Northern Territory Government

DEPARTMENT OF **HEALTH**

Western Desert Resources Roper Bar Iron Ore Mine

Adult mosquito trapping February 2012

Medical Entomology
Centre for Disease Control
Department of Health
Northern Territory Government

March 2012

1 Introduction

Western Desert Resources Limited (WDRL) proposes to construct and operate an iron ore mine within the Roper Bar Iron Ore Province, located in the Gulf Region of the Northern Territory, 50 km inland from the Gulf of Carpentaria at its closest point. The project area is approximately 60km south of the Aboriginal community of Ngukurr (Draft EIS Guidelines. Western Desert Resources Ltd – Roper Bar Iron Ore Project March 2012).

WDRL's exploration tenements in the region total almost 1850km2, and approximately 5000Ha is under Mineral Lease Application (MLA). The tenements contain an estimated resource of 311 million tonnes (Mt). Initial mining is proposed of the high grade deposit located at Areas E South (MLA28264), with 25Mt minable resource and an expected mine life of approximately eight years. (Draft EIS Guidelines. Western Desert Resources Ltd – Roper Bar Iron Ore Project March 2012).

Mine sites have the potential to create or exacerbate mosquito breeding, potentially from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge, 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. Mine sites can also be located in areas of seasonally high mosquito abundance, with associated pest and potential disease problems impacting on the workforce.

As part of the environmental process, all major developments in the NT are required to consider mosquitoes during the preparation of Environmental Impact Statements or Public Environmental Reports, to ensure new development does not create new mosquito breeding sites, and also to protect the health of workers. Medical Entomology, of the Centre for Disease Control (CDC), Northern Territory Department of Health (DOH) was subsequently commissioned by EcOz Environmental Services to conduct a Biting Insect Assessment of the mine site. The biting insect assessment was to include monthly trapping over a 12 month period, and a field investigation to identify actual or potential mosquito breeding sites.

This report outlines the results of the trapping conducted overnight on the 31st January/1st February 2012, as well as a desktop examination of aerial photography. The full biting insect assessment report will be produced after the final trapping is conducted in January 2013.

2 Methods

Adult biting insect traps were set at 4 locations around the proposed mine site on the afternoon of the 31st January 2012, and collected the following morning on the 1st of February 2012 after sunrise. Traps were set by EcOz environmental officers (M. Welch). The traps used were carbon dioxide baited encephalitis virus surveillance (EVS) traps. Each 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 traps were set around chest height and baited with approximately 1kg of dry ice. The GPS co-ordinate of the trap locations was recorded, with trap locations shown in Figure 1. Trap results are shown in Table 1. Trap sites were selected in areas where workers would be present, outside of the final disturbance envelope to allow for future monitoring after the site is developed.

The mosquitoes collected during trapping were killed by freezing and packaged by EcOz environmental officers, and then sent to the Medical Entomology Laboratory in Darwin for identification. Adult mosquitoes were identified with the aid of stereo microscopes and various taxonomic keys.

3 Results

3.1 Adult mosquito trapping 1st February 2012

The adult mosquito trap results are shown in Table 1, with trap locations shown in Figure 1.

Trap Site 1 – This site was located at the proposed process plant, nearby to low lying depressions and floodplains associated with a major drainage area. Trap Site 1 was the most productive trap site, with 345 adult female mosquitoes collected. The most abundant mosquito was the floodwater mosquito *Aedes normanensis,* with 112 adult females collected. Trap Site 1 was the second most productive site for *Ae. normanensis. Culex palpalis* was the next most abundant mosquito at this trap site with 86 adult females collected, with Trap Site 1 being the most productive trap site for this mosquito.

The tree hole breeding mosquito *Aedes elchoensis* was the third most abundant mosquito at Trap Site 1, with 70 adult females collected. Of the other mosquito species collected, the common banded mosquito *Culex annulirostris,* the northern salt marsh mosquito *Aedes vigilax* and the Australian malaria mosquito *Anopheles annulipes s.l.* were important from a pest and potential disease aspect.

Trap Site 2 – This site was located at the exploration camp, and was the third most productive trap site with a total of 242 adult female mosquitoes. The predominant mosquito collected was *Ae. normanensis* (116 females), making Trap Site 2 the most productive site for this species. *Culex palpalis* was the next most abundant species at Trap Site 2, with 43 females collected, followed by *Ae. elchoensis* (35 females). The important mosquitoes *Cx. annulirostris, Ae. vigilax* and *An. annulipes s.l.* were also recorded at Trap Site 2, with Trap Site 2 being the most productive for *An. annulipes s.l.*

Trap Site 3 – This trap was located at the mine camp, and was the second most productive trap site with a total of 278 female mosquitoes. *Aedes elchoensis* was the most abundant mosquito, with 127 females present, followed by *Ae. normanensis* (69 females). *Culex palpalis* was the third most abundant mosquito, with 45 adult females present. The important mosquitoes *Cx. annulirostris, Ae. vigilax* and *An. annulipes s.l.* were also recorded at Trap Site 3.

Trap Site 4, at the airstrip, was a trap fail due to motor failure. The few mossies that were in the trap were *Ae. elchoensis.*

3.2 Desktop examination of potential mosquito breeding sites

The desktop examination was conducted by using high resolution aerial photography from google earth. Figure 1 shows potential mosquito breeding areas that were deduced from examining the aerial photography.

The mine site is approximately 25km from the nearest tidal margins to the northeast, with further extensive tidal areas located approximately 30km to the north of the mine site, and 40km to the south east of the mine site. The presence of minor numbers of *Ae. vigilax* in the traps indicate dispersal from these tidal areas. There are likely to be very productive salt marsh mosquito breeding sites in these tidal areas that could lead to seasonal *Ae. vigilax* problems at the mine site. Depending on the extent of *Ae. vigilax* breeding sites, seasonal pest problems could range from low to high. Future trapping in the late dry season and early wet season should reveal likely seasonal problems if timed correctly. *Aedes vigilax* can fly in pest numbers over 50km from extensive tidal breeding sites.

The large drainage area that runs between the exploration camp and process plant appears to contain large areas of flooplains and poorly draining areas adjacent to the main creeklines. This includes large numbers of shallow ground pools. The poorly draining areas and ground pools are likely to be productive wet season breeding sites for *Ae. normanensis.* Based on the availability of potential breeding sites within and adjacent to the mine lease, it is possible that seasonally high *Ae. normanensis* problems will affect areas of the mine within 2-3km of seasonally flooded areas. The large lagoons to the north of the mine site also contain large floodout areas associated with each lagoon system that are likely to be breeding sites for *Ae. normanensis*.

The potential *Ae. normanensis* breeding sites discussed above could also be potential wet season and early dry season breeding sites for *Cx. annulirostris, Cx. palpalis* and *Anopheles* mosquitoes, particularly those areas with semi-aquatic grasses and reeds. The creeklines themselves could be breeding sites for these mosquitoes where semi-aquatic vegetation is present, mainly during the early dry season but possibly after first flooding in the early wet season when ponding may occur. Once the creeklines begin to flow, there will be no appreciable mosquito breeding. Some *Anopheles* species are also likely to breed in ground pools devoid of vegetation in the late wet season-early dry season. Based on the availability of potential breeding sites within and adjacent to the mine lease, numbers of the above mentioned mosquitoes, in particular *Cx. annulirostris* and *Cx. palpalis,* could reach seasonally high levels.

4 Discussion

4.1 Mosquito breeding sites

The potential mosquito breeding sites within and adjacent to the proposed mine site appear to be extensive. The mosquito breeding sites discussed in Section 3.2 are likely to provide appreciable numbers of pest and disease carrying mosquitoes to the mine site, with the possibility of high seasonal abundance of important mosquitoes such as *Cx. annulirostris* and *Ae. normanensis*. *Culex palpalis* is also likely to be present in seasonally moderate to high numbers. The potential malaria mosquitoes (*Anopheles*) are also likely to be present in appreciable numbers at the mine site. However further adult mosquito trapping and a ground investigation of potential breeding areas would be required to determine actual productivity. Mosquito breeding sites nearby to the proposed mine are likely to be most productive from the wet season to early dry season, while coastal breeding sites affecting the proposed mine are likely to be most productive in the late dry to early wet season.

The second most abundant mosquito collected during the trap night on 31st January/1st February was the mosquito *Aedes elchoensis.* This species is known to breed in tree holes and does bite humans (Lee et al 1982), however due to the limited size of potential breeding sites, it is unlikely to be present in high numbers at the mine site.

Artificial receptacles, such as used tyres, drums, rubbish items, rainwater tanks and other items that can pond water could act as breeding sites for endemic pest and disease carrying mosquitoes, and exotic dengue mosquitoes if an incursion occurs at the mine site. Therefore ponding in artificial receptacles should be prevented by storing them under cover, burying or removing rubbish items, or in the case of used tyres, providing them with drainage holes or filling the tyres with soil. Rainwater tanks should be appropriately screened at the inlet and overflow. The greatest risk of importing exotic dengue mosquitoes would be if items are sourced from North Queensland, if this was to occur then any potential water holding receptacles (mentioned above) that have held water, should be treated with an undiluted bleach solution or a suitable residual insecticide such as alpha-cypermethrin.

4.2 Mosquito pest and disease potential

There are likely to be high seasonal numbers of pest and potential disease carrying mosquitoes at the mine site. All areas of the mine are likely to be affected. The greatest risk period is likely to be during the wet season and early dry season, with periodic peaks starting from 9 days after large rainfall events, and extended peaks occurring during the latter wet season and early dry season when floodplains begin to recede. Further trapping would be required to determine the likely problem periods. Potential pest problems from salt marsh mosquitoes may also occur at the mine site during the late dry season and early wet season, starting around 11-12 days after the monthly high tide or heavy rainfall over the nearest tidal areas. Further trapping would be required to determine the likely problem periods.

Aedes normanensis can be a major pest mosquito, biting during the day in shaded areas, and during the night. It is a potential vector of Ross River virus (RRV), Barmah Forest virus (BFV), and Murray Valley encephalitis virus (MVEV). *Culex annulirostris* and *Cx. palpalis* can be major pest mosquitoes, are potential vectors of RRV, BFV, MVEV and Kunjin virus, and only bite at night. *Anopheles* species mosquitoes will pose a potential risk of malaria transmission, if a person returning from overseas with malaria is bitten by *Anopheles* mosquitoes at the mine site. *Anopheles* species mosquitoes only bite at night, and can be appreciable pest mosquitoes. Tree hole breeding mosquitoes such as *Ae. elchoensis* may cause localised pest problems in areas of uncleared woodland, but is not likely to be a major pest mosquito at the mine site.

Due to the potential for seasonal pest problems and mosquito borne disease transmission at the proposed mine site, staff at the mine site should be advised of appropriate personal protection measures from mosquitoes when problems occur. Further information can be found in Appendix 1 ‘Personal protection from mosquitoes and biting midges in the Northern Territory’. Suitable personal protection would include using personal repellents containing DEET or picaridin, the impregnation of field clothing with permethrin, or the use of outdoor protection devices such as mosquito lanterns or gas powered insecticide vaporisers. Measures should also be taken by the mine to reduce mosquito problems when they occur, such as barrier spraying with a suitable residual insecticide such as alpha-cypermethrin or bifenthrin.

The mosquito problems at Bing Bong Port can be extraordinary high during the wet season (Mosquito Monitoring Program McArthur River Mine 2010/11). Workers would also need to take measures to avoid being bitten by mosquitoes at Bong Bong, while residual barrier insecticide treatments should be applied to outdoor work areas.

4.3 Development aspects

Mine sites have the potential to create or exacerbate mosquito breeding, potentially from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge (ie from pit dewatering), general site disturbance, and waste water disposal, as well as the construction of roads and mine waste dumps. Any artificial receptacle sourced from North Queensland has the potential to introduce the exotic dengue mosquito *Aedes aegypti* into the Northern Territory.

General guidance on how to prevent the creation of mosquito breeding can be found in the Medical Entomology guideline ‘Guidelines for preventing mosquito breeding associated with mining sites in the Northern Territory’, Appendix 2. Specific comments should be sought from Medical Entomology during the design phase of the development, regarding any water holding structure, stormwater drains, water discharge sites and effluent treatment facilities.

As the proposed development would be located near floodplains and shallow creeklines, care should be taken to avoid disruption to natural flow paths. Therefore roads should have appropriate culverts and floodways, and waste rock stockpiles should not be located in drainage lines. Stormwater drains should have appropriate erosion prevention and silt retention structures, to prevent sediment runoff into natural drainage lines. There should be no dry season discharge from the mine site into natural drainage lines or floodplains, otherwise productive dry season mosquito breeding sites could be created.

Any artificial receptacle sourced from North Queensland, such as rainwater tanks, machinery items propped up by used tyres, items wrapped in plastic sheeting, and other items that could pond water, should be inspected for ponding and mosquito larvae. Any items ponding water, or that have previously ponded water, should be treated with an undiluted bleach solution to kill any larvae and mosquito eggs.

There are numerous extensive and productive mosquito breeding sites at Bing Bong Port. These sites have been identified, and where possible should be rectified. See the Mosquito Monitoring Program McArthur River Mine 2010/11 report for further details.

4.4 Limitations

This summary report provides background information on potential mosquito issues that could arise at the proposed mine site, based on the late January/early February overnight adult mosquito trapping, and an inspection of aerial photography. The remainder of the adult mosquito trapping program will provide more concise information on mosquito seasonal abundance and potential pest and disease problems. A ground inspection will provide more concise information on the likely productivity of potential mosquito breeding sites within the vicinity of the mine site. The final baseline biting insect report, to be produced after the final trapping in January 2013, will be the reference biting insect document for this development.

5 References

Draft EIS Guidelines. Western Desert Resources Ltd – Roper Bar Iron Ore Project March 2012. Department of Natural Resources, Environment, the Arts and Sports.

Guidelines for preventing mosquito breeding sites associated with mining sites. Medical Entomology handout, November 2005.

Warchot, A. (2011), 'Mosquito Monitoring Program McArthur River Mine 2010/11', Medical Entomology, NT Department of Health July 2011.

Whelan, P. I. (2010) 'Personal protection from mosquitoes and biting midges in the Northern Territory', Medical Entomology, NT Department of Health.

Figures

Figure 1. Western Desert Resources Roper Bar Iron Ore Project. Adult CO2 biting insect trap locations.

Legend

● Adult CO2 biting insect trap location

0 500 1,000 2,000 3,000 4,000 5,000 Meters

Absolute scale 1:50,000

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Tables

Table 1

WDR Roper Bar Iron Ore Project. Adult mosquito trapping results 1st February 2012

Date collected	1-Feb-2012																																	
	Ad. (Ady) catasticta		*Ae. (?) species 160*		*Ae. (Cha) elchoensis*		*Ae. (Mac) nr species 121*		*Ae. (Mac) species*		*Ae. (Mac) tremulus*		*Ae. (Mol) pecuniosus*		*Ae. (Och) normanensis*		*Ae. (Och) vigilax*		*An. (Cel) annulipes s.l.*		*An. (Cel) novaguinensis*		*An. species (hypomelanic)*		*Cq. (Coq) xanthogaster*		*Cx. (Cux) annulirostris*		*Cx. (Cux) palpalis*		*Trap failure mosquitoes*		**TOTALS**	
Trap location	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	**Total No. of females**	**Total No. of males**
WDR Roper River Iron Ore - Site 1 Process Plant	0	0	1	0	70	7	9	0	0	19	31	0	2	0	112	0	7	0	1	0	0	0	0	0	0	0	26	0	86	0	0	0	**345**	**26**
WDR Roper River Iron Ore - Site 2 Exploration Camp	3	0	3	0	35	3	3	0	0	2	1	0	6	0	116	0	9	0	17	0	1	0	1	0	1	0	3	0	43	0	0	0	**242**	**5**
WDR Roper River Iron Ore - Site 3 Mine Camp	0	0	1	0	127	11	3	0	0	2	4	0	11	0	69	0	4	0	6	0	0	0	0	0	0	0	8	0	45	0	0	0	**278**	**13**
WDR Roper River Iron Ore - Site 4 Airstrip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1		
TOTALS	**3**	**0**	**5**	**0**	**232**	**21**	**15**	**0**	**0**	**23**	**36**	**0**	**19**	**0**	**297**	**0**	**20**	**0**	**24**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**37**	**0**	**174**	**0**			**865**	**44**

Please note: When "Trap failure mosquitoes" and "Not collected" = "1" in the insect species columns, this means that the corresponding trap site was a trap failure or the trap was not set/collected.

Appendix 1

Northern Territory Government

DEPARTMENT OF **HEALTH AND FAMILIES**

Personal protection from mosquitoes & biting midges in the NT

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

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

7.0 ANIMAL DIVERSION

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

8.0 LIGHTING DIVERSION

Many mosquito and biting midge species are attracted to 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, aloevera gel, ice, or methylated spirits.

Ice packs to the general bite site will give usually give immediate relief for painful and itchy bites and swelling or blisters from of mosquitoes and biting midges in particular. The sooner the ice pack is applied after bites or reactions, the better the relief, and can often avoid more intense reactions. 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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Appendix 2

Northern Territory Government

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 creation suitable mosquito breeding sites.

2. Wet land filters

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

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

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

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

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

3. Weirs

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

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

4. Mine Waste Dumps

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

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

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

5. Sediment Traps

- Sediment traps need to be designed where possible to be free draining within a period of 5 days after flooding.
- Sediment traps that can not be free draining within 5 days must be steep sided and have a sloping bottom base to one end, with erosion protection (e.g. reno mattress) at the inflow and overflow facility.
- Sediment traps should be maintained by silt and vegetation removal on an annual basis. There should be a designated and designed access path for silt removal.
- Sediment traps with dry season low flows should be sampled for mosquito larvae monthly in the dry season and appropriate mosquito control programs arranged with the appropriate authority.

6. Borrow Pits

- Borrow pits, costeans or scrapes must be rehabilitated, where possible, such that they do not hold water for a period greater than 5 days. These sites within 5km of urban residential areas must be rehabilitated either by filling or rendering them to be free draining.
- Borrow pits that cannot be rehabilitated must be steep sided, have a sloping floor to one end and have surrounding stormwater catchments directed to the upper end, so that they will fill with silt over time.
- There should be no dry season low flows from storm water drainage directed into borrow pits.

7. Drainage Paths

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

8. Pit Dewatering

- Pit water discharge should be free of silt. Dry season pit water discharge should be directed into a water dam, and not into natural drainage lines or 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 matter 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.