

APPENDIX P

Baseline Biting Insect Assessment



Northern
Territory
Government

DEPARTMENT OF HEALTH

Mt Todd Gold Mine Baseline Biting Insect Assessment

February 2012 to January 2013

Study undertaken on behalf of GHD Pty Ltd for
Vista Gold Australia Pty Ltd

Medical Entomology
Centre for Disease Control
NT Department of Health
May 2013

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May 2013

List of Tables	5
List of Figures	5
List of Appendices	5
Executive summary	6
Findings	6
Mosquitoes	6
Recommendations	9
1.0 Introduction	11
2.0 Methods	12
2.1 Trapping	12
2.2 Larval mosquito surveys	12
2.3 Mosquito processing	13
3.0 Results	13
3.1 Potential mosquito breeding sites	13
3.1.1 Larval mosquito survey 8 th – 9 th February 2012	13
3.1.2 Desktop examination of potential mosquito breeding sites	16
3.2 Mosquito trapping February 2012 to January 2013	17
3.2.1 Species present	17
3.2.2 Spatial abundance	17
3.2.3 Seasonal abundance	18
3.3 Mosquito trapping March 1993 to June 1994	19
3.3.1 Comparison between peak season numbers 1993/94 & 2012/13	19
3.3.2 Comparison between trap sites	19
4.0 Discussion	20
4.1 Mosquitoes	20
4.1.1 <i>Aedes normanensis</i>	20
Potential Breeding sites	20
Seasonal abundance	20
Spatial abundance	21
Pest problems	21
Disease significance	21
4.1.2 <i>Culex annulirostris</i>	22
Potential Breeding sites	22
Seasonal abundance	22
Spatial abundance	23
Pest numbers	23
Disease potential	24
4.1.3 <i>Anopheles annulipes s.l.</i>	24
Potential breeding sites	24

Seasonal abundance	24
Spatial abundance	24
Pest numbers	25
Disease significance	25
4.1.4 <i>Other mosquitoes</i>	25
<i>Aedes vigilax</i> (northern salt marsh mosquito)	25
<i>Anopheles amictus</i>	25
<i>Coquillettidia xanthogaster</i> (the golden mosquito)	25
4.2 Mosquito breeding rectification	26
4.3 Mosquito breeding and development aspects	26
4.3.1 Proposed Horseshoe Creek and Stow Creek Diversion	26
4.3.2 New Tailings Storage Facility TSF2	26
4.3.3 Raw Water Dam-raising of wall by 2m	27
4.3.4 Constructed wetlands/wetland filters	27
4.3.5 Waste Rock Storage Facility and Stockpiles	27
4.3.6 Sediment traps/water ponds	27
4.3.7 Haul roads, access tracks	28
4.3.8 Effluent disposal	28
4.3.9 Mining pits and dewatering	28
4.3.10 Process plant	28
4.3.11 Artificial receptacles	28
4.4 Mosquito monitoring and control	29
4.5 Personal protection	30
4.6 Rehabilitation	30
4.7 Limitations	30
5.0 Conclusions	32
6.0 Recommendations	33
7.0 Acknowledgements	35
8.0 References (cited and uncited)	36
Figures	40
Tables	41
Appendix 1 – Mt Todd Gold Project Baseline Mosquito Monitoring Results 1993-94	42
Appendix 2 – Guidelines for preventing mosquito breeding sites associated with mining sites in the NT	43
Appendix 3 – Personal protection from mosquitoes and biting midges in the NT	44

List of Tables

- Table 1 – Larval Mosquito Survey Mt Todd Gold Mine 8th & 9th February 2012.
- Table 2 – Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected on all trap nights.
- Table 3 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Summary of all mosquito species collected on all trap nights at all trap sites.
- Table 4 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at all trap sites.
- Table 5 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 1 Morris Dam.
- Table 6 – Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 2 Tailings Dam East.
- Table 7 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 3 Tailings Dam West.
- Table 8 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 4 Stow Creek.
- Table 9 - Mt Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 5 Mine Site.
- Table 10 - Mt Todd Baseline Biting Insect Assessment. Comparison between 1993-1994 and 2012-2013 baseline mosquito trapping. Total number of all mosquitoes collected on all trap nights.
- Table 11 - Mt Todd Baseline Biting Insect Assessment. Comparison between 1993-1994 and 2012-2013 baseline mosquito trapping. Mosquito species by trap site.

List of Figures

- Figure 1 - Mt Todd Gold Mine Biting Insect Assessment. Adult biting insect trap locations, larval mosquito survey points and potential mosquito breeding areas.
- Figure 2 - Mt Todd Gold Mine Biting Insect Assessment. Larval mosquito survey 8th and 9th February 2012.

List of Appendices

- Appendix 1 – Mt Todd Gold Project Baseline Mosquito Monitoring Results 1993-94
- Appendix 2 – Guidelines for preventing mosquito breeding sites associated with mining sites in the Northern Territory
- Appendix 3 – Personal protection from mosquitoes and biting midges in the NT

Executive summary

The Mt Todd Gold Mine is located approximately 55 kilometres north of Katherine. Mining occurred in the 1990's and ceased in the 2000's (GHD April 2011). Vista Gold Australia Pty Ltd is proposing to re-establish and operate the Mt Todd Gold Mine (GHD April 2011).

Mine sites have the potential to create or exacerbate mosquito breeding, from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge, general site disturbance and 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 is sourced from this area. As part of the environmental process, all major developments in the NT are required to consider mosquitoes during the preparation of an Environmental Impact Statement or Public Environmental Report, to ensure new development does not create new mosquito breeding sites, and also to protect the health of workers. Medical Entomology, of the Centre for Disease Control (CDC), Northern Territory Department of Health (DOH) was subsequently commissioned by GHD Pty Ltd to conduct a Biting Insect Assessment of the mine site. The biting insect assessment was to include monthly adult mosquito trapping for 12 months, and a field investigation to identify actual and potential mosquito breeding sites.

A previous baseline biting insect assessment was conducted from March 1993 to June 1994 (Whelan 1994). This involved monthly adult mosquito trapping and a field survey to identify actual or potential mosquito breeding sites during the early period of the mine development.

The purpose of the current biting insect investigation was to identify current levels of pest and disease carrying mosquitoes, determine if past mining activities created new mosquito breeding sites, and provide advice on preventing the creation of new mosquito breeding sites when the mine is redeveloped.

This report outlines the results of the monthly adult mosquito trapping from February 2012 to January 2013, and the implications of the results in terms of pest and mosquito borne disease potential. The result of larval mosquito survey is also outlined in the report. The report also outlines mitigation measures to prevent exposure to mosquito problems, identifies artificially created mosquito breeding sites requiring rectification, and evaluates proposed development with a focus on preventing the creation or exacerbation of mosquito breeding.

Findings

Mosquitoes

- The most common mosquito present at Mt Todd Gold Mine was the floodwater mosquito *Aedes normanensis*. This mosquito is an aggressive pest mosquito, and would be periodically present throughout most areas of the mine in moderate

to high numbers during the wet season, with maximum numbers likely to occur in the late wet season. Pest problems would begin 9 days after flooding rainfall and last for one to two weeks. *Aedes normanensis* is a potential vector of Ross River virus, Barmah Forest virus and Murray Valley encephalitis virus.

- The most productive *Ae. normanensis* breeding sites appear to be located south of the Tailings Storage Facility, where potential breeding sites include the numerous borrow pits, scrapes, impeded drainage areas and seasonally flooded low lying areas associated with Horseshoe Creek and the disturbed ephemeral creekline north of the process plant area. Productive breeding sites also appear to be associated with Stow Creek, most likely in seasonally flooded low lying areas and depressions.
- The common banded mosquito *Culex annulirostris* was the second most common mosquito species at Mt Todd Gold Mine. This mosquito bites at night, and would be present in low to moderate numbers throughout most areas of Mt Todd Gold Mine. The peak season was from March to May. *Culex annulirostris* is a major potential vector of RRV, BFV, MVEV, Kunjin virus and many others.
- The most productive *Cx. annulirostris* breeding sites appear to be located south of the TSF, where potential breeding sites include the numerous borrow pits, scrapes, and impeded drainage areas associated with Horseshoe Creek and the disturbed ephemeral creekline near the process plant, and a disused plastic lined pond in the mine buildings area. Shallow creek inflow areas of the Raw Water Dam and the shallow NE margin of Morris Dam are also likely to contain potential breeding sites. Seasonally flooded areas associated with Stow Creek appear to be less productive. Residual dry season pools within creeklines at Mt Todd Gold Mine appear to be low productivity breeding sites only.
- The Australian malaria mosquito *Anopheles annulipes s.l.* was the third most common mosquito at Mt Todd Gold Mine, with overall numbers only slightly lower than *Cx. annulirostris* numbers. This mosquito bites at night, and would be present in low to moderate numbers throughout most areas of the mine. The peak season was from April to August. This species is a potential vector of Malaria. *Anopheles annulipes s.l.* breeding sites would be similar to *Cx. annulirostris*.
- Other mosquito species of importance in terms of pest or disease potential at Mt Todd Gold Mine included *Anopheles amictus*, *Culex palpalis*, *Mansonia uniformis* and *Coquillettidia xanthogaster*. However aside from *An. amictus*, these mosquitoes did not reach any appreciable seasonal peak in numbers, therefore are of lower significance compared to *Ae. normanensis*, *Cx. annulirostris* and *An annulipes s.l.*
- The proposed expansion of the mine could create new mosquito breeding sites, with wetlands, borrow pits, shallow ground depressions caused by machinery disturbance and road construction, pit dewatering, sediment traps/ponds, rock stockpiles, effluent dispersal and the construction of artificial ponds all having the potential to create new mosquito breeding sites.
- The Stow Creek and Horseshoe Creek diversions could potentially create new mosquito breeding sites by ground disturbance, erosion of the new channels and subsequent downstream sedimentation of the creeklines, or pooling in remnant sections of the creeklines.
- The raising of the Raw Water Dam wall by 2m is likely to result in a shift of the mosquito breeding sites upstream to the new shallow margins. Mosquito breeding

is likely to increase if the new margins of the dam will contain greater areas of shallow water, and conversely is likely to decrease if there is a reduction in the area of shallow water.

- Remnant septic tanks, along with other artificial receptacles such as disused machinery, building material, drums and any other item that can pond small amounts of water are potential breeding sites for endemic pest and potential disease carrying mosquitoes. Artificial receptacles would also act as potential breeding sites for exotic dengue mosquitoes, if an incursion occurs at the mine site.
- Rectification of the mosquito breeding depressions created by past development would reduce mosquito numbers affecting the mine site, and therefore reduce pest and potential mosquito borne disease transmission to staff.
- The larval control of mosquito breeding sites at Mt Todd Gold Mine would be time consuming to execute in natural breeding areas. However regular wet season inspections of development components that pond water, as well as the general development site, would assist in controlling mosquito numbers by identifying potential mosquito breeding sites that can be targeted for rectification.
- The use of residual barrier insecticides in select areas around the mine buildings could appreciably reduce adult mosquito numbers affecting staff.
- Staff would need to carry out personal protection from mosquitoes during certain periods of the wet season and post wet season, to prevent pest problems and reduce the risk of mosquito borne disease transmission.

Recommendations

- Mosquito breeding sites created by past mining activities should be rectified by filling, draining or a combination of both. This includes borrow pits, scrapes, areas of ponding upstream of access roads, ponding adjacent to rock stockpiles, shallow ground depressions, disused plastic lined ponds, disused septic tanks, the sediment trap in the creekline north of the process plant, and the large depressions colonised by *Typha* sp. south of the TSF.
- New development activities should avoid creating potential mosquito breeding sites. New or upgraded roads should have appropriate culvert provisions to prevent ponding upstream of the roads, borrow pits should be rendered free draining or filled when no longer required, water ponds should be deep and steep sided or plastic lined, sediment traps should be free draining or be deep and steep sided, and diversion drains should be constructed around rock stockpiles and the new TSF where they affect natural surface flows.
- The raising of the raw water dam wall should not result in any large increase in areas of shallow water compared to the current areas of shallow water, to prevent an increase in mosquito breeding associated with the dam.
- Any remnant sections of Horseshoe Creek and Stow Creek remaining after the creeks are diverted may need to be removed by filling, or regraded to flow into the new diversion channels, to prevent these remnant sections from becoming potential mosquito breeding sites. The diversion channels would require appropriate erosion prevention structures, to prevent the creation of eroded pools, and sedimentation of the downstream creeklines. Diverted channels should also be revegetated to create a shaded channel similar to the existing main channel of Horseshoe Creek and Stow Creek.
- There should be no dry season discharge of pit water into creeklines, to prevent altering the ecology of receiving creeklines. Dry season pit water should be discharged into a water dam that has the capacity to receive the water without overflowing.
- Wetland filters should be constructed and managed to minimise the potential for mosquito breeding. Details are outlined in Appendix 2. The discharge site for wetlands should be a well defined creek with shaded margins, such as the main channel of Horseshoe Creek or Stow Creek.
- Monthly inspections should be carried out at Mt Todd Gold Mine during the wet season, to identify areas of potential mosquito breeding associated with constructed or disturbed areas. Aspects to monitor would be the presence of emergent or margin vegetation in the water ponds, the presence of ponding, silt, erosion or vegetation in stormwater drains, the presence of ponding upstream of roads and alongside rock stockpiles, and the presence of shallow ground depressions ponding water.
- Effluent treatment and dispersal facilities should be in accordance with relevant Department of Health regulations and guidelines. Effluent dispersal should be in accordance with information outlined in the Medical Entomology guideline 'Mosquito breeding and sewage pond treatment in the Northern Territory'.
- Monthly inspections of artificial receptacles should be conducted around the mine site during the wet season, with any receptacle ponding water appropriately disposed of, stored under cover away from rain, provided with drainage holes or

treated with an appropriate larvicide, to prevent endemic mosquito breeding and potential exotic dengue mosquito breeding. Rainwater tanks and septic tanks should be inspected to ensure they are adequately screened/sealed to prevent mosquito entry.

- Artificial receptacles sourced from North QLD that appear to have previously held rainwater should be treated with a 10% chlorine solution or an appropriate residual insecticide (alpha-cypermethrin or lambda-cyhalothrin), to prevent the possible introduction of *Ae. aegypti* into Mt Todd Gold Mine.
- Any worker sourced or returning from an overseas country where malaria is endemic, who suddenly experiences high fever should stay indoors away from mosquito bites until cleared of malaria or treated for malaria by a health professional.
- The Mt Todd Gold Mine accommodation camps and mine personnel buildings should be treated with the barrier insecticide bifenthrin or alpha-cypermethrin when adult mosquito populations reach, or are expected to reach pest levels, or when there is a mosquito borne disease risk, to minimise the potential for mosquito borne disease transmission to workers. Particular potential risk periods for mosquitoes at Mt Todd Gold Mine would be 9 days after heavy wet season rainfall events, and during the late wet and early dry season. A qualified pest controller is recommended to carry out the treatments.
- During pest mosquito periods or potential mosquito borne disease risk periods, staff at Mt Todd Gold Mine should be advised to implement personal protection measures from mosquitoes. Up to date information can be found in the Medical Entomology handout 'Personal protection from mosquitoes and biting midges in the Northern Territory'.
- The mine site should be rehabilitated in accordance to information in this report and the Medical Entomology guideline 'Guidelines for preventing mosquito breeding sites associated with mining sites'.
- A biting insect management plan should be created, which summarises the potential mosquito risks, and outlines mitigation measures and commitments to managing and reducing mosquito populations at Mt Todd Gold Mine.

1.0 Introduction

The Mt Todd Gold Mine is located approximately 55 kilometres north of Katherine. Mining occurred in the 1990's and ceased in the 2000's (GHD April 2011). Vista Gold Australia Pty Ltd is proposing to re-establish and operate the Mt Todd Gold Mine (GHD April 2011).

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2.0 Methods

2.1 Trapping

Adult biting insect traps were set monthly at 5 locations around Mt Todd Mine during the afternoon, and collected the following morning after sunrise. Traps were set around the period of the full moon by Robbie Friel from Vista Gold Australia Pty Ltd during March 2012 to January 2013, with the February 2012 traps set by Medical Entomology and Robbie Friel during the initial site selection. The trap type used was a carbon dioxide baited encephalitis virus surveillance (EVS) trap. The trap consisted of an insulated bucket, a suction fan powered by two 'D' cell batteries, a 'grain of wheat' light, and a rigid collection container (4 litre, 220 mm in diameter) fitted with a muslin sleeve and very fine wire mesh vents. The 5 traps were set around chest height and baited with approximately 1kg of dry ice. The GPS co-ordinate of the trap locations were taken using a hand held Garmin GPS unit, and the trap locations are shown in Figure 1.

Three of the four trap sites from the 1993-94 investigation were relocated by GPS and reutilised for the current trapping (Trap Sites 1, 2 & 3). Trap Site 4 in the current investigation was located approximately 1km to the northeast of the previous trap location, while an additional trap site (Trap Site 5) was utilised in the mine buildings area. Therefore when comparing the current baseline investigation to the previous baseline investigation, only data from Trap Sites 1-3 would be used.

The mosquitoes collected during the February trapping were transported back to Darwin on the day of collection by Medical Entomology in an esky with dry ice, while the trap catches from the remainder of the trapping program were sent live in eskies on the same day of collection to the Medical Entomology Laboratory in Darwin. Adult mosquitoes were identified with the aid of stereo microscopes and various taxonomic keys.

2.2 Larval mosquito surveys

A field survey to identify actual and potential mosquito breeding sites was conducted on the 8th- 9th of February 2012. Potential mosquito breeding sites were examined for larvae using a 300ml white ladle, with potential sites identified in advance by examining aerial photography, and inspected on ground by navigating the mine site on 4WD quad bikes. Mosquito larvae were transported back to the Medical Entomology laboratory in Darwin and preserved in 70% alcohol for identification at a later period.

2.3 Mosquito processing

Collected adult mosquitoes were stored in a labelled petri dish in a freezer (-10°C) for later identification. For collections of up to 300 adult mosquitoes, all mosquitoes were individually identified with the aid of light microscopes and various taxonomic keys (Lee et al 1944, 1982, 1984, 1987 and 1989, Marks and Reye 1982, Russell 1996). For collections of over 300 mosquitoes, a sub-sample of 300 mosquitoes was taken from the bulk sample and all mosquitoes in the sub-sample identified, with the sub-sample and bulk samples individually weighed to calculate a multiplication factor. The multiplication factor was then applied to the bulk-sample to calculate final mosquito numbers. The bulk sample was scanned for extra species not located in the sub-sample. All species and totals for each individual collection were then entered into a database for evaluation.

3.0 Results

3.1 Potential mosquito breeding sites

3.1.1 Larval mosquito survey 8th – 9th February 2012

Numerous water ponding areas were examined at the mine site on the 8-9th of February 2012, with results shown in Table 1 and site locations and photos shown in Figure 2. Heavy rainfall of approximately 80mm fell on the night before the field survey commenced, which aided in identifying areas of water ponding around the mine site. Actual or potential mosquito breeding sites located during the survey are discussed below.

Site L1 - This site was a borrow pit adjacent to the track on the south side of the tailings dam, with a larger borrow pit approximately 90m to the south of this site. The borrow pit adjacent to the track was relatively shallow around the margins, and contained emergent grass. Aquatic predators of mosquito larvae were present in the pit, and no mosquito larvae were located. The borrow pit is likely to be a wet season breeding site for *Aedes normanensis*, and breeding site for *Culex annulirostris* and *Anopheles* mosquitoes during the late wet season and early dry season. The borrow pit could also be a short term *Cx. annulirostris* breeding site after initial flooding in the early or mid wet season, before aquatic predators such as bugs, beetles and fish colonise the pit.

Site L2 – This site was a grassy depression adjacent to Horseshoe Creek, where Trap Site 2 was set. No mosquito breeding was located. This depression is likely to be a wet season breeding site for *Aedes normanensis*, and breeding site for *Culex annulirostris* and *Anopheles* mosquitoes during the late wet season and early dry season. Short term *Cx. annulirostris* breeding may also occur after initial flooding in the early or mid wet season.

Larger areas of wet season flooding and potential breeding of the above mentioned species are likely to occur in the low lying area immediately to the south of L2, which was not surveyed.

Site L3 – The southwest corner of Morris Dam was inspected for mosquito breeding. Morris Dam was a small dam located adjacent to the southeast corner of the raw water dam. There was minimal semi-aquatic vegetation in this part of Morris Dam, and no mosquito breeding was located. An examination of aerial photography indicated the northeast corner of Morris Dam is relatively shallow and has emergent and aquatic vegetation, which would provide potential breeding habitat for *Cx. annulirostris*, *Anopheles* mosquitoes and *Coquillettidia xanthogaster* during the late wet season to mid dry season.

Site L4 – Site L4 was the southeast corner of the Raw Water Dam, at a shallow creek inflow area into the dam. The water was relatively shallow, with some emergent grass and waterlilies present. Emergent vegetation was upright and not dense, and no mosquito larvae were located. However during the late wet season to mid dry season when water levels recede and emergent vegetation lodges over, *Cx. annulirostris* and *Anopheles* sp. mosquitoes are likely to breed in the shallow vegetated pools left behind when the water recedes.

Site L5 – This site was a grassy floodway east of Horseshoe Creek. Upstream flooding appeared to be exacerbated by the access track across the floodway. Recent flooding had occurred, and no mosquito larvae were found. This floodway would be a likely breeding site for *Ae. normanensis* after flooding events, and *Cx. annulirostris* during periods of prolonged flooding. Other grassy floodways in the Mt Todd Gold Mine lease are also likely to be breeding sites for these mosquitoes, in particular *Ae. normanensis*.

Site L6 – There was shallow water ponding in large depressions near the southern wall of the Tailings Storage Facility (TSF). The presence of *Typha* sp. reeds indicated prolonged dry season ponding. Fish were present, and no mosquito larvae were located. The large depressions in this area could be breeding sites for *Ae. normanensis* after initial rain flooding events, and breeding sites for *Cx. annulirostris*, *Anopheles* mosquitoes and *Cq. xanthogaster*, particularly during the late wet to mid dry season. Short term *Cx. annulirostris* breeding may also occur after initial flooding in the early or mid wet season.

Site L7 – There were numerous shallow ground depressions in the disturbed area at the southwest corner of the TSF. No mosquito larvae were located. Mosquito species such as *Ae. normanensis*, *Cx. annulirostris* and *Anopheles* mosquitoes could breed in depressions in this area during the wet season.

Site L8 – This site was a borrow pit on both sides of the access track on the south margin of the heap leach pad. There was relatively dense emergent and aquatic vegetation in the depressions. No mosquito larvae were located at the time of the survey. The borrow pit is a probable wet season breeding site for *Ae. normanensis* and *Cx. annulirostris* after initial flooding, and *Cq. xanthogaster*, *Ma. uniformis*, *Cx. annulirostris* and *Anopheles* mosquito breeding site in the late wet and early dry season.

Site L9 – This site included an abandoned septic tank and adjacent disturbed area. The septic tank was not sealed, although no mosquito breeding was found in the tank. The adjacent disturbed area only contained minor ponding and no mosquito breeding. The abandoned tank is a potential breeding site for *Aedes notoscriptus* and *Culex quinquefasciatus*, while the adjacent disturbed area does not appear to be of any mosquito breeding significance due to the limited residual ponding after the recent heavy rainfall.

Site L10 – Site L10 was a grassy floodway adjacent to an ephemeral stream southeast of the mine process plant area. The ephemeral stream originated from north of the process plant, flowing past the east edge of the plant and down towards Stow Creek.

Low levels of *Verrallina reesi* breeding were located in the floodway. The floodway is also a likely wet season breeding site for *Ae. normanensis* after flooding events, and *Cx. annulirostris* during periods of prolonged flooding.

Site L11 – This site was a plastic lined water holding pond in an abandoned part of the process plant area. Moderate levels of *Cx. annulirostris* breeding were located in the dense grassy edges of the pond. This species is likely to breed in the pond throughout the wet season and into the early to mid dry season until the pond dries. Other mosquitoes that could breed in this pond include *Ae. normanensis* after initial flooding rain, and *Anopheles* species mosquitoes throughout the wet season and into the dry season.

Site L12 – This site was another grassy roadside depression at the mine site. No mosquito larvae were located. This depression is a potential wet season breeding site for *Cx. annulirostris*, *Anopheles* mosquitoes and *Ae. normanensis*.

Site L13 – Site L13 was a small shallow depression/borrow pit adjacent Mt Todd Rd and Stow Creek, fringed with a few paperbark trees. No mosquito breeding was located, although this depression and others along Stow Creek are likely breeding sites for *Ae. normanensis* after initial rain flooding, and *Cx. annulirostris*, *Anopheles* mosquitoes and *Cq. xanthogaster* during the late wet season to early dry season. Short term *Cx. annulirostris* breeding may also occur after initial flooding in the early or mid wet season.

Adjacent to this depression was a larger depression that contained deeper water with shaded margins, hence had a lower potential for mosquito breeding, although could be an *Ae. normanensis* breeding site after initial wet season flooding, and breeding site for *Cx. annulirostris* and *Anopheles* mosquitoes in residual shallow pools left behind when the depression dries in the early to mid dry season.

A shallow depression was located approximately 70m south of L13, and was similar in nature to L13 and therefore would have a similar potential as a mosquito breeding site.

Other sites - As well as the actual or potential mosquito breeding sites discussed above, there were numerous other potential mosquito breeding sites that were observed around the mine site. There were numerous ground depressions adjacent to the access track north of the mine process plant, which could be potential *Ae. normanensis*, *Cx. annulirostris* and *Anopheles species* breeding sites. Other areas of shallow ponding were scattered between the mine process plant and stockpiles to the west, and also directly west of the current office building.

Another disused septic tank was located at the mine at the old guard house at the entrance to the mine. The tank had an open top screened with a large gape mesh, and was ponding stagnant water, but had been colonised by water beetles and was not observed to be breeding mosquitoes. Disused unsealed septic tanks with such as this one can be appreciable breeding sites for *Ae. notoscriptus* and *Cx. quinquefasciatus*.

The plastic lined pond on the east side of the main office building had limited potential to be a mosquito breeding site, as it was free from semi-aquatic vegetation.

3.1.2 Desktop examination of potential mosquito breeding sites

Potential mosquito breeding sites that were not inspected during larval mosquito surveys were examined by aerial photography, and are discussed below.

The fenced plastic lined pond to the west of the current office building in the mine plant area appears to have some emergent vegetation growth, and could be a *Cx. annulirostris* breeding site similar to site L11. The small unlined pond at the southern margin of the heap leach facility could be an *Ae. normanensis* and *Cx. annulirostris* breeding site upon initial flooding, and *Cx. annulirostris* and *Anopheles species* breeding site when it dries in the late wet to early dry season.

Diversion drains and modified creeklines near the process plant are possible breeding sites for mosquitoes. The ephemeral creekline directly to the east and north of the old mine plant appears to be particularly disturbed, and has a low weir constructed across the creekline to create a shallow sediment pond, which could be a wet season breeding site for *Ae. normanensis* after early wet season ponding, and late wet season to mid dry season breeding site for *Anopheles species* and *Cx. annulirostris*. Natural residual pools along the length of the ephemeral creekline could be *Anopheles species* and *Cx. annulirostris* breeding sites during the late wet and early dry season.

The section of the ephemeral creekline south of Site L8 contains bare disturbed areas which could be wet season breeding sites for *Ae. normanensis*, and late wet and early dry season breeding sites *Anopheles species* mosquitoes. Natural residual pools along the length of the ephemeral creekline could be *Anopheles species* and *Cx. annulirostris* breeding sites during the late wet and early dry season.

The major creeklines at the mine site, such as Stow Creek and Horseshoe Creek, could contain localised breeding sites for mosquitoes such as *Cx. annulirostris* during

the early dry season (Whelan 1994). *Anopheles* mosquitoes are also likely to breed in residual pools within the creeklines during the late wet to mid dry season. Productivity of mosquito breeding within the creeklines would probably be low to moderate, unless there are areas of the creeklines with appreciable semi-aquatic vegetation. Seasonally flooded low lying areas associated with all of the creeklines at Mt Todd Gold Mine are likely to be *Ae. normanensis* breeding sites affecting the mine, and *Cx. annulirostris* breeding sites when prolonged flooding occurs.

The existing Batman, Tollis, and Golf Pits, as well as the Waste Rock Dump Retention Pond are unlikely to be appreciable mosquito breeding sites, due to a lack of emergent vegetation growth. Similarly, the 6 smaller ponds located between the process plant and Low Grade Ore Stockpile has minimal potential for mosquito breeding, due to a lack of emergent vegetation growth.

Further away from the mine process plant, the shallow vegetated margins of the Raw Water Dam, particularly on the eastern and northern edge where creek flows enter the dam, would be productive breeding sites for *Cx. annulirostris* and *Anopheles* species mosquitoes during the late wet to mid dry season. However these potential breeding sites are probably located too far away to have any appreciable impact on the mine process plant area.

3.2 Mosquito trapping February 2012 to January 2013

The results of the adult mosquito trapping program are shown in Tables 2-9. Trap locations are shown in Figure 1.

3.2.1 Species present

There were 39 species of mosquitoes collected during the trapping program, accounting for a total of 6966 adult female mosquitoes (Table 2). The most common mosquito was the floodwater *Aedes* mosquito *Aedes normanensis*, which accounted for 44.23% of all mosquitoes (Table 2). This was followed by the common banded mosquito *Culex annulirostris* (15.7%) and the Australian malaria mosquito *Anopheles annulipes s.l.* (12.46%). *Aedes lineatopennis* accounted for 6.95% of all mosquitoes, and *Anopheles amictus* accounted for 5.35% of all mosquitoes, with all other species accounting for a minor percentage of overall numbers (Table 2).

The species *Culex species near bitaeniorhynchus* was recorded for only the second time in the NT during the trapping program, with Marrara in Darwin Urban the only other area this species has been recorded. Additional field surveys and trapping by Medical Entomology at Mt Todd Gold Mine in May and June 2012 failed to capture any further adults or find the larvae of this species. Mosquitoes in this genus are not considered important as either human pest mosquitoes or potential disease carrying mosquitoes.

3.2.2 Spatial abundance

The most productive trap site was Trap Site 3, located at the south-west edge of the TSF. Trap Site 3 recorded 29.59% of all mosquitoes (Table 3). Trap Site 2, near the south east corner of the TSF was the next most productive trap, accounting for

24.05% of all mosquitoes, followed by Trap Site 4 Stow Creek (22.28%), Trap Site 1 Morris Dam (19.90%) and lastly Trap Site 5 Mine Site with 4.19% (Table 3).

Aedes normanensis was most abundant at Trap Site 3, with a total of 1310 adult females collected at this site during trapping (Table 4). Trap Site 2 was the second most productive site for *Ae. normanensis* (830), followed by Trap Site 4 (477), Trap Site 1 (345) and Trap Site 5 (119) (Table 4).

Culex annulirostris was recorded in relatively similar numbers at Trap Sites 2, 1 & 3, with 309, 295 and 273 adult females respectively (Table 4). Trap Site 4 collected 164 adult female *Cx. annulirostris*, with Trap Site 5 capturing 53 adult female *Cx. annulirostris* during the trapping program (Table 4).

Anopheles annulipes s.l. was most abundant at Trap Site 1, with 380 adult females collected at this site during the trapping (Table 4). Trap Site 4 was the next most productive site for *An. annulipes s.l.* with 260 adult females, followed by Trap Site 2 (145), Trap Site 3 (71) and Trap Site 5 (12) (Table 4).

Anopheles amictus was most abundant at Trap Site 3, with 169 adult females collected, followed by Site 2 with 81 females. The other trap sites collected overall numbers ranging from 36 to 47 adult females (Table 4).

When considering other potentially important mosquito species, the northern salt marsh mosquito *Aedes vigilax* was recorded in very minor numbers at all sites, the golden mosquito *Coquillettidia xanthogaster* and water lily mosquito *Mansonia uniformis* were recorded in minor numbers at all sites, and *Culex palpalis* was recorded in low numbers at Trap Site 1 (Table 4).

3.2.3 Seasonal abundance

The most productive month for mosquitoes at Mt Todd mine was April, which recorded 3844 adult female mosquitoes, accounting for 55.18% of all mosquitoes collected during the trapping at an average of 768 mosquitoes per trap (Table 2). More than half of the total mosquito numbers for April was comprised of the floodwater mosquito *Ae. normanensis* (2680), with *Ae. lineatopennis* (also a floodwater mosquito) the next most abundant mosquito with 465 adult females (Table 2). *Culex annulirostris* (160), *Anopheles amictus* (134), *An. annulipes s.l.* (131) and *Cx. palpalis* (57) were the next most common mosquitoes collected in April (Table 2).

May was the next most product month for mosquitoes, with a total of 505 adult female mosquitoes collected, accounting for 7.25% of the total catch at an average of 101 mosquitoes per trap (Table 2). The most abundant mosquito in May was *Cx. annulirostris* (253), followed by *An. annulipes s.l.* (70), *An. amictus* (56) and *Ae. normanensis* (47) (Table 2).

February and March recorded similar numbers of mosquitoes (362 & 379 adult females, average per trap of 72 & 79 respectively), followed by June (340), January (311) and August (298) (Table 2).

April was also the peak abundance month for *Ae. normanensis*, *Ae. lineatopennis*, *An. amictus*, *Anopheles meraukensis* and *Cx. palpalis*. May was the peak abundance month for *Cx. annulirostris*, while June was the peak abundance month for *An. annulipes s.l.* (Table 2). March was the peak abundance month for *Ma. uniformis*, while January was the peak abundance month for *Cq. xanthogaster* (Table 2).

3.3 Mosquito trapping March 1993 to June 1994

The report for the initial baseline biting insect assessment at Mt Todd Gold Mine is provided as Appendix 1. A comparison of the results from 1993-94 and 2012-13 from the sites Tailings Dam East, Tailings Dam West and Morris Dam are provided in Tables 10 & 11, with trap sites shown in Figure 1. The Stow Creek trap site was not included as the trap location used in 1993-94 and 2012-13 were too far apart to be compared, while the Mine Site trap site from 2012-13 was not included as there was no corresponding trap in 1993-94.

Note: In tables 10 and 11, the species *Culex annulirostris grp.* includes *Culex annulirostris* and *Culex palpalis*, which were identified separately for the 2012-13 baseline trapping program. The 2012/13 trap results indicated that *Cx. palpalis* was much less common than *Cx. annulirostris*.

3.3.1 Comparison between peak season numbers 1993/94 & 2012/13

The most productive month for trapping during the 1993-94 baseline trapping was March 1993, which recorded 2340 adult female mosquitoes (Table 10). The peak month during the 2012-13 baseline trapping was April 2012, which recorded 2765 adult female mosquitoes (Table 10).

Aedes normanensis reached a higher peak in the 2012-13 baseline trapping program (2174 in April 2012), compared to 1773 in March 1993. *Culex annulirostris* reached a higher peak during the 1993-94 baseline trapping program (732 in December 1993), compared to the 2012-13 trapping program which recorded 235 *Cx. annulirostris grp.* (223 *Cx. annulirostris* and 12 *Cx. palpalis* in May 2012) (Table 10).

Anopheles annulipes s.l. reached a relatively similar peak in both baseline trapping programs, with a peak of 233 in May 1994, and peak of 197 in June 2012 (Table 10). *Anopheles amictus* reached a higher peak of 117 adult females in April 2012, compared with a peak of 50 in September 1993, while *Cq. xanthogaster* reached a higher peak of 124 in May 1993, compared to a peak of 68 in February 2012 (Table 10). Overall, aside from *Cx. annulirostris grp.* numbers, there was no appreciable difference in peak season numbers for most important mosquitoes when comparing the 1993-94 and 2012-13 baseline mosquito trapping results.

3.3.2 Comparison between trap sites

The 1993-94 baseline trapping program was slightly more productive than the 2012-13 trapping program when comparing the three trap sites, with a total of 54.56% of all

mosquitoes (Table 11). Adult mosquito abundance at Morris Dam was similar over both baseline trapping periods. Tailings Dam East was moderately more productive in 1993-94, whilst Tailings Dam West was slightly more productive in 1993-94 (Table 11).

Aedes normanensis numbers were relatively similar at the three trap sites during the 1993-94 and 2012-13 trapping programs, whilst *An. annulipes s.l.* numbers were moderately higher at Tailings Dam East and Tailings Dam West in 1993-94, and moderately higher at Morris Dam in 2012-13 (Table 11).

Culex annulirostris grp. numbers were moderately higher at all three sites during the 1993-94 trapping program.

4.0 Discussion

4.1 Mosquitoes

4.1.1 *Aedes normanensis*

Potential Breeding sites

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

The seasonally high numbers recorded during trapping in April indicates appreciable breeding sites exist in the Mt Todd Gold Mine area. The highest peak was recorded in April at Trap Site 3, located adjacent to the south west corner of the TSF, with Trap Site 2 located alongside Horseshoe Creek the second most productive trap site. In terms of potential breeding sites, the borrow pits and low lying area alongside Horseshoe Creek near Trap Site 2 (Sites L1, L2 & L5), as well as the large depressions south of the TSF (L6) were the larger potential breeding sites nearby to the mine process plant. Localised depressions near Trap Site 3 (Site L7) appeared to be potential breeding sites, but were smaller compared to the depressions near Trap Site 2. Other potential breeding areas surveyed included the borrow pits south of the heap leachate area (Site L8), the natural grassy floodway nearby to Mt Todd Road (Site L10), and the depressions at (Site L13) and nearby to Trap Site 4.

The lower *Ae. normanensis* numbers in the traps set further away from the process plant area (Trap Sites 4 & 5) indicated the major breeding sites affecting the mine are located nearby to Trap Sites 2 & 3.

Seasonal abundance

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

Aedes normanensis was recorded in highest numbers at Mt Todd Gold Mine in April, with elevated abundance during February and March in the lead up to the April peak, and minor numbers in May during the 2012-13 trapping program. This species was most common in March during the 1993-94 trapping program, with elevated abundance also in December and January. *Aedes normanensis* was absent during the dry season during both baseline studies.

Spatial abundance

Aedes normanensis is generally most common within 2km of breeding sites, although can disperse up to 5km in pest numbers (Whelan 1997a). This mosquito was recorded at most trap sites in relatively high peak season numbers, indicating the presence of numerous breeding sites in the Mt Todd Gold Mine area. Trap results from both baseline studies indicated highest numbers in the areas southwest and southeast of the TSF, indicating this area of the mine site is likely to be most affected by this mosquito.

Trap Site 5 in the mine buildings area recorded relatively low *Ae. normanensis* numbers despite the occurrence of high numbers at Trap Site 3 located 800m to the northeast, however this is potentially a result of lights and other distractions such as the adjacent workers accommodation demountable resulting in reduced trap catches at Trap Site 5.

Relatively high peak season numbers at Trap Site 4 Stow Creek indicated the southern area of the mine site can also expect appreciable seasonal numbers, along with areas of the mine in the Morris Dam vicinity. All other areas of the mine within 2-3km of creeklines can expect seasonally appreciable *Ae. normanensis* numbers.

Pest problems

Aedes normanensis is considered a major pest species, and it bites mainly in the evening and at night although will bite in shaded areas during the daytime. Generally 30 or more adult females of this species in a CO2 baited EVS monitoring trap set inside residential areas indicates a likely pest problem (Whelan 1997a). This threshold was exceeded to a large extent in all of the trap sites except Trap Site 5 in April, indicating the likelihood of seasonally high pest problems in most areas of Mt Todd Gold Mine. Numbers of this mosquito were slightly above the pest threshold in most traps in February and March also.

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 (MVEV) (Whelan 1997a). However, *Ae. normanensis* 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 of MVEV and BFV (Russell & Kay 2002).

Due to the seasonally high numbers expected at Mt Todd Gold Mine, this species will pose a potential virus risk in the months of January to April. The risk of RRV and BFV transmission risk will be moderate to high in these months, while this species will also pose a potential risk of MVEV transmission.

4.1.2 *Culex annulirostris*

Potential Breeding sites

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).

Culex annulirostris was recorded in relatively low numbers throughout the 12 month trapping, indicating the absence of extensive or very productive breeding sites. Depressions with emergent vegetation such as Sites L1, L6 & L8 are likely to be the more important potential breeding sites, due to prolonged flooding and vegetation providing cover for larvae. Grassy floodways at the mine may not stay flooded long enough for populations to build up to high levels.

Late wet to mid dry season breeding in creeklines is likely to be localised, and mainly concentrated in open sections of the creeklines subject to sunlight and subsequently where emergent and margin vegetation could occur. The middle to latter stages of the dry season is likely to be more productive due to pools becoming shallower and not suitable for fish survival.

The highest numbers of this mosquito were recorded at Morris Dam in May, indicating breeding in residual pools along the shallow edges of both dams, most likely at Site L4 at the southern margin of the RWD, in the shallow margins in the north-east corner of Morris Dam, and further away in the larger shallow creek inflow areas located along the eastern and northern margin of the RWD.

Larval surveys located *Cx. annulirostris* breeding in a relatively large plastic lined pond in February (Site L11), indicating this site would have contributed to *Cx. annulirostris* abundance at the mine site during the wet season and early dry season.

Culex annulirostris numbers were moderately higher in 1993-94 compared to 2012-13, indicating the presence of breeding sites that are likely to seasonally vary in productivity depending on seasonal rainfall patterns.

Seasonal abundance

Culex annulirostris is generally most common in the months of January to August inclusive in the Top End of the NT (Whelan 1997a). Early to mid wet season abundance is usually a result of breeding in temporary flooded low lying areas and initial flooding of floodplains and reed swamps, while late wet to mid dry season abundance is usually a result of breeding in vegetated pools in receding swamps and floodplains and in residual pools in vegetated creeklines.

Numbers of this mosquito were relatively low, although there was a slight peak in the late wet season and early dry season in most traps in 2012-13, particularly at Trap Site 1 due to the receding dams leaving behind isolated breeding sites in their shallow margins. Trap Site 2 recorded its peak numbers in the mid dry season, indicating depressions in Horseshoe Creek were more productive during the middle to latter stages of the dry season. Long term ponding at the Site L6 *Typha* sp. depression may have contributed to some of the dry season abundance at Trap Site 2. The 1993-94 trap results revealed higher overall numbers during the early to mid wet season (December to February), with a smaller peak during the early dry season (May and June).

Therefore depending in seasonal rainfall patterns, peak abundance could occur either in the early-mid wet season, or early dry season, however all years are likely to experience elevated abundance during the early-mid wet season and late wet-early dry season.

Spatial abundance

Culex annulirostris can disperse up to 10km from extensive breeding sites, although are most abundant 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).

Culex annulirostris was present in all areas of the mine site in relatively similar, albeit relatively low numbers, indicating the presence of numerous localised breeding sites. Overall most areas of the mine site will be affected by *Cx. annulirostris*, with slightly higher numbers nearby to Morris Dam/Raw Water Dam and the disturbed areas south of the TSF.

Pest numbers

Culex annulirostris reaches pest levels when there are more than 50 per CO2 baited EVS trap per night, for traps set inside residential areas (Whelan 1997a). This level was rarely exceeded during trapping in 2012-13, with Sites 1-3 slightly exceeding the threshold on a few occasions, with the other trap sites not recording levels above this threshold. In 1993-94, the threshold was exceeded to a moderate degree at Tailings Dam West, Tailings Dam East, Morris Dam and Stow Creek during the early to mid wet season and early dry season (Whelan 1994, Appendix 1).

Culex annulirostris only bites at night, and is less persistent in the presence of lights, personal protective clothing and repellents (Whelan & Hayes 1993), therefore the levels recorded at Mt Todd Gold Mine during both baseline trapping programs

represented a potentially low to moderate pest problem during the peak season months.

Disease potential

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), Ross River virus (RRV) and Barmah Forest virus (BFV) (Merianos et al 1992, Whelan et al 1993, Russell & Kay 2004). Many other arboviruses have been isolated from this species (Whelan & Weir 1993).

The low to moderate levels of *Cx. annulirostris* at Mt Todd Gold Mine indicates this species can be expected to cause a low to moderate risk of arbovirus transmission during the wet season and early dry season.

4.1.3 *Anopheles annulipes s.l.*

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 mine would be late wet to mid dry season residual pools in the creek lines, borrow pits and other artificially created depressions at the mine site, and residual early to mid dry season pools in shallow margin areas of both the RWD and Morris Dam, particular the RWD which has several shallow creek inflow areas.

Trap results in 2012-13 indicated shallow pools left behind when Morris Dam and the RWD recede are likely to be the most productive breeding sites, followed by depressions and residual pools in Stow Creek. Trap results from 1993-94 indicated areas of ponding nearby to Tailings Dam East were also important breeding sites, most likely the nearby borrow pits and residual pools within Horseshoe Creek. All trap sites captured this mosquito over both baseline trapping programs, indicating the likely presence of numerous localised breeding sites at the mine site.

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). *Anopheles annulipes s.l.* was most abundant during the late wet season to mid-late dry season at the mine in 20012-13, and late wet season in 1993-94.

Spatial abundance

Anopheles annulipes s.l. has a smaller effective flight range compared to *Ae. normanensis* and *Cx. annulirostris*, and is most common within 2km of breeding sites, with peak numbers generally within 1km of their breeding sites. Highest numbers at the mine were recorded nearby to Morris Dam in 2012/13 and south of the TSF in 1993/94. Breeding sites associated with Morris Dam and the Raw Water Dam are unlikely to affect the mine buildings to any great extent, however breeding sites associated with Horseshoe Creek and the disturbed areas south of the TSF will

affect the mine process plant area. Areas of the mine within 1-2km of Stow Creek would also experience seasonal numbers of *An. annulipes s.l.*

Pest numbers

The nominal pest level for *An. annulipes s.l.* would be similar to *Anopheles farauti s.l.*, which is considered to be 30 per trap per trap night for a trap set within a residential area (Whelan 1997a). This level was exceeded at Morris Dam, Tailings Dam East and Stow Creek to a low to moderate extent in the late wet season to mid dry season during the 2012-13 baseline trapping. This species is generally not a major pest mosquito in the NT, and the levels recorded at Mt Todd Gold Mine suggest this species is only likely to cause seasonally low pest problems.

Disease significance

Anopheles annulipes s.l. is considered a likely vector of malaria (Russell & Kay 2004). However the *Anopheles annulipes s.l.* species complex is known to include at least 10 sibling species, and nothing is known of the vector competence of each sibling species (Russell & Kay 2004). Nevertheless, *An. annulipes s.l.* will pose a potential low to moderate malaria risk at Mt Todd Gold Mine.

As malaria is not endemic to Australia anymore, the risk of local malaria transmission would only occur if a person infected with malaria is bitten by *Anopheles* mosquitoes at Mt Todd Gold Mine. Therefore any personnel that have returned from overseas malarious areas and experience a sudden onset of fever should be considered as possibly having malaria, and be advised to seek medical attention and avoid night time exposure to mosquitoes. Only people with malaria that are exposed after sundown would be at risk of spreading malaria, as *Anopheles* mosquitoes bite only after dusk. People suspected of having malaria should not be rostered on for night shifts until appropriately treated or cleared of having malaria by a health professional.

4.1.4 Other mosquitoes

***Aedes vigilax* (northern salt marsh mosquito)**

This mosquito breeds in tidal areas, of which there are none nearby to Mt Todd Gold Mine. However this mosquito can disperse over 50km in pest numbers, and up to 200km from their breeding sites. Previous trapping in the Katherine area has revealed levels likely to cause low pest problems, and in some years this mosquito is expected to cause low pest problems at Mt Todd Gold Mine in the late dry-early wet season. Trapping in 1993-94 recorded low pest levels of this mosquito at Tailings Dam East (Whelan 1994). *Aedes vigilax* is a potential vector of RRV and BFV, and a major pest mosquito due to its aggressive and day biting habits.

Anopheles amictus

This mosquito was less abundant than *An. annulipes s.l.*, and breeds in open sunlit ground pools. Borrow pits, depressions and residual pools within creeklines would be potential breeding sites. This mosquito is regarded as a potential vector of malaria, and could pose a low risk at Mt Todd Gold Mine, mainly during the late wet and early dry season when the seasonal peak in numbers is expected to occur.

***Coquillettidia xanthogaster* (the golden mosquito)**

Coquillettidia xanthogaster usually breeds in association with semi-aquatic reeds such as *Eleocharis* and *Typha* sp. and paperbark swamps. The low numbers recorded during trapping indicated there were limited breeding sites for this species at the mine. The *Typha* reeds in the seepage area south of the Tailings Dam (Site L6) represent a typical breeding site for *Cq. xanthogaster*, along with the aquatic vegetation in the Site L8 borrow pit. Overall this mosquito is not likely to pose any major pest problems at Mt Todd Gold mine unless extensive potential breeding habitat is created.

4.2 Mosquito breeding rectification

Artificially created mosquito breeding sites at Mt Todd Gold Mine should be rectified, particularly as many are located next to the mine buildings. Borrow pits (Sites L1 & L8) should be filled or rendered free draining. Ponding caused by access road construction (Sites L2 & L12) should be rectified by draining (Site L2) or filling (Site L12). The ponding that occurs south of the TSF (Site L6) should be rectified, which is likely to involve improving drainage of the area towards Horseshoe Creek. Depressions near the south-west corner of the TSF (Site L7) should be filled and levelled. Disused ponds, such as Site L11, should be rectified by filling or removing the pond walls. All other artificially created depressions at Mt Todd Gold Mine should be rectified by filling or draining, or a combination of both.

Disused septic tanks should be filled with dirt, demolished, or disposed of such that they do not pond water and breed mosquitoes.

4.3 Mosquito breeding and development aspects

Information on minimising the mine site from creating new mosquito breeding sites can be found in the Medical Entomology handout 'Guidelines for preventing mosquito breeding associated with mining sites in the NT'. Some discussion on specific planning aspects is provided below, based on the proposed expansion of the mine (Appendix 2).

4.3.1 Proposed Horseshoe Creek and Stow Creek Diversion

The new diversion channel of both creeks should have appropriate erosion prevention structures provided, most notably at the start and end point of the new channel. Appropriate shading tree species should be planted as soon as possible after the channel is constructed, to provide shade over the creekline and thus prevent semi-aquatic vegetation growth and productive mosquito breeding in the early to mid dry season.

Any remnant sections of the diverted creeks that would not drain freely would need to be filled, or if possible, regraded to flow towards the new diversion channel.

4.3.2 New Tailings Storage Facility TSF2

The TSF2 is unlikely to pose a mosquito breeding issue, due to expected water quality in tailings dams usually unsuitable for productive mosquito breeding. Tailings Storage Facilities are usually designed to be large, deep open water bodies, further reducing the potential for productive mosquito breeding. If TSF2 is designed to be similar to the current TSF at the mine, then there is unlikely to be a mosquito issue.

There should be diversion drains provided around the base of TSF2 where necessary, along with appropriate silt retention structures to prevent sediment from flowing into Stow Creek, Horseshoe Creek and other drainage lines. Any isolated depressions caused by the TSF2 construction should be filled or drained. Seepage under the dam wall would need to be prevented, to prevent potential dry season ponding in downstream drainage lines or low lying areas.

4.3.3 Raw Water Dam-raising of wall by 2m

The raising of the raw water dam wall will shift the current mosquito breeding sites in shallow margins of the dam upstream to newly created shallow margins. Mosquito numbers would only rise if the newly flooded shallow margins are greater in extent compared to the current shallow margins. If this was to occur, the shallow margins should be excavated to create deeper water less prone to emergent vegetation growth. Conversely, mosquito numbers would decrease if the raising of the dam wall results in a reduction of the overall area of shallow water associated with the dam.

4.3.4 Constructed wetlands/wetland filters

The use of wetlands to polish water has the potential to create productive mosquito breeding sites. Mosquito species such as *Culex annulirostris* are likely to breed in shallow wetlands with dense semi-aquatic reeds, along with pest mosquitoes such as *Mansonia uniformis* and *Coquillettidia xanthogaster*. Wetland filters with dense *Typha* reeds have previously been implicated as productive mosquito breeding sites (Montgomery et al 1996).

Guidance on the design and management of wetland filters to reduce the potential for mosquito breeding can be found in Appendix 2. In addition to the information regarding wetlands in Appendix 2, the discharge site for wetlands should be a well defined creekline with shaded margins such as the central channel of Horseshoe Creek or Stow Creek.

4.3.5 Waste Rock Storage Facility and Stockpiles

There should be diversion drains provided around the base of the WRD and all other stockpiles where necessary, to prevent shallow ponding at the base of the stockpiles. Whilst the current WRD has a runoff collection pond which would also act as a sediment pond, appropriate silt retention structures should be provided in the diversion drains/runoff areas from the other stockpiles, to prevent sediment runoff from flowing into adjacent creeklines. Any isolated depressions caused by the construction of stockpiles should be filled or drained.

4.3.6 Sediment traps/water ponds

Any sediment trap/water pond should be deep (>1.8m) and have steep sides (1V:2H), to minimise the potential for emergent vegetation growth and mosquito breeding. If shallow ponds are required, they should have a plastic lining to minimise the potential for emergent and margin vegetation growth.

Sediment traps should be designed to drain within 3-4 days after the rainfall event, or be designed as deep (>1.8m) steep sided (1V:2H) structures. Sediment traps should not be constructed within creeklines.

4.3.7 Haul roads, access tracks

New roads should have appropriate culvert provisions where necessary, to ensure there is no shallow ponding caused by the road embankment. Borrow pits used to create roads should be rendered free draining or filled when no longer required.

4.3.8 Effluent disposal

Any new effluent treatment and disposal system should be a suitable design approved by the Environmental Health Section of the NT Department of Health. The disposal of effluent must be carried out in a manner that prevents the creation of ponding and breeding in receiving areas. Further information on effluent dispersal in regards to preventing mosquito breeding can be found in the Medical Entomology guideline 'Mosquito breeding and sewage pond treatment in the Northern Territory'.

4.3.9 Mining pits and dewatering

Active mining pits are unlikely to become mosquito breeding sites due to deep open water ponding. However pit dewatering has the potential to create mosquito breeding if the pit water is discharged into a creekline during the dry season, which could then alter the ecology of the creekline by promoting semi-aquatic reed growth and subsequently create potential mosquito breeding habitat. Therefore any dry season pit water discharge should be discharged into a dam that has the capacity to receive the discharge without overflowing.

4.3.10 Process plant

Any processing activity that has the potential to create dry season water discharge could create potential mosquito breeding sites. Any excess water created from operations should be appropriately conveyed to a suitable storage pond via a concrete lined open drain or pipe, and should not be discharged to a creekline or the natural surface.

4.3.11 Artificial receptacles

Artificial receptacles such as used tyres, drums, unscreened rainwater tanks, disused machinery, disused septic tanks and any rubbish items that can collect rainwater can be 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 have been occasionally found breeding in artificial receptacles include the potential malaria vector *An. annulipes* s.l. and the major arbovirus vector *Cx. annulirostris*. Large tyres in particular can be more productive in terms of amount of breeding and diversity of mosquito species.

Any used tyres, water drums, unscreened rainwater tanks, machinery items that can pond water (ie backhoe buckets, excavator tracks), disused machinery, building material and equipment wrapped in plastic sheeting, 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 appear to have previously held rainwater should be treated with a 10% chlorine solution or an appropriate residual insecticide (alpha-cypermethrin or lambda-cyhalothrin), to prevent the possible introduction of *Ae. aegypti* into Mt Todd Gold Mine.

Monthly inspections of artificial receptacles should be conducted during the wet season around the mine site, 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. Septic tanks systems should be regularly inspected to ensure the tank is completely sealed, and other potential mosquito entry points are suitably screened to prevent mosquito entry. Screens on rainwater tanks should be inspected for damage that could allow mosquito entry, and repaired as necessary. This would be required to prevent endemic mosquito breeding and minimise the potential for the re-introduction of *Ae. aegypti* from North Queensland.

4.4 Mosquito monitoring and control

The baseline trap results from 2012-13 were relatively similar to the baseline trap results from 1993-94 in terms of overall abundance of important mosquito species. Further adult mosquito monitoring is therefore not required, as the trap results have indicated the general problem periods, and thus the relevant mine site health and safety officer can use the baseline information to predict problem periods and alert mine staff of impending problem periods. However if the health and safety/environment officer at the mine requires adult mosquito trapping to assist in managing potential mosquito issues at the mine site, then fortnightly adult mosquito trapping at select sites using CO₂ baited EVS type traps would be best method of determining seasonal adult mosquito abundance.

Larval mosquito control would be best achieved by engineering means, as larval mosquito control using insecticides can be time consuming to carry out as it would require regular surveys of individual sites to locate mosquito breeding. Many potential mosquito breeding sites nearby to the process plant area are artificially created, therefore should be rectified to prevent ponding. All water ponds should be inspected monthly for the presence of emergent and margin vegetation, with vegetation removed to prevent the creation of mosquito breeding habitat in the ponds. Stormwater drains and sediment traps should be inspected monthly for ponding, silt accumulation, erosion and vegetation during the wet season, with any problem drain rectified during the dry season, and sediment traps should be desilted as necessary. The general development site should also be inspected monthly during the wet season to locate ground depressions that pond water for greater than 4-5 days, which should then be rectified during the dry season.

As discussed in Section 4.1.5.9, wet season inspections should be carried out to identify artificial receptacles that pond water, with appropriate rectification measures implemented to prevent receptacle mosquito breeding.

Natural breeding sites such as seasonally flooded low lying areas associated with creeklines would require detailed and numerous surveys to appropriately delineate the area of breeding, and would require helicopter control and a dedicated staff member to organise spraying operations, which is unlikely to be feasible for Mt Todd Gold Mine. However control of adult mosquitoes using an outdoor residual barrier insecticide would be achievable at Mt Todd Gold Mine. Residual barrier insecticides such as bifenthrin or alpha-cypermethrin can kill adult mosquitoes that rest in shaded

areas outside buildings, under demountables and in open work sheds, and appreciably reduce any mosquito problems. Barrier insecticides can be applied before expected *Ae. normanensis* peaks throughout the wet season (ie apply within 8 days of major flooding rainfall events), during October to January if *Ae. vigilax* problems occur, and during April to June when freshwater breeding mosquitoes reach their peak season levels.

4.5 Personal protection

Personal protection will be periodically required during the wet season, particularly when *Ae. normanensis* peaks occur after flooding rainfall events, and also in the late wet season when other freshwater breeding mosquitoes begin to increase in numbers. Early dry season abundance from *Anopheles* species and *Cx. annulirostris* may also warrant personal protection measures at night, particularly for *Cx. annulirostris* if there is a region wide risk of Murray Valley encephalitis virus transmission, and for *Anopheles* species if a worker is suspected of having malaria.

Personal protection can be undertaken by a number of means, with the best protection achieved from the use of personal repellents, light coloured protective clothing (which can be treated with permethrin), outdoor mosquito lanterns or gas powered outdoor insecticide vaporising devices, and outdoor residual barrier insecticides. Accommodation buildings should be appropriately screened/sealed to prevent mosquito entry. Further information can be found in Appendix 3 'Personal protection from mosquitoes and biting midges in the NT'.

4.6 Rehabilitation

The mine site should be rehabilitated to remove potential mosquito breeding sites. This will include removing artificial wetlands, sediment traps, water ponds, infrastructure, artificial receptacles and septic tanks that could pond water, rectifying borrow pits, shallow surface depressions and impeded drainage areas, and reinstating natural flow paths where practical.

Open pit voids can be left as water holding structures if they have steep sides (at least 1V:2H) and have a relatively deep wet season water level (at least 2m), and are stocked with local native fish.

4.7 Limitations

Monthly mosquito trapping can be insensitive for plague mosquito species such as *Aedes normanensis*, which suddenly appear around 9 days after rainfall events and persist in peak numbers for 1-2 weeks. Therefore monthly trapping had the potential to miss maximum monthly numbers of this mosquito.

The common banded mosquito *Culex annulirostris* sometimes reaches a short peak in numbers over a few weeks in the mid wet season, therefore monthly trapping had the potential to miss maximum mid wet season numbers.

Monthly mosquito trapping in general is relatively insensitive as mosquito populations can vary widely from week to week. Weekly or fortnightly adult mosquito trapping is generally the most informative adult mosquito trapping schedule.

5.0 Conclusions

- The most common mosquito present at Mt Todd Gold Mine was the floodwater mosquito *Aedes normanensis*. This mosquito is an aggressive pest mosquito, and would be periodically present throughout most areas of the mine in moderate to high numbers during the wet season, with maximum numbers likely to occur in the late wet season. Pest problems would begin 9 days after flooding rainfall and last for one to two weeks. *Aedes normanensis* is a potential vector of Ross River virus, Barmah Forest virus and Murray Valley encephalitis virus.
- The most productive *Ae. normanensis* breeding sites appear to be located south of the Tailings Storage Facility, where potential breeding sites include the numerous borrow pits, scrapes, impeded drainage areas and seasonally flooded low lying areas associated with Horseshoe Creek and the disturbed ephemeral creekline north of the process plant area. Productive breeding sites also appear to be associated with Stow Creek, most likely in seasonally flooded low lying areas and depressions.
- The common banded mosquito *Culex annulirostris* was the second most common mosquito species at Mt Todd Gold Mine. This mosquito bites at night, and would be present in low to moderate numbers throughout most areas of Mt Todd Gold Mine. The peak season was from March to May. *Culex annulirostris* is a major potential vector of RRV, BFV, MVEV, Kunjin virus and many others.
- The most productive *Cx. annulirostris* breeding sites appear to be located south of the TSF, where potential breeding sites include the numerous borrow pits, scrapes, and impeded drainage areas associated with Horseshoe Creek and the disturbed ephemeral creekline near the process plant, and a disused plastic lined pond in the mine buildings area. Shallow creek inflow areas of the Raw Water Dam and the shallow NE margin of Morris Dam are also likely to contain potential breeding sites. Seasonally flooded areas associated with Stow Creek appear to be less productive. Residual dry season pools within creeklines at Mt Todd Gold Mine appear to be low productivity breeding sites only.
- The Australian malaria mosquito *Anopheles annulipes s.l.* was the third most common mosquito at Mt Todd Gold Mine, with overall numbers only slightly lower than *Cx. annulirostris* numbers. This mosquito bites at night, and would be present in low to moderate numbers throughout most areas of the mine. The peak season was from April to August. This species is a potential vector of Malaria. *Anopheles annulipes s.l.* breeding sites would be similar to *Cx. annulirostris*.
- Other mosquito species of importance in terms of pest or disease potential at Mt Todd Gold Mine included *Anopheles amictus*, *Culex palpalis*, *Mansonia uniformis* and *Coquillettidia xanthogaster*. However aside from *An. amictus*, these mosquitoes did not reach any appreciable seasonal peak in numbers, therefore are of lower significance compared to *Ae. normanensis*, *Cx. annulirostris* and *An annulipes s.l.*
- The proposed expansion of the mine could create new mosquito breeding sites, with wetlands, borrow pits, shallow ground depressions caused by machinery disturbance and road construction, pit dewatering, sediment traps/ponds, rock stockpiles, effluent dispersal and the construction of artificial ponds all having the potential to create new mosquito breeding sites.

- The Stow Creek and Horseshoe Creek diversions could potentially create new mosquito breeding sites by ground disturbance, erosion of the new channels and subsequent downstream sedimentation of the creeklines, or pooling in remnant sections of the creeklines.
- The raising of the Raw Water Dam wall by 2m is likely to result in a shift of the mosquito breeding sites upstream to the new shallow margins. Mosquito breeding is likely to increase if the new margins of the dam will contain greater areas of shallow water, and conversely is likely to decrease if there is a reduction in the area of shallow water.
- Remnant septic tanks, along with other artificial receptacles such as disused machinery, building material, drums and any other item that can pond small amounts of water are potential breeding sites for endemic pest and potential disease carrying mosquitoes. Artificial receptacles would also act as potential breeding sites for exotic dengue mosquitoes, if an incursion occurs at the mine site.
- Rectification of the mosquito breeding depressions created by past development would reduce mosquito numbers affecting the mine site, and therefore reduce pest and potential mosquito borne disease transmission to staff.
- The larval control of mosquito breeding sites at Mt Todd Gold Mine would be time consuming to execute in natural breeding areas. However regular wet season inspections of development components that pond water, as well as the general development site, would assist in controlling mosquito numbers by identifying potential mosquito breeding sites that can be targeted for rectification.
- The use of residual barrier insecticides in select areas around the mine buildings could appreciably reduce adult mosquito numbers affecting staff.
- Staff would need to carry out personal protection from mosquitoes during certain periods of the wet season and post wet season, to prevent pest problems and reduce the risk of mosquito borne disease transmission.

6.0 Recommendations

- Mosquito breeding sites created by past mining activities should be rectified by filling, draining or a combination of both. This includes borrow pits, scrapes, areas of ponding upstream of access roads, ponding adjacent to rock stockpiles, shallow ground depressions, disused plastic lined ponds, disused septic tanks, the sediment trap in the creekline north of the process plant, and the large depressions colonised by *Typha* sp. south of the TSF.
- New development activities should avoid creating potential mosquito breeding sites. New or upgraded roads should have appropriate culvert provisions to prevent ponding upstream of the roads, borrow pits should be rendered free draining or filled when no longer required, water ponds should be deep and steep sided or plastic lined, sediment traps should be free draining or be deep and steep sided, and diversion drains should be constructed around rock stockpiles and the new TSF where they affect natural surface flows.
- The raising of the raw water dam wall should not result in any large increase in areas of shallow water compared to the current areas of shallow water, to prevent an increase in mosquito breeding associated with the dam.

- Any remnant sections of Horseshoe Creek and Stow Creek remaining after the creeks are diverted may need to be removed by filling, or regraded to flow into the new diversion channels, to prevent these remnant sections from becoming potential mosquito breeding sites. The diversion channels would require appropriate erosion prevention structures, to prevent the creation of eroded pools, and sedimentation of the downstream creeklines. Diverted channels should also be revegetated to create a shaded channel similar to the existing main channel of Horseshoe Creek and Stow Creek.
- There should be no dry season discharge of pit water into creeklines, to prevent altering the ecology of receiving creeklines. Dry season pit water should be discharged into a water dam that has the capacity to receive the water without overflowing.
- Wetland filters should be constructed and managed to minimise the potential for mosquito breeding. Details are outlined in Appendix 2. The discharge site for wetlands should be a well defined creek with shaded margins, such as the main channel of Horseshoe Creek or Stow Creek.
- Monthly inspections should be carried out at Mt Todd Gold Mine during the wet season, to identify areas of potential mosquito breeding associated with constructed or disturbed areas. Aspects to monitor would be the presence of emergent or margin vegetation in the water ponds, the presence of ponding, silt, erosion or vegetation in stormwater drains, the presence of ponding upstream of roads and alongside rock stockpiles, and the presence of shallow ground depressions ponding water.
- Effluent treatment and dispersal facilities should be in accordance with relevant Department of Health regulations and guidelines. Effluent dispersal should be in accordance with information outlined in the Medical Entomology guideline 'Mosquito breeding and sewage pond treatment in the Northern Territory'.
- Monthly inspections of artificial receptacles should be conducted around the mine site during the wet season, with any receptacle ponding water appropriately disposed of, stored under cover away from rain, provided with drainage holes or treated with an appropriate larvicide, to prevent endemic mosquito breeding and potential exotic dengue mosquito breeding. Rainwater tanks and septic tanks should be inspected to ensure they are adequately screened/sealed to prevent mosquito entry.
- Artificial receptacles sourced from North QLD that appear to have previously held rainwater should be treated with a 10% chlorine solution or an appropriate residual insecticide (alpha-cypermethrin or lambda-cyhalothrin), to prevent the possible introduction of *Ae. aegypti* into Mt Todd Gold Mine.
- Any worker sourced or returning from an overseas country where malaria is endemic, who suddenly experiences high fever should stay indoors away from mosquito bites until cleared of malaria or treated for malaria by a health professional.
- The Mt Todd Gold Mine accommodation camps and mine personnel buildings should be treated with the barrier insecticide bifenthrin or alpha-cypermethrin when adult mosquito populations reach, or are expected to reach pest levels, or when there is a mosquito borne disease risk, to minimise the potential for mosquito borne disease transmission to workers. Particular potential risk periods for mosquitoes at Mt Todd Gold Mine would be 9 days after heavy wet season

rainfall events, and during the late wet and early dry season. A qualified pest controller is recommended to carry out the treatments.

- During pest mosquito periods or potential mosquito borne disease risk periods, staff at Mt Todd Gold Mine should be advised to implement personal protection measures from mosquitoes. Up to date information can be found in the Medical Entomology handout 'Personal protection from mosquitoes and biting midges in the Northern Territory'.
- The mine site should be rehabilitated in accordance to information in this report and the Medical Entomology guideline 'Guidelines for preventing mosquito breeding sites associated with mining sites'.
- A biting insect management plan should be created, which summarises the potential mosquito risks, and outlines mitigation measures and commitments to managing and reducing mosquito populations at Mt Todd Gold Mine.

7.0 Acknowledgements

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Mosquitoes were identified by Jane Carter from Medical Entomology.

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Figures

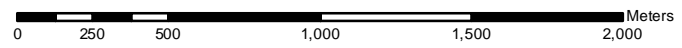
Figure 1 - Mount Todd Gold Mine Biting Insect Assessment. Adult biting insect trap locations, larval mosquito survey points and potential mosquito breeding areas.

Legend

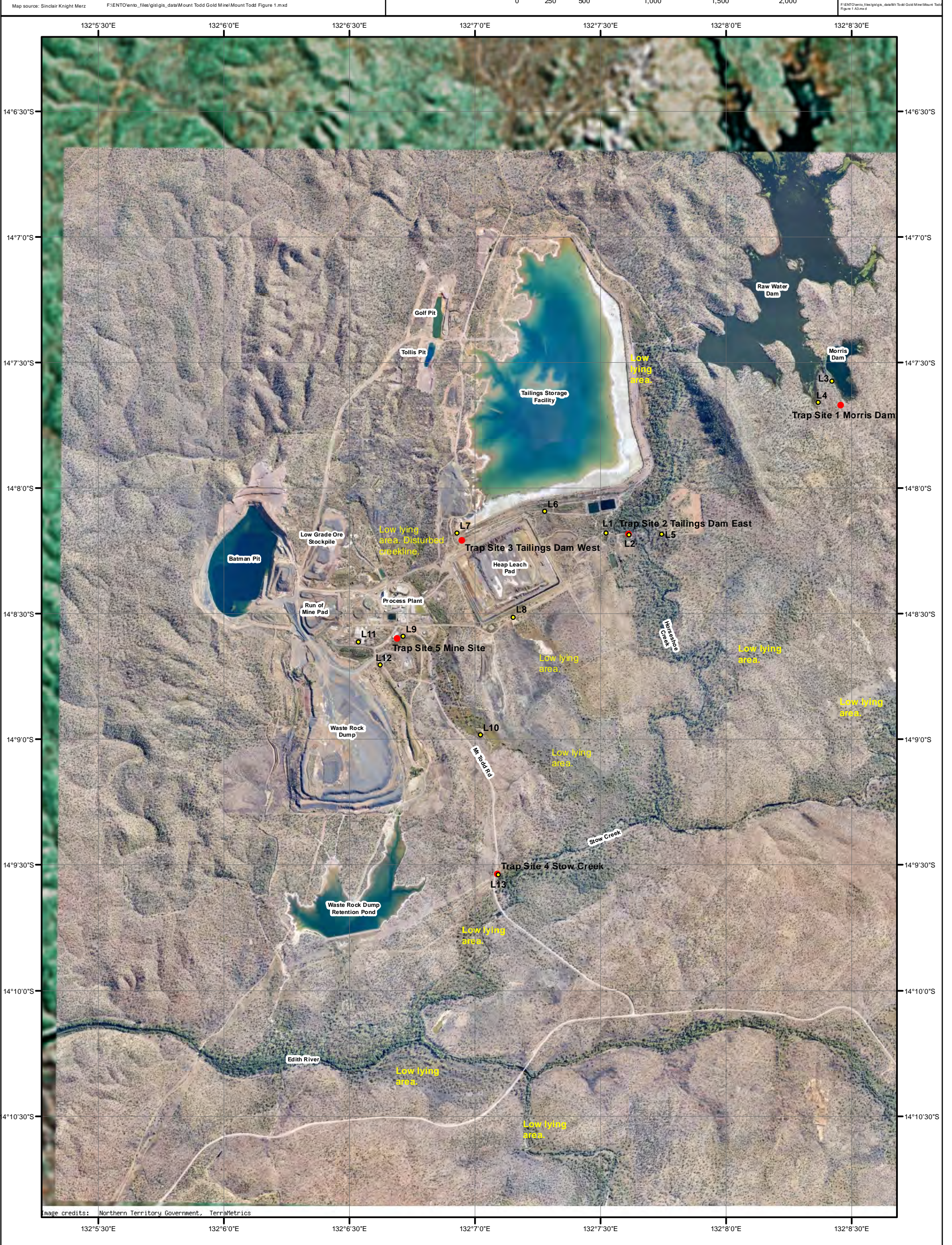
- Adult biting insect trap locations
- Larval mosquito sampling points



Absolute scale 1:25,000



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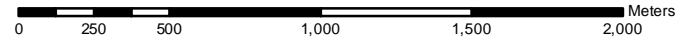
**Figure 2 - Mount Todd Gold Mine Biting Insect Assessment.
Larval mosquito survey 8th and 9th February 2012.**

Legend

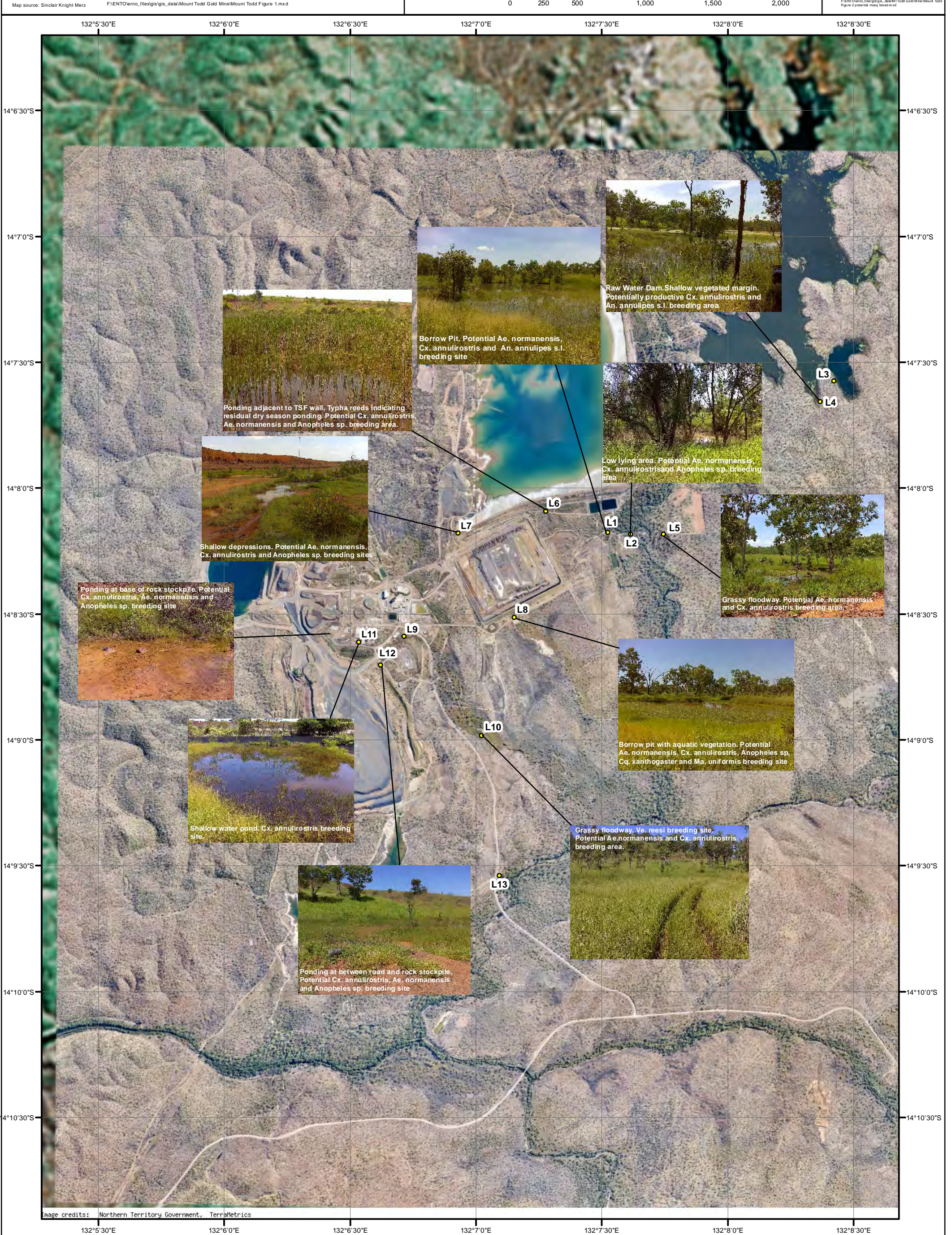
● Larval mosquito sampling points



Absolute scale 1:25,000



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F:\ENTO\ento_files\gis\gis_data\Mount Todd Gold Mine\Mount Todd Figure 1.mxd
Figure 2 potential mosq. breed.mxd



Tables

Date collected	Trap Location	Water presence	Water area	Breeding	No. of dips	Average per dip	Species	1st instar	2nd instar	3rd instar	4th instar	Pupae
8-Feb-12	L1 Borrow pits adjacent to Horseshoe creek	Pooling	1200	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L2 Grassy depression adjacent to Horseshoe creek	Pooling	500	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L3 Morris Dam, south west edge	Flooded	N/C	No	15	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L4 Raw water dam, southeast edge	Flooded	N/C	No	15	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L5 Grassy floodway east of Horseshoe creek	Pooling	2000	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L6 Seepage from Tailings Storage Facility, south margin	Pooling	1000	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
8-Feb-12	L7 Tailings Storage Facility, disturbed area near south west edge	Pooling	N/C	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
9-Feb-12	L8 Borrow pit and disturbed area both sides of road past heap leach pad	Pooling	1000	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
9-Feb-12	L9 Septic tank and adjacent disturbed area	Pooling	N/C	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
9-Feb-12	L10 Grassy floodway adjacent to ephemeral stream, south of mine site	Pooling	N/C	Yes	10	0.2	<i>Ve. (Ver) reesi</i>	0	2	0	0	0
9-Feb-12	L11 Small plastic lined water holding pond at mine site	Pooling	400	Yes	10	2	<i>Cx. (Cux) annulirostris</i>	5	0	1	1	0
9-Feb-12	L12 Roadside depression east of waste rock stockpile	Pooling	200	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0
9-Feb-12	L13 Stow Creek, depressions near road	Flooded	N/C	No	10	0	<i>Nil mosquitoes</i>	0	0	0	0	0

Table 2 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected on all trap nights.

Date collected	<i>Ad. (Ady) catasictia</i>	<i>Ae. (?) species 160</i>	<i>Ae. (Adm) alboscultellatus</i>	<i>Ae. (Cta) elchoensis</i>	<i>Ae. (Fin) kochi</i>	<i>Ae. (Fin) notoscriptus</i>	<i>Ae. (Mac) nr species 121</i>	<i>Ae. (Mac) species</i>	<i>Ae. (Mac) tremulus</i>	<i>Ae. (Mo) pecuniosus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Neo) lineatopennis</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>Ae. (Stg) subgroup</i>	<i>An. (Ano) bancroftii</i>	<i>An. (Ano) powelli</i>	<i>An. (Cel) amictus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) farauti s.l.</i>	<i>An. (Cel) hilli</i>	<i>An. (Cel) meraukensis</i>	<i>An. (Cel) novaguinensis</i>	<i>Cq. (Coq) near crassipes ?</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cui) pullus</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) gelatus</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Cux) quinquefasciatus</i>	<i>Cx. (Cux) siliens</i>	<i>Cx. (Cux) Vishnu group</i>	<i>Cx. (Lop) hilli</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Cx. (Ocu) near bitaeniorhynchus</i>	<i>Cx. (Ocu) starckeae</i>	<i>Ma. (Mnd) uniformis</i>	<i>Ur. (Ura) nivipes</i>	<i>Ve. (Ver) reesi</i>	Totals	%	No. of traps	Ave. per trap
9-Feb-12	0	0	1	5	1	0	0	0	0	1	0	7	178	1	0	0	0	1	3	3	1	1	0	0	76	4	28	2	13	0	0	0	0	2	0	0	31	0	3	362	5.20	5	72.4
8-Mar-12	0	0	0	0	3	1	0	1	0	0	0	2	121	0	0	0	0	0	9	0	0	3	0	0	17	6	114	0	0	0	0	1	0	3	0	0	82	0	16	379	5.44	5	75.8
11-Apr-12	3	1	0	14	3	9	0	0	0	8	37	465	2680	0	1	3	4	134	131	0	0	57	10	0	5	5	160	0	57	0	3	3	0	9	34	1	6	1	0	3844	55.18	5	768.8
9-May-12	1	0	1	1	1	2	2	0	1	0	2	8	47	0	0	15	0	56	70	0	1	23	1	2	1	0	253	0	12	1	0	4	0	0	0	0	0	0	0	505	7.25	5	101
5-Jun-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	13	233	0	0	15	0	1	0	0	54	0	9	0	0	0	0	0	0	0	0	0	0	340	4.88	5	68
5-Jul-12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	75	0	0	2	0	0	0	0	46	0	1	10	0	0	0	0	0	0	0	0	0	148	2.12	5	29.6
2-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	133	0	0	13	0	0	1	0	95	0	1	8	0	0	0	0	0	0	0	0	0	258	3.70	5	51.6
31-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	157	0	1	14	0	0	8	0	80	0	0	2	0	0	0	0	0	1	1	0	0	298	4.28	5	59.6
27-Sep-12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	45	0	1	2	0	0	10	0	43	0	2	1	1	0	0	1	0	0	0	0	162	2.33	5	32.4	
31-Oct-12	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	28	5	0	0	0	0	1	2	0	20	0	19	0	0	0	0	0	0	0	0	0	89	1.28	5	17.8	
29-Nov-12	0	0	0	3	0	1	0	0	9	0	0	0	20	17	0	0	0	23	0	1	0	0	0	0	0	46	1	5	0	0	0	0	1	0	0	0	0	127	1.82	5	25.4		
20-Dec-12	1	3	0	6	0	1	1	0	3	0	1	2	4	6	0	0	0	9	7	0	2	0	0	0	12	1	61	14	4	0	0	2	1	1	0	0	1	0	143	2.05	5	28.6	
30-Jan-13	0	2	1	3	0	0	0	0	5	2	0	0	31	9	0	2	0	1	0	0	2	0	0	0	107	17	94	23	3	0	0	3	0	4	0	0	2	0	311	4.46	5	62.2	
Totals	7	6	3	32	8	14	3	1	18	11	40	484	3081	47	1	36	4	373	868	4	8	130	11	4	239	33	1094	40	126	22	4	13	1	21	34	2	123	1	19	6966	100.00	65	107.2
%	0.10	0.09	0.04	0.46	0.11	0.20	0.04	0.01	0.26	0.16	0.57	6.95	44.23	0.67	0.01	0.52	0.06	5.35	12.46	0.06	0.11	1.87	0.16	0.06	3.43	0.47	15.70	0.57	1.81	0.32	0.06	0.19	0.01	0.30	0.49	0.03	1.77	0.01	0.27	100.00			
Ave. per trap	0.11	0.09	0.05	0.49	0.12	0.22	0.05	0.02	0.28	0.17	0.62	7.45	47.4	0.72	0.02	0.55	0.06	5.74	13.35	0.06	0.12	2	0.17	0.06	3.68	0.51	16.83	0.62	1.94	0.34	0.06	0.2	0.02	0.32	0.52	0.03	1.89	0.02	0.29	107.17			

Table 3 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Summary of all mosquito species collected on all trap nights at all trap sites

Trap location	9-Feb-12	8-Mar-12	11-Apr-12	9-May-12	5-Jun-12	5-Jul-12	2-Aug-12	31-Aug-12	27-Sep-12	31-Oct-12	29-Nov-12	20-Dec-12	30-Jan-13	Totals	%
Mt Todd Trap 1, Morris Dam	121	56	361	227	206	53	102	69	46	27	33	25	60	1386	19.90
Mt Todd Trap 2, Tailings Dam East	82	72	944	37	51	52	101	101	70	38	9	66	52	1675	24.05
Mt Todd Trap 3, Tailings Dam West	123	138	1460	69	28	5	14	42	21	7	46	16	92	2061	29.59
Mt Todd Trap 4, Stow Creek	26	75	947	150	51	24	35	82	20	7	20	31	84	1552	22.28
Mt Todd Trap 5, Mine Site	10	38	132	22	4	14	6	4	5	10	19	5	23	292	4.19
Totals	362	379	3844	505	340	148	258	298	162	89	127	143	311	6966	100.00
%	5.20	5.44	55.18	7.25	4.88	2.12	3.70	4.28	2.33	1.28	1.82	2.05	4.46	100.00	

Table 4 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at all trap sites.

Trap location	<i>Ad. (Ady) caelestis</i>	<i>Ae. (?) species 160</i>	<i>Ae. (Adm) alboscute/latus</i>	<i>Ae. (Cha) elchoensis</i>	<i>Ae. (Fir) kochi</i>	<i>Ae. (Fin) notoscriptus</i>	<i>Ae. (Mac) nr species 121</i>	<i>Ae. (Mac) species</i>	<i>Ae. (Mac) tremulus</i>	<i>Ae. (Mol) pecuniosus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Neo) lineatopennis</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>Ae. (Stg) subgroup</i>	<i>An. (Ano) bancroftii</i>	<i>An. (Ano) powelli</i>	<i>An. (Cel) amictus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) farauti s.l.</i>	<i>An. (Cel) hilli</i>	<i>An. (Cel) meraukensis</i>	<i>An. (Cel) novaguiniensis</i>	<i>Cq. (Coq) near crassipes ?</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cui) pullus</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) gelidus</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Cux) quinquefasciatus</i>	<i>Cx. (Cux) sitens</i>	<i>Cx. (Cux) Vismui group</i>	<i>Cx. (Lop) hilli</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Cx. (Ocu) near bitaeniorhynchus</i>	<i>Cx. (Ocu) starckeae</i>	<i>Ma. (Mnd) uniformis</i>	<i>Ur. (Ura) niviipes</i>	<i>Ve. (Ver) reesi</i>	Totals	%	No. of traps	Ave. per trap
Mt Todd Trap 1, Morris Dam	5	3	0	19	1	0	1	0	8	2	1	0	345	2	0	16	0	47	380	1	0	14	0	4	53	0	295	2	110	0	0	0	0	3	31	1	42	0	0	1386	19.90	13	106.6
Mt Todd Trap 2, Tailings Dam East	0	0	1	1	1	2	0	0	0	1	1	83	830	12	0	4	0	81	145	3	0	32	0	0	44	26	309	19	2	1	4	8	0	12	3	1	42	0	7	1675	24.05	13	128.8
Mt Todd Trap 3, Tailings Dam West	2	2	0	9	0	0	2	1	0	2	11	65	1310	14	0	1	4	169	71	0	5	0	5	0	60	5	273	17	6	2	0	4	0	1	0	0	20	0	0	2061	29.59	13	158.5
Mt Todd Trap 4, Stow Creek	0	1	1	2	6	12	0	0	8	6	26	335	477	7	0	15	0	40	260	0	0	83	6	0	69	1	164	2	3	0	0	1	0	4	0	0	13	0	10	1552	22.28	13	119.4
Mt Todd Trap 5, Mine Site	0	0	1	1	0	0	0	0	2	0	1	1	119	12	1	0	0	36	12	0	3	1	0	0	13	1	53	0	5	19	0	0	1	1	0	0	6	1	2	292	4.19	13	22.5
Totals	7	6	3	32	8	14	3	1	18	11	40	484	3081	47	1	36	4	373	868	4	8	130	11	4	239	33	1094	40	126	22	4	13	1	21	34	2	123	1	19	6966	100.00	65	107.2
%	0.10	0.09	0.04	0.46	0.11	0.20	0.04	0.01	0.26	0.16	0.57	6.95	44.23	0.67	0.01	0.52	0.06	5.35	12.46	0.06	0.11	1.87	0.16	0.06	3.43	0.47	15.70	0.57	1.81	0.32	0.06	0.19	0.01	0.30	0.49	0.03	1.77	0.01	0.27	100.00			
Ave. per trap	0.11	0.092	0.046	0.492	0.12	0.215	0.046	0.02	0.277	0.17	0.62	7.45	47.4	0.72	0.02	0.55	0.062	5.74	13.35	0.062	0.12	2	0.17	0.062	3.677	0.51	16.83	0.62	1.94	0.338	0.062	0.2	0.02	0.323	0.523	0.031	1.89	0.02	0.29	107.2			

Table 5 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 1 Morris Dam

Date collected	<i>Ad. (Ady) catasticta</i>	<i>Ae. (?) species 160</i>	<i>Ae. (Cha) elchoensis</i>	<i>Ae. (Fin) kochi</i>	<i>Ae. (Mac) nr species 121</i>	<i>Ae. (Mac) tremulus</i>	<i>Ae. (Mol) pecuniosus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>An. (Ano) bancroftii</i>	<i>An. (Cel) amictus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) farauti s.l.</i>	<i>An. (Cel) meraukensis</i>	<i>Cq. (Coq) near crassipes ?</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) gelidus</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Cx. (Ocu) near bitaeniorhynchus</i>	<i>Cx. (Ocu) starckeae</i>	<i>Ma. (Mnd) uniformis</i>	Totals	%
9-Feb-12	0	0	4	1	0	0	1	0	69	0	0	0	2	0	1	0	10	8	0	7	1	0	0	17	121	8.73
8-Mar-12	0	0	0	0	0	0	0	0	20	0	0	0	1	0	1	0	2	9	0	0	0	0	0	23	56	4.04
11-Apr-12	3	0	6	0	0	0	0	0	235	0	0	5	6	0	9	0	1	9	0	55	0	31	1	0	361	26.05
9-May-12	0	0	1	0	1	0	0	0	8	0	7	2	10	0	2	2	0	183	0	11	0	0	0	0	227	16.38
5-Jun-12	0	0	0	0	0	0	0	0	0	0	8	4	156	0	1	1	0	27	0	9	0	0	0	0	206	14.86
5-Jul-12	1	0	0	0	0	0	0	0	0	0	0	5	34	0	0	0	0	12	0	1	0	0	0	0	53	3.82
2-Aug-12	0	0	0	0	0	0	0	0	0	0	1	5	88	0	0	0	0	7	0	1	0	0	0	0	102	7.36
31-Aug-12	0	0	0	0	0	0	0	0	0	0	0	9	52	0	0	0	2	5	0	0	0	0	0	1	69	4.98
27-Sep-12	1	0	0	0	0	0	0	0	0	0	0	13	28	0	0	0	3	0	0	0	1	0	0	0	46	3.32
31-Oct-12	0	0	0	0	0	0	0	0	0	1	0	2	2	0	0	1	0	2	0	19	0	0	0	0	27	1.95
29-Nov-12	0	0	1	0	0	3	0	0	5	1	0	1	0	1	0	0	0	18	0	2	1	0	0	0	33	2.38
20-Dec-12	0	3	5	0	0	2	0	1	0	0	0	1	1	0	0	0	2	5	1	3	0	0	0	1	25	1.80
30-Jan-13	0	0	2	0	0	3	1	0	8	0	0	0	0	0	0	0	33	10	1	2	0	0	0	0	60	4.33
Totals	5	3	19	1	1	8	2	1	345	2	16	47	380	1	14	4	53	295	2	110	3	31	1	42	1386	100.00
%	0.36	0.22	1.37	0.07	0.07	0.58	0.14	0.07	24.89	0.14	1.15	3.39	27.42	0.07	1.01	0.29	3.82	21.28	0.14	7.94	0.22	2.24	0.07	3.03	100.00	

Table 6 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 2 Tailings Dam East

Date collected	<i>Ae. (Adm) alboscuteellatus</i>	<i>Ae. (Cha) elchoensis</i>	<i>Ae. (Fin) kochi</i>	<i>Ae. (Fin) notoscriptus</i>	<i>Ae. (Mol) pecuniosus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Neo) lineatopennis</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>An. (Ano) bancroftii</i>	<i>An. (Cel) amictus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) farauti s.l.</i>	<i>An. (Cel) meraukensis</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cui) pullus</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) gelidus</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Cux) quinquefasciatus</i>	<i>Cx. (Cux) sitiens</i>	<i>Cx. (Cux) Vishnui group</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Cx. (Ocu) near bitaeniorhynchus</i>	<i>Cx. (Ocu) starckeae</i>	<i>Ma. (Mnd) uniformis</i>	<i>Ve. (Ver) reesi</i>	Totals	%
9-Feb-12	1	0	0	0	0	0	2	30	1	0	0	0	3	0	22	2	7	0	1	0	0	0	0	0	11	2	82	4.90	
8-Mar-12	0	0	1	0	0	0	1	14	0	0	0	2	0	0	0	3	18	0	0	0	0	1	1	0	0	26	5	72	4.30
11-Apr-12	0	0	0	0	0	0	77	761	0	0	11	13	0	13	0	5	42	0	0	0	3	3	8	3	0	5	0	944	56.36
9-May-12	0	0	0	1	0	1	1	17	0	1	0	0	0	1	0	0	12	0	1	0	0	2	0	0	0	0	0	37	2.21
5-Jun-12	0	0	0	0	0	0	0	0	0	3	3	34	0	7	0	0	4	0	0	0	0	0	0	0	0	0	0	51	3.04
5-Jul-12	0	0	0	0	0	0	0	0	0	0	3	22	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	52	3.10
2-Aug-12	0	0	0	0	0	0	0	0	0	0	0	20	0	8	1	0	71	0	0	1	0	0	0	0	0	0	0	101	6.03
31-Aug-12	0	0	0	0	0	0	0	0	0	0	13	39	0	2	1	0	45	0	0	0	0	0	0	0	1	0	0	101	6.03
27-Sep-12	0	0	0	0	0	0	0	0	0	0	23	12	0	1	4	0	29	0	0	0	1	0	0	0	0	0	0	70	4.18
31-Oct-12	0	0	0	0	0	0	0	0	7	0	22	1	0	0	1	0	7	0	0	0	0	0	0	0	0	0	0	38	2.27
29-Nov-12	0	0	0	0	0	0	0	4	2	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	9	0.54
20-Dec-12	0	1	0	1	0	0	2	2	2	0	4	2	0	0	6	1	30	13	0	0	0	2	0	0	0	0	0	66	3.94
30-Jan-13	0	0	0	0	1	0	0	2	0	0	0	0	0	0	9	15	17	5	0	0	0	0	3	0	0	0	0	52	3.10
Totals	1	1	1	2	1	1	83	830	12	4	81	145	3	32	44	26	309	19	2	1	4	8	12	3	1	42	7	1675	100.00
%	0.06	0.06	0.06	0.12	0.06	0.06	4.96	49.55	0.72	0.24	4.84	8.66	0.18	1.91	2.63	1.55	18.45	1.13	0.12	0.06	0.24	0.48	0.72	0.18	0.06	2.51	0.42	100.00	

Table 7 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 3 Tailings Dam West

Date collected	<i>Ad. (Ady) catasticta</i>	<i>Ae. (?) species 160</i>	<i>Ae. (Cha) elchoensis</i>	<i>Ae. (Mac) nr species 121</i>	<i>Ae. (Mac) species</i>	<i>Ae. (Mol) pecuniosus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Neo) lineatopennis</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>An. (Ano) bancroftii</i>	<i>An. (Ano) powelli</i>	<i>An. (Cel) amictus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) hilli</i>	<i>An. (Cel) novaguinensis</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cui) pullus</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) gelidus</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Cux) quinquefasciatus</i>	<i>Cx. (Cux) Vishnui group</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Ma. (Mnd) uniformis</i>	Totals	%
9-Feb-12	0	0	1	0	0	0	0	4	64	0	0	0	1	1	1	0	36	1	8	2	3	0	0	0	1	123	5.97
8-Mar-12	0	0	0	0	1	0	0	0	49	0	0	0	0	2	0	0	5	2	61	0	0	0	0	0	18	138	6.70
11-Apr-12	0	1	7	0	0	2	11	60	1178	0	0	4	101	30	0	4	1	0	60	0	0	0	0	1	0	1460	70.84
9-May-12	1	0	0	1	0	0	0	1	7	0	1	0	25	3	0	1	0	0	28	0	0	0	1	0	0	69	3.35
5-Jun-12	0	0	0	0	0	0	0	0	0	0	0	0	3	7	0	0	0	0	18	0	0	0	0	0	0	28	1.36
5-Jul-12	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	2	0	0	0	0	0	0	5	0.24
2-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	9	0	0	1	0	0	0	14	0.68
31-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	6	17	1	0	0	0	17	0	0	1	0	0	0	42	2.04
27-Sep-12	0	0	0	0	0	0	0	0	0	0	0	0	8	4	1	0	0	0	8	0	0	0	0	0	0	21	1.02
31-Oct-12	0	0	0	0	0	0	0	0	0	2	0	0	1	1	0	0	0	0	3	0	0	0	0	0	0	7	0.34
29-Nov-12	0	0	0	0	0	0	0	0	5	4	0	0	19	0	0	0	0	0	17	0	1	0	0	0	0	46	2.23
20-Dec-12	1	0	0	1	0	0	0	0	2	1	0	0	3	1	0	0	0	0	6	0	1	0	0	0	0	16	0.78
30-Jan-13	0	1	1	0	0	0	0	0	5	7	0	0	0	0	2	0	18	2	36	15	1	0	3	0	1	92	4.46
Totals	2	2	9	2	1	2	11	65	1310	14	1	4	169	71	5	5	60	5	273	17	6	2	4	1	20	2061	100.00
%	0.10	0.10	0.44	0.10	0.05	0.10	0.53	3.15	63.56	0.68	0.05	0.19	8.20	3.44	0.24	0.24	2.91	0.24	13.25	0.82	0.29	0.10	0.19	0.05	0.97	100.00	

Table 8 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 4 Stow Creek

Date collected	Ae. (?) species 160	Ae. (Adm) alboscuteellatus	Ae. (Cha) elchoensis	Ae. (Fin) kochi	Ae. (Fin) notoscriptus	Ae. (Mac) tremulus	Ae. (Mol) pecuniosus	Ae. (Muc) alternans	Ae. (Neo) lineatopennis	Ae. (Och) normanensis	Ae. (Och) vigilax	An. (Ano) bancroftii	An. (Cel) amictus	An. (Cel) annulipes s.l.	An. (Cel) meraukensis	An. (Cel) novaguinensis	Cq. (Coq) xanthogaster	Cx. (Cui) pullus	Cx. (Cux) annulirostris	Cx. (Cux) gelidus	Cx. (Cux) palpalis	Cx. (Cux) Vishnui group	Cx. (Ocu) bitaeniorhynchus	Ma. (Mnd) uniformis	Ve. (Ver) reesi	Totals	%
9-Feb-12	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0	0	7	1	1	0	1	0	1	1	1	26	1.68
8-Mar-12	0	0	0	2	1	0	0	0	1	23	0	0	0	4	1	0	5	0	17	0	0	0	1	11	9	75	4.83
11-Apr-12	0	0	0	3	9	0	6	25	327	408	0	3	0	75	35	6	3	0	47	0	0	0	0	0	0	947	61.02
9-May-12	0	1	0	1	1	1	0	1	6	14	0	6	23	57	20	0	1	0	17	0	0	1	0	0	0	150	9.66
5-Jun-12	0	0	0	0	0	0	0	0	0	0	0	4	2	34	7	0	0	0	4	0	0	0	0	0	0	51	3.29
5-Jul-12	0	0	0	0	0	0	0	0	0	0	0	0	2	15	2	0	0	0	5	0	0	0	0	0	0	24	1.55
2-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	0	22	5	0	0	0	8	0	0	0	0	0	0	35	2.26
31-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	3	49	12	0	5	0	13	0	0	0	0	0	0	82	5.28
27-Sep-12	0	0	0	0	0	0	0	0	0	0	0	0	7	1	1	0	3	0	6	0	2	0	0	0	0	20	1.29
31-Oct-12	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	4	0	0	0	0	0	0	7	0.45
29-Nov-12	0	0	2	0	1	6	0	0	0	6	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	20	1.29
20-Dec-12	0	0	0	0	0	0	0	0	0	0	2	0	1	3	0	0	4	0	20	0	0	0	1	0	0	31	2.00
30-Jan-13	1	0	0	0	0	1	0	0	0	14	1	2	1	0	0	0	40	0	20	2	0	0	1	1	0	84	5.41
Totals	1	1	2	6	12	8	6	26	335	477	7	15	40	260	83	6	69	1	164	2	3	1	4	13	10	1552	100.00
%	0.06	0.06	0.13	0.39	0.77	0.52	0.39	1.68	21.59	30.73	0.45	0.97	2.58	16.75	5.35	0.39	4.45	0.06	10.57	0.13	0.19	0.06	0.26	0.84	0.64	100.00	

Table 9 - Mount Todd Baseline Biting Insect Assessment February 2012 to January 2013. Total number of all female mosquito species collected at Trap Site 5 Mine Site

Date collected	<i>Ae. (Adm) alboscuteletatus</i>	<i>Ae. (Cha) elchoensis</i>	<i>Ae. (Mac) tremulus</i>	<i>Ae. (Muc) alternans</i>	<i>Ae. (Neo) lineatopennis</i>	<i>Ae. (Och) normanensis</i>	<i>Ae. (Och) vigilax</i>	<i>Ae. (Stg) subgroup</i>	<i>An. (Cel) arcticus</i>	<i>An. (Cel) annulipes s.l.</i>	<i>An. (Cel) hilli</i>	<i>An. (Cel) meraukensis</i>	<i>Cq. (Coq) xanthogaster</i>	<i>Cx. (Cui) pullus</i>	<i>Cx. (Cux) annulirostris</i>	<i>Cx. (Cux) palpalis</i>	<i>Cx. (Cux) quinquefasciatus</i>	<i>Cx. (Lop) hilli</i>	<i>Cx. (Ocu) bitaeniorhynchus</i>	<i>Ma. (Mnd) uniformis</i>	<i>Ur. (Ura) nivipes</i>	<i>Ve. (Ver) reesi</i>	Totals	%
9-Feb-12	0	0	0	0	0	3	0	0	0	0	0	0	1	0	4	1	0	0	0	1	0	0	10	3.42
8-Mar-12	0	0	0	0	0	15	0	0	0	0	0	1	5	1	9	0	0	0	1	4	0	2	38	13.01
11-Apr-12	0	1	0	1	1	98	0	1	17	7	0	0	0	0	2	2	0	0	0	1	1	0	132	45.21
9-May-12	0	0	0	0	0	1	0	0	6	0	1	0	0	0	13	0	1	0	0	0	0	0	22	7.53
5-Jun-12	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0	4	1.37
5-Jul-12	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	10	0	0	0	0	0	14	4.79
2-Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	6	2.05
31-Aug-12	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	4	1.37
27-Sep-12	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	5	1.71
31-Oct-12	0	0	0	0	0	0	3	0	2	1	0	0	0	0	4	0	0	0	0	0	0	0	10	3.42
29-Nov-12	0	0	0	0	0	0	7	0	1	0	0	0	0	0	9	2	0	0	0	0	0	0	19	6.51
20-Dec-12	0	0	1	0	0	0	1	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	5	1.71
30-Jan-13	1	0	1	0	0	2	1	0	0	0	0	0	7	0	11	0	0	0	0	0	0	0	23	7.88
Totals	1	1	2	1	1	119	12	1	36	12	3	1	13	1	53	5	19	1	1	6	1	2	292	100.00
%	0.34	0.34	0.68	0.34	0.34	40.75	4.11	0.34	12.33	4.11	1.03	0.34	4.45	0.34	18.15	1.71	6.51	0.34	0.34	2.05	0.34	0.68	100.00	

**Appendix 1 – Mt Todd Gold Project
Baseline Mosquito Monitoring Results
1993-94**



Northern Territory Government

DE DEPARTMENT OF HEALTH
AND COMMUNITY SERVICES

MT. TODD GOLD PROJECT
Baseline Mosquito Monitoring Results

July 1994

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MT. TODD GOLD PROJECT

Baseline Mosquito Monitoring Results

**P. Whelan
Medical Entomology Branch
Department of Health & Community Services
in conjunction with Zapopan N.L./ Mt. Todd**

July, 1994

1.0 INTRODUCTION

The Mt. Todd Gold Project will involve the development of an open pit mine and the processing of a large low grade gold deposit near Mt. Todd, approximately 45 kilometres north, north-west of Katherine in the Northern Territory (Figure 1). The project proponent, Zapopan N.L., prepared a draft E.I.S. in November 1992 which included aspects of mosquito borne disease which had been previously raised by the Department of Health and Community Services. The E.I.S. undertook to determine baseline mosquito numbers in co-operation with the Medical Entomology branch of the Department of Health and Community Services.

Following initial discussions between Mr. Paul Jones and Ms. Helen May associated with the project and Peter Whelan of the Medical Entomology Branch, a baseline monitoring project was formulated and began on March 1993. This report summarises the results of this baseline monitoring and discusses the implication of the mosquito species, the relative numbers and the spatial and temporal distribution of the mosquitoes in the area.

2.0 METHODS

Four mosquito trapping sites were chosen on the basis of an initial inspection and information on proposed water storage dams, tailings storage, nearby creek lines and a pre-existing water storage dam (Morris Dam). The four trap sites are shown in Figure 2 and Figure 3.

The mosquito traps used were carbon dioxide baited E.V.S. traps (Rohe and Fall), with a modified collecting container. They were powered by two "D" cell batteries and included a "grain of wheat" light source. The traps were set once per month by the Environmental Officer for Zapopan. Traps were placed in the late afternoon before sunset and retrieved the following morning after sunrise. The mosquitoes were killed by freezing and forwarded in an esky to the Medical Entomology Branch for identification and counting.

A brief ground survey was carried out on the 16th and 17th June by the Senior Medical Entomologist, Peter Whelan and the Environmental Officer, Mr. Tom Morris to assess any ground water ponding due to the development and the possible emergence of new mosquito breeding sites.

3.0 RESULTS

3.1 Mosquito Monitoring Results

The complete mosquito monitoring results for the four trap sites are shown in Tables 1 - 4. The three most prevalent and medically important species are displayed in Figures 4 - 7. A summary of the results of the four sites is shown in Table 5 and Table 6. A graph of the rainfall from the ranger station at nearby Edith Falls is displayed in Figure 8.

3.2 Species Present

There were 32 species of mosquitoes detected in the base line monitoring program. This included seven (7) *Anopheles* species, eighteen (18) *Aedes* species and five (5) *Culex* species. The exotic species *Aedes aegypti* was not recorded as expected. Two medically important species that are of relevance in the Northern Territory, *Culex quinquefasciatus* and *Anopheles farauti* were not recorded.

3.3 Relative Numbers

The highest numbers of mosquitoes collected were, in decreasing order, *Culex annulirostris*(39.42%), *Aedes normanensis*(27.79%), *Anopheles annulipes*(15.62%) and *Coquillettidia xanthogaster*(3.4%).

3.4 Temporal Distribution

The highest total numbers of mosquitoes collected in 1994 was in February and this was largely due to *Cx. annulirostris*. In 1993 the highest numbers collected were in March and these were primarily due to the high numbers of *Ae. normanensis*(Table 6).

The peaks of occurrence of *Cx. annulirostris*, *Ae. normanensis*, *An. annulipes*, and *Cq. xanthogaster* was different in the two years. *Cx. annulirostris* was highest in May in 1993 and highest in February in 1994. *Ae. normanensis* was highest in March in 1993 and highest in January in 1994.

3.5 Spatial Distribution

The highest numbers of *Cx. annulirostris* were in the Tailings Dam East Site, followed by Stow Creek, Tailings Dam West and Morris Dam.

The highest numbers of *Ae. normanensis* were in Tailings Dam West, followed by Tailings Dam East, Stow Creek and Morris Dam.

The highest numbers of *An. annulipes* were in Tailings Dam East, followed by Stow Creek, Tailings Dam West and the Morris Dam(Table 5).

The highest number of *Cq. xanthogaster* was at Stow Creek.

Overall the least number of mosquitoes was recovered at the Morris Dam site, with the other three sites having comparable total numbers of the four major species.

3.6 Field survey

The field inspection on the 16th of June 1994 revealed no remaining surface pooling due to mine development. There were some areas that may have been minor additional sources of mosquitoes during or early after the "Wet" season. These areas included cleared areas on two

sides of the heap leach facility where pooling had obviously occurred. On one side this pooling had been recognised and measures taken to drain the area.

On the creek line between the Plant site and the Heap Leach facility, a silt retention facility has been built which resulted in a restriction of storm water in the creek line. This has caused some ecological change as evidenced by increased grass growth and could have resulted in localised and increased amounts of mosquito breeding. The silt retention structure has now been breached but an inspection of this site in the "Wet" season is warranted to determine if mosquito breeding is occurring in this site.

Larval sampling of Horseshoe Creek near site 2 indicated shallow surface pooling in the creek. Larvae of *Cx. annulirostris* and *An. annulipes* were found at the edges in protected sites with rotting leaf litter or in small cut off pools. The total area of these sites is not appreciable and these sources would be regarded as minor at this time of the year and not warranting any control consideration.

Other potential sites observed included numerous old borrow pits and costeans near Quigleys and in the Mount Todd general vicinity, but these were not considered to be significant mosquito sources and would dry up soon after the seasonal rainfall.

The most significant breeding sites were the poorly draining levee areas and the shallow drainage floors of Horseshoe creek and other minor creeks in the area. These areas appear to remain flooded for extended periods during the "Wet" season, have numerous small minor depressions, are well vegetated with grasses, and are of considerable area. An appreciable area of this type of habitat was also apparent in the vicinity of the security gate associated with Stow Creek. These habitats are likely to be significant sources of *Cx. annulirostris* and *Ae. normanensis*.

4.0 DISCUSSION

4.1 Trapping Sites

The Morris Dam Trap site is adjacent to a perennial and artificial freshwater storage dam, as well as being near the upper reaches of Horseshoe and Stow Creeks. This site is relatively distant from the mine development area and relatively well drained. It is relatively distant from the poorly drained lower reaches of the above creeks. The lower number of total mosquitoes indicates that there are no extensive areas of favourable mosquito breeding habitats near this site when compared with the other three sites.

The relative numbers of the various species present at this site probably represents a dispersal of mosquitoes from more productive habitats within 2 or 3 kilometres, rather than the production of mosquitoes in the vicinity of the trap site. This site represents an area of the upper reaches of creeks that dry out soon after the "Wet" season. The mosquito fauna here is not likely to be affected by the mine development and will be indicative of mosquito production from the natural and undisturbed habitats.

Morris Dam is not a productive mosquito habitat because it is relatively free of marginal semi aquatic vegetation and contains ample mosquito larval predators including fish, dragon fly and damsel fly larvae and aquatic bugs and beetles.

The Tailings Dam East site is on Horseshoe Creek, downstream from the anticipated site of a tailings storage dam. The site has been chosen to detect any changes in the ecology and subsequent mosquito production that may occur with prolonged or increased runoff or the retention of stormwater within the vicinity of the adjacent tailings storage.

The Tailings Dam West site is close to the mine development, including the plant site, the heap leach facility and the associated diversion drains. It is also close to the proposed tailings storage and a possible dam on an adjacent creek arising from the near Batman Ridge. This site should detect changes in the relative numbers of mosquitoes due to any changes in the ecology arising from the construction of the tailings dam, borrow pits, stormwater diversion, silt retention works and water storage dams. It should also be able to detect mosquito breeding in artificial sites such as containers, waste water and septic tanks.

The Stow Creek site is in the lower reaches of Stow Creek, near the Elizabeth River. This site reflects the more perennial pooling habitats and is a relatively undisturbed area well away from the mine site.

The fact that the present base-line data gathering has incorporated a period of significant earthworks does detract from the suitability of this data as purely baseline data before any development. However there has not been an appreciable modification of the ecology of the general area, apart from the construction of the mine facilities themselves, and an examination of the results from the four trap sites in the future should be able to detect if additional mosquito species have been introduced into the area, and if changes in the relative numbers of species has been due to the mine development.

4.2 Species present, medical importance and relative occurrence.

The species present at those expected from the general Katherine region. The noticeable variation in the species present from other collections in the Katherine/Pine Creek area is the absence of *An. farauti* and *Cx. quinquefasciatus*. The various species are discussed below under their respective species headings.

4.2.1 *Anopheles farauti*

An. farauti is the most important potential malaria vector in the Northern Territory. Malaria is not present in the Northern Territory, but mining in particular has a relatively high potential to reintroduce malaria into Australia because a relatively high proportion of a mines workforce is mobile and is sourced from overseas countries where malaria may be present. One potential problem is that cases of imported malaria may not be rapidly detected and they could then infect the local species of Anopheles mosquitoes. The absence of *An. farauti* is a good indication that the potential for malaria introduction in this area is not as great as a number of other areas in the "Top End" of the Northern Territory.

It is possible that *An. farauti* is present in the area and only reaches a detectable level for a short period or is present only in specific localities. However the results from this monitoring indicate that this species is at either very low levels or absent in this particular area.

4.2.2 Culex quinquefasciatus

Cx. quinquefasciatus is a species associated with human settlement. The larvae are usually found in septic tanks, polluted ground water and artificial containers. Its absence from the present monitoring results indicates that it may not be present in the general area. However there was no trap positioned at the mine site office and near the processing plant, so it is possible that this species may have already been introduced to the site and is at very low levels such that it has remained undetected. It was noticed on the inspection of the 17th of June that there were numerous large earth moving machinery tyres in the site yards. While they may be empty of water in the "Dry" season, they could be breeding sites of *Cx. quinquefasciatus* in and for the few months following the "Wet" season.

No septic tanks were inspected but they are required to be installed such that they are completely mosquito proof. An inspection of the septic tanks by the Environmental Officer is recommended to ensure that they are correctly installed or have not been damaged.

4.2.3 Culex annulirostris

Cx. annulirostris breeds in open sunlit ground pools, often in association with vegetation such as grasses and semi aquatic sedges and reeds. It can readily exploit ephemeral shallow grassy depressions following rain, as well as the more perennial pools. The highest numbers were at the Tailings Dam East site, near Horseshoe Creek, indicating that significant numbers are breeding in the shallow levee pools and the poorly draining drainage floors of this creek.

This species is likely to exploit poorly constructed water storage ponds, poorly cleared areas that contain depressions, and water retention structures that do not drain completely within four or five days of filling with water.

This species is the most prevalent in the area and has the greatest potential to transmit arboviruses such as epidemic polyarthritis, Australian encephalitis and Barmah Forest Disease. It is most likely to be prevalent from December to March during dry years and from December to June in the wetter years. Higher numbers of this species would persist around Stow Creek and Elizabeth River in the late "Dry" season due to the persistence of ground water and suitable breeding sites in the lower reaches of creeks nearest to Elizabeth River. As this species bites primarily after sundown, self protection measures are easily employed to give a good degree of protection against attack.

4.2.4 *Aedes normanensis*

This species breeds in newly flooded ephemeral ground pools during the "Wet" season. The eggs are laid during the latter part of the previous "Wet" season at the drying margins of ground pools. The eggs hatch soon after flooding following the first flooding rains of the "Wet" season and breeding continues in suitable sites as the "Wet" season continues.

The highest numbers of *Ae. normanensis* occurred in March 1993. They were higher than March 1994 and this can be correlated with the higher rainfall in February 1993 (Figure 8). It is probable that in January and February 1993 the numbers of this species were appreciably higher than in the corresponding months of 1994, due to the higher rainfall and more extensive area of available breeding sites.

In both years, numbers fell dramatically with the cessation of rain, indicating that this species is primarily exploiting the ephemeral pooling and is not utilising the areas of persistent pooling in the more defined creeks.

The trapping sites at Tailings Dam East and at Tailings Dam West are near to relatively large areas of the low lying poorly draining levees and drainage floors of Horseshoe Creek and the branch of the creek that arises near Batman Ridge. These areas are likely to be the significant sources of this species.

Ae. normanensis is a significant potential vector of epidemic polyarthritis and a potential vector of Australian encephalitis and Barmah Forest virus disease. It can bite in significant numbers during the day in shaded areas and can be a major pest around sundown and for up to two hours after. Its persistent biting habits require significant self protection measures.

4.2.5 *Anopheles annulipes*

This species breeds in open sunlit ephemeral and perennial ground pools, often in association with vegetation such as grasses or leaf litter that offers some protection from aquatic predators. It is a potential vector of malaria and can be a minor pest.

The numbers of *An. annulipes* did reach appreciable numbers at the end of the "Wet" season and then gradually declined to June when surface pooling had largely dried up. The greatest numbers were at the Stow Creek site and the Tailings Dam East site, indicating that more appreciable breeding sites exist near Horseshoe Creek compared to the other sites near the mine.

The fact that it is only at relatively high numbers for a short period of time and that the relative numbers are not great, indicates that the current potential for malaria transmission is relatively low in this area compared with a lot of other areas in the "Top End". However the potential for malaria transmission will still remain for that period when this species is abundant.

4.2.6 Coquillettidia xanthogaster

Cq. xanthogaster breeds in relatively permanent water in association with semi aquatic vegetation such as *Eleocharis*, *Typha*, and various grasses, as well as aquatic flora such as the water lilies *Nelumbo* or *Nymphaea*. It can reach pest numbers in the early to mid Dry season, depending on the availability and persistence of suitable habitats. In 1993, following a heavy rainfall year, there was a short period of abundance, but significant numbers were not recorded in the following drier year. This may be due to the relatively short persistence of suitable habitats in drier years.

The highest numbers were recorded from the Stow Creek site, where aquatic vegetation such as water lilies is likely to exist. The numbers of this species at the other trap sites is more likely to represent the dispersal of this species from Stow Creek.

This species is not a known vector of any human disease pathogens in Australia.

4.2.7 Aedes elchoensis

Ae. elchoensis breeds in natural tree holes that are filled with rain. The highest numbers of this species were in the Tailings Dam West trap which is closest to the Yinberrie Hills. It is possible that this species is breeding in similar tree holes in the *Eucalyptus* species in which the Gouldian finch nests.

This species does not reach pest proportions and is not a vector of any human disease pathogens in Australia.

4.2.8 Anopheles amictus

An. amictus breeds in open sunlit ground pools. It is often found at the margins of receding pools in the absence of any marginal vegetation and frequently with colloidal clay suspensions. This is only a minor species here and its low numbers probably indicates the speed at which the open ephemeral ground pools dry up at the end of the "Wet" season and the relatively small number of suitable remnant pools that persist into the "Dry" season.

4.2.9 Aedes pseudonormanensis

Ae. pseudonormanensis is a floodwater species that breeds in ground water pools. It can be found breeding in similar situations as *Ae. normanensis*. It does not reach the abundance of *Ae. normanensis* but is regarded as a potential vector of epidemic polyarthritis. It is not likely to be a significant pest or vector in this area.

4.2.10 Anopheles meraukensis.

An. meraukensis is a ground water species, often found breeding in relatively clear water with semi aquatic vegetation or grasses. It reaches its highest numbers soon after the "Wet" season and does not persist into the "Dry" season in appreciable numbers. The highest numbers were found at the Tailings Dam East site, and probably breeds in association with *Cx. annulirostris*.

4.2.11 Aedes vigilax

The salt marsh mosquito was recorded in relatively low numbers. However this species is usually under represented in carbon dioxide baited traps. It was recorded at a maximum level of 32 per trap night in January 1994 at the Tailings Dam East site. This level can represent a pest problem for unprotected people. It is possible that this species was present at significantly higher numbers at the December to January period but because of the long interval between sampling it may not have been detected at the higher levels. This species is generally present only in significant numbers for approximately a week following the high tides at the latter stage of the "Dry" season at sites distant from its coastal salt marsh breeding sites.

It can bite during the day, particularly in shaded areas, and can be a significant pest. It is a potential vector of epidemic polyarthritis. Periods of high occurrence of this species indicate a relatively high potential for epidemic polyarthritis transmission which would require increased self protection. Its presence at Mt. Todd indicates that it is dispersing at least 150 kilometres and possibly up to 200 kilometres from its coastal habitats. The highest numbers at the Tailings Dam East site and Stow Creek probably represent more suitable harbouring sites of shade and higher humidity rather than any indication of proximity to the nearest breeding site.

4.2.12 Aedes aegypti

The dengue vector *Ae. aegypti* is not present in the Northern Territory. However the presence of the large machinery tyres at the mine site offers suitable breeding places for this species if it is inadvertently introduced from Queensland. In addition, it could be imported from Queensland in tyres if the tyres are sourced from an area where *Ae. aegypti* currently exists. It is recommended that all the large machinery tyres be either stored undercover, holed or filled with sand or soil so that they cannot retain rainwater.

4.3 Potential Breeding Sites.

There are a number of potential mosquito breeding sites in the vicinity of the mine site. The most important are discussed below.

4.3.1 Wet season flooded drainways and creeks.

Both the upper and the lower reaches of Horseshoe Creek and Stow Creek are likely to include significant areas of poorly draining floodways and flooded levee pooling during the "Wet" season that will provide suitable and productive habitats for the two most abundant mosquito species.

The most productive areas near the mine are likely to be the lower reaches of Horseshoe Creek near the Tailings East site and along the creek that arises near Batman Ridge. Any development such as silt retention structures or storage dams on these creeks is likely to lead to significant increases in numbers of *Cx. annulirostris* and *Ae. normanensis*. Conversely any measure that improves the drainage of these areas or the construction of facilities that removes areas of poorly draining floodways is likely to reduce the numbers of these species.

4.3.2 Dry season creeks

The upper reaches of Horseshoe Creek and Stow Creek are likely to dry up soon after the "Wet" season, with the water in the lower reaches largely confined to the defined and deeper channels. The lower reaches will continue to breed mosquitoes after the finish of the rains, but at decreasing levels as the "Dry" season progresses.

In the early "Dry" season the upper and the lower reaches of these creeks are likely to provide favourable harbouring and resting sites, as well as breeding sites for *Cx. annulirostris*. This will increase the probability of survival of individual mosquitoes in these sites and it will be these areas that will give rise to potentially infected mosquitoes that could impact on the plant site.

In the mid and late "Dry" season, the creeks are not likely to be significant mosquito breeding sites, either because they are dry or only contain pools that are defined, with bare margins and numerous aquatic predators of larvae. In addition, there is a considerable distance between the persistent pools and the plant site, so that even minor numbers are not likely to cause a significant pest or public health problem for personnel at the plant site for the majority of the "Dry" season.

4.3.3 Pooling due to impeded stormwater runoff.

Various artificial structures and earth disturbances could lead to increased mosquito breeding near the plant site. Any site clearing that does not allow adequate "Wet" season drainage or leads to minor depressions can produce sources of *Ae. normanensis* and *Cx. annulirostris*. Areas that are prepared for future heap leach facilities and waste dumps would need particular attention.

Perhaps the most productive artificial sites will be silt retention facilities in drainage lines. These are likely to have increased vegetation growth, including grasses, and lead to the retention of storm water for periods long enough for mosquitoes to complete their larval development. Any silt retention structure should be able to completely drain within four days after rain. This should satisfy the silt retention purpose and prevent additional mosquito breeding.

4.3.4 Artificial containers

Artificial containers such as tyres, drums, old car bodies, disused machinery, and any rubbish items that can collect rain water can lead to mosquito breeding. The closer these items are to personnel areas, the more the potential pest problem there is likely to be. The large machinery tyres that are used to define roads and those in storage yards are particular problems because of the considerable volume of water that they can hold. In addition any tyres or other machinery that has been transported from Queensland poses the risk of importing the exotic dengue fever mosquito *Ae. aegypti*. All artificial containers should be either stored under cover, disposed of by land fill or otherwise rectified so that they can not retain rain water. Large machinery tyres could be filled with earth or be holed to prevent pooling.

4.3.5 Retention dams and water storage

Large retention dams and water storages have a potential to become mosquito breeding sites. However, with attention to the slope of the margins, these structures can largely be made mosquito free. The Morris Dam is not a significant source of mosquitoes because of the relatively steep margins and the lack of vegetation at the margins.

4.3.6 Septic tanks and waste water

Septic tanks and waste water from excess watering of gardens or wash down operations has a large potential to breed a number of mosquito species including *Cx. quinquefasciatus*. Septic tanks in particular have an enormous capacity to breed mosquitoes because of the high organic content and the lack of any biological control organisms. All waste water should be correctly collected, stored and disposed of such that it can not breed mosquitoes. *Cx. quinquefasciatus* is not present in the area at present and a number of precautionary measures such as the elimination of containers holding water and the correct sealing of septic tanks could prevent the introduction or establishment of this species.

4.4 Potential mosquito borne diseases

The most important endemic mosquito borne diseases in the Katherine area are Australian encephalitis and epidemic polyarthritis and Barmah Forest disease (Appendix 1). There is no vaccine against these diseases so the best method of prevention is self protection (Appendix 2). The period of greatest risk is from when *Ae. normanensis* occur in the early "Wet" season until when the numbers of *Cx. annulirostris* reach relatively low levels in the mid "Dry" season.

4.5 Future mosquito monitoring

This monitoring forms the base-line level that can be used to determine if and when any additional mosquito species are introduced to the area and if there are significant rises in the relative numbers of any mosquitoes that could be attributed to the operation of the mine. Monitoring could start again when there is concern that there is an additional problem or when it is thought that there are unseasonal numbers of mosquitoes.

The present base-line data has a limitation in that it is relatively insensitive at once a month and that it covers only one year. The longer the present monitoring is continued, the more sensitive the data will be to detect changes that are not related to rainfall and other natural variations.

5.0 CONCLUSIONS

There were 32 species of mosquitoes detected in the Mount Todd area. Two medically important species, *An. farauti* and *Cx. quinquefasciatus* appear to be absent from the area.

The most abundant species were *Cx. annulirostris* and *Ae. normaniensis*. These two species are potential vectors of a number of arbovirus diseases including Australian encephalitis, epidemic polyarthritis and Barmah Forest disease.

The relative numbers of mosquitoes in the area is closely related to rainfall, with the period of potential pest problems occurring from December to June. There are only minor numbers of mosquitoes at other periods.

The greatest numbers of mosquitoes are likely to be produced in the poorly draining drainage floors of Horseshoe Creek and other small creeks in the vicinity of the plant site.

There are a number of protective and preventative measures that the company can take to reduce the potential of increasing the mosquito problems in the area. One of the most important measures is to educate personnel of the potential problems and the necessary self protection measures.

6.0 Acknowledgements

This base-line monitoring was performed on behalf of Zapopan and their cooperation and ready assistance is gratefully acknowledged. The traps were set and dispatched by Mr. Les Madlinski and Mr. Tom Morris of Zapopan and their willing assistance is particularly acknowledged. Mr. Tom Morris assisted with the field survey in June 1994 and his valuable assistance and comments are gratefully acknowledged. Mr. Morris also supplied the rainfall data from the Conservation Commission ranger station at Edith Falls.

The mosquitoes were all identified by the staff of the Medical Entomology laboratory and the expertise of the senior technical officer Ms. Gwenda Hayes and the technical officers Mr. Ross Nowland and Ms. Kerrith Donnan is gratefully acknowledged. A special acknowledgement is given to Ms. Gwenda Hayes who prepared the graphs and tables of the results.

FIGURE 1

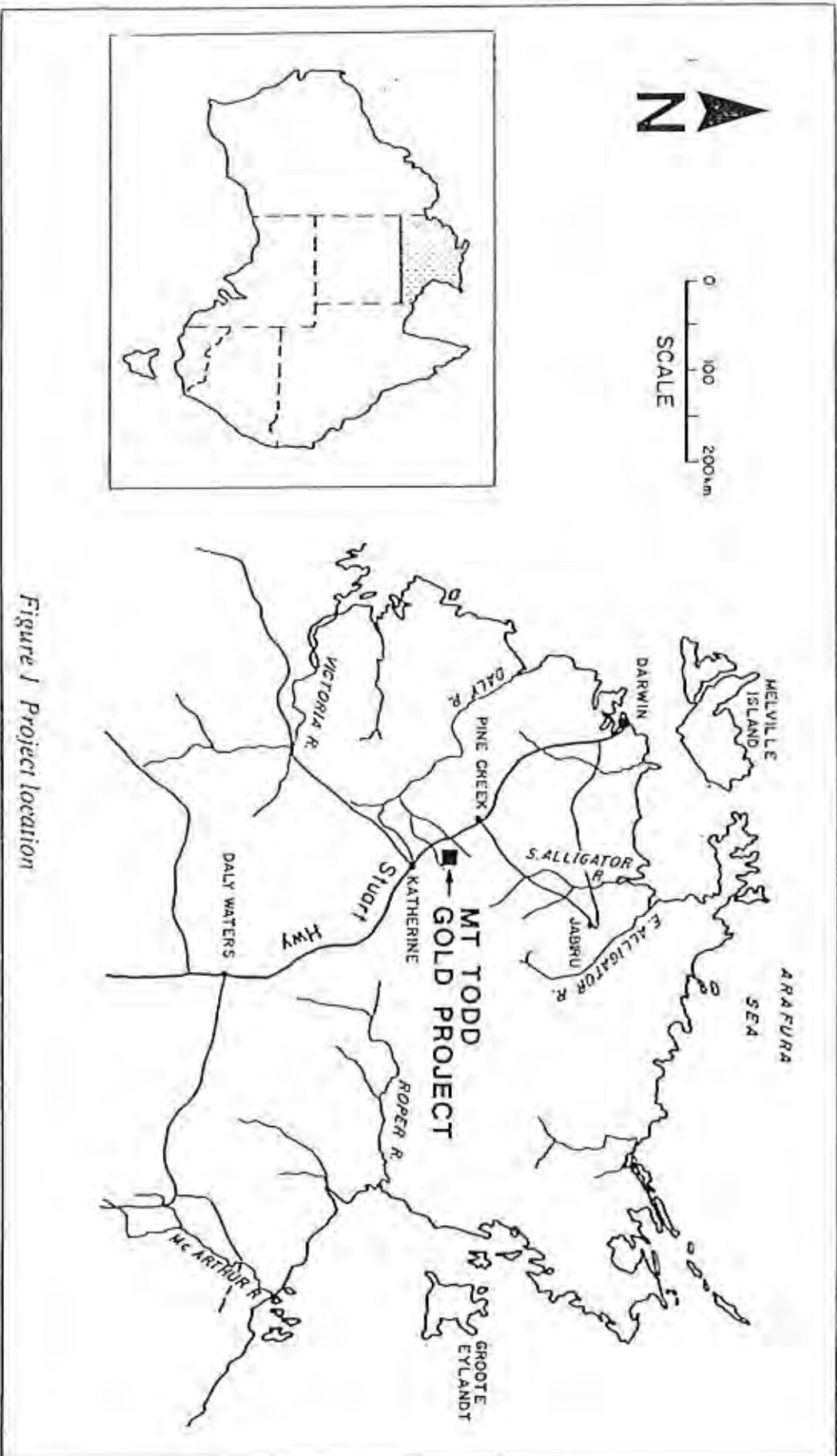
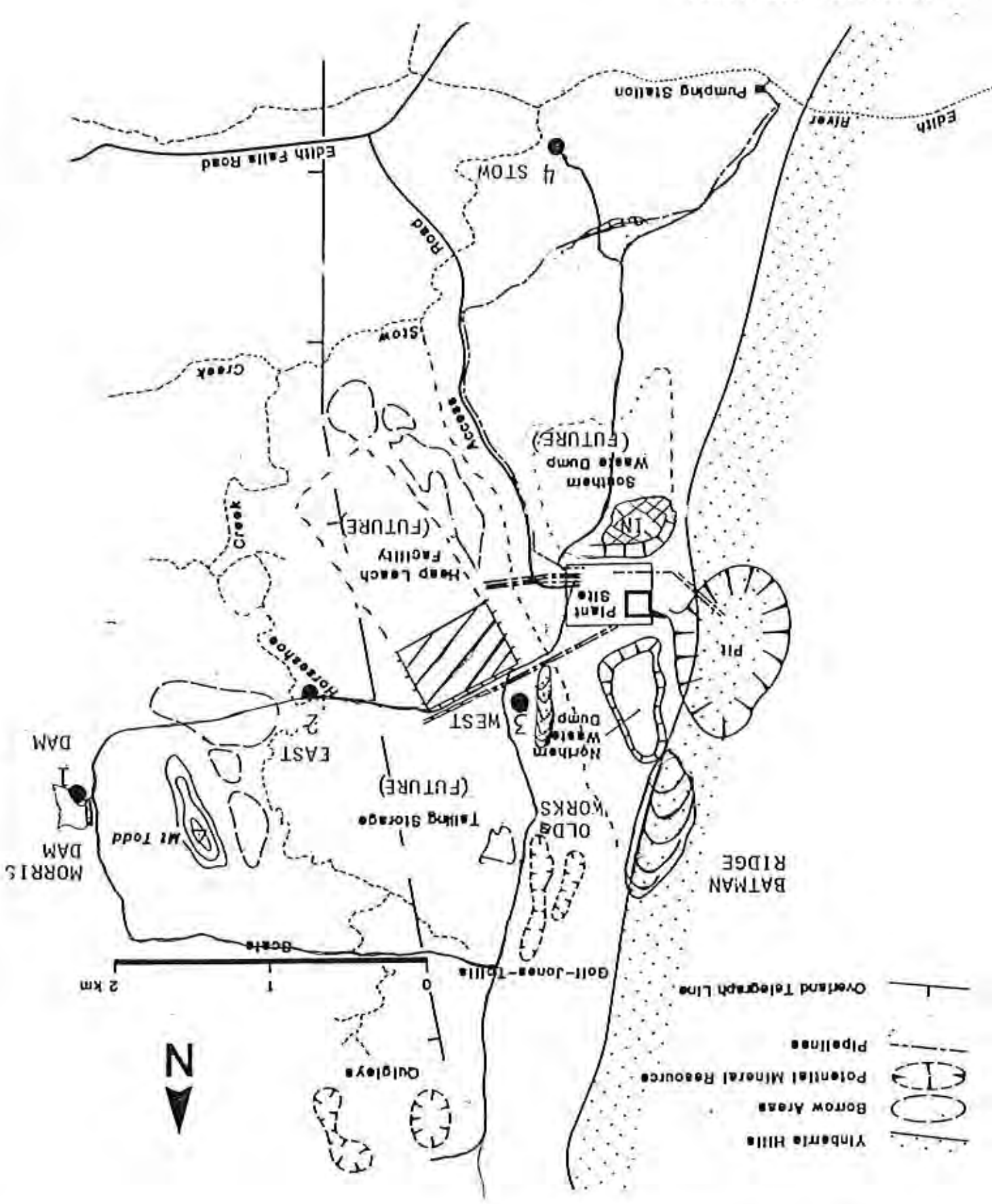


Figure 1 Project location

FIGURE 3 ADULT MOSQUITO TRAP SITES MT TODD



MOSQUITO TRAP SITES

- 1 MORRIS DAM
- 2 TAILINGS DAM EAST
- 3 TAILINGS DAM WEST
- 4 STOW CREEK

FIGURE 4

MOUNT TODD MOSQUITO MONITORING MARCH 1993 TO JUNE 1994

SELECTED SPECIES AT STOW CREEK

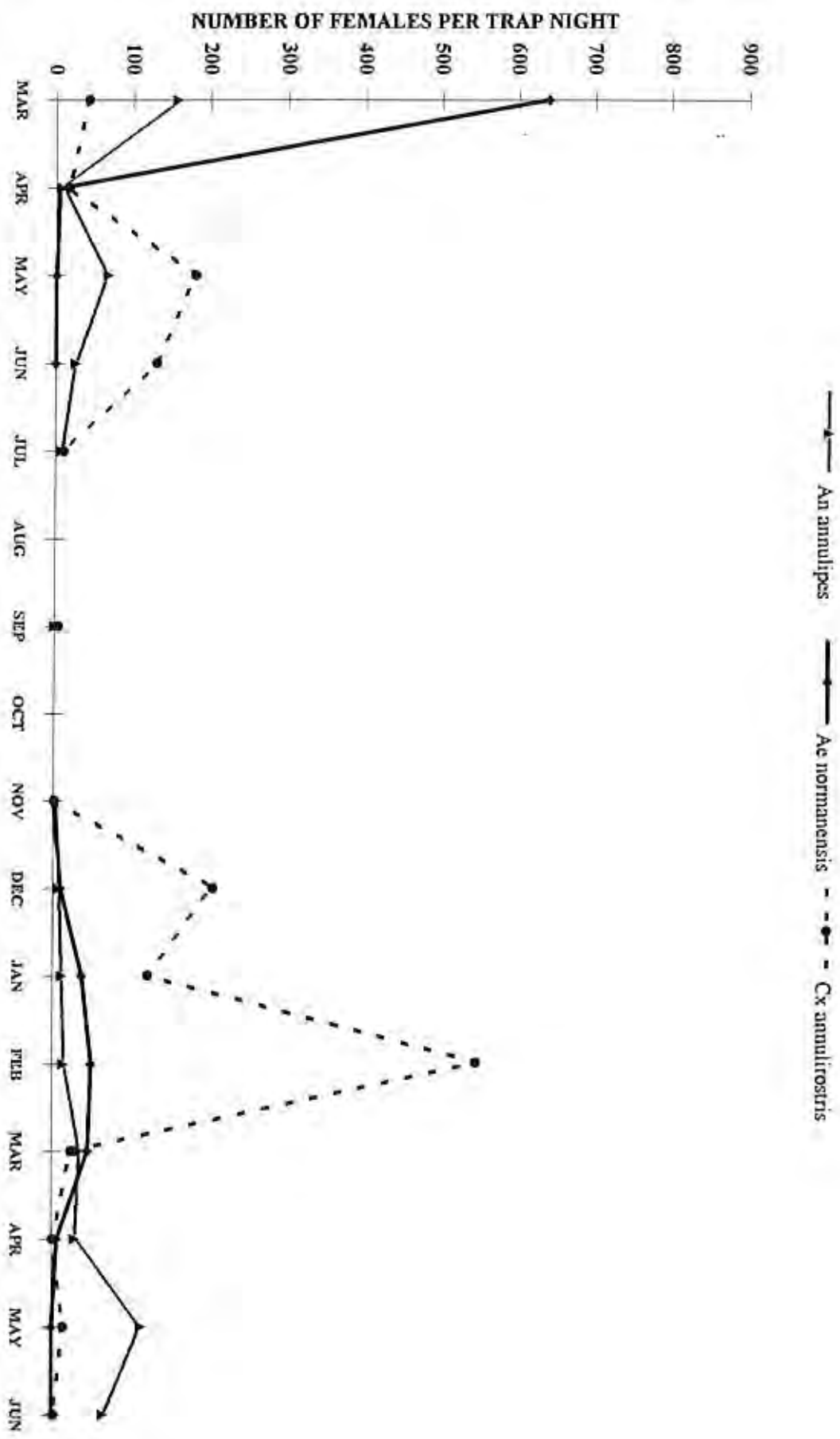


FIGURE 5

MOUNT TODD MOSQUITO MONITORING MARCH 1993 TO JUNE 1994

SELECTED SPECIES AT MORRIS DAM

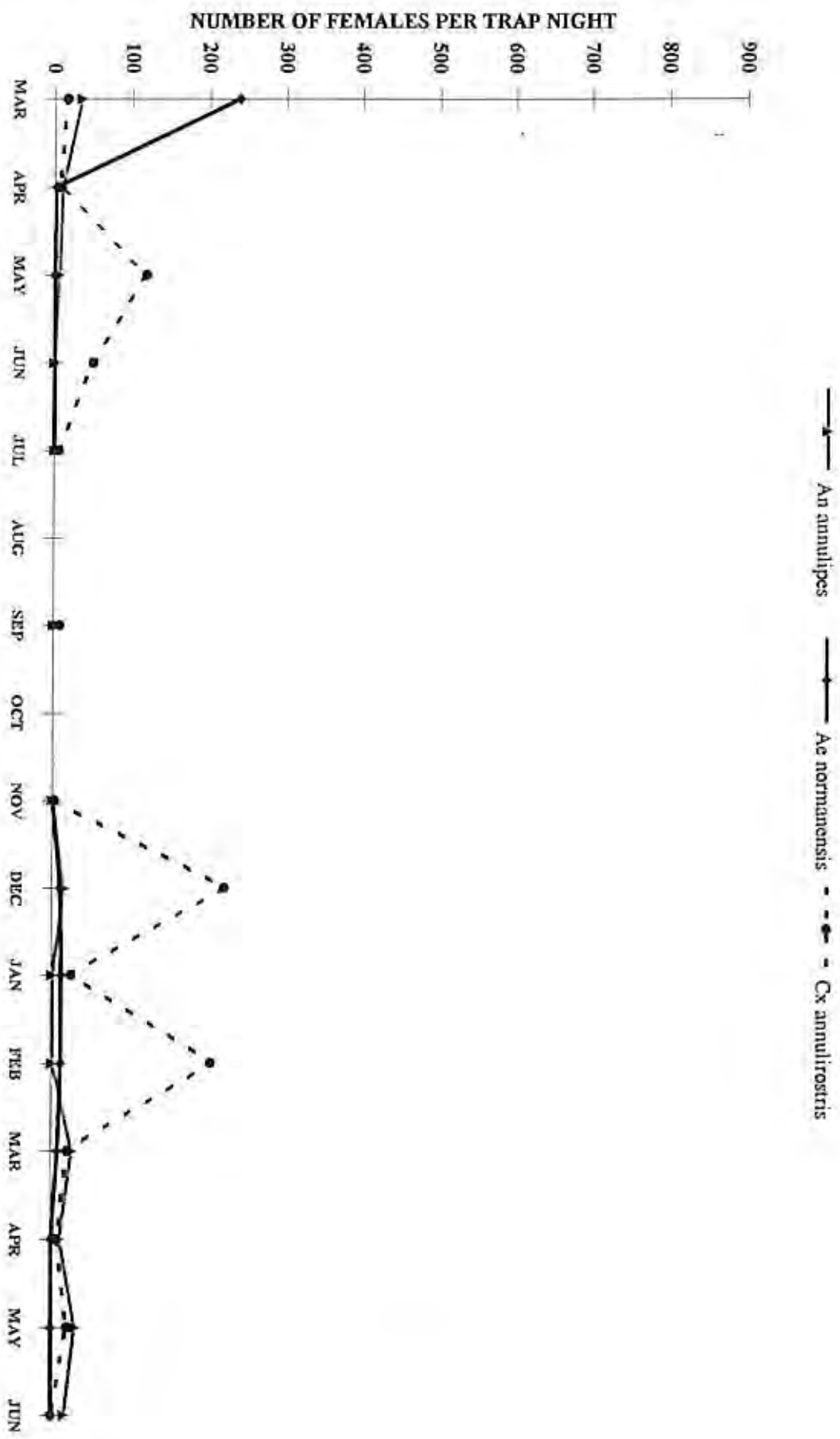


FIGURE 6

MOUNT TODD MOSQUITO MONITORING MARCH 1993 TO JUNE 1994

SELECTED SPECIES AT TAILINGS DAM EAST

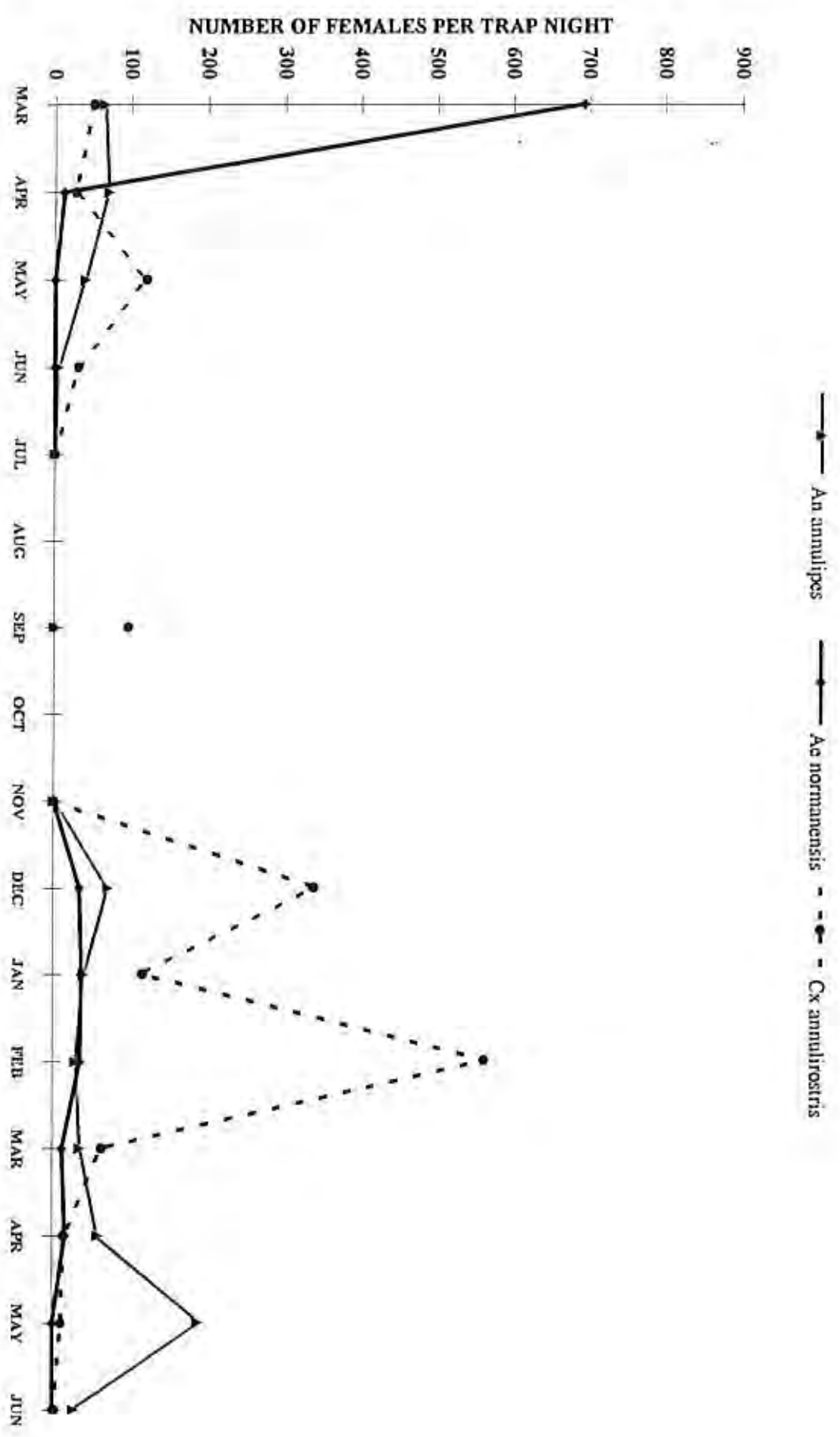


FIGURE 7

MOUNT TODD MOSQUITO MONITORING MARCH 1993 TO JUNE 1994

SELECTED SPECIES AT TAILINGS DAM WEST

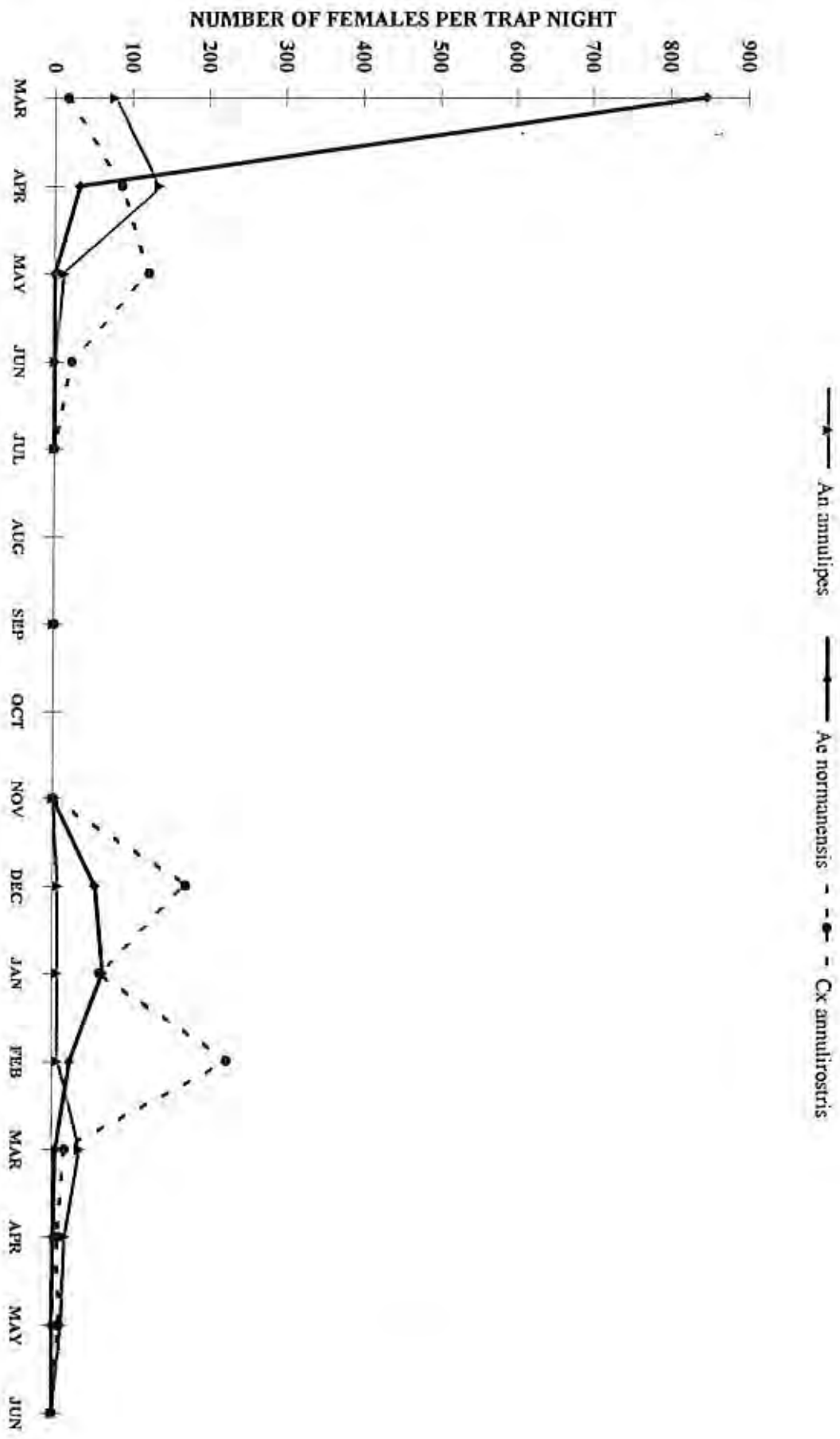


FIGURE 8

EDITH FALLS MONTHLY RAINFALL JAN 1993 TO JUN 1994

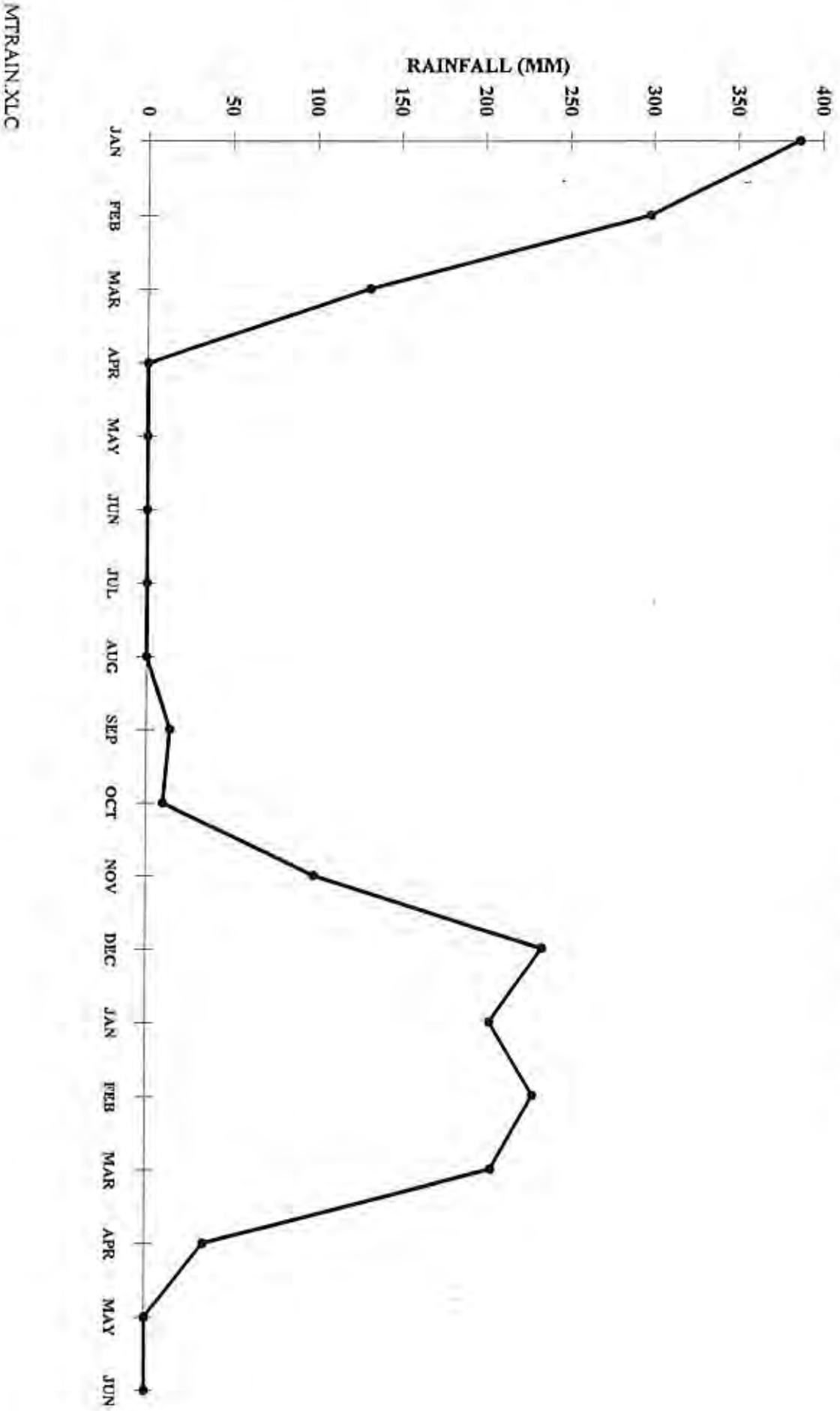


TABLE 1 MOUNT TODD BASE LINE MOSQUITO MONITORING DATA STOW CREEK MARCH 1993-JUNE 1994
 MEDICAL ENTOMOLOGY BRANCH. DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	DATE												TOTAL	%				
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb			Mar	Apr	May	June
An annulipes	157	9	68	26	9	No	No	3	4	8	12	15	36	30	116	67	557	16.90
An amictus			3	14	11	Trap	5	11	3	1	3	4		4	19	2	75	2.28
An bancroftii	2		3	1		Set											11	0.33
An. hilli												2					2	0.06
An merakensis	7		8								2	2	7	7	17	1	51	1.55
An novaguineensis	5	2											2				9	0.27
An powelli																	0	0.00
An (hypomelanic form)	2																2	0.06
Ae alboscutellatus																	0	0.00
Ae alfermans																	0	0.00
Ae brittini												1					1	0.03
Ae elchoensis		22	3	1	1		1		1	8	8	11				2	50	1.52
Ae kochi																	0	0.00
Ae lineatopennis	2																2	0.06
Ae normanensis	639	5	1						10	38	38	51	47	7			798	24.21
Ae notoscriptus	2																2	0.06
Ae pecuniosus	21	3									6						30	0.91
Ae pseudonormanensis																	6	0.18
Ae reesi	45									2	2	2	9				58	1.76
Ae (Och) species 159																	4	0.12
Ae stoneorum										2	2						3	0.09
Ae tremulus	5	7								3	4					1	20	0.61
Ae. vigilax										21	21						47	1.43
Ae. (Mac) sp 76																	0	0.00
Ae. (Mac) sp 125																	0	0.00
Ae. (?) species 160		2	1						1								4	
Ae. (Mac) damaged									1								1	0.03
Cx annulirostris	42	17	181	131	11		5	1	207	123	123	548	25	1	15	2	1309	39.71
Cx bitaenorrhynchus	2											2					4	0.12
Cx pullus	19											9	5	1			34	1.03
Cx starkeae																	0	0.00
Cx Vishnui grp																	0	0.00
Ip punctolateralis																	0	0.00
Cq xanthogaster		1	207	3			3									1	215	6.52
Ma uniformis			1														1	0.03
Ur albescens																	0	0.00
TOTALS	950	68	476	176	32	0	14	0	12	239	215	678	143	50	167	76	3296	99.88
%	28.82	2.06	14.44	5.34	0.97	0.00	0.42	0.00	0.36	7.25	6.52	20.57	4.34	1.52	5.07	2.31	100.00	

TABLE 2 MOUNT TODD BASE LINE MOSQUITO MONITORING DATA MORRIS DAM MARCH 1993-JUNE 1994
 MEDICAL ENTOMOLOGY BRANCH, DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	DATE												TOTAL	%				
	Mar 16	Apr 16	May 14	Jun 18	Jul 20	Aug	Sep 17	Oct	Nov 3	Dec 9	Jan 12	Feb 11			Mar 11	Apr 21	May 26	June 17
An annulipes	35	10	6	1	1	No	No	16	1	1	1	1	27	11	31	17	156	12.06
An amictus	1	1	1	1	1	Trap	Trap	5	3	5				5	3	2	27	2.09
An bancroftii						Set	Set				1						0	0.00
An hilli																	1	0.08
An meraukensis	2		2											2			6	0.46
An novaguinensis	1		1									1					3	0.23
An powelli																	0	0.00
An (hypomelanic form)																	0	0.00
Ac alboscuteellatus																	0	0.00
Ac alternans	1																1	0.08
Ac britteni																	0	0.00
Ac elchoensis	2	2	2	2	2			6	6	6	6	6	2	2	1	1	30	2.32
Ac kochi																	0	0.00
Ac lineatopennis																	0	0.00
Ac normanensis	239	2						11	13	13	12	8					285	22.04
Ac notoscriptus																	0	0.00
Ac pecuniosus	1								1								2	0.15
Ac pseudonormanensis	10												7				17	1.31
Ac reesi																	0	0.00
Ac (Och) species 159	1																6	0.46
Ac stoneorum	4																4	0.31
Ac tremulus	1	1							1	1	4	1				1	4	0.31
Ac. vigilax									2		4	1					12	0.93
Ac (Mac) sp 76										5							0	0.00
Ac (Mac) sp 125																	0	0.00
Ac (?) species 160								3	3								6	0.46
Cx annulirostris	16	7	118	49	6		8	221	25	25	204	20	20	7	20		703	54.37
Cx bitaeniorhynchus																	0	0.00
Cx pullus	1								2	2	3	1	1	1			8	0.62
Cx starkeae																	0	0.00
Cx Vishnu gfp				1													1	0.08
Tp punctolateralis																	0	0.00
Cq xanthogaster			18									1					19	1.47
Ma uniformis			2														2	0.15
Ur albescens																	0	0.00
TOTALS	313	22	150	53	10	0	13	262	58	4.49	17.79	5.49	2.17	4.25	1.62	1293	100.00	
%	24.21	1.70	11.60	4.10	0.77	0.00	1.01	20.26	4.49	0.54	17.79	5.49	2.17	4.25	1.62	100.00		

TABLE 3

MOUNT TODD BASE LINE MOSQUITO MONITORING DATA TAILINGS DAM EAST MARCH 1993 - JUNE 1994
 MEDICAL ENTOMOLOGY BRANCH, DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	DATE												TOTAL	%				
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb			Mar	Apr	May	June
An annulipes	65	70	40	5	0	No	17	No	3	72	41	11	36	59	190	28	636	18.51
An amictus		3	3	3	0	Trap	50	Trap	3	17	3		1	14	13		110	3.20
An bancroftii		2				Set		Set									2	0.06
An hilli																	0	0.00
An merakensis	13	24	13							1	8	2	20	5			86	2.50
An novaguineensis																	0	0.00
An powelli																	0	0.00
An (hypomelanic form)																	0	0.00
Ae albocutellatus	3																3	0.09
Ae alternans	2																2	0.06
Ae britteri	1																1	0.03
Ae eichoensis	3	8	7	1					1	6	9	18	2	2			57	1.66
Ae kochi	3																3	0.09
Ae lineatopennis	3	1										1					5	0.15
Ae normanensis	692	12								35	38	36	13	17			843	24.53
Ae notoscriptus	5	3									1	2					3	0.09
Ae pseudonormanensis	16										1	12		2			23	0.67
Ae reesi											1						6	0.17
Ae (Och) species 159	1																1	0.03
Ae stoneorum	19										3						29	0.84
Ae tremulus																	7	0.20
Ae. vigilax											32	10	6				48	1.40
Ae(Mac) sp. 76											1						1	0.03
Ae(Mac) sp. 125																	0	0.00
Ae (?) species 160										1							1	0.03
Cx annulirostris	51	27	120	31			97			339	117	564	64	15	11	2	1438	41.85
Cx bitaeniorhynchus												4	1				5	0.15
Cx pullus	8	3								1	15	10	6	1			44	1.28
Cx starckeae																	0	0.00
Cx Vishnu gip																	0	0.00
Ip puctolateralis																	0	0.00
Cq xanthogaster			62				2										64	1.86
Ma uniformis																	0	0.00
Ur. albescens																	0	0.00
TOTALS	883	155	245	40	0	0	149	0	4	471	263	701	143	130	221	31	3436	100.00
%	25.70	4.51	7.13	1.16	0.00	0.00	4.34	0.00	0.12	13.71	7.65	20.40	4.16	3.78	6.43	0.90	100.00	

TABLE 4 MOUNT TODD BASE LINE MOSQUITO MONITORING DATA TAILINGS DAM WEST MARCH 1993- JUNE 1994
 MEDICAL ENTOMOLOGY BRANCH, DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	DATE												TOTAL	%				
	Mar 16	Apr 16	May 14	Jun 18	Jul 20	Aug	Sep 17	Oct	Nov 3	Dec 9	Jan 12	Feb 11			Mar 11	Apr 21	May 26	June 17
An annulipes	77	135	12	1	0	No	No			7	6	7	37	17	12		311	11.96
An amictus	1	1	1			Trap	Trap			1		1		9	1	0	15	0.58
An bancroftii						Set	Set										1	0.04
An hilli																	0	0.00
An meruensis		14												3	1		17	0.65
An novaguinensis			1							1			5				8	0.31
An powelli														2			2	0.08
An (hypomelanic form)																	0	0.00
Ae albocutellatus																	0	0.00
Ae alternans	4																4	0.15
Ae brittnei	1													1			2	0.08
Ae elchoensis	9	1	21	10					9	8	30	1	4	4			97	3.73
Ae kochi																	0	0.00
Ae lineatopennis																	0	0.00
Ae normanensis	845	32							55	65	23	5	2				1027	39.50
Ae notoscriptus																	0	0.00
Ae pecuniosus	17	5								3	6						31	1.19
Ae pseudonormanensis	175													8	1		184	7.08
Ae reesi														2			2	0.08
Ae (Och) species 159	4												11				11	0.42
Ae stoneorum													8				12	0.46
Ae tremulus	1	1	1							2	13		5	1			24	0.92
Ae. vigilax										9	7		3				22	0.85
Ae. (Mac) sp. 76										4							4	0.15
Ae. (Mac) sp. 125										4							4	0.15
Ae (?) species 160	1									5	3						9	0.35
Cx annulirostris	17	86	121	22			1		1	172	61	225	16	7	9		738	28.38
Cx bitaeniorhynchus																	0	0.00
Cx pullus											2	5	1				8	0.31
Cx starkae	1																1	0.04
Cx Vishnuu grp																	0	0.00
Ip punctolateralis															1		1	0.04
Cg xanthogaster	1		62														63	2.42
Mia uniformis																	0	0.00
Ur. albescens												2					2	0.08
TOTALS	1150	279	219	34	0	0	0	0	4	253	164	319	97	51	29	0	2600	100.00
%	44.23	10.73	8.42	1.31	0.00	0.00	0.00	0.00	0.15	9.73	6.31	12.27	3.73	1.96	1.12	0.00	100.00	

TABLE 5

MOUNT TODD BASE LINE MOSQUITO MONITORING DATA MARCH 1993 - JUNE 1994

TOTAL NUMBER OF FEMALE MOSQUITOES FROM ALL SITES

MEDICAL ENTOMOLOGY BRANCH. DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	SITE				TOTALS	%
	STOW	WEST	EAST	MORRIS		
An annulipes	557	311	636	156	1660	15.62
An amictus	75	15	110	27	227	2.14
An bancroftii	11	1	2	0	14	0.13
An hilli	2	0	0	1	3	0.03
An meraukensis	51	17	86	6	160	1.51
An novaguinensis	9	8	0	3	20	0.19
An powelli	0	2	0	0	2	0.02
An (hypomelanica form)	2	0	0	0	2	0.02
Ae alboscuteclatus	0	0	3	0	3	0.03
Ae alternans	0	4	2	1	7	0.07
Ae briteni	1	2	1	0	4	0.04
Ae elchoensis	50	97	57	30	234	2.20
Ae kochi	0	0	3	0	3	0.03
Ae lineatopennis	2	0	5	0	7	0.07
Ae normanensis	798	1027	843	285	2953	27.79
Ae notoscriptus	2	0	3	0	5	0.05
Ae pecuniosus	30	31	23	2	86	0.81
Ae pseudonormanensis	6	184	16	17	223	2.10
Ae reesi	58	2	6	0	66	0.62
Ae (Och) species 159	4	11	3	6	24	0.23
Ae stoneorum	3	12	29	4	48	0.45
Ae tremulus	20	24	7	4	55	0.52
Ae. vigilax	47	22	48	12	129	1.21
Ae(Mac) sp. 76	0	4	1	0	5	0.05
Ae(Mac) sp. 125	0	4	0	0	4	0.04
Ae (?) species 160	4	9	1	6	20	0.19
Ae (Mac) damaged	1	0	0	0	1	0.01
Cx annulostris	1309	738	1438	703	4188	39.42
Cx bitaeniorhynchus	4	0	5	0	9	0.08
Cx pullus	34	8	44	8	94	0.88
Cx starkeae	0	1	0	0	1	0.01
Cx Vishnui grp	0	0	0	1	1	0.01
Tp punctolateralis	0	1	0	0	1	0.01
Cq xanthogaster	215	63	64	19	361	3.40
Ma uniformus	1	0	0	2	3	0.03
Ur albescens	0	2	0	0	2	0.02
TOTALS	3296	2600	3436	1293	10625	100
%	31.02	24.47	32.34	12.17	100.00	

TABLE 6

MOUNT TODD BASE LINE MOSQUITO MONITORING DATA MARCH 1993-JUNE 1994

MONTHLY TOTALS OF FEMALE MOSQUITOES FROM ALL SITES

MEDICAL ENTOMOLOGY BRANCH. DEPARTMENT OF HEALTH AND COMMUNITY SERVICES.

MOSQUITO SPECIES	DATE												TOTALS		%			
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr		May	June	
<i>An annulipes</i>	334	224	126	32	10	N	0	N	4	103	60	53	136	117	349	112	1600	15.62
<i>An amictus</i>	2	4	8	18	12	0	60	0	9	34	6	1	1	32	36	4	227	2.14
<i>An banerthi</i>	2	3	3	1	0	0	0	0	0	0	1	4	0	0	0	0	14	0.13
<i>An halli</i>	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	3	0.03
<i>An ineraukensis</i>	22	38	23	0	0	R	0	R	0	0	3	10	9	32	22	1	160	1.51
<i>An novaguineensis</i>	6	2	2	0	0	A	0	A	0	0	1	0	8	0	1	0	20	0.19
<i>An powelli</i>	0	0	0	0	0	P	0	P	0	0	0	0	0	2	0	0	2	0.02
<i>An (dysomelanic form)</i>	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.02
<i>Ae albocinctellatus</i>	0	0	0	0	0	S	0	0	0	0	0	0	0	0	0	0	0	
<i>Ae albocinctus</i>	3	0	0	0	0	E	0	0	0	0	0	0	0	0	0	3	0.03	
<i>Ae algeriensis</i>	7	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.07		
<i>Ae britanni</i>	0	2	0	0	0	0	0	0	0	0	0	1	0	1	0	0	4	0.04
<i>Ae eldredgei</i>	12	33	33	14	3	1	22	31	1	22	31	65	1	8	7	3	234	2.20
<i>Ae kochi</i>	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.03
<i>Ae lanitopani</i>	5	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	0.07
<i>Ae normaniensis</i>	2415	51	1	0	0	0	111	154	0	111	154	122	73	26	0	0	2953	27.79
<i>Ae notoverptus</i>	2	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	5	0.05
<i>Ae pecuniosus</i>	44	11	0	0	0	0	0	5	0	0	5	24	0	2	0	0	86	0.81
<i>Ae pseudonormaniensis</i>	201	0	0	0	0	0	0	0	0	0	0	0	21	1	0	0	223	2.10
<i>Ae reesi</i>	45	0	0	0	0	0	0	3	0	16	3	2	16	0	0	0	66	0.62
<i>Ae (Och) speiseri 139</i>	1	1	0	0	0	0	0	0	0	0	0	0	22	0	0	0	24	0.23
<i>Ae stenostrum</i>	27	0	0	0	0	0	0	5	0	16	5	0	16	0	0	0	48	0.45
<i>Ae tremulus</i>	6	9	1	1	0	0	0	6	0	23	6	23	0	5	1	3	55	0.52
<i>Ae vespilac</i>	0	0	0	0	0	0	0	67	9	0	67	42	11	0	0	0	129	1.21
<i>Ae (Mae) sp 76</i>	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0	5	0.05
<i>Ae (Mae) sp 125</i>	0	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0	4	0.04
<i>Ae (?) species 160</i>	0	3	1	0	0	0	10	6	0	10	6	0	0	0	0	0	20	0.19
<i>Ae (Mae) damaged</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0.01
<i>Cx annularis</i>	126	137	540	233	17	0	111	0	4	939	326	1541	125	30	55	4	4188	39.42
<i>Cx bitaeniorhynchus</i>	2	0	0	0	0	0	0	0	0	0	0	6	1	0	0	0	9	0.08
<i>Cx pallus</i>	28	3	0	0	0	0	0	19	0	1	19	27	13	3	0	0	94	0.88
<i>Cx stuckeae</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.01
<i>Cx Victoria spp</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.01
<i>Ip punctolateralis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cq xanthopygaster</i>	0	2	349	3	0	0	5	0	0	0	0	0	0	0	0	1	361	3.40
<i>Mn uniformis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.03
<i>Ur albescens</i>	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.02
TOTALS	3296	524	1090	303	42	0	177	0	27	1225	700	1928	454	259	472	128	10625	99.98
%	31.02	4.93	10.26	2.85	0.40	0	1.67	0	0.25	11.53	6.59	18.15	4.27	2.44	4.44	1.20	100.00	

Arboviruses, Mosquitoes and Public Health In Australia

by Richard C. Russell
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Arboviruses are viruses transmitted between animal (bird or mammal) hosts and humans by insect vectors such as mosquitoes. Some of these viruses are known to cause major or minor disease in humans. There are a number of arboviruses of public health concern in Australia; the *flaviviruses* Dengue virus (actually a group of 4 related viruses), Murray Valley Encephalitis virus and Kunjin virus, the *alphaviruses* Ross River virus and Barmah Forest virus, and the *bunyavirus* Gan Gan virus, have all been shown to produce a clinical illness of greater or lesser severity.

Dengue viruses cause dengue fever, an acute febrile illness with headache and joint pains, that can appear in a more severe form called Dengue Haemorrhagic Fever that involves internal bleeding and is sometimes followed by severe shock that may have fatal results in children. Dengue fever in Australia is a concern primarily for Queensland because the vector *Aedes aegypti* is found currently only in that state. In recent years many cases of dengue have been seen in northern coastal Queensland, and the situation is one of great public health concern; a single case of haemorrhagic syndrome was reported this year from Charters Towers.

Humans are the reservoir for the dengue viruses, and the mosquito vectors are closely associated with humans and their domestic habitat. *Ae aegypti* is primarily a day-biting mosquito whose larvae are found almost exclusively in clean water in containers such as water tanks, tyres, bottles, tins, and pot-plant bases in and around residential buildings.

Murray Valley encephalitis (MVE) virus and Kunjin (KUN) virus are both causative agents of the syndrome known as Australian encephalitis, potentially a very severe illness, although the latter virus has not to date been incriminated in any of the fatal cases. Although estimates of subclinical rates indicate that only 1 in 500 to 3000 infections will result in encephalitic disease, fatality rates of about 20-30% might be expected amongst these during major epidemics, and many of those that recover will have neurological sequelae resulting in physical and mental disabilities.

There have been no cases of MVE infection in southeastern Australia since the last major outbreak of 1974, although a number of cases have occurred in northern Western Australia, the Northern Territory and northern Queensland in the intervening years. KUN virus has been active intermittently in the north and southeast of the country over the past two decades, and human infections have occurred in the southeast during 1984 and 1991 at least.

MVE virus is thought to be endemic in northern Australia and epidemic in the southeast, although whether it is introduced to the southeast from the north prior to outbreaks or whether it is actually endemic and persists at (currently) undetectable levels of activity in the southeast is not known. There is more evidence that KUN virus is actually endemic in the southeast as well as in the north. Both viruses are thought to be primarily associated with water birds as the vertebrate hosts, and the mosquito *Culex annulirostris*, a riverine freshwater species, is accepted as being the most important vector to humans during epidemic situations although other species may be involved in natural and amplification cycles.

Other flaviviruses are known from Australia, including Kokobera, Stratford, Edge Hill, and Alfuy viruses, and the first-mentioned Kokobera is reported to be responsible for at least a mild illness in humans.

Ross River (RR) virus has become increasingly recognised in recent decades as the cause of annual cases and



Personal Protection From Mosquitoes

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PERSONAL PROTECTION FROM MOSQUITOES

MOSQUITO BITES

Mosquitoes in the Northern Territory can be found from the most arid regions in the Centre, to the hot humid north. In each region, particular species can reach such numbers as to make their bites intolerable to unprotected people. Although the bite itself can be painful and extremely annoying, the reaction to the bite and the possibility of the spread of various viral diseases is cause for concern.

Only a female mosquito bites and this is to take a blood meal, which is necessary for the development of her eggs. Both males and females feed on plant sugars and flower nectar which are their sources of energy.

Mosquitoes show considerable variation in their preference for hosts, with some species feeding selectively on either cattle, horses, marsupials, birds or man.

The time of feeding varies for different species. Many mosquitoes feed just after sunset while others are more active later in the night, or in the afternoon or morning.

The place of feeding is varied, with 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 bites, fine stylets sheathed in the proboscis are inserted into the skin and while sucking blood through a channel in the stylets, saliva is injected down an adjacent channel. This saliva contains substances that the human body recognises as foreign and stimulates a reaction. Sometimes the saliva can contain pathogenic viruses 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 mosquito 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.

Mosquitoes create problems in the enjoyment of outdoor activities, causing a reluctance to enter certain areas after sundown or forcing people to be confined to mosquito-proof areas at certain times of the year. Mosquito bites on stock or domestic animals can cause loss of production or severe irritation to the animals. Personal protection measures can offer considerable protection from mosquito bites, as well as offering protection against mosquito-borne disease.

SCREENING

The best method of avoiding mosquito attack at night is to stay inside insect-screened houses. Screens can be made of galvanised iron, copper, bronze, aluminium or plastic. Near the ocean, iron or copper screens are not recommended because of the corrosive action of salt sprays. Screens should be of the correct mesh, fit tightly and be in good repair. Mosquitoes frequently follow people into building and for this reason, screen doors should open outward and have automatic closing devices. Insecticides such as permethrin, sprayed on or around screens may give added protection against mosquitoes or biting midges (sometimes incorrectly referred to as sandflies), but care is needed as some insecticides affect screens. If camping out in the Top End of the Northern Territory, it is advisable to use a tent which is mosquito proof.

MOSQUITO NETS

These are useful in temporary camps or in unscreened houses. 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 which 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.

MOSQUITO 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 mosquito entry. Thick clothing or tightly woven material offers protection against mosquito bites. Light coloured, long sleeved shirts and full length trousers are recommended. Sleeves and collars should be kept buttoned and trousers tucked in socks when mosquitoes are biting. Protection is very necessary near areas of salt marsh or mangroves when the salt marsh mosquitoes are abundant during the day, or near large fresh water coastal swamps where the water hyacinth, malaria or common banded mosquitoes may be very abundant and may bite in shaded areas during the day. Protection is also warranted near the large floodplains, rivers or lagoons further inland.

REPELLENTS

Relief from mosquito attack may be obtained by applying certain chemicals to the skin and clothing to repel mosquitoes. Repellents with the chemical diethyl toluamide (DEET) give the best protection. Note that repellents such as Aerogard, which is formulated to repel flies, are not efficient against mosquitoes. Repellents such as Rid, Tropical strength Aerogard, Bushmans or Muskol, with higher amounts of DEET are the most efficient. Repellents are available as a spray, cream or gel. The creams or gels are usually longer lasting than the aerosol formulations. When applied, repellents will prevent mosquito bites from 2 hours to half a day, depending on the species of mosquitoes or the physical activity the wearer is engaged in.

Many repellents effect plastics and care is also needed near the eyes and lips. Protection from mosquito penetration through clothes can be obtained by applying a light application of aerosols containing permethrin to the exterior of clothing.

Electronic ultrasonic repellers do not repel mosquitoes and should not be relied upon for personal protection.

MOSQUITO AVOIDANCE

The sensible approach to mosquito avoidance is the avoidance of areas which are known to have high mosquito activity. In particular, extensive areas of mangroves near salt marsh habitats are to be avoided at night and particularly for a 10 day period, 8 days after the highest spring tide from August to December. When camping or choosing a permanent living site, a distance of at least 1.6 km from areas of extensive mangroves is recommended. Avoid large areas of dense forest near mangroves, large swamps or sluggish, ill defined creeks. Other areas of high mosquito activity are the large, flooded paperbark forests and coastal plains in early to mid dry season. Any creek that empties into the mangroves can be expected to have high mosquito and biting midge numbers at least 2 km upstream from the tidal limit.

If camping or house sites are desired near creeks and rivers, those water bodies which are steep sided, with little marginal vegetation, swiftly running and not arising from or emptying into a nearby swampy area would have a reduced potential for high mosquito numbers. Exposed beaches or cliffs away from mangroves are also preferred sites. In the open forest, sites most suitable to avoid mosquitoes would be on hills or rises at least 2km away from drainage lines or creeks. Camping near congregations of domestic animals will serve to divert

mosquitoes to alternative hosts. Similar considerations can be made when planning residential sites and animal holding areas in the rural situation.

LIGHTING

Many mosquito species are attracted to light and this can cause mosquito problems in the unscreened house or when camping. The use of yellow incandescent bulbs or yellow fluorescent tubes rather than white light will reduce the attractiveness to mosquitoes. An incandescent light placed at a distance from a house or camp can serve to attract mosquitoes to an alternative area.

INSECTOCUTORS AND ELECTRONIC REPELLERS

Electric insect insectocutors utilizing an attracting light have been claimed to kill mosquitoes or clear areas of mosquitoes and thus protect people. These claims have not been substantiated and these devices can not be relied on for protection from mosquitoes. Electronic insect repellents do not offer any protection against mosquitoes.

ADULT MOSQUITO CONTROL

If mosquitoes have entered a screened area they can be knocked down with pyrethrin aerosols. Care should be taken to read the label and ensure it is only a knockdown aerosol suitable for spraying in the air.

Other devices that can be effective at killing and/or repelling mosquitoes include mosquito coils and electric insecticide pads. These devices are only effective in relatively closed areas such as inside buildings or where there are only slight breezes and should be backed up with other measures such as suitable protective clothing.

Large scale mosquito control can be achieved using portable or industrial fog generators, by backpack misters, or by heavy duty ultra-low-volume aerosol generators. The insecticides of choice in these machines is Malathion or Bioresmethrin. Control relies on good access, light vegetation, and light breezes in the right direction. Control will only be temporary and re-invasion of mosquitoes will occur within one to a few hours.

EMERGENCY MOSQUITO AVOIDANCE

Sheltering downwind next to smoky fires can offer considerable protection. Climbing relatively high trees can also offer protection from some species. Other emergency protection measures include coating the skin with mud or burying yourself shallow sand with some form of head protection. If all else fails, keep running. Remember the best forms of protection, and the most comfortable, require an awareness and preparation.

Appendix 2 – Guidelines for preventing mosquito breeding sites associated with mining sites in the NT



Northern
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DEPARTMENT OF HEALTH AND FAMILIES

Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites

Medical Entomology
Centre for Disease Control
Department of Health and Families
Northern Territory Government
Darwin NT
November 2005

Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites

Peter Whelan and Allan Warchot

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 creating 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 creek lines 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 manner that there is no ground surface or water filled receptacle 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 3 – Personal protection from mosquitoes and biting midges in the NT



Northern
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DEPARTMENT OF HEALTH AND FAMILIES

Personal protection from mosquitoes & biting midges in the NT

Peter Whelan AM
Medical Entomology
Centre for Disease Control
Department of Health and Families
Northern Territory Government
October 2010

Personal protection from mosquitoes & biting midges in the NT

P. I. Whelan

Department of Health and Families

October 2010

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 MOSQUITOES AND 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 small capillaries in 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 histamine like 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 northern salt marsh mosquitoes *Aedes vigilax* and various other pest mosquitoes. 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 appreciable rain. Salt marsh mosquito and midge pest calendars are available from the health website

http://www.health.nt.gov.au/Medical_Entomology/index.aspx

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 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 with small dendritic creeks or estuarine areas with muddy banks are potential sources of mangrove 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, drums, fallen palm fronds, pot plant drip trays, plant striking buckets, animal water, garden equipment, plastic sheeting, 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. Fish ponds or ponds used for frogs can be rectified by the addition of a few fish.

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, deltamethrin, bifenthrin, or alpha-cypermethrin 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. Tents can be made more mosquito effective by spraying them inside and out with bifenthrin or alpha-cypermethrin.

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 dipping impregnation with permethrin (Lines et al. 1985) or by spraying them inside and out with bifenthrin, lambda-cyhalothrin or alpha-cypermethrin..

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, loose fitting long sleeved shirts and full-length trousers are recommended. Dark clothing such as dark blue denim or black clothing is much more attractive to salt marsh mosquitoes than white clothing. Many mosquitoes including salt marsh mosquitoes or *Anopheles bancroftii* will bite through tight fitting shirts or pants. 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 good protection, with DEET based repellents the best. Many botanical based products do not offer sufficient protection. Some specific repellent products, such as standard Aerogard, which are formulated to repel flies, are generally not efficient against mosquitoes or biting midges. Brands with DEET such as Rid, Tropical Strength Aerogard, Bushman's, and Muskol, or products with picaridin such as 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 concentrations of DEET greater than 20%. Protection from mosquito penetration through open weave or close fitting 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 gels are best and creams usually last longer than the aerosol formulations. Repellents can prevent bites from 1 to 4 hours, depending on the repellents, the species of biting insect, or the physical activity of the wearer. In general aerosol alcohol based repellents will

only give one hour protection in the tropics so reapplication is necessary. Products labelled low irritant generally mean less active ingredient.

There are some new metofluthrin vapour active pyrethroid spatial repellents on the market where there is passive evaporation from impregnated strips or pads. These have been shown to be very effective in preventing landing or biting of many species of mosquitoes and midges, even in outdoor situations within a close surround of the devices, or within rooms in more enclosed areas.

Insecticide impregnated mosquito coils offer good protection in relatively wind protected areas, while the allethrin pad candle heated mosquito lanterns or gas operated allethrin mosquito protection devices offer excellent protection in patio or veranda or other outdoor situations. Mosquito lanterns or gas powered pad dispensers are cost effective for events such as barbeques or congregations of people, with two or more dispersed around the group to cater for breeze direction. Candle devices need care with the candles, while the gas powered models are safe and effective in situation on boats and vessels. They work best in still or very light breeze conditions.

Electronic insect repellents 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 repellents 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 white light. This can cause pest problems in unscreened houses or when camping. The use of yellow or even better 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 or house or premises they can be knocked down with hand held 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.

There are automatic wall mounted dispensers of aerosol for killing adult mosquitoes or flies that dispense mainly pyrethrins. These are registered for use either indoors or outdoors so care is needed in reading the labels. Generally these dispense aerosol in short bursts every 20 to 40 seconds and can last up to 40 hours before refilling. Outdoors devices need to be in wind protected areas such as verandas and patios.

Other devices that can be effective at killing and/or repelling biting insects include mosquito coils (Charlwood & Jolley 1984) and electric plug in insecticide pads. The plug in pad devices are every effective inside buildings but care is needed in reading the labels. These devices are only effective in relatively protected or closed areas such as patios, inside buildings or where there are only slight breezes. Use of coils in outdoor or unscreened areas 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, bioresmethrin or pyrethrum. 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 may 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 the older residual insecticides such as maldison, or permethrin sprayed as a mist spray to point of run off on building surfaces or nearby vegetation can sometimes give short term (a few days to a few weeks) 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, lambda-cyhalothrin and alpha-cypermethrin that can be used as barrier sprays and provide excellent (up to 6 weeks) protection (Standfast et al 2003, Li et al 2010). These residual insecticides can be applied according to label recommendations with the aid of a garden sprayer for dark coloured walls, fences and solid surfaces on the outside of houses or back pack mechanical misters in a band 1-2 m high on low thick vegetation and shrubbery areas around houses. If there is no vegetation screen, black weed matting or shade cloth 1-2 m high all around fence lines in urban settings can substitute for vegetation as the application surface. Application should be at label rates and made to the point of just before runoff. For vegetation care is needed to apply under leaves as well as on leaves and surfaces. Use of these insecticides can give immediate relief from salt marsh mosquito plagues on a house block scale and the effect should last up to 4 weeks.

Application can be done by householders with appropriate equipment and familiarization with the chemical and provisions and safeguards for use, although generally it is advisable for applications to be done by a licensed pesticide company.

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 crème and topical antihistamine products, and non-proprietary products such as paw paw ointment, tea tree oil, eucalyptus oil, aloe vera gel, ice, or methylated spirits.

Ice packs to the general bite site will usually give immediate relief for painful and itchy bites and swelling or blisters from 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. Some people have had good results from the

application of paw paw ointment following bite reactions in the reducing the itching and aiding the healing process.

Other products for internal application for more general symptoms include oral 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, warnulpu, 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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