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Proposed strategic aerial control trails of major *Ochlerotatus vigilax* breeding sites that affect Wallaby Beach and Nhulunbuy Township

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1.0 Background

Nhulunbuy is situated in Arnhem Land on the Gove Peninsula, approximately 650km east of Darwin. It is a mining community associated with Alcan Mining. The Nhulunbuy Corporation is responsible for conducting mosquito control operations around Nhulunbuy. Mosquito control includes a combination of larvicide and adult fogging operations that are conducted by a contractor, Dave Suter of Arnhem Land Pest Control and his staff.

A mosquito surveillance program is also conducted in Nhulunbuy by Environmental Health Officers from the Department of Health and Community Services (DHCS) in conjunction with the Medical Entomology Branch (MEB) of DHCS. The program consists of six routine adult Encephalitis Vector Surveillance traps (CO₂ baited light traps) that are located at Wallaby Beach, Buffalo Creek, Rear Jasper, Contractors Village, the Industrial Estate and Nhulunbuy South. These traps are set and collected on a weekly basis and the catch is identified by Medical Entomology Branch staff in Darwin. If the numbers of *Ochlerotatus vigilax* and *Culex annulirostris* go beyond predetermined threshold levels, it triggers recommendations for fogging for adult mosquitoes.

Ochlerotatus vigilax is considered to be the major vector of Ross River virus (RRV) in coastal areas and *Culex annulirostris* is considered to be the major inland vector species for RRV in the NT (Russell 2002, Whelan & Weir 1993). Both of these species have also been implicated as vectors for Barmah Forest virus (BFV) in the NT (Boyd & Kay 2001, Whelan & Hayes 1992). The high seasonal numbers of both of these species, particularly *Oc. vigilax*, raises concerns for the potential for a polyarthritic virus outbreak in Nhulunbuy, similar to the outbreak that occurred in the area in 1992. Ross River virus and BFV outbreaks are commonly associated with seasonal increases in vector abundance (Russell & Kay 2004, Whelan et al. 1997), and the trend of increasing numbers of *Oc. vigilax* detected at Wallaby Beach, Contractors Village and Buffalo Creek highlights this concern.

Since 1993 large peaks of the salt marsh mosquito have been recorded in some of the routine adult traps that are set around the Gove Peninsula. In particular the Wallaby Beach, Contractors Village and Buffalo Creek trap sites (Nhulunbuy Regional Report 2003/04, DHCS). In 2003/04 the average numbers of *Oc. vigilax* adults detected per trap night at these three routine trap sites were: 134.75 at Wallaby Beach, 30.43 at Buffalo Creek and 22.34 at Contractors Village (Table 3). The 2004/05 period has seen two of these trap sites, Wallaby Beach and Buffalo Creek, record their highest average numbers of salt marsh mosquito per trap night for the previous nine years (Table 3).

The Wallaby Beach trap site has consistently recorded the highest average numbers per trap night of *Oc. vigilax*, of the six routine adult trap sites on the Gove peninsula. At Wallaby

Beach, average numbers per trap night of this species have been steadily rising over the past four years, after low levels were recorded in 2000/01 (Table 3 & Fig.1). *Oc. vigilax* numbers at the Wallaby Beach trap site reached the second highest recorded peak in the wet season during the last financial year (Fig. 1). This trend is concerning, and could indicate a possible change in available breeding sites. This could be due to environmental factors, such as an increase in the area of depressions in the SPL 270, leading to larger breeding pools, or to chemical factors, such as a possible build up of resistance to temephos insecticide. With the possibility of the numbers of *Oc. vigilax* becoming worse next financial year, it is important to investigate reasons for the large population spike that occurs at the start of each wet season, and to take appropriate control measures.

2.0 Current Situation

2.1 Breeding Areas near Wallaby Beach (see Fig. 2)

Ochlerotatus vigilax breeds in brackish and saline water and thrive in areas that flood and dry up frequently. The major breeding areas of concern for this species are the Special Lease 270 (reclaimed red mud ponds), Crocodile Creek, Macassar Creek, the Western Mudflats and potentially the upper tidal margins of No-Name Creek and North Creek. Many of these sites are tidally influenced and small hatchings of *Oc. vigilax* can occur after some of the larger spring tides each month. However, the pattern of large hatchings appears to be seasonal, and closely related to the first large rain events of each wet season. This indicates that the rains are flooding depressions in the reclaimed red mud ponds, as well as in some of the nearby upper tidal areas, and creating a large area of breeding sites.

The Special Lease 270 area is of particular importance as this site has numerous large depressions in the landscape, as well as design problems in the drainage system. Large areas of the site are capable of holding water long enough for large-scale salt marsh mosquito breeding to occur after the first monsoonal rains. If there are no further large rain events for a 2 – 4 week period, some breeding areas can dry out and therefore become susceptible to another large hatching. This is due to the fact that *Oc. vigilax* only lay their eggs on drying mud, where they remain until the eggs become flooded and hatch out after the next rain event. The rock lined drains within the lease area have acted as numerous dams, which are capable of holding water in small pools at areas along the drain line after large rain events. As the pools dry out at the end of each wet season and between rain events, the exposed silt offers *Oc. vigilax* an ideal egg-laying habitat.

At the western mudflats, the lower region of Freshwater Creek, at the junction where it meets the mudflats, is a known breeding site for *Oc. vigilax*. This area is a tidally affected breeding site, which is usually accessible for control by quad bike during the wet season. The depressions in the southeastern part of the mudflats are also known to breed *Oc. vigilax* when the *Eleocharis* reed areas around the mangrove margins become flooded after large rains. These areas are inaccessible by quad bike during the wet season.

There are three major known breeding sites at Crocodile Creek that can potentially breed year round on spring tides over 3.4 metres. All of these sites also have the potential to breed after a big rain event, especially the site at the top of the creek system, which overflows into the mangrove margins during the wet season and floods a large adjacent plain of *Eleocharis* reeds.

There are some potential *Oc. vigilax* breeding sites at the top of Macassar Creek, amongst the large stands of brackish fern to the west of Dimbuka Rocks. This site is also a known *Anopheles farauti* sl breeding site (Wilson 2000), and has the potential to provide large hatches of *Oc. vigilax* after the first monsoon rainfalls. There are also three potential salt marsh mosquito breeding sites close to the mouth of the creek, in a series of large mangrove cut-off pools that have formed behind beach dunes, and pool water after large tide events, or large rain events.

2.2 Other Breeding Sites

Two other locations on the Gove Peninsula that have been previously surveyed and identified as major breeding areas for *Oc. vigilax* are, Buffalo Creek and Rainbow Beach (Whelan 1980 & 1981). Mosquitoes breeding at these sites do not affect the Wallaby Beach area, but have the potential to disperse in large seasonal pest numbers into the Nhulunbuy town-ship. Contractors Village is usually more affected by *Oc. vigilax* originating from North Creek or the Western Mudflats.

Buffalo Creek can currently be accessed for effective control of *Oc. vigilax* during the early wet season. Rainbow Creek is more difficult to control, although it's distance from Nhulunbuy, 3km, reduces the numbers of mosquitoes dispersing into the town, compared to Buffalo Creek. Records show that Buffalo Creek and Rainbow Creek do not produce the high numbers of *Oc. vigilax* at the beginning of the wet season that are detected at Wallaby Beach, and therefore Buffalo Creek and Rainbow Beach have not been included in the proposed heli-control operations.

2.3 Current Control Measures

Dave Suter from East Arnhem Pest Control carries out adult vector control operations under the supervision and request from Tony O'Riley of the Nhulunbuy Corporation. Adult mosquito control is initiated and carried out depending on pest threshold levels for the two main vector species *Culex annulirostris* and *Ochlerotatus vigilax* as proposed in a 1995 MEB report (Montgomery & Love 1995). When the number of *Cx. annulirostris* is higher than 100 per trap in the Rear Jasper, Contractors Village or Buffalo Creek routine traps, fogging is carried out once a week in the appropriate breeding or harbourage habitats. These trap sites are used to assess the necessity of adult mosquito control because they are closest to residential areas. For a number higher than 200 per trap, the fogging regime is increased to three times per week. The numbers for *Oc. vigilax* inducing the same fogging frequency are 50 and 100 per trap, respectively.

Tony O'Riley, from Nhulunbuy Corporation, and Dave Suter, from Arnhem Land Pest control carry out larval surveys in liaison with the Medical Entomology Branch. High tides (over 2.9-3.0 m) or substantial rain (in excess of 20 mm in 24 h) determine the need for larval surveys. The breeding sites are visited about 2-3 days after initiation events. Control is carried out using Abate 10SG (temephos) for hand application controlling, and *Bacillus thuringiensis israelensis* when using spray equipment. Larval surveys are limited to areas accessible during the wet season. The Western Mudflats become inaccessible during the wet season and the Nhulunbuy Lagoon, Crocodile Creek and the Special Lease 270 are only accessible from the edges. Larval control is therefore limited to the areas that can be controlled by all terrain vehicle spray equipment.

3.0 Proposed Aerial Control Measures

3.1 Overview

The new Alcan G3 Expansion Project will see an influx of new workers, mostly from southern states, into Nhulunbuy. The workers construction village will be located just inside the south -western borders of the town lease on Arnhem Road and is expected to house up to 1700 workers at the peak of the construction phase.

Due to the large numbers of adult *Oc. vigilax* that are dispersing out of the Wallaby Beach area during the early wet season, there is a potential for an increased incidence of polyarthritic viruses (Ross River virus and Barmah Forest virus) in the area. This concern is based on the fact that many of the new G3 workforce will possibly have little immunity to these arboviruses. One of the major NT vectors of these diseases (Whelan & Weir 1993), the salt marsh mosquito *Oc. vigilax*, is very robust and can disperse up to 50km from breeding sites, although its' highest numbers occur within 5km of breeding sites. It has the potential to occur in extremely high numbers at certain times of the year. This is important when considering that the refinery, Wallaby Beach residential and recreation area and Nhulunbuy township are all within 5km of the major *Oc. vigilax* breeding sites to the west of the township.

There was a previous outbreak of polyarthritic virus disease in the Gove area in 1992, when 180 arbovirus like cases were reported in a five-month period (Whelan & Hayes 1992). This was also the first large outbreak of Barmah Forest virus disease in Australia (Merianos et al. 1992). The MEB investigated the outbreak in an effort to determine the causative agents of the outbreak. It was concluded that *Oc. vigilax* was the probable vector in the early and middle periods of the epidemic, while the later epidemic was probably caused by *Oc. vigilax* and *Cx. annulirostris* (Whelan & Hayes 1992). As well as the significant health risk posed by the high numbers of this mosquito, it is also a major and severe pest species and is a very aggressive day biting species.

Previous and current control methods have not prevented large numbers of *Oc. vigilax* in the Wallaby Beach area. The large population spike of this species usually appears 9 – 10 days after the first monsoon rains (Fig. 1). Access to, and control of, many of the breeding sites is difficult because of wet season access. This applies especially to the Western Mudflats and the Special Lease 270 areas.

It is proposed that an aerial control program of the major mosquito breeding sites surrounding Wallaby Beach be trialled in the 2005/2006 wet season. The aim of the proposed trials is to determine if the large numbers of *Oc. vigilax* emerging after the early monsoon rains can be controlled. To achieve this, treatments will need to be applied in a strategic manner. Historically early rain has been shown to be the major influence on large hatches of *Oc. vigilax* in the Wallaby Beach area. Aerial control treatments, if successful, will be limited to 1 – 3 operations at the beginning of each wet season. The first monsoonal rains will trigger surveys, and if large amounts of *Oc. vigilax* larvae are detected, an aerial control treatment will be conducted. Once the initial hatchings caused by the flooding events at the targeted breeding sites have been controlled, *Oc. vigilax* numbers should show reduced levels compared with previous years, and should remain low if sites are continuously flooded. If the sites become dry, and are re-flooded, additional survey and control operations may need to be carried out. However, it is unlikely that any more than two aerial control treatments will be required during one season.

3.1 Pre-control Survey

It is recommended that before each heli-control operation, an initial ground survey be undertaken 2 days after the triggering rain event. The surveys should focus on the major breeding sites described in the attached tables, and the aim will be to detect the larvae at the 2nd instar stage. During the survey, the breeding areas should be mapped. During control application, the helicopter should be directed to the identified breeding sites by someone familiar with the area, preferably the person that undertook the survey. Breeding sites will need to be controlled before larvae reach the late 4th instar, or pupal stages, in order for the larvicides to act efficiently.

3.2 Control Operations

Laynhapuy Aviation, based in Nhulunbuy, has the helicopter, the required certification and the equipment to apply granular insecticides. The hopper that applies the insecticide has a 0.3 cubic metre capacity and the helicopter, with one hours fuel, can lift up to 300kg of granular product. The swath width of the application equipment is approximately 12 metres. However calibrations with sand will have to be carried out to determine exact application rates and the effective swath widths. The helicopter is equipped with a Trimble Flight 3 DGPS, which is accurate to within 500mm and is capable of recording all flight and application data. This data can be downloaded and applied to aerial photographs of the area in a GIS system at the MEB offices in Darwin to give exact areas of control.

3.3 Post Control Survey

To determine the effectiveness of the control operation it is necessary to conduct a post control survey of the areas where treatment was applied. The best recommended practise for testing the effectiveness of S-methoprene (see Sec. 3.4) is to collect samples of pupae once they have appeared in the treated breeding sites. The pupae should be placed in a petri dish on filter paper moist with water from the breeding site, and then their emergence rates monitored over the next 2 – 3 days in a laboratory or controlled room. If the treatment has been successful the Altosand (see Sec. 3.4) would have affected the pupae's ability to emerge as an adult from the pupal skin. A successful result will be dead pupae or dead adults half emerged from the pupal skin in the petri dish. An unsuccessful treatment will result in adults successfully emerging from the pupal skins in the petri dish.

A threshold level of around 90% mortality should be used as an acceptable level of control. Anything below this level may result in large numbers of adult mosquitoes dispersing out of the breeding area and a re-treatment should be considered. When a growth regulator is used, the collection of accurate data on exactly which areas have been treated is critical. The collection of samples from a small, untreated area during post control surveys may result in a costly and unnecessary re-treatment operation.

3.4 Insecticides

The recommended insecticide for the helicopter application trials is Altosand, an insect growth regulator that releases the active ingredient S-methoprene. The type of insecticide that can be used during the proposed trails is restricted to the granular variety, as the only aerial application equipment available is an under slung bucket (hopper) that is equipped for

granular application. The hopper is currently being used to apply the granular insecticide Amdro, as part of the crazy ant eradication project being conducted in East Arnhem Land. The hopper will have to be re-calibrated for the application of Altosand.

One of the advantages of using a granular treatment is that it minimises drift, reducing the amount of product required and thereby the operational costs. They are also excellent for penetrating vegetation, which will be a factor in Nhulunbuy when treating breeding areas in mangroves and along heavily vegetated watercourses. Altosand is widely used for mosquito control in Australia, and is a commonly applied treatment in aerial control operations.

Another major advantage of Altosand is that it is very cost effective when compared to the two other available granular treatments suitable for aerial application, Abate 10SG and Altosid Pellets, which are comparable in price (See Table 1 & 2). The costs per kilogram for Altosand (\$190 per 20kg) is much less than that of Abate (\$388.91 per 20kg) and Altosid Pellets (\$2171.40 per 20kg). Application rates are also lower for Altosand (3-4kg/Ha) than for Abate (5-10kg/Ha), and the same as the application rates for Altosid Pellets (3-4kg/Ha). Another advantage of Altosand is that unlike Abate, it does not have any non-target effects and has minimal impact on the environment.

Another disadvantage of Abate is that its use could dictate the need for repeated applications after rain or tide events during the week of application. The use of Altosand (active ingredient S-methoprene), which has a residual effect of 7 – 10 days, would allow a longer period of control, and therefore potentially reduce the amount of control operations required.

Abate 10SG has been used extensively for larval control in Nhulunbuy for the previous ten years, raising some resistance concerns (Bell 1989). As part of resistance avoidance, it is recommended to rotate the use of insecticides, integrating the periodic usage of S-methoprene, Abate and *Bti* into Nhulunbuy's mosquito management plans. While there has been no demonstrated effect of mosquito resistance to Abate in Australia, there have been a number of instances of resistance in *Ochlerotatus*, *Culex* and *Aedes* mosquito larvae in other regions of the world (WHO 1992).

4.0 Costing of Proposed Aerial Control Trials (see Table 1 & 2)

4.1 Helicopter and Insecticide Costs

The total proposed control area is 27.93 Ha, calculated from an extrapolation from 40 known breeding, and potential breeding sites located at the SPL 270, Macassar Creek, Crocodile Creek, Western Mudflats, North Creek and No-Name Creek (Table 1 & 2, Fig. 2). The area was calculated by plotting a number of known and potential breeding sites into a GIS, and the sum total area calculated. It is probable that not all of these sites would need to be controlled at the same time during the aerial treatment operations. Estimated costing for the aerial control trials are outlined in Table 1 and 2. The estimates were based on the areas of control, costs of insecticide and helicopter costs. The costs of applying the recommended insecticide, Altosand, have been calculated at the higher recommended application rate of 4kg per hectare. This rate is recommended for control of areas that have high numbers of mosquito larva (>10 per dip), which would apply to the breeding sites being targeted in this trial.

If all proposed areas were controlled in one operation, using Altosand, the total helicopter and insecticide costs are estimated to be \$6337.14. It is estimated that for effective control of the

total potential breeding areas, the volume of Altosand required is approximately 111.72 kg, applied at the higher recommended rate of 4kg per hectare. This weight of insecticide can be easily dispersed from one load of the under slung bucket (capacity 300kg). When compared to Abate 10SG this is a large saving of fuel and flight time, as the Abate application rates and overall estimated product weight is much larger. If all proposed areas were controlled, using Abate 10SG, the total cost is estimated to be \$16,140.57. It is estimated that for effective control of the total potential breeding areas the volume of Abate 10SG required is approximately 279.3kg, applied at the recommended rate of 10kg per hectare.

However it is unlikely that all areas will be breeding simultaneously, and it is more likely that only some of the identified potential breeding sites will need to be controlled. This is due mainly to the fact that the targeted breeding areas are affected differently by rain and tide events. Some breeding area in the Crocodile Creek system become inundated after 3.4 metre tides, while others are only affected by 3.6 metre and above tides (refer MEB Larval Mosquito Survey at Nhulunbuy & Wallaby Beach 2005). Rain also inundates different areas of the SPL 270, with some becoming inundated for most of the wet season (D. Suter, personnel comment).

4.2 Incidental Costs

Other costs to be considered that are not included in Table 1 and 2 are the pre and post control survey expenses (approximately \$520 each), pre-control helicopter familiarisation and GPS acquisition of control areas (approximately 30-60 min, \$600-\$1200), and freight costs for chemicals to be shipped from Darwin to Nhulunbuy by sea (approximately \$200). The pre-control helicopter flight allows the larval surveyor to show the pilot exactly which areas need to be controlled, and these area can be marked on a map for the pilot to refer to during the control phase, or marked with a GPS for reference.

4.3 Total Estimates

Depending on the environmental variables of the early monsoon season, the proposed aerial control operations to reduce high seasonal numbers of the salt marsh mosquitoes around Nhulunbuy could range from \$5,000 - \$15,000. These figures comprise approximately all of the costs of controlling at least the 3 major known breeding areas (SPL 270, Crocodile Creek and the Western Mudflats), a minimum of once (\$5,000) compared with costs for controlling all of the breeding sites a maximum of twice during the wet season (\$15,000). These figures are an approximation only, and until a trial operation has been conducted, it is difficult to accurately estimate all the costs involved.

5.0 Role of the Medical Entomology Branch

The Medical Entomology Branch can offer assistance with the organisation of the trials as well as offering personnel experienced in aerial mosquito control for the trial operations in Nhulunbuy. This will include return travel costs for two MEB staff members to Nhulunbuy after the first monsoonal rainfalls in the 2005/06 wets season. MEB staff can provide assistance to Arnhem Land Pest Control and Laynhapuy Aviation with the pre-control surveys, calibration of application equipment, aerial control operations and post-control surveys. MEB will also provide a review and analysis of the trial based on data collected before, during and after the aerial control trials. All other costs, including insecticide, helicopter hire and pest contractor expenses will need to be met by local stakeholders.

6.0 References

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7.0 List of Figures & Tables

Figure 1: Total Monthly rainfall in relation to *Oc. vigilax* at the Wallaby Beach trap site July 1990 to May 2005.

Figure 2: Potential aerial control areas for salt marsh mosquitoes (*Ochlerotatus vigilax*) on Gove Peninsula.

Table 1: Summary of estimated Abate 10SG insecticide and Helicopter costs for proposed aerial control operations based on an estimated delivery rate of 3Ha/minute.

Table 2: Summary of estimated Altosand insecticide and Helicopter costs for proposed aerial control operations based on an estimated delivery rate of 3Ha/minute.

Table 3: Total average number of female *Ochlerotatus vigilax* caught per trap per year in selected mosquito traps from 1996/97 – 2003/04.

**Figure 1: NHULUNBUY. Total Monthly rainfall in relation to *Oc. vigilax* at the Wallaby Beach trap site
July 1990 to May 2005**

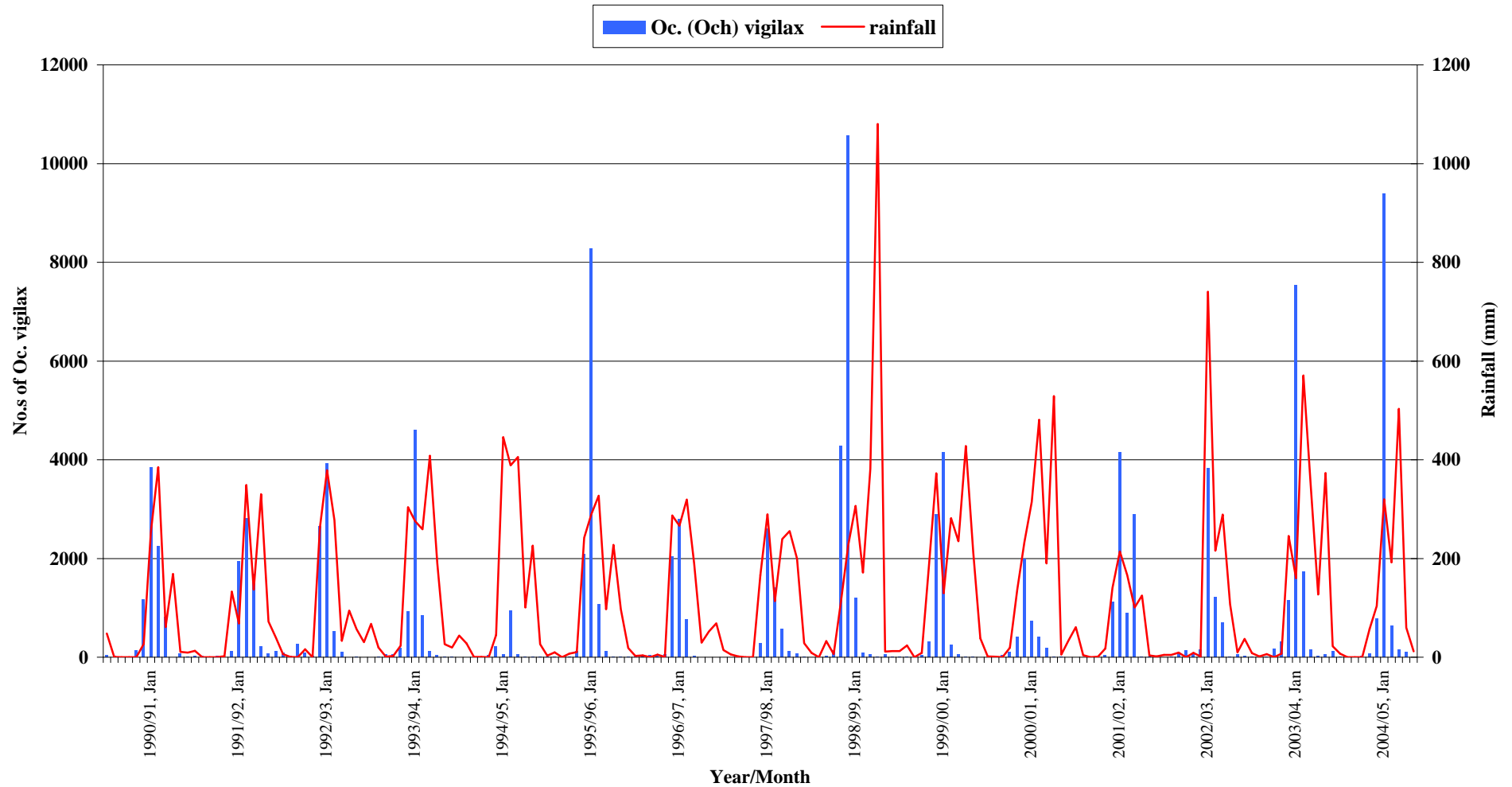


Fig 2: Potential aerial control areas for salt marsh mosquitoes (*Ochlerotatus vigilax*) on Gove Peninsula



TABLE 1 Summary of estimated Abate 10SG insecticide and Helicopter costs for proposed aerial control operations based on an estimated delivery rate of 3Ha/minute													
Control Area ID	Area (m2)	Area (Ha)	Location	Insecticide Type	Recommended Application Rate Kg/Ha	Cost per kg of Abate 10 SG \$/Kg	Calculated insecticide usage per control area (Kg)	Insecticide Costs per control area	Est. Flow Rate of hopper (Ha/min) based on 10kg/ha @ 92km/hr	Heli costs (\$/min) @ rate (\$1200/hr)	Approx Heli time per control area (minutes)	Helicopter costs per control area	Total Helicopter and Insecticide Costs
1	4508	0.45	SPL 270	Abate 10 SG	10	38.90	4.5	\$175.05	3	\$20.00	1.35	\$27.00	\$202.05
2	2794	0.28	SPL 270	Abate 10 SG	10	38.90	2.8	\$108.92	3	\$20.00	0.84	\$16.80	\$125.72
3	4952	0.50	SPL 270	Abate 10 SG	10	38.90	5	\$194.50	3	\$20.00	1.50	\$30.00	\$224.50
4	3130	0.31	SPL 270	Abate 10 SG	10	38.90	3.1	\$120.59	3	\$20.00	0.93	\$18.60	\$139.19
5	840	0.08	SPL 270	Abate 10 SG	10	38.90	0.8	\$31.12	3	\$20.00	0.24	\$4.80	\$35.92
6	2791	0.28	SPL 270	Abate 10 SG	10	38.90	2.8	\$108.92	3	\$20.00	0.84	\$16.80	\$125.72
7	2403	0.24	SPL 270	Abate 10 SG	10	38.90	2.4	\$93.36	3	\$20.00	0.72	\$14.40	\$107.76
8	726	0.07	SPL 270	Abate 10 SG	10	38.90	0.7	\$27.23	3	\$20.00	0.21	\$4.20	\$31.43
9	2556	0.26	SPL 270	Abate 10 SG	10	38.90	2.6	\$101.14	3	\$20.00	0.78	\$15.60	\$116.74
10	9451	0.95	SPL 270	Abate 10 SG	10	38.90	9.5	\$369.55	3	\$20.00	2.85	\$57.00	\$426.55
11	4256	0.43	SPL 270	Abate 10 SG	10	38.90	4.3	\$167.27	3	\$20.00	1.29	\$25.80	\$193.07
12	2122	0.21	SPL 270	Abate 10 SG	10	38.90	2.1	\$81.69	3	\$20.00	0.63	\$12.60	\$94.29
13	4201	0.42	SPL 270	Abate 10 SG	10	38.90	4.2	\$163.38	3	\$20.00	1.26	\$25.20	\$188.58
14	2610	0.26	SPL 270	Abate 10 SG	10	38.90	2.6	\$101.14	3	\$20.00	0.78	\$15.60	\$116.74
15	1298	0.13	SPL 270	Abate 10 SG	10	38.90	1.3	\$50.57	3	\$20.00	0.39	\$7.80	\$58.37
16	555	0.06	SPL 270	Abate 10 SG	10	38.90	0.6	\$23.34	3	\$20.00	0.18	\$3.60	\$26.94
17	15294	1.53	SPL 270	Abate 10 SG	10	38.90	15.3	\$595.17	3	\$20.00	4.59	\$91.80	\$686.97
18	11110	1.11	SPL 270	Abate 10 SG	10	38.90	11.1	\$431.79	3	\$20.00	3.33	\$66.60	\$498.39
19	15322	1.53	SPL 270	Abate 10 SG	10	38.90	15.3	\$595.17	3	\$20.00	4.59	\$91.80	\$686.97
20	21602	2.16	SPL 270	Abate 10 SG	10	38.90	21.6	\$840.24	3	\$20.00	6.48	\$129.60	\$969.84
21	4619	0.46	SPL 270	Abate 10 SG	10	38.90	4.6	\$178.94	3	\$20.00	1.38	\$27.60	\$206.54
22	20741	2.07	SPL 270	Abate 10 SG	10	38.90	20.7	\$805.23	3	\$20.00	6.21	\$124.20	\$929.43
13.79		SPL 270 Total					137.9	\$5,364.31			41.37	\$827.40	\$6,191.71
23	11092	1.11	Crocodile Creek	Abate 10 SG	10	38.90	11.1	\$431.79	3	\$20.00	3.33	\$66.60	\$498.39
24	4510	0.45	Crocodile Creek	Abate 10 SG	10	38.90	4.5	\$175.05	3	\$20.00	1.35	\$27.00	\$202.05
25	21259	2.13	Crocodile Creek	Abate 10 SG	10	38.90	21.3	\$828.57	3	\$20.00	6.39	\$127.80	\$956.37
3.69		Crocodile Creek Total					36.9	\$1,435.41			11.07	\$221.40	\$1,656.81
26	5543	0.55	Western Mudflats	Abate 10 SG	10	38.90	5.5	\$213.95	3	\$20.00	1.65	\$33.00	\$246.95
27	4227	0.42	Western Mudflats	Abate 10 SG	10	38.90	4.2	\$163.38	3	\$20.00	1.26	\$25.20	\$188.58
0.97		Western Mudflats Total					9.7	\$377.33			2.91	\$58.20	\$435.53
28	5677	0.57	North Creek	Abate 10 SG	10	38.90	5.7	\$221.73	3	\$20.00	1.71	\$34.20	\$255.93
29	3678	0.37	North Creek	Abate 10 SG	10	38.90	3.7	\$143.93	3	\$20.00	1.11	\$22.20	\$166.13
30	9743	0.97	North Creek	Abate 10 SG	10	38.90	9.7	\$377.33	3	\$20.00	2.91	\$58.20	\$435.53
31	5483	0.55	North Creek	Abate 10 SG	10	38.90	5.5	\$213.95	3	\$20.00	1.65	\$33.00	\$246.95
2.46		North Creek Total					24.6	\$956.94			7.38	\$147.60	\$1,104.54
32	1620	0.16	No name Creek	Abate 10 SG	10	38.90	1.6	\$62.24	3	\$20.00	0.48	\$9.60	\$71.84
33	3758	0.38	No name Creek	Abate 10 SG	10	38.90	3.8	\$147.82	3	\$20.00	1.14	\$22.80	\$170.62
34	12217	1.22	No name Creek	Abate 10 SG	10	38.90	12.2	\$474.58	3	\$20.00	3.66	\$73.20	\$547.78
35	12576	1.26	No name Creek	Abate 10 SG	10	38.90	12.6	\$490.14	3	\$20.00	3.78	\$75.60	\$565.74
3.02		No name Creek Total					30.2	\$1,174.78			9.06	\$181.20	\$1,355.98
36	1156	0.12	Dimbuka Rocks	Abate 10 SG	10	38.90	1.2	\$46.68	3	\$20.00	0.36	\$7.20	\$53.88
37	842	0.08	Dimbuka Rocks	Abate 10 SG	10	38.90	0.8	\$31.12	3	\$20.00	0.24	\$4.80	\$35.92
38	526	0.05	Dimbuka Rocks	Abate 10 SG	10	38.90	0.5	\$19.45	3	\$20.00	0.15	\$3.00	\$22.45
39	29263	2.93	Dimbuka Rocks	Abate 10 SG	10	38.90	29.3	\$1,139.77	3	\$20.00	8.79	\$175.80	\$1,315.57
3.18		Dimbuka Rocks Total					31.8	\$1,237.02			9.54	\$190.80	\$1,427.82
40	8219	0.82	Black Hole	Abate 10 SG	10	38.90	8.2	\$318.98	3	\$20.00	2.46	\$49.20	\$368.18
0.82		Black Hole Total					8.2	\$318.98			2.46	\$49.20	\$368.18
Total		27.93					279.3	\$10,864.77			83.79	\$1,675.80	\$12,540.57
Note: Additional helicopter flight time will be required for travel to control areas, between control areas and return from control areas. Pilot estimates this time to be approximately 3 hours.													\$3,600
TOTAL													\$16,140.57

TABLE 2 Summary of estimated Altosand insecticide and Helicopter costs for proposed aerial control operations based on an estimated delivery rate of 3Ha/minute

Control Area ID	Area (m2)	Area (Ha)	Location	Insecticide Type	Recommended Application Rate Kg/Ha	Cost per kg of Altosand \$/Kg	Calculated insecticide usage per control area (Kg)	Insecticide Costs per control area \$/area	Est. Flow Rate of hopper (Ha/min) based on 10kg/ha @ 92km/hr	Heli costs (\$/min) @ rate (\$1200/hr)	Approx Heli time per control area (minutes)	Helicopter costs per control area	Total Helicopter and Insecticide Costs
1	4508	0.45	SPL 270	ALTOSAND	4	9.50	1.8	\$17.10	3	\$20.00	1.35	\$27.00	\$44.10
2	2794	0.28	SPL 270	ALTOSAND	4	9.50	1.12	\$10.64	3	\$20.00	0.84	\$16.80	\$27.44
3	4952	0.50	SPL 270	ALTOSAND	4	9.50	2	\$19.00	3	\$20.00	1.50	\$30.00	\$49.00
4	3130	0.31	SPL 270	ALTOSAND	4	9.50	1.24	\$11.78	3	\$20.00	0.93	\$18.60	\$30.38
5	840	0.08	SPL 270	ALTOSAND	4	9.50	0.32	\$3.04	3	\$20.00	0.24	\$4.80	\$7.84
6	2791	0.28	SPL 270	ALTOSAND	4	9.50	1.12	\$10.64	3	\$20.00	0.84	\$16.80	\$27.44
7	2403	0.24	SPL 270	ALTOSAND	4	9.50	0.96	\$9.12	3	\$20.00	0.72	\$14.40	\$23.52
8	726	0.07	SPL 270	ALTOSAND	4	9.50	0.28	\$2.66	3	\$20.00	0.21	\$4.20	\$6.86
9	2556	0.26	SPL 270	ALTOSAND	4	9.50	1.04	\$9.88	3	\$20.00	0.78	\$15.60	\$25.48
10	9451	0.95	SPL 270	ALTOSAND	4	9.50	3.8	\$36.10	3	\$20.00	2.85	\$57.00	\$93.10
11	4256	0.43	SPL 270	ALTOSAND	4	9.50	1.72	\$16.34	3	\$20.00	1.29	\$25.80	\$42.14
12	2122	0.21	SPL 270	ALTOSAND	4	9.50	0.84	\$7.98	3	\$20.00	0.63	\$12.60	\$20.58
13	4201	0.42	SPL 270	ALTOSAND	4	9.50	1.68	\$15.96	3	\$20.00	1.26	\$25.20	\$41.16
14	2610	0.26	SPL 270	ALTOSAND	4	9.50	1.04	\$9.88	3	\$20.00	0.78	\$15.60	\$25.48
15	1298	0.13	SPL 270	ALTOSAND	4	9.50	0.52	\$4.94	3	\$20.00	0.39	\$7.80	\$12.74
16	555	0.06	SPL 270	ALTOSAND	4	9.50	0.24	\$2.28	3	\$20.00	0.18	\$3.60	\$5.88
17	15294	1.53	SPL 270	ALTOSAND	4	9.50	6.12	\$58.14	3	\$20.00	4.59	\$91.80	\$149.94
18	11110	1.11	SPL 270	ALTOSAND	4	9.50	4.44	\$42.18	3	\$20.00	3.33	\$66.60	\$108.78
19	15322	1.53	SPL 270	ALTOSAND	4	9.50	6.12	\$58.14	3	\$20.00	4.59	\$91.80	\$149.94
20	21602	2.16	SPL 270	ALTOSAND	4	9.50	8.64	\$82.08	3	\$20.00	6.48	\$129.60	\$211.68
21	4619	0.46	SPL 270	ALTOSAND	4	9.50	1.84	\$17.48	3	\$20.00	1.38	\$27.60	\$45.08
22	20741	2.07	SPL 270	ALTOSAND	4	9.50	8.28	\$78.66	3	\$20.00	6.21	\$124.20	\$202.86
		13.79	SPL 270 Total				55.16	\$524.02			41.37	\$827.40	\$1,351.42
23	11092	1.11	Crocodile Creek	ALTOSAND	4	9.50	4.44	\$42.18	3	\$20.00	3.33	\$66.60	\$108.78
24	4510	0.45	Crocodile Creek	ALTOSAND	4	9.50	1.8	\$17.10	3	\$20.00	1.35	\$27.00	\$44.10
25	21259	2.13	Crocodile Creek	ALTOSAND	4	9.50	8.52	\$80.94	3	\$20.00	6.39	\$127.80	\$208.74
		3.69	Crocodile Creek Total				14.76	\$140.22			11.07	\$221.40	\$361.62
26	5543	0.55	Western Mudflats	ALTOSAND	4	9.50	2.2	\$20.90	3	\$20.00	1.65	\$33.00	\$53.90
27	4227	0.42	Western Mudflats	ALTOSAND	4	9.50	1.68	\$15.96	3	\$20.00	1.26	\$25.20	\$41.16
		0.97	Western Mudflats Total				3.88	\$36.86			2.91	\$58.20	\$95.06
28	5677	0.57	North Creek	ALTOSAND	4	9.50	2.28	\$21.66	3	\$20.00	1.71	\$34.20	\$55.86
29	3678	0.37	North Creek	ALTOSAND	4	9.50	1.48	\$14.06	3	\$20.00	1.11	\$22.20	\$36.26
30	9743	0.97	North Creek	ALTOSAND	4	9.50	3.88	\$36.86	3	\$20.00	2.91	\$58.20	\$95.06
31	5483	0.55	North Creek	ALTOSAND	4	9.50	2.2	\$20.90	3	\$20.00	1.65	\$33.00	\$53.90
		2.46	North Creek Total				9.84	\$93.48			7.38	\$147.60	\$241.08
32	1620	0.16	No name Creek	ALTOSAND	4	9.50	0.64	\$6.08	3	\$20.00	0.48	\$9.60	\$15.68
33	3758	0.38	No name Creek	ALTOSAND	4	9.50	1.52	\$14.44	3	\$20.00	1.14	\$22.80	\$37.24
34	12217	1.22	No name Creek	ALTOSAND	4	9.50	4.88	\$46.36	3	\$20.00	3.66	\$73.20	\$119.56
35	12576	1.26	No name Creek	ALTOSAND	4	9.50	5.04	\$47.88	3	\$20.00	3.78	\$75.60	\$123.48
		3.02	No name Creek Total				12.08	\$114.76			9.06	\$181.20	\$295.96
36	1156	0.12	Dimbuka Rocks	ALTOSAND	4	9.50	0.48	\$4.56	3	\$20.00	0.36	\$7.20	\$11.76
37	842	0.08	Dimbuka Rocks	ALTOSAND	4	9.50	0.32	\$3.04	3	\$20.00	0.24	\$4.80	\$7.84
38	526	0.05	Dimbuka Rocks	ALTOSAND	4	9.50	0.2	\$1.90	3	\$20.00	0.15	\$3.00	\$4.90
39	29263	2.93	Dimbuka Rocks	ALTOSAND	4	9.50	11.72	\$111.34	3	\$20.00	8.79	\$175.80	\$287.14
		3.18	Dimbuka Rocks Total				12.72	\$120.84			9.54	\$190.80	\$311.64
40	8219	0.82	Black Hole	ALTOSAND	4	9.50	3.28	\$31.16	3	\$20.00	2.46	\$49.20	\$80.36
		0.82	Black Hole Total				3.28	\$31.16			2.46	\$49.20	\$80.36
Total		27.93					111.72	\$1,061.34			83.79	\$1,675.80	\$2,737.14
Note: Additional helicopter flight time will be required for travel to control areas, between control areas and return from control areas. Pilot estimates this time to be approximately 3 hours.													\$3,600
TOTAL													\$6,337.14

TABLE 3:**MOSQUITO MONITORING PROGRAM NHULUNBUY.****AVERAGE NUMBERS OF FEMALE OCHLEROTATUS VIGILAX CAUGHT PER TRAP PER YEAR IN SELECTED MOSQUITO TRAPS FROM 1996/97 - 2003/04.**

TRAP SITE	TOTAL NUMBER OF MOSQUITOES								
	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
Buffalo Creek	7.42	20.73	16.11	10.09	20.34	13.94	13.17	28.60	30.43
Contractors Village	4.85	6.59	7.63	3.99	3.93	41.95	17.06	16.07	22.34
Wallaby Beach	38.46	32.86	105.16	50.40	27.37	68.91	52.03	100.75	134.75