Village to what was recorded by Montgomery et al (1999a), although this species may be present in higher numbers if the wetland filters and other water impoundments at the Cosmo Project Area have not been rectified or maintained.

Mansonia uniformis was recorded in minimal numbers at the Brocks Creek Project area, and in relatively high numbers at the Cosmo Project Area at the 'Wetland Filter' site in the month of June (Montgomery et al 1996a, 1999a). The breeding site for this species at the Cosmo Project Area was probably the wetland filter (Montgomery et al 1999a). Potential breeding sites for this species are similar to *Cq. xanthogaster.* This species is likely to be encountered in minor to low numbers at the proposed mine sites, and potentially moderate to high numbers if artificial breeding sites for this species are created. At the Brock Creek camp, this species may be encountered in moderate to high numbers if the wetland filters have not been rectified or maintained.

5.2 Mosquito breeding and development aspects

5.2.1 Water dams

Large retention dams and water storage sites have the potential to become mosquito breeding sites for species such as *Cx. annulirostris*, *An. annulipes s.l.*, *An. farauti s.l.*, *Cq. xanthogaster* and *Ma. uniformis*. However, with attention to the slope of the margins, these structures can largely be made mosquito free. Guidelines on the design of water dams can be found in Appendix 3, 'Guidelines for preventing mosquito breeding sites associated with mining sites'.

5.2.2 Wetland filters

Wetland filters were breeding sites for *Cx. annulirostris* and *An. annulipes s.l.* at the Brocks Creek Project Area, and potential breeding sites for *Cx. xanthogaster*, *Ma. uniformis* and *Ae. normanensis* (Montgomery et al 1996a). Wetland filters are also potential breeding sites for *An. farauti s.l.* However, the appropriate design and maintenance of wetland filters will significantly reduce the potential for mosquito breeding in these structures. If wetland filters are to be utilised for the Princess Louise and North Point mine sites, they should be constructed and maintained in accordance with information provided in Appendix 3.

5.2.3 Silt traps

Silt traps have the potential to become mosquito breeding sites for *Cx. annulirostris, An. annulipes s.l., An. farauti s.l., Ae. normanensis, Cx. xanthogaster* and *Ma. uniformis.* Silt traps should be designed to completely drain within five days after rain, to prevent ponding for periods that will enable mosquito breeding. Further guidance on the design and maintenance of silt traps can be found in Appendix 3.

5.2.4 Borrow pits

Borrow pits have the potential to become breeding sites for numerous mosquito species, if they are capable of ponding water for periods greater than 5 consecutive days. Further information on ensuring borrow pits do not become mosquito breeding sites can be found in Appendix 3.

5.2.5 Mine waste dumps

Mine waste dumps have the potential to create mosquito breeding sites, from water and silt runoff from the waste dumps, or the inappropriate siting of mine waste dumps. Guidance on ensuring mine waste dumps do not create mosquito breeding sites can be found in Appendix 3.

5.2.6 Drainage paths

The creation of roads across drainage paths has the potential to create breeding sites for various mosquito species, if adequate culvert provisions are not provided. For example, a large potential mosquito breeding site was created at the Brocks Creek Project Area when a road was constructed over an ephemeral creek line, and the culvert was positioned higher than the upstream natural surface (Montgomery et al 1996a). Guidance on ensuring the construction of roads do not create mosquito breeding sites can be found in Appendix 3.

5.2.7 Pit water discharge

Pit water discharge has the potential to create extensive mosquito breeding sites, particularly if pit water discharge was to occur during the dry season. Pit water discharge should be free of silt, and dry season pit water discharge should be directed into a water dam, and not into natural drainage lines or creek lines unless there is provision to prevent the growth of semi-aquatic reeds in the discharge area.

Pit water discharge could alternatively be used for irrigation during the dry season, as long as the pit water is appropriately dispersed in a manner that will prevent the creation of water ponding or water runoff into low lying areas or creek lines.

5.2.8 Ground depressions

Any depression created as a result of construction activities, such as vehicle disturbance or shallow depressions caused by site clearing, that are capable of ponding rain water for periods greater than 5 consecutive days, could become mosquito breeding sites for various mosquito species. It is recommended that the development site be maintained free of these potential mosquito breeding sites.

5.2.9 Waste water disposal

If not already approved, the waste water disposal system at the Cosmo Village must be approved by the Department of Health and Community Services, to prevent the creation of extensive breeding or pest and disease carrying mosquito species, which is what previously occurred at the Cosmo Howley Village when waste water was inappropriately disposed of into a creek line (Montgomery et al 1999a). Applicable guidelines and regulations include the MEB guidelines 'The Prevention of Mosquito Breeding in Sewage Treatment Facilities' and the DHCS Environmental Health regulations 'Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Re-use of Sewage Effluent'.

5.2.10 Artificial receptacles

Artificial receptacles such as used tyres, drums, disused machinery and any rubbish items that can collect rain water are potential mosquito breeding sites. Mosquito species that are commonly found breeding in artificial receptacles are *Aedes notoscriptus* and *Culex quinquefasciatus,* with the former a potential vector of RRV. Mosquito species that occasionally breed in artificial receptacles include the potential malaria vector *An. annulipes s.l.* and the major arbovirus vector *Cx. annulirostris.*

Any used tyres, water drums, rainwater tanks, machinery items that can pond water (ie backhoe buckets, excavator tracks), building material and equipment wrapped in plastic sheeting or with the potential to hold water, and any other item capable of ponding even small amounts of water, which are sourced from North Queensland, has the potential to introduce the dengue mosquito *Aedes aegypti* as drought resistant eggs. Artificial receptacles that have previously held rain water should be treated with a 10% chlorine solution or an appropriate residual insecticide (deltamethrin or lambda-cyhalothrin), to prevent the possibility of the introduction of *Ae. aegypti* into the Princess Louise and North Point mine sites. See Appendix 6 'Recommended interim water receptacle treatment for exotic mosquitoes on international foreign fishing vessels arriving in Australia' for further details on chlorination treatments.

Periodic inspections of artificial receptacles should be conducted during the wet season at the mine sites and mine camp, with any receptacle found ponding water either disposed of, stored under cover, have drainage holes drilled or treated with an appropriate insecticide on an appropriate schedule, to prevent potential mosquito breeding and minimise the potential for the re-introduction of *Ae. aegypti* from North Queensland.

5.3 Mosquito avoidance and control

5.3.1 Personal protection

Personal protection from mosquitoes will most likely be required during certain periods of the year at the mine sites and mine camp. Most mosquito species bite at night, so can be relatively easily avoided by avoiding night time exposure, although some species such as the salt marsh mosquito *Ae. vigilax* and the floodwater mosquito *Ae. normanensis* can bite in shaded areas during the daytime as well as at night, so will be more noticeable. If work activities are to be conducted at night, appropriate personal protection measures may be required. The wet season and early dry season are likely to be the periods of the year when mosquitoes will be most abundant. Information on personal protection from mosquitoes can be found in Appendix 4.

5.3.2 Mosquito control

Any areas of artificial water ponding at the mine sites should be periodically inspected for mosquito larvae, or the presence of habitat indicators such as grass and semi-aquatic reed growth at the water margin. Those areas of artificial water ponding found breeding mosquitoes, or with the potential to breed mosquitoes, should be programmed for annual maintenance during the dry season months. Temporary mosquito control can be achieved using the mosquito larvicides ‘methoprene’ or ‘*Bacillus thuringiensis* var. *israelensis* (B.t.i.)’, until a permanent engineering solution or maintenance is implemented.

Fish are major predators of mosquito larvae. Where water quality permits, all areas of artificial water ponding should be stocked with predatory native fish species, such as the black lined rainbow fish, various grunter species, various gudgeon species, the pacific blue eye or glass perchlets.

There may be periods when adult mosquito populations from natural breeding sites reach pest levels and workers request adult mosquito control, or when the potential for mosquito borne disease transmission is high. The current best practice for adult mosquito control in Australia is to use the barrier insecticide ‘bifenthrin’, which is a residual insecticide with low irritancy to mosquitoes, thus increases the adult mosquito-insecticide contact time to provide better control (WHO 2002). Further information on bifenthrin barrier treatments can be found in Appendix 5. Bifenthrin can be applied to external walls, under demountables, on insect screens, floorboards, areas of dense vegetation and other likely mosquito harbourage areas around mine building and accommodation areas to control adult mosquitoes. The months of December to May, when the transmission risk for many arboviruses is at its greatest, will be the months when bifenthrin treatments will be most beneficial.

All personnel will be house at the mine camp at Cosmo Village (Penny Barker pers. comm.). Seasonal mosquito problems are known to exist in the Cosmo Project Area (Montgomery et al 1999a). If potential mosquito breeding facilities such as wetland filters, water dams, silt traps and other water holding facilities, as outlined in previous mosquito assessment reports (Montgomery et al 1999a), still exist in the Cosmo Project Area and have not been maintained or rectified, mosquito problems affecting at the mine camp will be similar or greater than what was outlined by Montgomery et al (1999a). It is recommended that all potential water holding facilities within at least 2km of the Cosmo Village be inspected for maintenance requirements such as desilting and vegetation removal, or permanent rectification.

The existing pits adjacent to the Princess Louise and North Point mine sites (Figure 1) should be inspected for the potential for mosquito breeding. Potential mosquito breeding sites will be characterised by shallow edges with grass or semi-aquatic reed growth. If potential mosquito breeding habitat is located, these should be rectified by deepening any shallow edges, and removing margin vegetation.

The existing dams and pits located over 2km to the south and south west of the Princess Louise mine sites could be sources of mosquitoes to the Princess Louise mine site. If mid to late dry season mosquito problems exist at the Princess Louise mine site, and nearby water impoundments have been excluded as breeding sites, these water dams and pits should be inspected for the presence of extensive larval habitat and mosquito breeding, with rectification works such as deepening any shallow edges or vegetation removal carried out if practical, or mosquito breeding treated with a residual methoprene formulation.

The Fountain Head mine area should be inspected in the wet season for potential artificial mosquito breeding sites, with any artificial mosquito breeding sites rectified where practical during the following dry season.

The prevention of mosquito breeding and control of mosquito breeding in artificial receptacles will be particularly important at the Princess Louise and North Point mine sites and Cosmo Village, please refer to Section 5.2.10 of this report.

5.4 Decommissioning and rehabilitation

A decommissioning and rehabilitation plan should be in place to ensure no actual and potential mosquito breeding sites remain after cessation of mining operations, to prevent negative impacts on the future use of the land and surrounding areas. All disturbed areas should be rehabilitated to be free draining where practical.

At the Princess Louise and North Point mine sites, this may involve removing and appropriately grading all sediment ponds and silt traps, removing all bund walls created for the development, removing infrastructure and artificial receptacles that could pond water, removing water dams and reinstating existing flowpaths where practical, rehabilitating borrow pits, and removing wetland filters if they are to be utilised for this mining development.

Facilities such as open pit voids and water dams can be left as water holding pits if they are constructed with steep sides (at least 1:2 slope), and are stocked with fish during the rehabilitation process.

5.5 Limitations

The information on mosquito abundance provided in this report was only an estimation of what may be encountered at the Princess Louise and North Point mine sites, based on an examination of aerial photography and topographical maps and previous baseline mosquito assessments conducted in the general vicinity. To provide a more accurate indication on mosquito abundance at the Princess Louise and North Point mine sites, monthly trapping for 12 months, and peak abundance trapping for *Ae. normanensis* and *Ae. vigilax* would have been required, and a ground assessment of potential mosquito breeding sites would also have been required.

The Princess Louise and North Point mines sites appear to be located closer to more extensive natural seasonally flooded areas (associated with the Margaret River) compared to the Brocks Creek and Cosmo Project Areas, therefore could be subject to greater levels of mosquitoes. However, the Brocks Creek and Cosmo Project Areas were subject to some mosquitoes breeding in artificially created areas, therefore the information from these studies could not be considered as true baseline information (ie from natural breeding sites only), which made predicting likely abundance more complex. The predictions of mosquito abundance at the North Point and Princess Louise mine sites were based on the technical experience of the authors and mosquito information from the general Pine Creek region, which may not hold true in some instances where there are small but productive mosquito breeding sites that could not be determined using topographical information and aerial photography.

6.0 Conclusions

6.1 Mosquito populations

The most important mosquito species likely to be encountered at the Princess Louse and North Point mine sites will be *Aedes normanensis, Culex annulirostris, Aedes vigilax, Anopheles annulipes s.l., Anopheles farauti s.l., Coquillettidia xanthogaster* and *Mansonia uniformis.*

Aedes normanensis is likely to be sourced from ephemeral creek lines and flooded ground depressions within 5km of the proposed mine sites and Cosmo Village, with breeding sites within 2km of the mine sites and mine camp being the major source of this species. Artificial breeding sites affecting the mine camp would include un-rectified or un-maintained wetland filters within 5km of the camp, with those within 2km of the camp the major potential source. This species is likely to be present during the wet season months of October to April, and peak numbers will occur from 9 days after significant flooding rain and last for up to 2 weeks. This species is likely to be encountered in seasonally low to high numbers.

Culex annulirostris is likely to be sourced from the vegetated margins of ephemeral creek lines and flooded ground depressions within 4km of the proposed mine sites and mine camp, with breeding sites within 2km of the mine sites and mine camp being the major source of this species. Artificial breeding sites that may potentially affect both the Princess Louise and North Point mine sites include the existing pits adjacent to the North Point and Princess Louise mines. Artificial breeding sites that may also potentially affect the Princes Louise mine include the dams within 4km to the south and south east of the Princes Louise mine.

Culex annulirostris is likely to be present in the wet season and early dry season, with peaks in the early wet season months of December and January, and in the early dry season months of March to early June. This species may be present in the mid to late dry season at both mine sites and the mine camp if affected by breeding in artificial water impoundments. Seasonal *Cx. annulirostris* abundance is likely to be low to moderate from natural breeding sites, and potentially high if supplemented by breeding in artificial sites. Artificial breeding sites affecting the Cosmo Village would include un-rectified or un-maintained wetland filters and water impoundments within 4km of the camp, with those within 2km of the camp the major potential source.

Aedes vigilax is likely to be sourced from the distant tidal areas associated with the Adelaide River or Daly River. This species will be dispersing over 50km to the proposed mine sites. Peak abundance for this species is likely to occur in the months of September to January inclusive, with this species likely to appear at the proposed mine sites around 14-15 days after monthly high tides or significant rainfall over the tidal areas of the Adelaide or Daly Rivers, and persist for around 1 week. This species is likely to be present in seasonally low to high numbers.

Anopheles annulipes s.l. is likely to be sourced from the vegetated margins of ephemeral creek lines and flooded ground depressions within 2km of the proposed mine sites, and potentially the existing pits adjacent to the mine sites. Artificial breeding sites affecting the Cosmo Village would include un-rectified or un-maintained wetland filters and water impoundments within 2km of the mine camp. Peak abundance is likely to occur in the wet season and early dry season months of December to May from natural breeding sites. Abundance of this species may continue into the mid to late dry season if significant breeding sites are associated with the existing pits adjacent to the mine sites, and if potential breeding sites at Cosmo Project Area have not been rectified or maintained. This species is likely to be present in seasonally low numbers at the proposed mine sites and mine camp.

Anopheles farauti s.l. is likely to be sourced from the vegetated margins of ephemeral creek lines and flooded ground depressions within 2km of the proposed mine sites, and potentially the existing pits adjacent to the mine sites. Artificial breeding sites affecting the Cosmo Village would include un-rectified or un-maintained wetland filters and water impoundments within 2km of the mine camp. Peak abundance is likely to occur in the months of February to May at the proposed mine sites, with abundance likely to continue into the dry season if this species is breeding in the existing pits adjacent to the Princess Louise and North Point mine sites, and if potential breeding sites at Brocks Creek have not been rectified or maintained.

Other mosquito species such as *Coquillettidia xanthogaster* and *Mansonia uniformis* may be seasonally present at the Princess Louise and North Point mine sites, most likely sourced from vegetated areas of nearby ephemeral creek lines and flooded ground depressions, and also from the existing pits adjacent to the North Point and Princes Louise mines if the margins are vegetated with grass and/or semi-aquatic reeds. Artificial breeding sites affecting the Cosmo Village would include un-rectified or un-maintained wetland filters and water impoundments within 2km of the mine camp. Peak season abundance from both of these species is likely to occur in the months of March to June.

6.2 Mosquito borne disease and pest problems

Culex annulirostris is the major arbovirus vector in the NT, capable of transmitting RRV, BFV, MVEV, Kunjin virus and many others. This species is likely to cause seasonally low to moderate pest problems and disease risk, and potentially high pest problems and disease risk if artificial breeding sites for this species are created. This species only bites at night, so will only affect unprotected workers after sundown.

Aedes vigilax is a major potential vector or RRV and BFV. This species is a significant pest species, as it bites in shaded areas during the daytime as well as at night. *Aedes vigilax* is likely to cause seasonally low to high pest problems and disease risk at mine sites and mine camp.

Aedes normanensis bites in shaded areas during the daytime as well as in the evening and at night. This species is a potential vector of Ross River virus (RRV), Barmah Forest virus (BFV) and Murray Valley encephalitis virus (MVEV), although this species is not considered as important as a vector mosquito compared to *Culex annulirostris* and *Aedes vigilax.* This species is likely to cause seasonally moderate to high pest problems and potential disease risk at the mine sites and mine camp.

Anopheles annulipes s.l. and *Anopheles farauti s.l.* are potential vectors of malaria. The risk for malaria transmission will occur if a person with the infectious stages of malaria is bitten by *Anopheles* mosquitoes at the mine site or mine camp. These species are generally not significant pest mosquitoes, and are expected to cause nuisance to low pest problems only at the mines sites and mine camp. *Anopheles* mosquitoes only bite at night, so will only pose a potential malaria or pest problem after sundown.

Coquillettidia xanthogaster and *Mansonia uniformis* are not known to transmit human disease in Australia, but can be significant pest mosquitoes. These species bite at night, and may cause seasonal low pest problems at the Princess Louise and North Point mine sites and mine camp. If artificial breeding sites for these species are created, then moderate to high pest problems could be encountered at the mine sites. If artificial breeding sites for these species are present at the Cosmo Project Area, then moderate to high pest problems could be encountered at the Cosmo Village.

6.3 Mosquito breeding and development aspects

Mining activities have the potential to create new mosquito breeding sites, or exacerbate existing mosquito breeding sites. Mosquito species that could take advantage of artificially created mosquito breeding sites include *Ae. normanensis, Cx. annulirostris, An. annulipes s.l., An. farauti s.l., Cq. xanthogaster* and *Ma. uniformis.* Development aspects that have the potential to create mosquito breeding include the construction of roads, water storage dams, sediment traps, pit dewatering, waste water disposal, mine waste dumps, site clearing, and storage of artificial receptacles.

Equipment such as machinery, used tyres, drums, rainwater tanks, building material wrapped in plastic sheeting, and any other item capable of ponding even small amounts of water, which are sourced from North Queensland and have previously held rainwater, have the potential to introduce the dengue mosquito *Aedes aegypti* into the NT. If equipment is to be sourced from North Queensland, mitigation measures should be put in place to ensure the dengue mosquito is not introduced into the NT.

6.4 Mosquito avoidance and control

It is most likely that personal protection from mosquitoes will be required during certain periods of the year, mainly the wet season and early dry season. Most mosquito species bite at night time so can be easily avoided, unless outdoor mining activities are conducted at night, in which case personal protection may be required. *Aedes vigilax* and *Aedes normanensis* can bite during the daytime in shaded areas, so personal protection from these species may be periodically required at the mine sites and mine camp during the months of September to January inclusive for *Ae. vigilax*, and October to April for *Ae. normanensis*.

Any areas of artificial water ponding at the mine sites would be potential mosquito breeding sites. The best method of mosquito control would be to prevent mosquito breeding in artificial water impoundments by preventing the creation of suitable habitat for mosquito larvae, which would be through appropriate design and maintenance of these facilities. Temporary mosquito control in artificial sites can be achieved using the mosquito larvicides methoprene or *Bacillus thuringiensis* var. *israelensis* (B.t.i.), until mosquito breeding rectification can be achieved.

Adult mosquito control could be utilised around the mine camp and mine facilities during periods of high mosquito populations. The insecticide of choice would be bifenthrin, due to the low irritancy effect of this insecticide on adult mosquitoes.

6.5 Mine closure and rehabilitation

If the mine sites are not appropriately rehabilitated upon cessation of mining operations, there is the potential that mosquito breeding sites will remain after mining operations, which would impact on the future use of the land.

7.0 Recommendations

1. All workers should be advised that pest and disease carrying mosquito species will be periodically present at the mine sites and mine camp, and be advised of potential problem periods and appropriate personal protection measures. Appropriate personal protection measures can be found in Appendix 4.

2. All artificial water impoundments within at least 2km of the Cosmo Village should be inspected for the potential for mosquito breeding, with those facilities no longer required for future mining in the Cosmo Project Area rectified where practical, and those facilities that will be required for future mining in the Cosmo Project Area maintained to prevent mosquito breeding.

3. All water impoundments, access roads, mine waste dumps, sediment traps, pit dewatering activities and stockpile sites should be constructed and operated in accordance to information provided in this report and the Medical Entomology Branch guideline ‘Guidelines for preventing mosquito breeding sites associated with mining sites’, provided as Appendix 3.

4. If wetland filters are to be utilised to process mine waste water, they should be constructed and maintained in accordance with the Medical Entomology Branch guideline ‘Guidelines for preventing mosquito breeding sites associated with mining sites’, provided as Appendix 3.

5. Waste water from the Cosmo Village must be disposed of in accordance to relevant Department of Health and Community Services guidelines. Relevant guidelines include the MEB guidelines ‘The Prevention of Mosquito Breeding in Sewage Treatment Facilities’ and the DHCS Environmental Health regulations ‘Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Re-use of Sewage Effluent’.

6. The existing pits adjacent to the North Point and Princess Louise mine sites should be inspected for actual or potential mosquito breeding. If the pits have the potential for mosquito breeding, rectification works such as deepening any shallow edges and/or margin vegetation removal should be conducted to prevent mosquito breeding.

7. Any equipment sourced from North Queensland that has previously held rainwater should be treated with a 10% chlorine solution (see Appendix 6) or appropriate residual insecticide such as lambda-cyhalothrin or deltamethrin, to prevent the introduction of the dengue mosquito *Aedes aegypti.*

8. Periodic inspections of artificial receptacles should be conducted around the mine sites in the wet season, with any receptacle ponding water appropriately disposed of, stored under cover away from rain, have drainage holes drilled or treated with an appropriate larvicide, to prevent endemic mosquito breeding and potential *Ae. aegypti* breeding. Artificial receptacles can include disused machinery, used tyres, drums, rainwater tanks, building material wrapped in plastic sheeting, buckets, bins and general rubbish items.

9. All water impoundments created at the Princess Louise and North Point mine sites should be inspected by a relevant mine officer in the dry season for maintenance requirements such as desilting and margin vegetation removal. All water impoundments should be stocked with native fish species that predate on mosquito larvae, where water quality permits.

10. Any worker sourced or returning from an overseas country where malaria is endemic, who experiences high fever should be kept indoors away from mosquito bites until cleared of malaria or treated for malaria by a health professional.

11. The Cosmo Village and mine personnel buildings at the Princess Louise and North Point mine sites should be treated with the barrier insecticide bifenthrin when adult mosquito populations reach pest levels, to minimise the potential for mosquito borne disease transmission. Further information on bifenthrin treatments can be found in Appendix 5.

12. The numerous dams and water impoundments located over 2km to the south and south west of the Princess Louise mine are potential mosquito breeding sites. If dry season mosquito problems are encountered at the Princess Louise mine site, these dams should be inspected for the presence of extensive larval mosquito habitat, with rectification works conducted where practical, or mosquito breeding controlled with a methoprene formulation.

13. The Fountain Head mine site should be inspected in the wet season for any areas of artificial water ponding, with those areas of water ponding rectified where practical during the following dry season.

14. The mine site should be rehabilitated in accordance to information in this report and the relevant MEB guideline (Appendix 3).

8.0 Acknowledgements

The Medical Entomology Branch wishes to thank Penny Barker from URS Australia Pty Ltd for providing aerial photography of the proposed mine sites and background information on the mining proposal.

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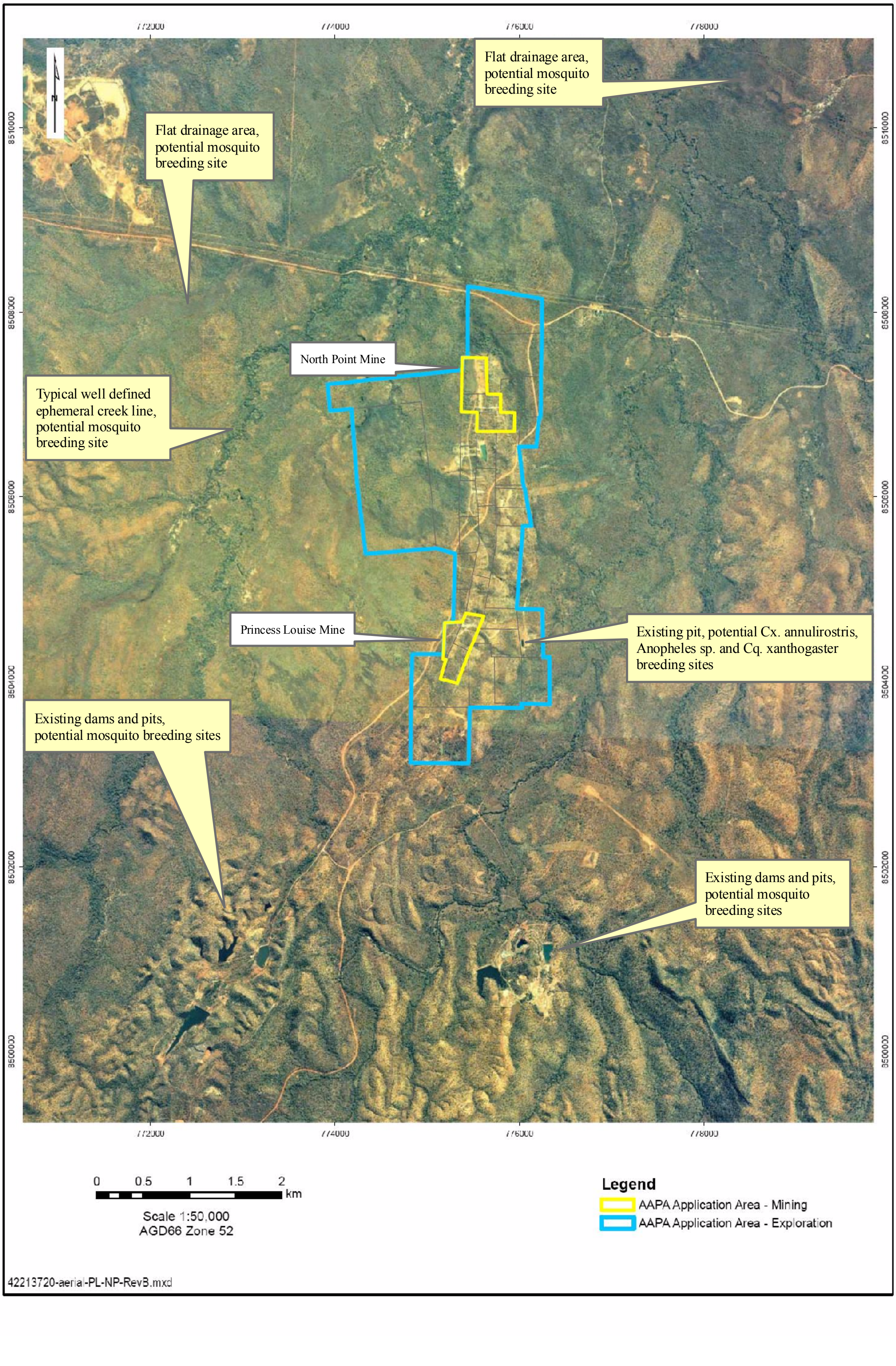
Figures

Figure 1: Princess Louise and North Point Project Area. Potential mosquito breeding sites.



F:\ento\ento_files\gis_data\Princess Louise and North Point mines\Figure 1 Princess Louise and North Point mine.mxd

Figure 2 - Proposed Princess Louise and North Point mine sites general area

Scale

= 10 square km

Image source: NATMAP produced by Geoscience Australia
Commonwealth of Australia 2004

F:\ENTO\ento_files\gis\gis_data\Princess Louise and North Point mines\Figure 2

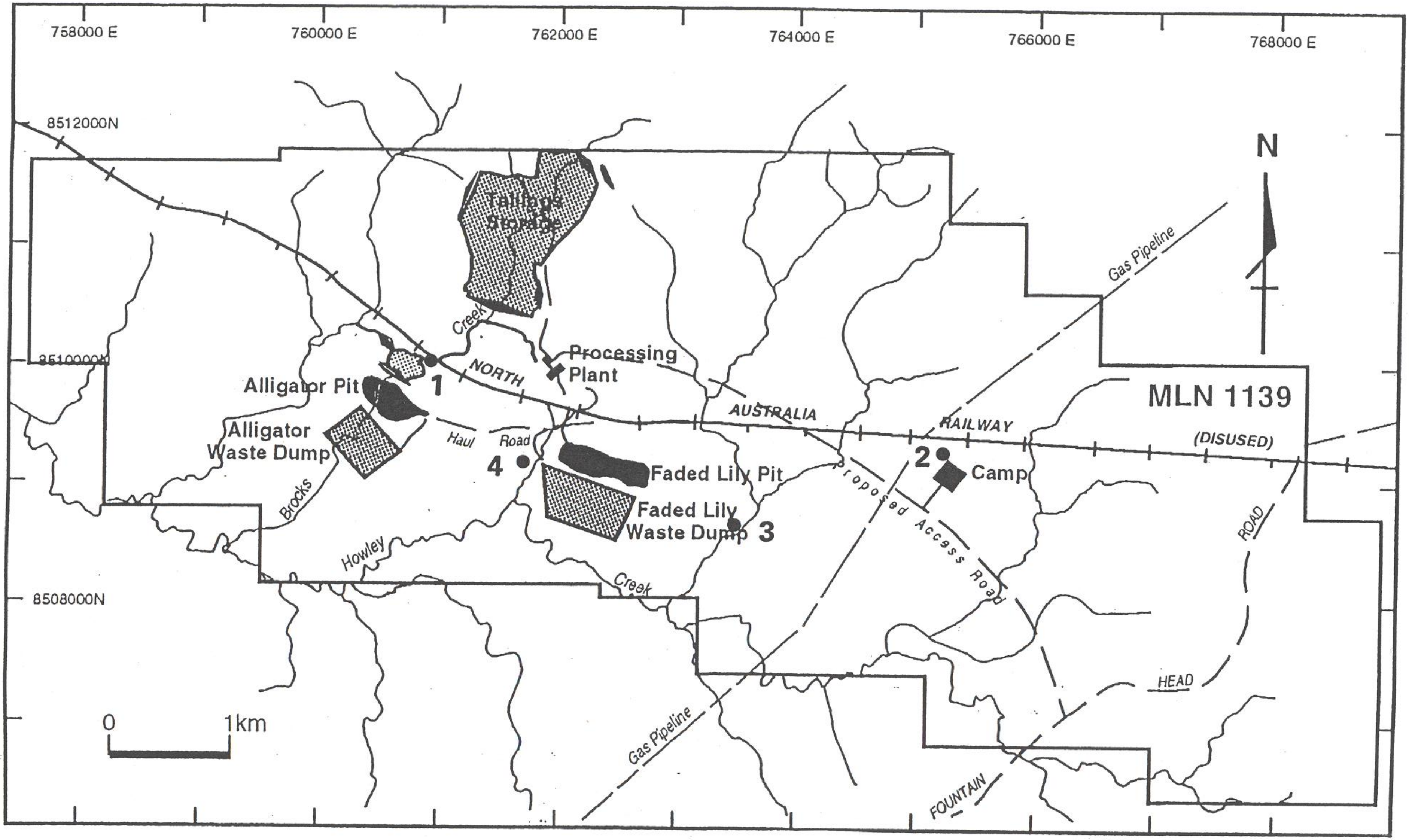


Figure 3 – Adult mosquito trap locations Brocks Creek Gold Project September 1995 to November 1996

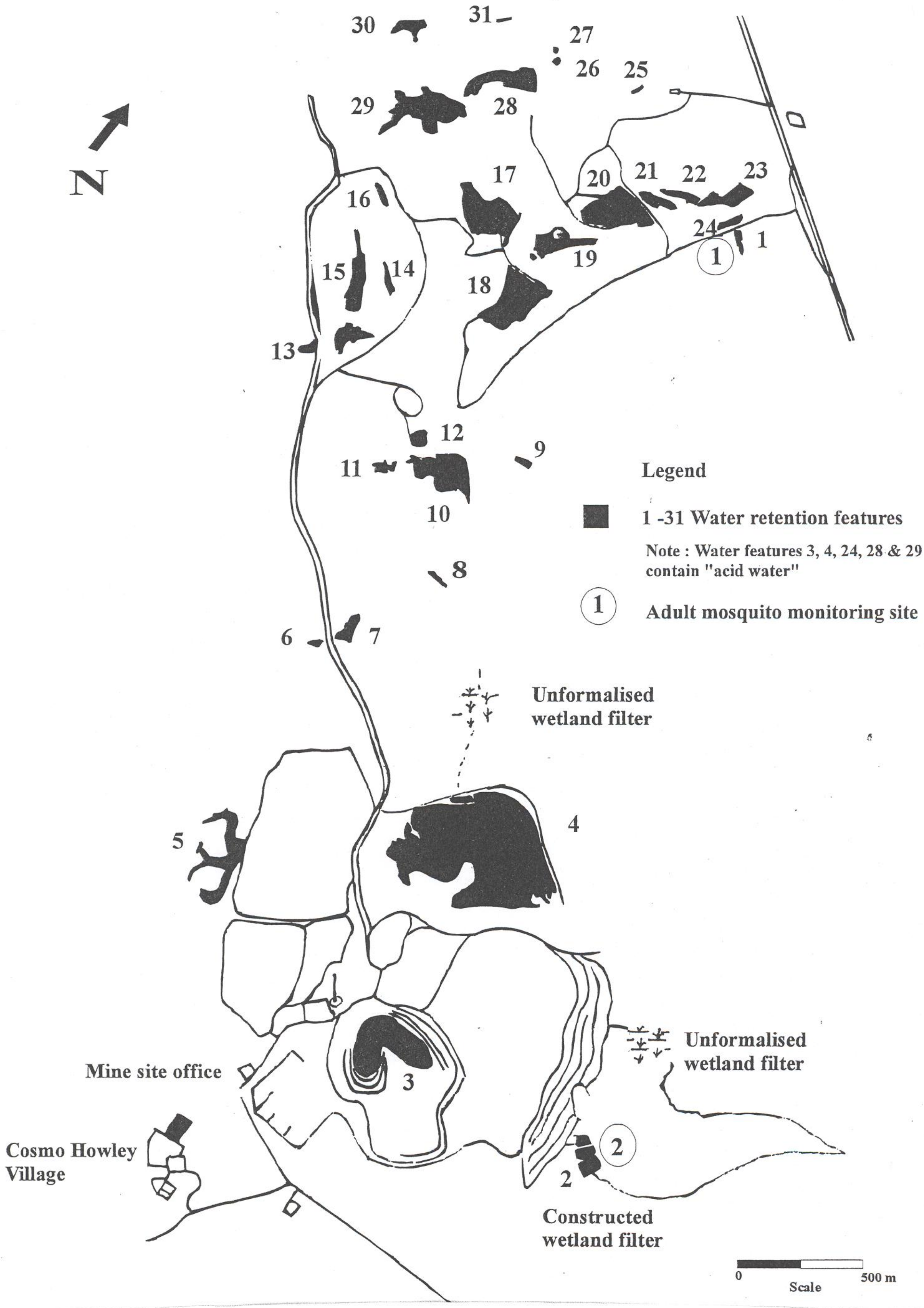


Figure 4 – Adult mosquito trap locations Northern Gold/Burnside Project March 1996 to March 1997

Tables

TABLE 1. **BROCKS CREEK MINE BASE LINE MOSQUITO MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.**
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING C02 BAITED EVS TRAPS AT SITE 1.

MOSQUITO SPECIES	DATE															ANNUAL	% OF
	28-Sep	28-Oct	28-Nov	28-Dec	30-Jan	04-Mar	28-Mar	27-Apr	30-May	30-Jun	04-Jul	30-Aug	27-Sep	01-Nov	28-Nov	TOTAL	ANNUAL TOTAL
Ad. (Ady) catasticta																**0**	**0.00**
Ae. (Adm) alboscutellatus			1						1							**2**	**0.08**
Ae. (Cha) elchoensis	1														10	**11**	**0.43**
Ae. (Fin) britteni																**0**	**0.00**
Ae. (Fin) kochi																**0**	**0.00**
Ae. (Fin) notoscriptus								1	1							**2**	**0.08**
Ae. (Fin) pecuniosus				1	1		3									**5**	**0.20**
Ae. (Mac) stoneorum																**0**	**0.00**
Ae. (Mac) tremulus	1														1	**2**	**0.08**
Ae. (Muc) alternans														1	1	**2**	**0.08**
Ae. (Neo) lineatopennis				2				4						8		**14**	**0.55**
Ae. (Och) normanensis		79	12	3	2		43	137	2					12	1,181	**1471**	**57.60**
Ae. (Och) pseudonormanensis				5												**5**	**0.20**
Ae. (Och) sp.159				2												**2**	**0.08**
Ae. (Och) vigilax			1	2											5	**8**	**0.31**
Ae. (Stg) katherinensis																**0**	**0.00**
Ae. (Ver) funereus																**0**	**0.00**
Ae. (Ver) reesi				4	3		10	1								**18**	**0.70**
An. (Ano) bancroftii	1					1		3	1		2					**8**	**0.31**
An. (Ano) powelli																**0**	**0.00**
An. (Cel) sp.																**0**	**0.00**
An. (Cel) amictus	1	11							3		1		4	10	5	**35**	**1.37**
An. (Cel) annulipes	1	2	10	28	3		2	17	81		11		4	20	5	**184**	**7.20**
An. (Cel) farauti							4									**4**	**0.16**
An. (Cel) hilli					1								1			**2**	**0.08**
An. (Cel) meraukensis				1	2	5	2	2	4							**16**	**0.63**
An. (Cel) novaguinensis																**0**	**0.00**
Cq. (Coq) xanthogaster	6				11	4	9	11			54		16	3	10	**124**	**4.86**
Cx. (Cui) pullus		1		1	15	4	1	10	2		2			6		**42**	**1.64**
Cx. (Cux) sp.																**0**	**0.00**
Cx. (Cux) annulirostris	8	24	2	67	58	7	1	6	9		53			207	134	**576**	**22.55**
Cx. (Cux) bitaeniorhynchus					6	1										**7**	**0.27**
Cx. (Cux) quinquefasciatus																**0**	**0.00**
Cx. (Cux) sitiens																**0**	**0.00**
Cx. (Cux) squamosus																**0**	**0.00**
Cx. (Cux) vicinus														1		**1**	**0.04**
Cx. (Lop) cubiculi																**0**	**0.00**
Cx. (Lop) hilli				1												**1**	**0.04**
Cx. (Lop) species 155																**0**	**0.00**
Cx. (Lop) species 167																**0**	**0.00**
Ho. ( ) species 157																**0**	**0.00**
Ma. (Mnd) uniformis					3	6	2									**11**	**0.43**
Mi. (Eto) elegans							1									**1**	**0.04**
Tp. (Trp) magnesianus																**0**	**0.00**
Ur. (Ura) albescens																**0**	**0.00**
Ur. (Ura) nivipes																**0**	**0.00**
Ur. (Ura) novaguinensis																**0**	**0.00**
Totals	**19**	**117**	**26**	**117**	**105**	**28**	**78**	**192**	**104**		**123**		**25**	**268**	**1352**	**2554**	**100.00**
% of Annual Totals	**0.74**	**4.58**	**1.02**	**4.58**	**4.11**	**1.10**	**3.05**	**7.52**	**4.07**		**4.82**		**0.98**	**10.49**	**52.94**	**100.00**	
																2554	

TABLE 2. **BROCKS CREEK MINE BASE LINE MOSQUITO MONITORING DATA**
SEPTEMBER 1995 - DECEMBER 1995.
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING C02 BAITED EVS TRAPS AT SITE 2.

MOSQUITO SPECIES	DATE					% OF
	28-Sep	28-Oct	28-Nov	28-Dec	TOTAL	TOTAL
Ae. (Cha) elchoensis	5	28	6	T	**39**	**21.79**
Ae. (Fin) pecuniosus			1	R	**1**	**0.56**
Ae. (Mac) tremulus		1		A	**1**	**0.56**
Ae. (Och) normanensis		32	53	P	**85**	**47.49**
Ae. (Och) pseudonormanensis		11	1		**12**	**6.70**
Ae. (Och) vigilax			3	E	**3**	**1.68**
An. (Cel) amictus	1	8		N	**9**	**5.03**
An. (Cel) annulipes			2	D	**2**	**1.12**
Cq. (Coq) xanthogaster	8			S	**8**	**4.47**
Cx. (Cux) annulirostris	9	5	5		**19**	**10.61**
Totals	**23**	**85**	**71**		**179**	**100.00**
% of Totals	**12.85**	**47.49**	**39.66**	**0.00**	**100**	

TABLE 3. **BROCKS CREEK MINE BASE LINE MOSQUITO MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.**
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING C02 BAITED EVS TRAPS AT SITE 3.

MOSQUITO SPECIES	DATE															ANNUAL TOTAL	% OF TOTAL
	28-Sep	28-Oct	28-Nov	28-Dec	30-Jan	04-Mar	28-Mar	27-Apr	30-May	30-Jun	04-Jul	30-Aug	27-Sep	01-Nov	28-Nov		
Ad. (Ady) catasticta																**0**	**0.00**
Ae. (Adm) alboscutellatus			67	12	4		10	18	1							**112**	**2.84**
Ae. (Cha) elchoensis				1							1					**2**	**0.05**
Ae. (Fin) britteni				1												**1**	**0.03**
Ae. (Fin) kochi																**0**	**0.00**
Ae. (Fin) notoscriptus					1		2	2							2	**7**	**0.18**
Ae. (Fin) pecuniosus					1											**1**	**0.03**
Ae. (Mac) stoneorum					1									3		**4**	**0.10**
Ae. (Mac) tremulus			6													**6**	**0.15**
Ae. (Muc) alternans																**0**	**0.00**
Ae. (Neo) lineatopennis					1		36	44						29	2	**112**	**2.84**
Ae. (Och) normanensis			322	16	23		86	248						115	241	**1051**	**26.64**
Ae. (Och) pseudonormanensis				1										3		**4**	**0.10**
Ae. (Och) sp.159																**0**	**0.00**
Ae. (Och) vigilax	2		20	3										11	13	**49**	**1.24**
Ae. (Stg) katherinensis																**0**	**0.00**
Ae. (Ver) funereus																**0**	**0.00**
Ae. (Ver) reesi				3	30	2	106									**141**	**3.57**
An. (Ano) bancroftii				2	7		54	32	8		2			3	2	**110**	**2.79**
An. (Ano) powelli																**0**	**0.00**
An. (Cel) sp.													18		25	**43**	**1.09**
An. (Cel) amictus	5		3	2					1		4		26	19	17	**77**	**1.95**
An. (Cel) annulipes	24		41	33	20	2	4	74	73		30			75	21	**397**	**10.06**
An. (Cel) farauti				2			36	5								**43**	**1.09**
An. (Cel) hilli																**0**	**0.00**
An. (Cel) meraukensis				2	40	5	20	97	43		6					**213**	**5.40**
An. (Cel) novaguinensis																**0**	**0.00**
Cq. (Coq) xanthogaster	8		3	5	20	6	20	16	1		13		6		1	**99**	**2.51**
Cx. (Cui) pullus				6	121	1								3		**131**	**3.32**
Cx. (Cux) sp.													1			**1**	**0.03**
Cx. (Cux) annulirostris	13		96	162	147	3	26	30	40		158		2	611	31	**1319**	**33.43**
Cx. (Cux) bitaeniorhynchus							2									**2**	**0.05**
Cx. (Cux) quinquefasciatus																**0**	**0.00**
Cx. (Cux) sitiens																**0**	**0.00**
Cx. (Cux) squamosus																**0**	**0.00**
Cx. (Cux) vicinus																**0**	**0.00**
Cx. (Lop) cubiculi																**0**	**0.00**
Cx. (Lop) hilli																**0**	**0.00**
Cx. (Lop) species 155																**0**	**0.00**
Cx. (Lop) species 167																**0**	**0.00**
Ho. ( ) species 157																**0**	**0.00**
Ma. (Mnd) uniformis					1	3	6	5						5		**20**	**0.51**
Mi. (Eto) elegans																**0**	**0.00**
Tp. (Trp) magnesianus																**0**	**0.00**
Ur. (Ura) albescens																**0**	**0.00**
Ur. (Ura) nivipes																**0**	**0.00**
Ur. (Ura) novaguinensis																**0**	**0.00**
Totals	**52**		**558**	**251**	**417**	**22**	**408**	**571**	**167**		**214**		**53**	**877**	**355**	**3945**	**100.00**
% of Annual Totals	**1.32**		**14.14**	**6.36**	**10.57**	**0.56**	**10.34**	**14.47**	**4.23**		**5.42**		**1.34**	**22.23**	**9.00**	**100.00**	
																3945	

TABLE 4.

BROCKS CREEK MINE BASE LINE MOSQUITO MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING C02 BAITED EVS TRAPS AT SITE 4.

MOSQUITO SPECIES	DATE															ANNUAL TOTAL	% OF TOTAL
	28-Sep	28-Oct	28-Nov	28-Dec	30-Jan	04-Mar	28-Mar	27-Apr	30-May	30-Jun	04-Jul	30-Aug	27-Sep	01-Nov	28-Nov		
Ad. (Ady) catasticta									1							**1**	**0.03**
Ae. (Adm) alboscutellatus		2	1				1	8						1		**13**	**0.44**
Ae. (Cha) elchoensis																**0**	**0.00**
Ae. (Fin) britteni																**0**	**0.00**
Ae. (Fin) kochi																**0**	**0.00**
Ae. (Fin) notoscriptus																**0**	**0.00**
Ae. (Fin) pecuniosus																**0**	**0.00**
Ae. (Mac) stoneorum					1											**1**	**0.03**
Ae. (Mac) tremulus															1	**1**	**0.03**
Ae. (Muc) alternans							1	2							1	**4**	**0.13**
Ae. (Neo) lineatopennis			5	3			36	164	2					44	9	**263**	**8.82**
Ae. (Och) normanensis		62	207	16	6		90	158	1					26	452	**1018**	**34.13**
Ae. (Och) pseudonormanensis																**0**	**0.00**
Ae. (Och) sp.159																**0**	**0.00**
Ae. (Och) vigilax		2	8											7	32	**49**	**1.64**
Ae. (Stg) katherinensis																**0**	**0.00**
Ae. (Ver) funereus																**0**	**0.00**
Ae. (Ver) reesi				13	9		49									**71**	**2.38**
An. (Ano) bancroftii					3		7	12								**22**	**0.74**
An. (Ano) powelli																**0**	**0.00**
An. (Cel) sp.													3			**3**	**0.10**
An. (Cel) amictus	9	4	5	1					1		1		12	23	9	**65**	**2.18**
An. (Cel) annulipes	10	13	12	16	1		20	64	56		21		3	68	35	**319**	**10.69**
An. (Cel) farauti						1	43									**44**	**1.48**
An. (Cel) hilli							1							3	3	**7**	**0.23**
An. (Cel) meraukensis					17	1	88	66	39		2					**213**	**7.14**
An. (Cel) novaguinensis																**0**	**0.00**
Cq. (Coq) xanthogaster	18	2	1	2	26	6	32	22			32		52	3	3	**199**	**6.67**
Cx. (Cui) pullus		2			77	4	1	2								**86**	**2.88**
Cx. (Cux) sp.													5			**5**	**0.17**
Cx. (Cux) annulirostris	16	64	39	120	140	4	2	18	18		38			87	20	**566**	**18.97**
Cx. (Cux) bitaeniorhynchus					7											**7**	**0.23**
Cx. (Cux) quinquefasciatus																**0**	**0.00**
Cx. (Cux) sitiens																**0**	**0.00**
Cx. (Cux) squamosus																**0**	**0.00**
Cx. (Cux) vicinus																**0**	**0.00**
Cx. (Lop) cubiculi																**0**	**0.00**
Cx. (Lop) hilli																**0**	**0.00**
Cx. (Lop) species 155																**0**	**0.00**
Cx. (Lop) species 167						5										**5**	**0.17**
Ho. ( ) species 157																**0**	**0.00**
Ma. (Mnd) uniformis					1	1	16	2								**20**	**0.67**
Mi. (Eto) elegans							1									**1**	**0.03**
Tp. (Trp) magnesianus																**0**	**0.00**
Ur. (Ura) albescens																**0**	**0.00**
Ur. (Ura) nivipes																**0**	**0.00**
Ur. (Ura) novaguinensis																**0**	**0.00**
Totals	**53**	**151**	**278**	**171**	**288**	**22**	**388**	**518**	**118**		**94**		**75**	**262**	**565**	**2983**	**100.00**
% of Annual Totals	**1.78**	**5.06**	**9.32**	**5.73**	**9.65**	**0.74**	**13.01**	**17.37**	**3.96**		**3.15**		**2.51**	**8.78**	**18.94**	**100.00**	
																2983	

TABLE 5. **BROCKS CREEK MINE BASE LINE MOSQUITO MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.**
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING C02 BAITED EVS TRAPS AT SITE 5.

MOSQUITO SPECIES	DATE															ANNUAL TOTAL	% OF TOTAL
	28-Sep	28-Oct	28-Nov	28-Dec	30-Jan	04-Mar	28-Mar	27-Apr	30-May	30-Jun	04-Jul	30-Aug	27-Sep	01-Nov	28-Nov		
Ad. (Ady) catasticta																**0**	**0.00**
Ae. (Adm) alboscutellatus																**0**	**0.00**
Ae. (Cha) elchoensis					2		6	2	1		1					**12**	**0.43**
Ae. (Fin) britteni																**0**	**0.00**
Ae. (Fin) kochi																**0**	**0.00**
Ae. (Fin) notoscriptus				1			2									**3**	**0.11**
Ae. (Fin) pecuniosus				1			2									**3**	**0.11**
Ae. (Mac) stoneorum							2									**2**	**0.07**
Ae. (Mac) tremulus				5	2				2		2					**11**	**0.40**
Ae. (Muc) alternans							2	2								**4**	**0.14**
Ae. (Neo) lineatopennis				1	1			4								**6**	**0.22**
Ae. (Och) normanensis				1	1		218	40						3	632	**895**	**32.37**
Ae. (Och) pseudonormanensis															12	**12**	**0.43**
Ae. (Och) sp.159							4	1							4	**9**	**0.33**
Ae. (Och) vigilax				6			4								16	**26**	**0.94**
Ae. (Stg) katherinensis																**0**	**0.00**
Ae. (Ver) funereus																**0**	**0.00**
Ae. (Ver) reesi								1								**1**	**0.04**
An. (Ano) bancroftii				1	5		21									**27**	**0.98**
An. (Ano) powelli									17							**17**	**0.61**
An. (Cel) sp.																**0**	**0.00**
An. (Cel) amictus				1				2	4		17		4		16	**44**	**1.59**
An. (Cel) annulipes				2	6		2	34			10				24	**78**	**2.82**
An. (Cel) farauti						1	2									**3**	**0.11**
An. (Cel) hilli				6	1						1		2			**10**	**0.36**
An. (Cel) meraukensis				2	3		2	1	1							**9**	**0.33**
An. (Cel) novaguinensis							1	5								**6**	**0.22**
Cq. (Coq) xanthogaster				21	17	22	73	2			87		11		16	**249**	**9.01**
Cx. (Cui) pullus				2	18		4									**24**	**0.87**
Cx. (Cux) sp.																**0**	**0.00**
Cx. (Cux) annulirostris				155	212	6	208	280	123		238		13	10	60	**1305**	**47.20**
Cx. (Cux) bitaeniorhynchus																**0**	**0.00**
Cx. (Cux) quinquefasciatus																**0**	**0.00**
Cx. (Cux) sitiens																**0**	**0.00**
Cx. (Cux) squamosus																**0**	**0.00**
Cx. (Cux) vicinus																**0**	**0.00**
Cx. (Lop) cubiculi																**0**	**0.00**
Cx. (Lop) hilli																**0**	**0.00**
Cx. (Lop) species 155																**0**	**0.00**
Cx. (Lop) species 167																**0**	**0.00**
Ho. ( ) species 157																**0**	**0.00**
Ma. (Mnd) uniformis					1	4	4									**9**	**0.33**
Mi. (Eto) elegans																**0**	**0.00**
Tp. (Trp) magnesianus																**0**	**0.00**
Ur. (Ura) albescens																**0**	**0.00**
Ur. (Ura) nivipes																**0**	**0.00**
Ur. (Ura) novaguinensis																**0**	**0.00**
Totals				**205**	**269**	**33**	**557**	**374**	**148**		**356**	**0**	**30**	**13**	**780**	**2765**	**100.00**
% of Annual Totals				**7.41**	**9.73**	**1.19**	**20.14**	**13.53**	**5.35**		**12.88**	**0.00**	**1.08**	**0.47**	**28.21**	**100.00**	
																2765	

TABLE 6.

BROCKS CREEK BASE LINE MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.

TOTAL NUMBER OF FEMALE MOSQUITOES CAUGHT FROM SITES 1, 3, 4 and 5 (SUMMARY BY DATE).

MOSQUITO SPECIES	DATE															TOTAL	% OF TOTAL
	28-Sep	28-Oct	28-Nov	28-Dec	30-Jan	04-Mar	28-Mar	27-Apr	30-May	30-Jun	04-Jul	30-Aug	27-Sep	01-Nov	28-Nov		
Ad. (Ady) catasticta	0	0	0	0	0	0	0	0	1	N	0	N	0	0	0	**1**	**0.01**
Ae. (Adm) alboscutellatus	0	2	69	12	4	0	11	26	2	O	0	O	0	1	0	**127**	**1.04**
Ae. (Cha) elchoensis	1	0	0	1	2	0	6	2	1		2		0	0	10	**25**	**0.20**
Ae. (Fin) britteni	0	0	0	1	0	0	0	0	0	T	0	T	0	0	0	**1**	**0.01**
Ae. (Fin) kochi	0	0	0	0	0	0	0	0	0	R	0	R	0	0	0	**0**	**0.00**
Ae. (Fin) notoscriptus	0	0	0	1	1	0	4	3	1	A	0	A	0	0	2	**12**	**0.10**
Ae. (Fin) pecuniosus	0	0	0	2	2	0	5	0	0	P	0	P	0	0	0	**9**	**0.07**
Ae. (Mac) stoneorum	0	0	0	0	2	0	2	0	0	S	0	S	0	3	0	**7**	**0.06**
Ae. (Mac) tremulus	1	0	6	5	2	0	0	0	2		2		0	0	2	**20**	**0.16**
Ae. (Muc) alternans	0	0	0	0	0	0	3	4	0	S	0	S	0	1	2	**10**	**0.08**
Ae. (Neo) lineatopennis	0	0	5	6	2	0	72	216	2	E	0	E	0	81	11	**395**	**3.23**
Ae. (Och) normanensis	0	141	541	36	32	0	437	583	3	T	0	T	0	156	2506	**4435**	**36.21**
Ae. (Och) pseudonormanensis	0	0	0	6	0	0	0	0	0		0		0	3	12	**21**	**0.17**
Ae. (Och) sp.159	0	0	0	2	0	0	4	1	0		0		0	0	4	**11**	**0.09**
Ae. (Och) vigilax	2	2	29	11	0	0	4	0	0		0		0	18	66	**132**	**1.08**
Ae. (Stg) katherinensis	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ae. (Ver) funereus	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ae. (Ver) reesi	0	0	0	20	42	2	165	2	0		0		0	0	0	**231**	**1.89**
An. (Ano) bancroftii	1	0	0	3	15	1	82	47	9		4		0	3	2	**167**	**1.36**
An. (Ano) powelli	0	0	0	0	0	0	0	0	17		0		0	0	0	**17**	**0.14**
An. (Cel) sp.	0	0	0	0	0	0	0	0	0		0		21	0	25	**46**	**0.38**
An. (Cel) amictus	15	15	8	4	0	0	0	2	9		23		46	52	47	**221**	**1.80**
An. (Cel) annulipes	35	15	63	79	30	2	28	189	210		72		7	163	85	**978**	**7.99**
An. (Cel) farauti	0	0	0	2	0	2	85	5	0		0		0	0	0	**94**	**0.77**
An. (Cel) hilli	0	0	0	6	2	0	1	0	0		1		3	3	3	**19**	**0.16**
An. (Cel) meraukensis	0	0	0	5	62	11	112	166	87		8		0	0	0	**451**	**3.68**
An. (Cel) novaguinensis	0	0	0	0	0	0	1	5	0		0		0	0	0	**6**	**0.05**
Cq. (Coq) xanthogaster	32	2	4	28	74	38	134	51	1		186		85	6	30	**671**	**5.48**
Cx. (Cui) pullus	0	3	0	9	231	9	6	12	2		2		0	9	0	**283**	**2.31**
Cx. (Cux) sp.	0	0	0	0	0	0	0	0	0		0		6	0	0	**6**	**0.05**
Cx. (Cux) annulirostris	37	88	137	504	557	20	237	334	190		487		15	915	245	**3766**	**30.75**
Cx. (Cux) bitaeniorhynchus	0	0	0	0	13	1	2	0	0		0		0	0	0	**16**	**0.13**
Cx. (Cux) quinquefasciatus	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Cx. (Cux) sitiens	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Cx. (Cux) squamosus	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Cx. (Cux) vicinus	0	0	0	0	0	0	0	0	0		0		0	1	0	**1**	**0.01**
Cx. (Lop) cubiculi	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Cx. (Lop) hilli	0	0	0	1	0	0	0	0	0		0		0	0	0	**1**	**0.01**
Cx. (Lop) species 155	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Cx. (Lop) species 167	0	0	0	0	0	5	0	0	0		0		0	0	0	**5**	**0.04**
Ho. ( ) species 157	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ma. (Mnd) uniformis	0	0	0	0	6	14	28	7	0		0		0	5	0	**60**	**0.49**
Mi. (Eto) elegans	0	0	0	0	0	0	2	0	0		0		0	0	0	**2**	**0.02**
Tp. (Trp) magnesianus	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ur. (Ura) albescens	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ur. (Ura) nivipes	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Ur. (Ura) novaguinensis	0	0	0	0	0	0	0	0	0		0		0	0	0	**0**	**0.00**
Totals	**124**	**268**	**862**	**744**	**1079**	**105**	**1431**	**1655**	**537**		**787**		**183**	**1420**	**3052**	**12247**	**100**
% of Annual Totals	**1.01**	**2.19**	**7.04**	**6.07**	**8.81**	**0.86**	**11.68**	**13.51**	**4.38**		**6.43**		**1.49**	**11.59**	**24.92**	**100.00**	

TABLE 7.

BROCKS CREEK BASE LINE MOSQUITO MONITORING DATA SEPTEMBER 1995 - NOVEMBER 1996.

TOTAL NUMBER OF FEMALE MOSQUITOES FROM SITES 1, 3, 4 and 5 (SUMMARY BY SITES).

MOSQUITO SPECIES	SITE 1	SITE 3	SITE 4	SITE 5	TOTAL	%
Ad. (Ady) catasticta	0	0	1	0	**1**	**0.01**
Ae. (Adm) alboscutellatus	2	112	13	0	**127**	**1.04**
Ae. (Cha) elchoensis	11	2	0	12	**25**	**0.20**
Ae. (Fin) britteni	0	1	0	0	**1**	**0.01**
Ae. (Fin) notoscriptus	2	7	0	3	**12**	**0.10**
Ae. (Fin) pecuniosus	5	1	0	3	**9**	**0.07**
Ae. (Mac) stoneorum	0	4	1	2	**7**	**0.06**
Ae. (Mac) tremulus	2	6	1	11	**20**	**0.16**
Ae. (Muc) alternans	2	0	4	4	**10**	**0.08**
Ae. (Neo) lineatopennis	14	112	263	6	**395**	**3.23**
Ae. (Och) normanensis	1471	1051	1018	895	**4435**	**36.21**
Ae. (Och) pseudonormanensis	5	4	0	12	**21**	**0.17**
Ae. (Och) sp.159	2	0	0	9	**11**	**0.09**
Ae. (Och) vigilax	8	49	49	26	**132**	**1.08**
Ae. (Ver) reesi	18	141	71	1	**231**	**1.89**
An. (Ano) bancroftii	8	110	22	27	**167**	**1.36**
An. (Ano) powelli	0	0	0	17	**17**	**0.14**
An. (Cel) sp.	0	43	3	0	**46**	**0.38**
An. (Cel) amictus	35	77	65	44	**221**	**1.80**
An. (Cel) annulipes	184	397	319	78	**978**	**7.99**
An. (Cel) farauti	4	43	44	3	**94**	**0.77**
An. (Cel) hilli	2	0	7	10	**19**	**0.16**
An. (Cel) meraukensis	16	213	213	9	**451**	**3.68**
An. (Cel) novaguinensis	0	0	0	6	**6**	**0.05**
Cq. (Coq) xanthogaster	124	99	199	249	**671**	**5.48**
Cx. (Cui) pullus	42	131	86	24	**283**	**2.31**
Cx. (Cux) sp.	0	1	5	0	**6**	**0.05**
Cx. (Cux) annulirostris	576	1319	566	1305	**3766**	**30.75**
Cx. (Cux) bitaeniorhynchus	7	2	7	0	**16**	**0.13**
Cx. (Cux) vicinus	1	0	0	0	**1**	**0.01**
Cx. (Lop) hilli	1	0	0	0	**1**	**0.01**
Cx. (Lop) species 167	0	0	5	0	**5**	**0.04**
Ma. (Mnd) uniformis	11	20	20	9	**60**	**0.49**
Mi. (Eto) elegans	1	0	1	0	**2**	**0.02**
Totals	**2554**	**3945**	**2983**	**2765**	**12247**	**100.00**
% of Annual Totals	**20.85**	**32.21**	**24.36**	**22.58**	**100.00**	

TABLE 8. **SUMMARY OF NORTHERN GOLD MINE BASELINE MOSQUITO MONITORING, MARCH 1996 - MARCH 1997**
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING CO_2 BAITED EVS TRAPS

MOSQUITO SPECIES	DATE													ANNUAL TOTAL	% OF ANNUAL TOTAL
	28-Mar	30-Apr	28-May	28-Jun	30-Jul	29-Aug	26-Sep	30-Oct	28-Nov	31-Dec	29-Jan	28-Feb	27-Mar		
Ad. (Ady) catasticta	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Ae. (Adm) alboscutellatus	0	1	0	0	0	0	0	0	4	7	20	0	0	**32**	**0.75**
Ae. (Cha) elchoensis	0	0	0	0	0	0	0	0	1	0	0	1	0	**2**	**0.05**
Ae. (Fin) notoscriptus	0	0	0	0	0	0	0	0	0	0	2	2	0	**4**	**0.09**
Ae. (Fin) pecuniosus	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**	**0.02**
Ae. (Mac) stoneorum	0	0	0	0	0	0	0	0	0	0	25	6	1	**32**	**0.75**
Ae. (Mac) tremulus	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**	**0.02**
Ae. (Muc) alternans	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**	**0.07**
Ae. (Neo) lineatopennis	1	11	0	0	0	1	0	70	7	12	1	0	1	**104**	**2.45**
Ae. (Och) normanensis	52	11	0	0	0	0	0	73	414	25	8	3	59	**645**	**15.19**
Ae. (Och) pseudonormanensis	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Ae. (Och) vigilax	0	0	0	0	0	1	0	3	7	1	2	0	0	**14**	**0.33**
Ae. (Ver) funereus	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**	**0.02**
Ae. (Ver) reesi	6	8	0	0	0	0	0	0	0	14	284	135	3	**450**	**10.60**
An. (Ano) bancroftii	3	6	5	7	0	0	0	0	0	1	8	2	2	**34**	**0.80**
An. (Cel) amictus	0	0	3	0	0	3	1	2	2	0	0	0	0	**11**	**0.26**
An. (Cel) annulipes	1	20	47	3	11	4	4	5	9	1	0	13	7	**125**	**2.94**
An. (Cel) farauti	2	16	0	1	0	0	0	0	0	0	4	8	4	**35**	**0.82**
An. (Cel) hilli	0	0	0	0	1	3	6	0	0	1	0	1	0	**12**	**0.28**
An. (Cel) meraukensis	12	115	31	0	0	2	0	0	0	0	4	30	3	**197**	**4.64**
An. (Cel) novaguinensis	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Cq. (Coq) xanthogaster	2	24	0	739	119	183	45	3	2	22	22	7	1	**1169**	**27.53**
Cx. (Cui) pullus	0	2	0	0	0	0	0	4	6	19	71	51	24	**177**	**4.17**
Cx. (Cux) annulirostris	1	7	44	122	63	62	29	300	81	33	216	49	63	**1070**	**25.20**
Cx. (Cux) bitaeniorhynchus	0	0	0	0	0	0	0	0	0	4	18	48	0	**70**	**1.65**
Cx. (Cux) sitiens	0	0	0	3	0	0	0	0	0	0	0	0	0	**3**	**0.07**
Cx. (Cux) squamosus	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Cx. (Cux) vicinus	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Cx. (Cux) Vishnui grp.	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Cx. (Lop) hilli	0	0	0	0	0	0	0	0	0	0	2	0	0	**2**	**0.05**
Cx. (Lop) species 167	0	0	0	0	0	0	0	0	0	8	4	1	0	**13**	**0.31**
Ma. (Mnd) uniformis	12	13	0	7	1	4	0	1	0	1	0	0	0	**39**	**0.92**
Mi. (Eto) elegans	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Totals	**92**	**234**	**130**	**882**	**195**	**263**	**85**	**464**	**534**	**151**	**691**	**357**	**168**	**4246**	**100.00**
% of Annual Totals	**2.17**	**5.51**	**3.06**	**20.77**	**4.59**	**6.19**	**2.00**	**10.93**	**12.58**	**3.56**	**16.27**	**8.41**	**3.96**	**100.00**	

TABLE 9. **SUMMARY OF NORTHERN GOLD MINE BASELINE MOSQUITO MONITORING, MARCH 1996 - MARCH 1997**
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING CO_2 BAITED EVS TRAPS

MOSQUITO SPECIES	DATE													ANNUAL TOTAL	% OF ANNUAL TOTAL
	28-Mar	30-Apr	28-May	28-Jun	30-Jul	29-Aug	26-Sep	30-Oct	28-Nov	31-Dec	29-Jan	28-Feb	27-Mar		
Ad. (Ady) catasticta	0	0	1	2	0	0	0	0	0	0	0	0	0	**3**	**0.07**
Ae. (Adm) alboscutellatus	0	0	0	0	0	0	0	0	0	18	0	0	0	**18**	**0.44**
Ae. (Cha) elchoensis	0	0	1	0	0	0	0	0	1	0	1	0	0	**3**	**0.07**
Ae. (Fin) notoscriptus	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Ae. (Fin) pecuniosus	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**	**0.02**
Ae. (Mac) stoneorum	0	0	0	0	0	0	0	0	0	0	5	0	3	**8**	**0.19**
Ae. (Mac) tremulus	0	0	0	0	0	0	0	0	1	1	0	0	0	**2**	**0.05**
Ae. (Muc) alternans	0	1	0	0	0	0	0	0	1	0	0	0	0	**2**	**0.05**
Ae. (Neo) lineatopennis	2	0	0	0	0	0	0	0	0	0	0	1	0	**3**	**0.07**
Ae. (Och) normanensis	34	26	0	0	0	0	0	21	459	20	12	1	172	**745**	**18.02**
Ae. (Och) pseudonormanensis	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**	**0.12**
Ae. (Och) vigilax	0	0	0	0	0	0	0	0	13	0	0	0	0	**13**	**0.31**
Ae. (Ver) funereus	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Ae. (Ver) reesi	0	0	0	0	0	0	0	0	0	5	104	16	0	**125**	**3.02**
An. (Ano) bancroftii	6	0	0	6	0	0	0	0	0	0	1	0	2	**15**	**0.36**
An. (Cel) amictus	1	0	1	3	2	4	0	1	0	2	0	0	9	**23**	**0.56**
An. (Cel) annulipes	0	0	1	12	6	11	0	0	4	1	3	12	17	**67**	**1.62**
An. (Cel) farauti	7	1	0	0	0	0	0	0	0	0	0	2	1	**11**	**0.27**
An. (Cel) hilli	0	0	0	3	0	0	6	0	1	0	0	0	0	**10**	**0.24**
An. (Cel) meraukensis	7	2	1	1	0	0	0	0	0	0	2	4	7	**24**	**0.58**
An. (Cel) novaguinensis	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.02**
Cq. (Coq) xanthogaster	6	9	0	243	205	69	2	0	0	20	4	6	2	**566**	**13.69**
Cx. (Cui) pullus	0	0	2	0	0	0	0	0	1	9	34	78	9	**133**	**3.22**
Cx. (Cux) annulirostris	57	8	114	281	474	212	80	43	68	108	56	46	296	**1843**	**44.58**
Cx. (Cux) bitaeniorhynchus	0	0	0	0	0	0	0	0	0	0	0	2	0	**2**	**0.05**
Cx. (Cux) sitiens	0	0	1	9	0	2	0	0	0	0	3	6	0	**21**	**0.51**
Cx. (Cux) squamosus	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**	**0.05**
Cx. (Cux) vicinus	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**	**0.02**
Cx. (Cux) Vishnui grp.	0	0	1	0	0	1	0	0	0	0	0	0	0	**2**	**0.05**
Cx. (Lop) hilli	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**
Cx. (Lop) species 167	0	0	0	0	0	0	0	0	0	0	1	1	0	**2**	**0.05**
Ma. (Mnd) uniformis	1	0	0	471	0	2	2	0	0	3	0	2	1	**482**	**11.66**
Mi. (Eto) elegans	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.02**
Total	**122**	**48**	**123**	**1032**	**687**	**301**	**90**	**65**	**549**	**187**	**227**	**177**	**526**	**4134**	**100.00**
% of Annual Totals	**2.95**	**1.16**	**2.98**	**24.96**	**16.62**	**7.28**	**2.18**	**1.57**	**13.28**	**4.52**	**5.49**	**4.28**	**12.72**	**100.00**	

TABLE 10. SUMMARY OF NORTHERN GOLD MINE BASELINE MOSQUITO MONITORING, MARCH 1996 - MARCH 1997
TOTAL NUMBER OF ADULT FEMALE MOSQUITOES CAUGHT USING CO_2 BAITED EVS TRAPS

MOSQUITO SPECIES	DATE													ANNUAL TOTAL	% OF ANNUAL TOTAL
	28-Mar	30-Apr	28-May	28-Jun	30-Jul	29-Aug	26-Sep	30-Oct	28-Nov	31-Dec	29-Jan	28-Feb	27-Mar		
Ad. (Ady) catasticta	0	0	1	2	0	0	0	0	0	0	0	0	0	**3**	**0.04**
Ae. (Adm) alboscutellatus	0	1	0	0	0	0	0	0	4	25	20	0	0	**50**	**0.60**
Ae. (Cha) elchoensis	0	0	1	0	0	0	0	0	2	0	1	1	0	**5**	**0.06**
Ae. (Fin) notoscriptus	0	0	0	0	0	0	0	0	0	0	2	2	0	**4**	**0.05**
Ae. (Fin) pecuniosus	0	0	0	0	0	0	0	0	1	0	1	0	0	**2**	**0.02**
Ae. (Mac) stoneorum	0	0	0	0	0	0	0	0	0	0	30	6	4	**40**	**0.48**
Ae. (Mac) tremulus	0	0	0	0	0	0	0	0	1	2	0	0	0	**3**	**0.04**
Ae. (Muc) alternans	0	1	0	0	0	0	0	3	1	0	0	0	0	**5**	**0.06**
Ae. (Neo) lineatopennis	3	11	0	0	0	1	0	70	7	12	1	1	1	**107**	**1.28**
Ae. (Och) normanensis	86	37	0	0	0	0	0	94	873	45	20	4	231	**1390**	**16.59**
Ae. (Och) pseudonormanensis	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**	**0.06**
Ae. (Och) vigilax	0	0	0	0	0	1	0	3	20	1	2	0	0	**27**	**0.32**
Ae. (Ver) funereus	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**	**0.01**
Ae. (Ver) reesi	6	8	0	0	0	0	0	0	0	19	388	151	3	**575**	**6.86**
An. (Ano) bancroftii	9	6	5	13	0	0	0	0	0	1	9	2	4	**49**	**0.58**
An. (Cel) amictus	1	0	4	3	2	7	1	3	2	2	0	0	9	**34**	**0.41**
An. (Cel) annulipes	1	20	48	15	17	15	4	5	13	2	3	25	24	**192**	**2.29**
An. (Cel) farauti	9	17	0	1	0	0	0	0	0	0	4	10	5	**46**	**0.55**
An. (Cel) hilli	0	0	0	3	1	3	12	0	1	1	0	1	0	**22**	**0.26**
An. (Cel) meraukensis	19	117	32	1	0	2	0	0	0	0	6	34	10	**221**	**2.64**
An. (Cel) novaguinensis	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.01**
Cq. (Coq) xanthogaster	8	33	0	982	324	252	47	3	2	42	26	13	3	**1735**	**20.70**
Cx. (Cui) pullus	0	2	2	0	0	0	0	4	7	28	105	129	33	**310**	**3.70**
Cx. (Cux) annulirostris	58	15	158	403	537	274	109	343	149	141	272	95	359	**2913**	**34.76**
Cx. (Cux) bitaeniorhynchus	0	0	0	0	0	0	0	0	0	4	18	50	0	**72**	**0.86**
Cx. (Cux) sitiens	0	0	1	12	0	2	0	0	0	0	3	6	0	**24**	**0.29**
Cx. (Cux) squamosus	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**	**0.02**
Cx. (Cux) vicinus	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**	**0.01**
Cx. (Cux) Vishnui grp.	0	0	1	0	0	1	0	0	0	0	0	0	0	**2**	**0.02**
Cx. (Lop) hilli	0	0	0	0	0	0	0	0	0	0	2	0	0	**2**	**0.02**
Cx. (Lop) species 167	0	0	0	0	0	0	0	0	0	8	5	2	0	**15**	**0.18**
Ma. (Mnd) uniformis	13	13	0	478	1	6	2	1	0	4	0	2	1	**521**	**6.22**
Mi. (Eto) elegans	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.01**
Total	**214**	**282**	**253**	**1914**	**882**	**564**	**175**	**529**	**1083**	**338**	**918**	**534**	**694**	**8380**	**100.00**
% of Annual Totals	**2.55**	**3.37**	**3.02**	**22.84**	**10.53**	**6.73**	**2.09**	**6.31**	**12.92**	**4.03**	**10.95**	**6.37**	**8.28**	**100.00**	

Appendix 1

Northern Territory Government

Department of Health and Community Services

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT PEST AND VECTOR STATUS HABITATS AND BREEDING SITES

P.I. Whelan

Medical Entomology Branch

Department of Health and Community Services

1997

Minor update January 2004

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PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
PEST AND VECTOR STATUS HABITATS
AND BREEDING SITES

Peter Whelan
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NT Department of Health and Community Services
1997
Minor update January 2004

These summary tables are intended as a guide and for assistance to environmental health officers and other public health officers involved in mosquito awareness, surveillance and control programs. They are of a general nature only. They are based on selected literature and my 25 years of field experience as an entomologist in the NT.

Flight range
Adult mosquitoes generally disperse in reasonable numbers, at least 1.6 km from their breeding site. However, some fly much longer distances in search of blood meals (eg. *Oc. vigilax, Oc. normanensis* and *Cq. xanthogaster*) and some generally do not fly far at all (eg. *Ve. funerea, Oc. kochi, Oc. tremulus, Cx. quinquefasciatus* and *Ma. uniformis)*

Species identities
Where there are species complexes which are difficult or impossible to separate morphologically, there is no data regarding the vector capacity of the individual members of the complex. For example, *An. farauti* (formerly *An. farauti* No. 1) is a probable vector of malaria in New Guinea and was probably responsible for the Cairns epidemic in 1942. However, there is no indication of the vector performance of *An.hinesorum* (formerly *An. farauti* No. 2) or *An. torresiensis* (formerly *An. farauti* No. 3) in Australia.

Pest levels
Pest level is very subjective and depends on the population of people subjected to attack and their habits/clothing/location at sunset in an overall setting of size and productivity of nearest breeding sites. CO2 trap levels below the threshold may still be a localised nuisance but are not regarded as at a significant pest level. CO2 trap thresholds generally hold for the Top End of the NT but may vary under different local conditions such as, proximity to breeding site and productivity of breeding site, the topography and vegetation between breeding sites and residential areas, and location and exact position of mosquito traps.

Total of all species present at a given location gives an indication of the total pest level. For protected people, (people inside screened houses at night after sundown) there is no real pest problem even at very high levels. Before sundown the pests in residential areas are primarily *Ochlerotatus vigilax* and *Ochlerotatus notoscriptus* within flight range of breeding sites and on a seasonal basis. Other species can be pests in shaded/heavily vegetated areas at times during the day but generally have peak biting levels in the first two hours after sundown.

MAJOR PEST AND VECTOR MOSQUITO SPECIES IN THE TOP END OF THE NT*

Peter Whelan, Medical Entomology Branch, Department of Health and Community Services 1997

SPECIES	PEST STATUS [1]	VECTOR STATUS
An. annulipes s.l. [2]	Widespread pest, bites at night and will enter houses.	Potential malaria vector.
An. bancroftii	Major pest, widespread, bites anytime near breeding site, nightly or shaded areas elsewhere.	Potential malaria vector.
An. farauti s.l. [2]	Local pest, bites at night. Uncommon, except near mostly sub-coastal and extensive freshwater or brackish swamps.	Major potential vector of malaria.
An. hilli	Coastal pest, bites at night, enters houses. Common near brackish water swamps.	Potential malaria vector.
An. meraukensis	Local pest, bites after dark. Very common near extensive freshwater swamp.	Not potential malaria vector.
Cx. annulirostris	Major pest, very common and widespread in both urban an rural areas. Bites mainly in evening and at night.	Major arbovirus vector of Murray Valley encephalitis virus (MVEV), Kunjin virus, Ross River virus (RRV) and Barmah Forest virus (BFV) and dog heart worm. Vector of numerous other arboviruses.
Cx. quinquefasciatus	Major urban pest, bites at night, indoors, rests indoors, populations common with polluted water in dry season.	Potential arbovirus vector (MVEV). Vector of heartworm of dogs.
Cx. sitiens	Localized coastal pest, breeds in brackish or tidal waters, disperses widely, bites at night.	Probably no diseases. Possible RRV disease.
Cq. xanthogaster	Major localized pest near extensive reed swamps, disperses widely, bites at night, or in dense shade in day, attracted to lights.	No diseases. Filariasis in frill neck lizard
Ma. uniformis	Localized pest, bites at night near the breeding site, attracted to lights, does not disperse far from breeding sites.	No diseases.
Fl. kochi	Local pest at breeding site, does not disperse. Restricted to *Pandanus* thickets.	No diseases.
Oc. normanensis	Major pest, bites in evening and night within 3 km of breeding sites. Plagues in inland areas a week after widespread flooding rains in wet season.	Major vector of Ross River and Barmah Forest viruses. Potential vector of MVEV. Potential vector of many other arboviruses.
Oc. notoscriptus	Local urban pest, receptacle or tree hole breeder, bites persistently, anytime in cool shade. Found naturally in forest areas.	Potential Ross River virus vector. Major vector of heartworm of dogs.
Oc. tremulus	Local urban pest, receptacle or tree hole breeder, bites at sundown and dawn. Often caught in forest areas.	No diseases.
Oc. vigilax	Major pest, bites day or night within 5 km of breeding sites. Plagues associated with high tides in late dry season, early wet season. Fly up to 60 km in pest numbers.	Major vector of Ross River and Barmah Forest virus diseases and dog heartworm. Potential vector of many other arboviruses.
Ve. funerea	Local pest near breeding grounds, does not disperse. Common by day only locally inclosed forrest near tidal brackish swamps & Creeks.	Potential RRV and BFV arbovirus vector.

*** Adapted and revised from P. Liehne et al. "Mosquitoes and biting midge investigation, Palmerston 1982 -85".**

BIOLOGICAL ATTRIBUTES OF THE MAJOR PEST AND VECTOR MOSQUITO SPECIES IN THE TOP END^ OF THE NT* **Peter Whelan, Medical Entomology Branch, Department of Health and Community Services 1997**		
SPECIES	**IMMATURE STAGES**	**ADULT STAGES**
An. annulipes s.l.	Eggs laid singly on water surface; any freshwater body but numerous near *Eleocharis* reed swamps; temporary or permanent; some receptacles; larvae float on water surface and feed on particles on top of water.	Feeds on a variety of mammals include cattle and humans. Bites at night, especially dawn and dusk. Flies up to 2 km from breeding site; rests in cool shady locations such as stream margins, drains etc.
An. bancroftii	Eggs laid singly. Dark larvae, feeds at water surface; found in heavily shaded fresh to slightly brackish ground pools or swamps, especially in paperbark or *Eleocharis* reed swamps.	Feeds on all mammals readily; will fly up to 4 km from breeding site; bites any time near breeding site, nightly or in shade elsewhere.
***An. farauti s.l.* (Includes *An. farauti, An. hinesorum* and *An. torresiensis*)**	Eggs laid singly on surface; larvae feed on water surface. *An. farauti* breeds in brackish water; *An. hinesorum* and *An. torresiensis* breed in freshwater swamps and pools. Larval habitat often sunlit.	Bites readily at night; feeds on humans, other mammals and birds. Will fly approximately 2 km from the breeding site.
An. hilli	Eggs laid singly on surface; larvae feed at surface; sunlit or shaded brackish to saline ground pools or swamps. Numerous in *Schoenoplectus* reed swamps near coast.	Bites humans, cattle and horses; mainly after sunset. Disperses up to 4 km from breeding site.
An. meraukensis	Eggs laid singly on surface of water; larvae feed at the surface; usually in freshwater *Eleocharis* reed swamps, sunlit or shaded.	Bites readily at dusk, feeds on humans and other mammals.
Cx. annulirostris	Eggs deposited as rafts of up to 200 on the water surface; larvae hang from surface and feed on suspended particles; breed in freshwater pools and swamps with emergent vegetation temporary or permanent; will colonize domestic receptacles and breed readily in semi polluted water in storm drains or sewage effluent with vegetation.	Adults are the most common species encountered in the NT and are present throughout the year; feed at night and will bite humans, other mammals and birds; will fly distances of up to 10 km from the breeding site, although common up to 4 km from breeding site.
Cx. quinquefasciatus	Eggs laid as rafts on the surface; breeding grounds are polluted to fresh domestic waters; major sources are septic tanks, leach drains, primary sewage ponds and other polluted ground waters.	Severe domestic pest of humans but will feed on poultry and dogs as well; will feed and rest indoors; bites at night; flies up to 1 km from breeding site.
Cx. sitiens	Eggs laid as rafts on surface; brackish coastal ground pools under tidal influence with or without vegetation; larvae hang from the surface and rest on bottom. Feed on suspended matter or on substrate.	Bites mammals and birds at night; pest near coast, will fly up to 5 km but common within 2 km of breeding site.
Cq. xanthogaster	Eggs laid as small raft on the surface; larvae attach themselves to the stems of aquatic plants by a modified siphon and obtain oxygen from the plants; breed in semi-permanent to permanent swamps with emergent vegetation; associated with *Eleocharis* and *Typha* reeds, water lilies and paperbark; larvae feed on suspended material in the water.	Adults are strong fliers and will disperse widely up to 3 - 5 km. Readily feed on birds and mammals including humans; rest in cool vegetation and bite mainly at dusk, also shade during day. Strongly attracted to light and easily disturbed.
Ma. uniformis	Eggs laid as small cluster attached to the under surface of floating leaves water lilies and plant stems; larval habitats and breeding area similar to *Cq. xanthogaster.*	Adults bite humans, other mammals and birds readily at night. Severe pest in cool shade near breeding site during the day and evening; generally does not fly more than 1 - 2 km from breeding sites; strongly attracted to light; adults rest in dense vegetation; pest in the wet season near breeding areas only.

SPECIES	IMMATURE STAGES	ADULT STAGES
Oc. vigilax	Eggs deposited singly in the mud or near plant stems in suitable habitats; breeds in tidal pools and marshes, usually those filled by tides in upper tidal zone associated with *Schoenoplectus littoralis* or landward ill draining mangrove areas; larvae browse on substrate.	Major and severe pest species; adults feed very readily on humans, other mammals and birds, day or night; will fly up to 60 km; shelter in thick vegetation.
Fl. kochi	Eggs laid singly on the axils of *Pandanus* leaves. Larvae feed on detritus and debris in the water collected in the axil space.	Severe pests near the breeding sites. Do not disperse far from the breeding habitat.
Oc. normanensis	Eggs deposited singly in drying mud substrate in poorly draining floodways. Pale larvae can be inconspicuous in colloidal clay suspension water. Tend to dive to bottom when disturbed. Feed by browsing on substrate. Mainly inland rural habitats.	Major pest species. Extreme numbers after flooding rains for 1- 2 weeks. Feeds readily on humans and other mammals, mainly in evening and night. Will fly 3 - 5 km in pest numbers.
Oc. notoscriptus	Eggs laid singly on the sides of tree holes. Dark larvae hang from the surface by siphon and feed by browsing on the substrate. Common in domestic receptacle habitats.	Feeds on humans and all mammals; bites day or evening in the cool shade. Does not disperse widely.
Ve. funerea	Eggs laid singly on moist substrate at edge of breeding area, usually shaded with some salt influence. Dark larvae hang from water surface, generally feeding by browsing on the bottom of the water body.	Vicious biter in cool shaded vegetation near breeding site in day and in evening. Does not continue biting in sun. Do not disperse far from the breeding habitat.
*** Adapted, revised and expanded from P. Liehne et al. "Mosquitoes and biting midge investigation, Palmerston 1982-85". ^ Applicable for general area of Top End north of and including Mataranka, Larrimah, from Victoria River to Roper River mouths.**		

SEASONAL PREVALENCE OF THE MAJOR PEST AND VECTOR MOSQUITO SPECIES IN THE TOP END OF THE NT*

Peter Whelan Medical Entomology Branch, Department of Health and Community Services 1997

SPECIES	SUMMARY OF BIOLOGY & SEASONAL PREVALENCE
An. annulipes s.l.	Freshwater streams and vegetated swamps. Low to moderate numbers in the wet season, the persistence of populations after the wet season dependent on surface water.
An. bancroftii	Freshwater, paperbark and *Eleocharis* reed swamps and creeks. High to very high numbers at post wet and early dry season, when emergent vegetation at peak and standing water starting to recede.
An. farauti s.l.	Brackish and freshwater species, in vegetated swamps or creeks. Low to moderate numbers in late wet and early post wet season.
An. hilli	Brackish/saltwater breeder, often associated with *Schoenoplectus* reed swamps or creeks or remnant pools in landward mangroves. Low numbers except near extensive brackish water swamps in late wet and early dry season.
An. meraukensis	Open shallow freshwater *Eleocharis* reed swamps and creeks. Moderate to high numbers in the late and immediate post wet season,
Ma. uniformis	Same as *Cq. xanthogaster* but more associated with floating vegetation, (water lilies). Moderate to very high numbers near habitats in late wet, early dry season.
Cx. annulirostris	Breeds in the vegetated margins and pools in permanent and semi-permanent swamps, creeks and floodways Exploits temporary vegetated ground pools in wet season. High numbers in polluted or wastewater with vegetation in dry season. High to very high numbers in the early to mid dry season.
Cx. quinquefasciatus	Domestic water sites, often with organic pollution. Moderate numbers in mid to late dry season, but can be present all year.
Cx. sitiens	Breeds in salt to brackish coastal pools or swamps. Low numbers except locally in tidal pools in upper tide zone in late dry, early wet season, and late wet season.
Cq. xanthogaster	Breeds in freshwater *Eleocharis* reed swamps and creeks. Very high numbers in mid to late dry season when maximum plant growth present in permanent and semi permanent swamps and creeks.
Fl. kochi	Breeds in *Pandanus* axils. Moderate numbers in wet season in *Pandanus* thickets.
Oc. normanensis	Floodwater, ground pool breeder in poorly draining floodways associated with creeks and rivers. Very high numbers during wet season, absent at other times.
Oc. notoscriptus	Tree hole or artificial receptacle breeder. Low numbers in wet season but persists in dry season with artificial breeding sites.
Oc. tremulus	Tree hole or receptacle breeder. Low numbers in wet season and early dry season.
Oc. vigilax	Breeds in tidal to brackish swamp or tidal pools in creeks. Extreme numbers in the very late dry and early wet season.
Ve. funerea	Brackish to tidal ground pools in tidal creeks and swamps, often in shade. Localised pest numbers in the pre wet and wet.

*** Adapted, revised and expanded from P. Liehne et al. “Mosquitoes and biting midge investigation, Palmerston 1982-85”.**

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
PEST AND DISEASE VECTOR STATUS
Peter Whelan 1997
Medical Entomology Branch, Department of Health and Community Services

Species/	**Nuisance status**	**Disease Vector Status**		**Potential vectors in the NT**	**Peak Abundance**
(Common Name)		**Current**	**Potential**		
Ochlerotatus vigilax (Salt marsh mosquito)	+++++	+++	++++	RRV BFV	September - January
Ochlerotatus normanensis (Floodwater mosquito)	+++++	+++	++++	RRV BFV	January - April
Culex annulirostris (Common banded mosquito)	+++++	+++++	+++++	MVEV, KUN RRV, BFV, JEV, others	January - August
Culex gelidus (The frosty mosquito)	+	+	+++	MVEV, KUNV, RRV BFV, JEV, others	January-April
Culex palpalis (Freshwater banded mosquito)	+++	++	+++	MVEV, KUNV RRV, BFV, JEV, others	January-August
Anopheles bancroftii (Black malaria mosquito)	+++	Nil	+	Malaria (possible)	February - July
Coquillettidia xanthogaster (The golden mosquito)	+++	Nil	Nil	None known	March - August
Mansonia uniformis (Waterlily mosquito)	+++	Nil	Nil	None known	March - June
Anopheles farauti s.l. (Australian malaria mosquito)	+	Nil	+++++	Malaria (probable)	March - June
Culex quinquefasciatus (Brown house mosquito)	+++	+	+	MVEV (possible)	January - Jun
Ochlerotatus notoscriptus (Receptacle mosquito)	+	+	++	RRV (probable)	Jan - June
Verallina funerea (Brackish water moquito)	+++	+	++	RRV, BFV (probable)	Oct - Jan
LEGEND					
RRV - Ross River virus BFV - Barmah Forest virus	MVEV - Murray Valley encephalitis virus JEV - Japanese encephalitis virus KUNV - Kunjin virus			+ Minor pest on Disease Potential	+++++ Major pest on Disease Potential

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
INDICATIVE PEST LEVELS
Peter Whelan 2002
Medical Entomology Branch, Department of Health and Community Services

Species	**Main distribution**	**Peak Period**	**CO_2 Trap at Residence ***	**CO_2 Trap at Monitoring Site #**
Ochlerotatus vigilax	Top End, north of Wave Hill, Larrimah and Borroloola	September - January	20	50
Ochlerotatus normanensis	Subcoastal Top End south to Ti Tree	January - April	30	50
Culex annulirostris	NT wide	January to August	50	100
Anopheles bancroftii	Top End north of Victoria and Roper River, south to Larrimah	February - July	30	60
Coquillettidia xanthogaster	Top End north of Victoria and Roper River, south to Larrimah	March - August	30	60
Mansonia uniformis	Top End south to Larrimah	March - June	30	60
Anopheles farauti s.l.	Top End north of Port Keats, Pine Creek, and Numbulwar	March - June	30	50
Culex quinquefasciatus	NT wide, primarily near residential areas	January - June	20	30
Ochlerotatus notoscriptus	NT wide, generally near residential areas	January - June	30	30
Verrallina funerea	Top End primarily coastal and sub-coastal but occasionally south to Larrimah	Nov - March	20	100

Pest Levels

* Indicative significant pest threshold levels (mosquitoes per CO_2 trap per night) at residence for relatively unprotected people at peak biting times.

Indicative significant pest threshold levels (mosquitoes per CO2 trap per night) in residential areas from monitoring sites close to but outside of residential areas, and for monitoring sites between the residential areas and major mosquito breeding areas that are within 2km of residential areas.

Problem Mosquito Species In The Top End Of The NT
Habitat and Flight Range
Peter Whelan 1997
Medical Entomology Branch, Department of Health and Community Services

Species/Common name	Habitat Description	Habitat Indicators	Flight Range & Pest Solutions
Ochlerotatus vigilax (Salt marsh mosquito)	Brackish reed swamps Upper mangrove margin and tidal creek extremities	Extensive mangrove areas with freshwater creek entry. Tidally or sea spray affected rock pools, depressions in coastal sand dunes and vegetated areas above tidal limit. Disturbed upper tidal areas. Tidal brackish swamps with *Schoenoplectus* reeds.	0 - 5 km major pest 5 - 50 km pest numbers 50 - over 200 km dispersal
Ochlerotatus normanensis (Floodwater mosquito)	Flooded freshwater sub-coastal or inland floodways and creeks	Broad, flat sub-coastal and inland drainage floors of minor and major creeks.	0 - 2 km major pest 2 - 5 km pest numbers
Culex annulirostris (Common banded mosquito)	Freshwater and coastal reed swamps. Streams, storm drains, and sewage effluents	Extensive reed swamps with *Eleocharis* or *Typha* reeds. Temporary flooded grasslands in sub-coastal and inland areas with organic matter. Sewage effluent and organic waste water with grass, *Lemna* (Duckweed), *Azolla* (water fern).	0 - 3 km major pest 2 - 10 km pest numbers 10 - 15 km dispersal
Verrallina funerea (brackish mosquito)	Upper reaches of mangroves with fresh water inflow. Rain filled coastal swamps	Brackish mangroves & mangrove fern. Schoenoplectus reed swamps. Shaded rainfilled coastal depressions & creeklines. Under beach hibiscus & Casuarina trees	0-500m minor pest Day pest in closed forrest near breeding sites.
Anopheles bancroftii (Black malaria mosquito)	Freshwater and coastal reed swamps. Shaded streams and swamps	Extensive seasonally inundated *Melaleuca* paperbark swamps. *Eleocharis* and *Typha* reed swamps.	0 - 3 km major pest 3 - 5 km pest numbers
Coquillettidia xanthogaster (The golden mosquito)	Freshwater swamps with reeds Vegetated streams	Extensive *Eleocharis* and *Typha* reed swamps. Paperbark creek lines.	0 - 3 km major pest 3 - 5 km pest numbers
Mansonia uniformis (Waterlily mosquito)	Extensive freshwater reed swamp	Extensive *Eleocharis* and *Typha* reed swamps with water lilies.	0 - 2 km major pest 2 - 3 km dispersal
Anopheles farauti s.l. (Australian malaria mosquito)	Coastal and brackish reed swamps Freshwater swamps and vegetated streams	Brackish *Schoenoplectus* and *Eleocharis* reed swamps. Upper reaches of mangrove creeks with freshwater influence.	0 - 1.5 km minor pest 1.5 - 3 km dispersal
Culex quinquefasciatus (Brown house mosquito)	Storm drains, artificial receptacles Septic tanks Waste water ponds	Polluted ground or artificial receptacles. Filamentous green algae, *Lemna* (Duckweed), Azolla (water fern), or high organic water. Tyres, drums and other receptacles	0 - 500 m major pest 500 m - 1 km pest numbers
Ochlerotatus notoscriptus (Receptacle mosquito)	Tree holes or artificial receptacles	Trees with natural collections of water including *Eucalyptus, Ficus, Poinciana* and *Adansonia*. Tyres, drums, pot plant drip trays, roof gutters, rainwater tanks.	0 - 500 m minor pest 500 m - 1 km dispersal

Appendix 2

ARBOVIRUS DISEASE RISK PERIODS IN THE NORTHERN TERRITORY

VIRUS	FROM VECTORS/ ABUNDANCE & LONGEVITY	FROM VIRUS ISOLATION	FROM SENTINEL ANIMALS	FROM CASE DATA	PEAK RISK PERIOD
MVE	JAN-SEPT	MAR	DEC-OCT	FEB-JULY	MAR-MAY
KUNJIN	JAN-SEPT	APRIL-JUN	DEC-SEPT	MAY-JUN	MAR-MAY
RRV	NOV-SEPT	JAN-APR	-	JAN-DEC	JAN-MAR
BF	NOV-SEPT	DEC-APR	-	DEC-OCT	JAN-MAR

Appendix 3

Northern
Territory
Government

Department of Health
and Community Services

GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES

Peter Whelan and Allan Warchot
November 2005

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GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES

Peter I. Whelan & Allan Warchot

Medical Entomology Branch
Department of Health and Community Services
November 2005

General Comments

All mining operations need to include a section in an Environmental Management Plan for the monitoring and control of mosquitoes. This is necessary because of the potential of mine sites to provide extensive breeding sites for mosquitoes of pest and disease significance. Mine sites also provide the potential for the introduction of mosquito species and mosquito borne diseases into the NT that are either exotic to the NT or have previously been eliminated.

The monitoring of adult mosquitoes in any new mine should include trapping of adult mosquitoes once a month at a number of sites for the initial 12 months baseline mosquito monitoring program. The baseline mosquito monitoring program provides an indication of the seasonal distribution of the mosquito species present and the relative potential impact of mosquito borne disease to mine personnel.

The monitoring and control of mosquito larvae should be an ongoing operation for the life of the mine. Mosquito larvae must be controlled with an approved mosquito larvicide (*Bacillus thuringiensis* var. *israelensis* or methoprene) as part of an organised monitoring and control program. Any mosquito control program should be discussed with the Medical Entomology Branch of the Department of Health and Community Services with regard to methods and insecticides.

Accommodation for personnel should be sited as far as possible from the most important biting insect breeding sites and be adequately insect screened or otherwise protected to reduce the impact of mosquitoes.

The potential for artificially created mosquito breeding sites can be minimised with the appropriate design of water holding facilities and water management procedures.

1. WATER DAMS

- All water storage dams should be constructed with relatively steep sides (45° slope minimum) to discourage the establishment of semi-aquatic vegetation (eg. *Typha* and *Eleocharis* reeds) that will provide suitable habitats for mosquito breeding.

- Dam margins should be as straight as possible to minimise the linear area available for the establishment of semi-aquatic vegetation.

- Where possible, any closely grouped dams should be joined together to minimise the linear margin of vegetation.

- The bottom of any dam should be graded as level as possible, with a slight slope to one end to form a deeper section for periods of low water. This will remove the potential for the formation of isolated pools as the water level recedes in the dry season.

- Areas surrounding any dam that will be flooded during the wet season should be graded to enable water to drain freely into the dam as the water level recedes, without the formation of isolated pools that are capable of retaining water for a period greater than 5 days.

- There must be no islands formed within any dam. All areas of impounded water should have a relatively deep (2 m) wet season stabilised water level to prevent the emergence of semi-aquatic vegetation.

- Any drainage line directed into a dam must be fitted with a sediment trap or erosion prevention structures just upstream from the dam. This is necessary to prevent the formation of "alluvial fans" that will promote the establishment of semi-aquatic vegetation in the area of the fan where silt will be progressively deposited.

- Any overflow areas from dams should have erosion protection measures to prevent the creation of plunge pools.

- Local native fish should be introduced or have access into any dams where the water quality is suitable for their survival, to provide natural predators for the control of mosquito larvae.

- The margins of any water dam should be inspected annually for vegetation growth such as semi-aquatic vegetation and grass. Any dense marginal vegetation should be herbicided or physically removed, to prevent the vegetation from creation suitable mosquito breeding sites.

2. WET LAND FILTERS

- Wetland filters have the potential to provide prolific breeding sites for mosquito species of pest and disease significance. If no other alternative is available for the treatment and disposal of waste water, a wetland filter should incorporate the ability to annually reduce the build up of any dead vegetation. Plans for wetland filter design and siting should be forwarded to the Department of Health and Community Services (Medical Entomology Branch) at the planning stage to ensure that their potential impact on the health of mine site personnel is minimised.

- Annual maintenance could be achieved by dividing a wetland filter into separate sections. A dual system will enable water to be directed into one section of the filter while vegetation is burnt or otherwise reduced in the other section. An ability to manipulate the water level in the filter to strand or drown vegetation would be beneficial for the management of vegetation and mosquito numbers.

- Stocking the wetland filter with local native fish will provide a significant measure for controlling mosquito larvae. The provision of fish however will not remove the need for annual maintenance of the wetland filter.

- Where appropriate, consideration should be given to the provision of a fish ladder on any overflow facility to enable the dispersal of fish into and upstream of the filter.

- Wetland filters may need to be removed after mining operations are completed to enable the future development of adjacent land.

3. WEIRS

- Any spillways must be fitted with erosion prevention structures to prevent scouring and siltation of creek lines during periods of overflow.

- Fish ladders should be constructed where appropriate to enable the upstream dispersal of fish following periods of dam overflow.

4. MINE WASTE DUMPS

- The final surface of mine waste dumps should be contoured so that the surface area is free draining and has no surface depressions.

- Any runoff from a waste dump should be directed to a silt trap to prevent any siltation of natural creek lines. Siltation in creek lines can promote the formation of isolated pools or disrupt fish ecology and may lead to the subsequent establishment of mosquito breeding sites.

- Mine waste dumps should be located away from natural drainage lines, to prevent the upstream impoundment of natural surface water flows. If impractical to locate mine waste dumps away from natural drainage lines, diversion drains will be required to direct surface water flows around the waste dump.

5. SEDIMENT TRAPS

- Sediment traps need to be designed where possible to be free draining within a period of 5 days after flooding.

- Sediment traps that can not be free draining within 5 days must be steep sided and have a sloping bottom base to one end, with erosion protection (e.g. reno mattress) at the inflow and overflow facility.

- Sediment traps should be maintained by silt and vegetation removal on an annual basis. There should be a designated and designed access path for silt removal.

- Sediment traps with dry season low flows should be sampled for mosquito larvae monthly in the dry season and appropriate mosquito control programs arranged with the appropriate authority.

6. BORROW PITS

- Borrow pits, costeans or scrapes must be rehabilitated, where possible, such that they do not hold water for a period greater than 5 days. These sites within 5km of urban residential areas must be rehabilitated either by filling or rendering them to be free draining.

- Borrow pits that cannot be rehabilitated must be steep sided, have a sloping floor to one end and have surrounding stormwater catchments directed to the upper end, so that they will fill with silt over time.

- There should be no dry season low flows from storm water drainage directed into borrow pits.

7. DRAINAGE PATHS

- Natural drainage patterns should be maintained where possible. Access roads across drainage lines may need to be fitted with culverts of sufficient size to prevent upstream flooding for periods that will enable mosquito breeding. Culverts should be installed flush with the upstream surface level. Erosion prevention structures will need to be constructed on the downstream side of any culvert, and erosion prevention structures may also be required at the headwalls of any culvert.

- Any disruption to surface drainage should be removed at the end of the mining operations.

8. PIT DEWATERING

- Pit water discharge should be free of silt. Dry season pit water discharge should be directed into a water dam, and not into natural drainage lines or creeklines unless there is provision to prevent the growth of semi-aquatic reeds in the discharge area.

9. WASTE WATER DISPOSAL

- Septic tanks must be installed to DHCS guidelines and should be inspected on an annual basis by the Environmental Officer to ensure that tanks and their effluents do not breed mosquitoes.

- Discharge, overflow or excess effluent from sewage treatment systems must be disposed of in a manner approved by DHCS. A sprinkler disposal system is suitable under most situations. Infiltration systems are acceptable if soil conditions are favourable. The discharge of excess effluent into ephemeral creek lines is not acceptable.

- Sewage ponds should be constructed with steep sides with an impervious lining and be regularly maintained to prevent vegetative growth at the margins (see *"The prevention of mosquito breeding in sewage treatment facilities"*, available from the Medical Entomology Branch). Surface debris and algal scum should be removed on a regular basis. Monitoring of mosquito larvae should be conducted in sewage ponds on a regular basis and control treatments conducted when necessary.

- Disposal of water into “Application areas” must ensure that water does not pool for a period greater than 5 days.

10. ARTIFICIAL CONTAINERS

- Rainwater tanks must be adequately screened to prevent the entry of mosquitoes.

- Any container capable of holding water, eg. machinery tyres, drums, disused tyres, tanks, pots, etc. should be stored under cover, be provided with drainage holes, emptied on a weekly basis, treated with an appropriate insecticide on an appropriate schedule, or disposed of in an appropriate dump site to prevent the formation of mosquito breeding sites.

- No used tyres, machinery or other containers that have previously held rain water should be brought to the NT from Queensland unless the containers or machinery has been thoroughly treated with chlorine or an appropriate insecticide to remove the possibility of the introduction of drought resistant eggs of exotic *Aedes* mosquito species.

11. RUBBISH AND GARBAGE DUMPS

- Rubbish and garbage dumps must be operated in such a matter that there is no ground surface or water filled receptale pooling of water for a period greater than 5 days, to prevent the formation of mosquito breeding sites.

- Rubbish and garbage dumps must be rehabilitated by filling and surface contouring to ensure they are free draining and have no surface depressions.

12. DECOMMISSIONING AND REHABILITATION

- A decommissioning and rehabilitation plan should be in place for all mining operations to ensure no actual or potential mosquito breeding sites remain after cessation of mining operations. All disturbed areas should be rehabilitated to be free draining where practical. The proponent should consult the Medical Entomology Branch for input when preparing this document.

- Aspects to consider when decommissioning and rehabilitating a mine site include removing and appropriately grading all sediment ponds, removing all bund walls created for the development, removing infrastructure and artificial receptacles that could pond water, removing water dams and reinstating existing flowpaths where practical, rehabilitating borrow pits, removing wetland filters, sediment traps, and other facilities that could pond water and breed mosquitoes.

- Facilities such as open pit voids and water dams can be left as water holding pits if they are constructed with steep sides (at least 1:2 slope), and stocked with fish during the rehabilitation process.

13. NOTES

- These guidelines replace former guidelines 'Guidelines for preventing mosquito breeding sites associated with mining sites', by Brian Montgomery and Peter Whelan May 1997.

Appendix 4

Northern Territory Government
Department of Health and Community Services

PERSONAL PROTECTION FROM MOSQUITOES & BITING MIDGES IN THE NT

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Published in "Australian Mosquito Control Manual" by a panel of authors, Editors C. Morris and P. Dale. Australian Mosquito Control Association, 1998, ISBN 0-646-35310-1.

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PERSONAL PROTECTION FROM MOSQUITOES & BITING MIDGES

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April 2004

Adapted from paper by P. Whelan in "Australian Mosquito Control Manual" by a panel of authors, Editors C. Morris and P. Dale. Australian Mosquito Control Association, 1998, ISBN 0-646-35310-1.

1.0 MOSQUITO & BITING MIDGE BITES

Mosquitoes and biting midges (genus Culicoides and sometimes erroneously called sand flies) can reach sufficient numbers in various localities to be considered serious pests. The bites themselves can be painful and extremely annoying, and people suffer varying degrees of reaction to bites (Lee 1975). However the possibility of the spread of various diseases by their blood sucking habits to either humans or animals is a more serious outcome. Mosquitoes can carry viruses such as Murray Valley encephalitis, Kunjin, Ross River, and Barmah Forest virus, which cause human disease (Russell 1995). Biting midges do not carry any pathogens in Australia that cause human disease.

Female mosquitoes or biting midges bite to take blood from their hosts, which is necessary for the development of eggs.

Mosquitoes and biting midges show considerable variation in their preference for hosts. Some species feed selectively on cattle, horses, marsupials, amphibians, birds or humans, while other species are relatively indiscriminate feeders.

The time of feeding varies for different species. Many mosquitoes feed just after sunset while others are more active at other times including late in the night, in the late afternoon, or in the early morning. Biting midges are most active in the evening and early morning.

The place of feeding by mosquitoes or biting midges is varied. Some species, such as the brown house mosquito, readily entering houses to feed on people, while others will only bite people outdoors.

When a mosquito or biting midge bites, fine stylets sheathed in the proboscis are inserted into the skin. Blood is sucked up through one of the channels in the stylets, while saliva is injected down an adjacent channel. This saliva contains substances that the human body recognises as foreign and often stimulates a bite reaction. Sometimes the saliva can contain viruses or other pathogens that can cause disease.

Some people can become very sensitive after being bitten and suffer a general reaction from further bites. The bites may itch for days, producing restlessness, loss of sleep and nervous irritation. Scratched bites can lead to secondary infections and result in ugly scars. On the other hand, some people become tolerant to particular species and suffer little after-effects from repeated bites.

Biting insects create problems in the enjoyment of outdoor activities, causing a reluctance to enter certain areas after sundown or forcing people to be confined to insect-proof areas at certain times of the year. Personal protection and avoidance measures can offer considerable protection from bites, as well as offering protection against mosquito-borne disease.

2.0 MOSQUITO & BITING MIDGE AVOIDANCE

A sensible precaution to prevent biting insect attack is to avoid areas that are known to have high biting insect activity.

The upper high tide areas near creeks or low-lying areas, particularly near salt marsh habitats, can be significant sources of salt marsh mosquitoes (particularly *Ochlerotatus vigilax* and various other pest mosquitoes (Russell 1995). The period of high salt marsh mosquito activity is usually during the late dry season and early wet season in tropical latitudes. Generally they are prevalent for one to two weeks after the highest tides of the month or significant rain. Dense vegetation near the breeding sites should be avoided during the day over this period. Pest problems during the evening and night can occur within 3 km of productive breeding sites (Whelan, Merianos et al., 1997).

Other areas of high mosquito activity are the large seasonally flooded areas associated with rivers or drainage lines, flooded coastal swamps, extensive reed swamps and lagoons, ill defined or poorly draining creeks, extensive irrigation areas, and wastewater disposal facilities. Densely shaded areas near these habitats should be avoided during the day, and accommodation areas should be at least 3 km from extensive areas of these habitats.

Extensive areas of mangroves or estuarine areas with sandy beaches are potential sources of biting midges. These midges have seasonal and monthly population peaks with the monthly peaks usually associated with the tidal regime. When camping or choosing a permanent living site, a separation distance of at least 2 km from these areas is recommended unless specific biting insect investigations indicate there are no seasonal pest problems (Whelan 1990, Whelan, Hayes et al., 1997).

If camping or selecting house sites near creeks, rivers or lagoons, choose localities of the water body which have steep margins or little marginal emergent vegetation, have swiftly running water with little marginal pooling or vegetation, or do not arise from or empty into a nearby swamp area. Exposed beaches or cliffs away from mangrove or estuary areas are preferred sites to avoid both mosquitoes and biting midges. In more inland areas, locations on hills or rises at least 3 km from ill defined drainage lines, poorly flowing creeks and seasonally flooded areas should avoid the worst mosquito problems.

In residential areas, a local source of mosquitoes may be the cause of the problem. Check nearby potential artificial sources of mosquitoes such as disused swimming pools, receptacles such as tyres and drums, blocked roof gutters, old fishponds, or localised ponding of drains. Sites with mosquitoes breeding can be rectified by physically removing the source or through the use of insecticides.

3.0 SCREENING

The best method of avoiding attack at night is to stay inside insect-screened houses. Screens can be made of galvanised iron, copper, bronze, aluminium or plastic. Near the coast, iron or copper screens are not recommended because of the corrosive action of salt sprays. Homes near biting midge breeding sites require either fine mesh screens or lightproof curtains.

Screens should be of the correct mesh, fit tightly and be in good repair. Biting insects frequently follow people into buildings and for this reason, screen doors should open outward and have automatic closing devices. Insecticides such as permethrin or deltamethrin sprayed on or around screens may give added protection against mosquitoes or biting midges, but care is needed as some insecticides affect screens.

It is advisable to use an insect proof tent when camping near potential biting insect areas. Coastal areas subject to attack by biting midges require tents to be fitted with a finer mesh screening.

4.0 MOSQUITO NETS

Mosquito nets are useful in temporary camps or in unscreened houses near biting insect breeding areas. Generally standard mosquito nets are not sufficient to prevent biting midge attack. White netting is best as mosquitoes accidentally admitted into the net are easily seen and killed. The net is suspended over the bed and tucked under the mattress. An aerosol pyrethrin spray can be used to kill mosquitoes that enter the net. Care is needed not to leave exposed parts of the body in contact with the net, as mosquitoes will bite through the net. Nets can be made more effective by impregnation with permethrin (Lines et al. 1985).

5.0 INSECT PROOF CLOTHING

Head nets, gloves and boots can protect parts of the body, which are not covered by other clothing. Head nets with 1-1.5 meshes to the centimetre are recommended for good visibility and comfort, and additional treatment of the net with a repellent will discourage insect attack. Thick clothing or tightly woven material offers protection against bites. Light coloured, long sleeved shirts and full-length trousers are recommended. For particular risk areas or occupations, protective clothing can be impregnated with permethrin or other synthetic pyrethroid insecticides such as bifenthrin to give added protection (Burgess et al. 1988). Sleeves and collars should be kept buttoned and trousers tucked in socks during biting insect risk periods. Protection is very necessary near areas of salt marsh, mangroves, or large fresh water swamps where the various species of mosquitoes may be very abundant during the day in shaded situations, as well as at night.

6.0 REPELLENTS

Relief from biting insect attack may be obtained by applying repellents to the skin and clothing (Schreck et al. 1984). Many repellents affect plastics and care is needed when applying them near mucous membranes such as the eyes and lips.

Repellents with the chemical diethyl toluamide (DEET) or picaridin give the best protection. Some specific repellent products, such as Aerogard, which are formulated to repel flies, are generally not efficient against mosquitoes or biting midges. Brands such as Rid, Tropical Strength Aerogard, Bushman's, Muskol, or Repel include specific products that are effective. Those products with higher amounts of DEET or picaridin are usually the most efficient.

Application of repellents over large areas of the body or on extensive areas of children is not recommended particularly those repellents with high concentrations of DEET. Protection from mosquito penetration through open weave clothes can be obtained by applying a light application of aerosol repellent to the exterior of clothing. Repellents should be supplementary to protective clothing and should not be regarded as substitutes.

Personal repellents are available as sprays, creams or gels. The creams or gels usually last longer than the aerosol formulations. Repellents can prevent bites from 2 to 4 hours, depending on the repellents, the species of biting insect, or the physical activity of the wearer.

Electronic insect repellers that emit ultrasonic or audible sounds do not offer any protection against mosquitoes or biting midges. They are based on a false premise and have been found to have no repellent effect under scientific testing (Curtis 1986). Electronic ultrasonic repellers do not repel mosquitoes or biting midges and should not be relied upon for personal protection (Mitchell 1992).

Plants with reported insecticidal properties such as neem trees and the citrosa plant have not been shown to act as mosquito repellents just by growing in the vicinity of people (Mitchell 1992, Matsuda et al. 1996). Growing or positioning these plants near evening activity areas will not prevent mosquito attack. However some plants have some repellency effects as smoke or liniments (see section 12, emergency biting insect protection)

7.0 ANIMAL DIVERSION

Camping upwind near congregations of stock or domestic animals will serve to divert mosquitoes or biting midges to alternative hosts. Similar considerations can be made when planning residential sites and animal holding areas in a rural situation. Dogs of darker colour tend to attract some species of mosquitoes more than lighter colours and can divert some pest problems from people in close vicinity in outdoor situations in the evening.

8.0 LIGHTING DIVERSION

Many mosquito and biting midge species are attracted to light. This can cause pest problems in unscreened houses or when camping. The use of yellow or red incandescent bulbs or fluorescent tubes rather than white light will reduce the attractiveness of lights to insects. An incandescent or ultra violet light placed at a distance from a house or camp can serve to attract insects to an alternative area. This is more effective if the light is close to the breeding site, or between the breeding site and the accommodation area. The attractive lights should not be close to accommodation or directly down wind of accommodation areas. Light proof curtains or similar screening can be very effective in reducing the attraction of biting insects to areas that are illuminated at night.

9.0 ADULT INSECT CONTROL

If mosquitoes or biting midges have entered a screened area they can be knocked down with pyrethrin aerosols. Care should be taken by reading the label to ensure only knockdown aerosols suitable for spraying in the air are used in proximity to people or food.

Other devices that can be effective at killing and/or repelling biting insects include mosquito coils (Charlwood & Jolley 1984) and electric insecticide pads. These devices are only effective in relatively closed areas such as inside buildings or where there are only slight breezes. They should be backed up with other measures such as suitable protective clothing or repellents

Large scale adult biting insect control can be achieved for short terms (hours) by using portable or industrial fog generators, backpack misters, or heavy duty ultra-low-volume aerosol generators to knock down active adult insects. The insecticides of choice in these machines are Maldison or Bioresmethrin. Control relies on good access, open vegetation, and light breezes in the direction of the breeding or harbouring sites. Application should only be during the peak biting insect activity period of those insects actually causing the problem, which is usually the late evening and early night.

There are some synthetic pyrethroid aerosol products available as outdoor yard or patio repellents. Control will only be temporary (hours) and re-invasion will usually occur within hours or from one to a few days, depending on the species, nearby vegetation, proximity to breeding sites, environmental conditions and times of activity of the pest species.

Application of residual insecticides such as maldison, permethrin or other synthetic pyrethroids sprayed as a mist spray to point of run off on building surfaces or nearby vegetation can sometimes give short term (a few days) relief. This method is useful as a barrier protection when large numbers of mosquitoes or biting midges are present near accommodation or outdoor use areas (Helson & Surgeoner 1985). There are some longer term residual synthetic pyrethroids such as bifenthrin that can be used as barrier sprays and provide a number of weeks protection (Standfast et al 2003). These residual insecticides can be applied according to label recommendations with the aid of a garden sprayer. Care must be taken with all synthetic pyrethroids around fishponds, fish tanks and other nearby fish habitats to avoid spray drift or run off, as these insecticides are efficient fish poisons.

10.0 INSECTOCUTORS AND INSECT TRAPS

Electric insect insectocutors and other trap or killing devices utilising an attracting light or carbon dioxide have been claimed to clear areas of biting insects and thus protect people. These claims have not been substantiated in outdoor situations with people nearby. While trap devices can attract biting insects, as well as a range of other insects, these devices can not be relied on for protection from biting insect attack (Mitchell 1992). When used in outdoor situations it is possible that they can increase local problems by attracting insects to the vicinity of people. Attractive odours and carbon dioxide emitted by humans then divert the insects from the trap device to the people.

11.0 TREATMENT OF BITES

Relief from bites and prevention of secondary infection can be obtained by the application of various products, either to the skin or internally. The effectiveness of various products is variable, depending on individual reaction. Skin application products include proprietary products such as Eurax, Stingose, Medicreme, Katers lotion, Dermocaine and Paraderm creme, and non-proprietary products such as tea tree oil, eucalyptus oil, aloe vera gel, ice, or methylated spirits.

Ice packs to the general bite site will give usually give immediate relief for painful and itchy bites and swelling or blisters from of mosquitoes and biting midges in particular. The sooner the ice pack is applied after bites or reactions, the better the relief, and can often avoid more intense reactions.

Other products for internal application for more general symptoms include antihistamine products such as Phenergan, Telfast and Vallergan. Check with your doctor or pharmacist for any products for the latest product and safety information.

12.0 EMERGENCY BITING INSECT PROTECTION

There are a number of emergency measures that can be taken when exposed to biting insects with no protection. Sheltering downwind next to smoky fires can offer considerable protection. Burning dung or aromatic and oil producing foliage from plants such as Hyptis (horehound), Vitex (black plum), Calytrix (Turkey bush), Melaleuca species (Paper bark) and Eucalyptus species (gum trees) can make the smoke more effective. A small native plant Pterocaulon serrulatum (warnulpu) has sticky strongly aromatic leaves, and branches are burnt or the moist leaves are rubbed on the skin by Aborigines in the Katherine district to repel mosquitoes (Aborigines of the NT 1988). Climbing relatively high trees or choosing locations exposed to the wind can also offer protection from some species.

Some protection can be obtained by rubbing exposed skin areas with the leaves of certain plants such as eucalypts, turkey bush, warnulpa, paperbarks or tea-trees that contain volatile oils. However these are not as efficient as proprietary repellents containing deet or picaridin. Other emergency protection measures include coating the skin with mud, or burying yourself in shallow sand with some form of head protection. If all else fails, keep running. The best form of protection, and the most comfortable, require an awareness of the potential problems and adequate preparation.

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Appendix 5

Bull. Mosq. Control Assoc. Aust. Vol. 15 (2) 2003.

FIELD EVALUATION OF BISTAR 80SC AS AN EFFECTIVE INSECTICIDE HARBOURAGE TREATMENT FOR BITING MIDGES (*CULICOIDES*) AND MOSQUITOES INFESTING PERIDOMESTIC SITUATIONS IN AN URBAN ENVIRONMENT

By

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Abstract

Excellent residual control of adult biting midges and mosquitoes was recorded at River Heads, Hervey Bay, by applying Bistar 80SC (FMC Chemicals) as a 0.1% bifenthrin in water mix to external resting surfaces in peri-domestic situations. Application of the mix as a coarse spray (150-200 micron droplets) resulted in a 97%-75% reduction in biting midge numbers in the first month of field evaluation, with a 65% mean reduction in numbers at six weeks post-treatment. Of the midge species controlled during this evaluation, 81% were *Culicoides ornatus*, and 19% *Culicoides subimmaculatus*.

With regards to the mosquitoes controlled during the evaluation, an even higher level of efficacy was achieved, with a 99%-94% reduction in numbers during the first month, and 94% mean reduction in numbers over the six week evaluation period. Of these, the saltmarsh arbovirus vector *Ochlerotatus vigilax* represented 78%.

These are significant results, as the authors are unaware of any other method which has achieved an effective, sustained reduction in adult biting midge numbers. Accordingly, the suitability of the method for provision of household protection and integration with existing vector control programs is discussed, and recommendations made for future management of this valuable insecticide.

Introduction

It is well documented that mosquitoes (Russell 1998) and biting midges (*Culicoides* spp.) (Kettle 1965, Howie 2002) seriously impact on human health in Australia. With respect to mosquitoes, several *Ochlerotatus*, *Aedes* and *Culex* species have been implicated in the transmission of arboviruses and canine filaria (Boreham and Marks 1986, Watson and Kay 1998, Hanna et al. 1999, Ryan et al. 1999, Boyd and Kay 2000). With biting midges, it is females from the genus *Culicoides* which impact most severely on the health and comfort of humans and animals (Kettle 1965, Linley et al. 1983, Kay and Standfast 1987). This biting behaviour can result in adverse economic effects on land development, property values, tourism, recreation and work-related activities (Linley and Davies 1971, Howie 2002). In Hervey Bay in 2002, the biting midge problem is estimated to have cost residents $61 million (Ratnayake et al. 2003). Additionally, *Culicoides* are also known to transmit protozoans, filarial worms, and viruses (Kettle 1965, Blanton and Wirth 1979, Linley et al. 1983).

In response to this threat, some larger coastal Queensland Local Governments allocate significant resources towards broadscale larviciding for mosquitoes (Brown et al. 1999). Unfortunately, there is no registered larvicide for biting midges. This is because the larvae occur in environmentally sensitive areas of the inter-tidal zone, and dispersal patterns are poorly know (Shivas 2001). Also, required dosages are environmentally damaging (Standfast unpub data). This leaves aerosol (thermal fogging and ULV) insecticide applications against adults as the only option available. The method only provides short-term relief from biting, and repeated applications are necessary and expensive. It is for these reasons that a sustained effective method is required, and one that provides household protection has been identified as a priority (Shivas 2001).

Accordingly, Bifenthrin (FMC Chemicals) was selected for evaluation as an effective insecticide surface treatment for biting midges and mosquitoes harbouring on ornamental plants, fences and walls surrounding domestic situations at River Heads, Hervey Bay (Queensland, Australia). This suburb was selected as a test site, as a recent public health study found that residents experience reduced health levels as a consequence of biting midges, and that an effective control method is desperately needed (Howie 2002). Bifenthrin, a non-alpha cyano (low skin irritant) synthetic pyrethroid, which is used world-wide against a range of agricultural pests, was considered an ideal candidate insecticide as it is characterized by:

1) low irritancy to mosquitoes, and thus increases mosquito-bifenthrin contact time (WHO 2002);
2) very low vapor pressure (1.81 10-7 mmHg);
3) low water solubility (<1 μg/litre) and good stability to hydrolysis and photolysis (2 years at 500C. under natural daylight); and
4) long residual efficacy against target insects (WHO 1998, 2002; Hougard et al. 2002; Yadav et al. 2003).
5) safety to humans: “Noting its safety and efficacy, Bifenthrin 10WP is recommended for indoor residual spraying” (WHO/CDS/WHOPES/2001.4).

In house-scale trials in India, Bifenthrin (10% wettable powder) applied at a rate of 25 mg/m^2 provided persistent (>80% mortality for 24 weeks) insecticidal activity against *Anopheles culicifacies* on mud and brick surfaces (Yadav 2003).

It was these characteristics that led to selection of an 8% water-based, no-odor, non-irritant, suspension concentrate (SC) formulation for evaluation in Queensland against biting midges. Although this FMC Chemicals formulation is registered in Australia as a surface treatment for mosquitoes, it has not been evaluated for efficacy against biting midges infesting domestic situations. Therefore, this study was undertaken to produce efficacy data for biting midges, and in doing so provide a tool for control of these insects of public health and economic importance. Additional efficacy data was also collected for mosquitoes.

Materials and Methods

Study Site. Public support for this evaluation at River Heads (Plate 1) was received at a River Heads public forum, held on the 2nd October 2002. There was 80% positive support from the public for this evaluation. The Environmental Protection Agency, and Department of Primary Industries – Fisheries, also supported the evaluation as it did not impact on the environmentally sensitive marine park surrounding River Heads. The evaluation was conducted under NRA Research Permit 5547.

Plate 1. River Heads, Hervey Bay, Queensland. Clean estuarine sand and muddy sand surrounding River Heads provides larval habitat for *Culicoides subimmaculatus* Lee & Reye, while estuarine mud produces *Culicoides ornatus* Taylor. Saltmarsh and mangrove habitats produce the mosquito arbovirus vector, *Ochlerotatus vigilax* (Skuse).

Once the above detailed approval had been obtained, eight houses comprised of four randomized pairs (1 treatment + 1 untreated control) were selected, and the householders consent obtained ca. 2 weeks prior to the treatment date (29th October, 2002).

Plate 2. On the properties selected for evaluation, external surfaces where mosquitoes and midges rest (fences, walls, ornamental plants and bushes) were identified for treatment.

Application of Bistar 80 SC (Active Ingredient: 8% bifenthrin). In order to obtain the required efficacy data for biting midges, the 8% SC formulation was applied as per the label directions for applications against mosquitoes under conditions of high pest pressure, and when maximum residual protection is desired. The label directions state that at a recommended rate of 125 mL/10L: "*on non-porous surfaces apply as a coarse spray at the rate of 1 litre of emulsion per 20 m^2. When treating non-porous surfaces do not exceed the point of run-off. On porous surfaces or use through power equipment, spray at the rate of 1 litre of emulsion per 10 m^2. When treating porous surfaces do not exceed the point of run-off. To control mosquitoes apply prepared emulsion to surfaces where insects rest or harbour. Reapply as necessary.*"

Accordingly, a 0.1% mix (125 mL/10L water) was applied as per the label instructions described above, to external building and ornamental plant surfaces (Plate 2). To do this a Solo Back Pack Sprayer (Solo, Germany) was calibrated by the Centre for Pesticide Application and Safety (University of Queensland, Gatton Campus) to deliver a dilute spray comprised of large (150-200 micron) droplets.

Table 1. Property treatment rates.

Treatment Property No.	Property Size	Volume of 8% SC Applied[1]
1	1012 m^2	875 ml
2	1012 m^2	750 ml
3	1012 m^2	500 ml
4	1012 m^2	625 ml

[1] The volume of 8% SC applied to the various properties varied according to house size and % ornamental coverage.

Surveillance and Identification. CDC-type light traps powered by a rechargeable 6 volt battery, were used to measure peri-domestic biting midge and mosquito populations in

Plate 3. Median midge and mosquito numbers caught overnight in unbaited vs baited light traps.

treatment and control properties. Light trap collections were made on the evening prior to treatment, and then each night for 9 nights post-treatment. Sampling frequency was then reduced to weekly collections for six weeks post-treatment.

To do this, one trap was hung from a tree within the fenced-off yard of each treatment and control property. On each sampling occasion, each trap was baited with 750 g dry ice and 2.5 ml Octenol (1 Octen-3-ol). The dry ice was housed in the purpose built 1 litre ice container, and the Octenol contained in a 4 ml microreaction vial. An exposed cotton pipe cleaner wick was used to release the Octenol. The traps were operated from 1500 to 0700 hours. Each day the collections were transported to the laboratory for sorting, counting, and identification according to the descriptions in Marks (1982). All collections were stored in 70% ethanol. The above described baited light trapping method was chosen on the basis of catches recorded in an evaluation of trapping efficacy conducted between 1500 and 0700 hours, 7 days prior to the application of the 8%SC formulation. In order to determine if un-baited traps would provide sufficient numbers for statistical analyses, the catches recorded from 5 x un-baited light traps were compared with what was caught in 5 x light traps baited with CO_2 and Octenol.

Environmental data. Environmental parameters in terms of wind speed, direction, temperature and humidity were measured on a vacant allotment at River Heads using a portable EnvironData Weather Master 2000 (EnvironData, 44 Percy St, Warwick, QLD. 4370 Australia).

Statistical Quantification of Treatment Efficacy. For both biting midges and mosquitoes, 12 hours pre-treatment and six weeks post-treatment field data, comprising 62 light trap collections were made. As the pre-treatment data was normally distributed, a t-test was used to test for significant differences between treatment and control properties. For the post-treatment data, and pre-treatment comparison of light trapping efficiency, a non-parametric Mann-Whitney Rank Sum Test was used to test for statistically significant differences in the median values between counts from treatment and control properties, and baited vs un-baited light-traps, respectively. This non-parametric test was utilized as the collected data failed a test for normality (see skewness values Table 5). We did not expect the long-term data to be normally distributed as biting midge and mosquito populations exhibit both spatial and temporal variability (Shivas 2001). Factors such as wind direction and speed, humidity, topography, harborage and emergence patterns all contribute to patchy distribution. Accordingly, we utilized the Henderson & Tilton (1955) formula to calculate weekly % reduction for fluctuating test populations:

$$\% \text{ control} = 100 \times \left[1 - \frac{Ta \times Cb}{Tb \times Ca}\right]$$

Where: Ta = population in treatment post-treatment
Tb = population in treatment pre-treatment
Ca = population in control post-treatment
Cb = population in control pre-treatment

Results

The field evaluation from late October to mid December was conducted in warm, humid, calm conditions (Table 2).

Table 2. Mean ± SD 24 hour environmental conditions during field evaluation.

Temperature ^{O}C.	% Relative Humidity	Wind Speed km/hr	Wind Direction (Degrees)
23 ± 3	78 ± 17	7 ± 3	118 ± 66

In the pre-treatment evaluation of trapping efficiency, baited light traps caught significantly (P<0.01) higher biting midge and mosquito numbers (Plate 3). On the night prior to treatment, there was no statistically significant difference in the numbers of biting midges (P<0.43) or mosquitoes (P<0.51) collected from properties identified for treatment or untreated controls (Table 3).

Table 3. 12-hour pre-treatment biting midge and mosquito numbers on properties selected for evaluation of Bistar 80SC efficacy.

Group	N	Mean	Std Dev	t	Df	95%CI	*P*
Pre-Treatment Biting Midges	4	51	81	0.84	6	-65 to 134	0.43
Control Biting Midges	4	17	11				
Pre-Treatment Mosquitoes	4	56	38	0.70	6	-408 to 227	0.51
Control Mosquitoes	4	147	257				

In contrast, over the six week post-treatment period, a statistically highly significant difference in the median numbers of biting midges (P<0.02) and mosquitoes (P<0.01) collected from treated and control properties was recorded (Table 4). In contrast to an average of 441 biting midges and 25 mosquitoes collected from treated properties, 2,989 biting midges and 169 mosquitoes were collected from untreated control properties (Table 5). In terms of species composition, 78% of the collected mosquitoes species were the saltmarsh *Oc. vigilax*, with *C. ornatus* and *C. subimmaculatus* representing 81% and 19% of the collected biting midge species, respectively.

Table 4. Mann-Whitney Rank Sum analysis for six weeks biting midge and mosquito field data.

Group	N	Median Number	25%	75%	T	*P*
Biting Midge						
Treatments	54	276	66	682	2652	<0.02
Controls	54	425	122	1856		
Mosquitoes						
Treatments	54	8	4	34	1802	<0.01
Controls	54	106	46	210		

Table 5. Descriptive Statistics for 6 weeks field Data.

Biting Midge (n = 54 trap collections)

	Skewness	Range	Max	Min	Median	Mean
Treatment	1.46	2,011	2,012	1	276	441
Control	2.21	21,914	21,948	34	425	2,989

Mosquitoes (n = 54 trap collections)

	Skewness	Range	Max	Min	Median	Mean
Treatment	2.50	186	186	0	8	25
Control	2.40	875	879	4	106	169

In terms of % reduction over time, biting midge numbers were reduced by 97% to 75% in the first month, with a 65% mean reduction over the 6 week study period (Fig. 1). Mosquito numbers were reduced by 99% to 94% in the first month, with a 94% mean reduction over the 6 week study period. Rainfall events were recorded in the first, third, fifth and sixth weeks of the study (Hervey Bay Airport Meteorological Data) (Fig. 1).

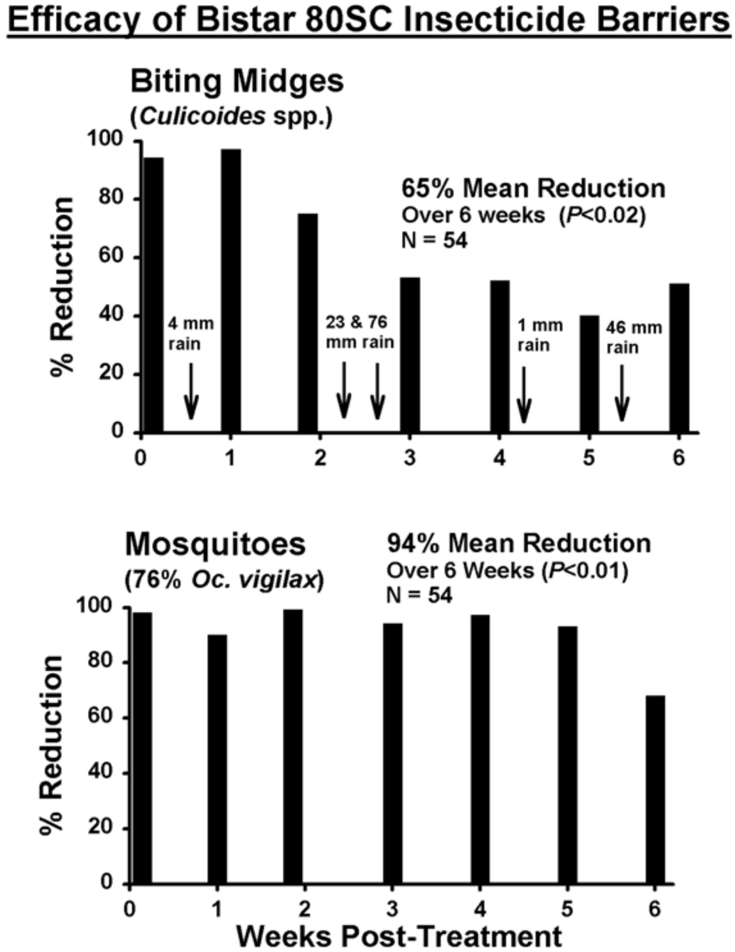

Fig. 1. % Reduction of peri-domestic biting midge and mosquito numbers over a six week study period. Rainfall events are also recorded.

Discussion

The authors are unaware of any other study which details effective, sustained reduction in adult biting midge numbers. The successful Bistar 80SC application was achieved during periods of peak biting midge and saltmarsh mosquito emergence, and despite rainfall events on six occasions. In doing so, the method meets Shivas (2001) recommendation for biting midge control, in that a sustained, effective method is required, and one that provides household protection is a priority. The peri-domestic applications also satisfied the EPA and Fisheries concerns, as they provide a safe alternative to broadscale application of organophosphates to sensitive estuarine habitats, at rates that would be ecologically disastrous. Also, in terms of comfort to the Local Government personnel applying the product, and the residents of treated properties, the bifenthrin molecules non-alpha-cyano characteristics were appreciated. No skin or eye irritation characteristics occurred, and as expected with a bifenthrin SC formulation, no staining of peoples properties or phyto-toxic effects were recorded.

This study also highlights the fact that harborage treatments are suitable for integration with existing Local Government vector control programs. Mosquito arbovirus vectors such as *Oc. vigilax* and *Culex annulirostris* Skuse have the ability to disperse over great distances (Johansen et al. 2001). This makes thorough treatment of the numerous and often unidentified larval habitats expensive, problematic, and often impossible. Effective vector control programs are required, as arboviruses such as dengue in north Queensland, and West Nile in the USA are increasing in prevalence.

In refining this method, accurate laboratory determination of the Bistar 80SC concentration-mortality relationship for major biting midge and mosquito species of public health importance is essential. The incorporation of a discriminating dose test (2x LC_{95}) in routine monitoring programs will aid early detection of developing bifenthrin tolerance if it occurs. Future research efforts should also be dedicated towards determination of the longevity of control effected by Bistar 80SC applications on various resting surfaces. Surfaces such as treated and untreated wood, bricks, and waxy leaf surfaces would all retain bifenthrin at differing concentrations over time. Re-treatment strategies could vary depending on the predominant harborage or resting surface present in a given domestic situation. Accordingly, the authors recommend that a resistance management strategy be developed to safeguard the longevity of this valuable formulation. Bistar 80SC is one of the few effective options we have available for control of these adult insects of major public health significance.

Acknowledgements

Dr Pat Dale (Griffith University – Australian School of Environmental Studies), Darran Thomas (Gold Coast City Council - Entomology) and Mike Muller (Brisbane City Council – Mosquito & Pest Services) reviewed this article. The Hervey Bay City Council, River Heads Community and the Biting Midge Research and Management Committees provided guidance and encouragement. Ian Francis, Kim Watson (FMC), Nicholas Woods, Gary Dorr (Centre for Pesticide Application & Safety), and Darryl McGinn (Mosquito Consulting Services) provided technical guidance and useful discussion. Garrard's Pesticides Pty Ltd provided the Solo Backpack sprayer.

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Appendix 6

Northern Territory Government
Department of Health and Community Services

RECOMMENDED INTERIM WATER RECEPTACLE TREATMENT FOR EXOTIC MOSQUITOES ON INTERNATIONAL FOREIGN FISHING VESSELS ARRIVING IN AUSTRALIA

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May 2005

(Updated 23 May 2006)

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RECOMMENDED INTERIM WATER RECEPTACLE TREATMENT FOR EXOTIC MOSQUITOES ON INTERNATIONAL FOREIGN FISHING VESSELS ARRIVING IN AUSTRALIA

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13 May 2005
(Updated 23 May 2006)

1.0 Introduction

Exotic *Aedes* mosquito larvae are commonly found in receptacles as equipment or cargo that hold or have held water, on overseas vessels arriving in the NT of Australia. This applies especially to international foreign fishing vessels (IFFV) from Indonesia, which are commonly intercepted fishing in Australian waters by the Royal Australian Navy (RAN) and Customs and detained in Darwin or Gove harbours. The drinking water storage receptacles aboard these vessels are often found to contain *Aedes aegypti* and *Aedes albopictus* larvae. Drinking water storage receptacles are the most commonly detected type of container to carry exotic mosquito pupae, larvae and eggs into the Northern Territory. *Aedes* species eggs are desiccation resistant and can often be present in either water holding or dry receptacles. The eggs are laid just above the water level on the inner surfaces of receptacles. Approved procedures to treat drinking water receptacles only allow the use of chlorine, due to the residue concerns posed by the use of insecticides. These treatments are part of routine quarantine inspection and control procedures on vessels or aircraft in the 400 m quarantine zone around air and seaports.

As part of the previously recommended chlorination procedures, any water holding receptacles were emptied and treated with a chlorine spray to kill possible exotic *Aedes* eggs on inner surfaces. (Ritchie 2001, Whelan & Lamche 2002, Mosquito Control Association of Australia Inc., 2002). However, the previously recommended receptacle treatments that involved spraying the receptacle surface with a 1% active ingredient (AI) chlorine solution to the point of run-off did not adequately kill 100% of mosquito eggs (Ritchie & Montgomery, 2005 unpublished). This was due to the mosquito eggs not being exposed to the chlorine solution for a long enough period. The vertical position of the treated surface, the large clusters of eggs, the sometimes low relative humidity and the dilution of the chlorine solution are all factors that affected the efficacy of the previous treatment recommendations (Ritchie & Montgomery, 2005 unpublished).

Recent re-evaluations of the efficacy of chlorine against *Aedes aegypti* eggs, as well as the development of new egg treatment methods that use detergents, can be combined to provide an improved interim method of receptacle treatment. These recommendations are in response to requests by AQIS for suitable receptacle treatment protocols for drinking water receptacles aboard IFFV's. These recommendations will also hold for refugee vessels and general vessels carrying cargo that holds water, or other receptacles, from overseas. The recommendations are for procedures to treat drinking water receptacles containing, or likely to contain exotic mosquito pupae, larvae and/or eggs.

2.0 Recommendations (see Fig. 1)

2.1 Collection of larval and adult samples

When a water storage receptacle breeding site is identified it is important to try and collect larval, pupal and/or pupal skin samples before treating the receptacle. If the IFFV has landed in Australia before being intercepted, the collection of these samples allows an effective risk analysis of an exotic vector incursion to be undertaken. It will also allow a timely and adequate monitoring response to be set up in the event of a suspected or potential incursion, as well as the rapid implementation of any control or eradication procedures that are required if there is a confirmed exotic vector incursion.

2.1 The treatment procedure

The recommended procedure for the treatment of drinking receptacles aboard IFFVs is to firstly pump, siphon, or pour out the stored water into the sea and to spray the inner receptacle surfaces with a chlorine/detergent solution to kill any eggs that may be present. All mosquito larvae and pupae would be killed by disposal into the sea, and any eggs remaining on the receptacle wall will be killed by the chemical treatment.

The chemical treatment comprises a mixture of 4.8 litres of a liquid sodium hypochlorite solution, that has at least 10% AI, combined with approximately 200ml of liquid dishwashing detergent. The 10% sodium hypochlorite solution can be purchased as 'liquid chlorine' (with at least a 10% AI) from most pool shops. The liquid concentrate detergent can be any major domestic or commercial brand name. The ingredients should be mixed thoroughly in a 5-litre pressure sprayer and applied liberally to the point of run off to all of the inner surfaces of the water storage receptacle. The receptacle should then be sealed with a lid or cover and left to stand. This process should be repeated after thirty minutes. Once the receptacle has been treated twice over a sixty-minute period it should remain sealed and let stand for another twenty-four hours, after which it can be thoroughly cleaned and rinsed.

2.2 Improvements in the treatment procedure

The two major problems with the previous chlorine surface treatment was that the chlorine solution did not remain in contact with the eggs for long enough to kill them, and that the 1% chlorine solution was too dilute to kill large numbers, and clusters of eggs. Recent studies have found that chlorine solutions with a 10% AI rate, when applied to *Aedes* eggs and left in contact with the eggs for at least an hour, and then left to incubate for at least 24 hours in a high humidity environment, can achieve a 100% mortality rate (Ritchie & Montgomery, 2005 unpublished). Other studies have found that by adding detergent to a chlorine solution, the mixture becomes a lot more viscous and can adhere to the walls of the receptacle for a longer period of time (Sherman et al. 1998).

By increasing the strength of the chlorine solution that is in direct contact with the eggs, as well as increasing the time that the treatment mixture is in contact with the eggs and sealing the receptacle to increase the humidity, these interim treatment procedures will provide a more effective control of *Aedes* eggs in IFFV water receptacles than the previous recommendations. The previous recommendations use only a 1% AI chlorine solution for surface treatment of eggs, which has been shown to be too dilute, as well as too thin so that it runs off vertical surfaces too quickly (Ritchie & Montgomery, 2005 unpublished).

References

Mosquito Control Association of Australia Inc. (2002): Control of Container Breeding and Exotic Mosquitoes, in: Australian Mosquito Control Manual, revised edition; p. G0-G12.

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Fig. 1: Interim treatment procedures for water receptacles on IFFVs

Step 1
Collect larvae, pupae and pupal skins from water storage receptacle.

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Step 2
Empty, siphon or pump contents of receptacle into sea.

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Step 3
Prepare chemical treatment mixture in a 5-litre pressure sprayer. The mixture includes 4.8 litres of liquid chlorine solution that has at least a 10% active ingredient, and 200ml of liquid concentrate detergent. Mix well by agitation of sprayer

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Step 4
Spray all interior surfaces of receptacle liberally to run off with chlorine/detergent mixture using a 5litre pressure spray. Seal receptacle and let stand for 30 minutes.

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Step 5
Open receptacle and re-spray all interior surfaces of receptacle liberally to run off with chlorine/detergent mixture. Seal receptacle and let stand for another 30 minutes.

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Step 6
Leave receptacle sealed for another twenty-four (24) hours, allowing eggs to incubate. Rinse and wash receptacle.