Cobaki Lakes

Biting Midge and Mosquito Control Plan

For

LEDA MANORSTEAD Pty Ltd
Level 1, Cavill Park
46 Cavill Avenue, Surfers Paradise
Qld 4217

14 May 2008

Prepared by

Darryl McGinn
Director and Principal Investigator

Mosquito Consulting Services Pty Ltd
ACN 095 739 067
PO Box 339, Mt Ommaney 4074
Ph./Fax: (07) 33761856
Mobile: 0404043867
e-Mail: mosquitosi@iprimus.com.au
ABN: 16 095 739 067

1.0 Introduction

In May 2007 Leda Manorstead Pty Ltd engaged Mosquito Consulting Services Pty Ltd to provide consulting advice in relation to its development at Cobaki Lakes. The advice was sought in response to the Director General's Requirements responding to Leda's Concept Plan Application. Part 4.4 of the DGR's requires the proponent to address Tweed Shire Council's DCP 25 – Biting Midge and Mosquito Control.

Council's DCP 25 highlights the risks with biting midge and mosquitoes to residential developments generally within the coastal areas of the Tweed Council; guides such development to minimise and control these risks; and is the basis of assessing developments for the suitability of management strategies recommended by the DCP or proposed alternatives. Tweed Shire Council's medical entomologist has been consulted through the preparation of this report with respect to site history, existing biting midge and mosquito risks including the status of mosquito-borne disease transmission, nuisance biting and practical control measures that may appropriately moderate existing and future public health impacts. Consultation with the Northern Rivers Area Health Service of the NSW Health was also undertaken to further assess the public health issues and provide the healthiest outcomes achievable from the opportunity to minimise mosquito-borne disease transmission.

2.0 Cobaki Lakes Development Biting Midge and Mosquito Risk Assessment

2.1 Risk Management Methodology

The biting midge and mosquito risk assessment and management methodology for this strategy was guided by the Australian and NZ standard for risk management AS/NZS 4360. It gives a framework to consider risk in a disciplined approach that can be repeated in the future to evaluate changes in risk and measure outcomes. The risk management framework follows the subsequent basic steps:

- **Identify the Hazard** (Mosquito borne disease, nuisance biting, public complaints)
- **In what Context** (The site's exposure to potential mosquito breeding, the design of the development)
- **Identify the Risks** (as a product of hazard and the likelihood of exposure)
- **Prioritise Risks** (What risks are important,)
- **Control the Important Risks**
- **Evaluate Control Effectiveness.**

2.2 Mosquito and Biting Midge Hazards to Humans

2.2.1 Disease

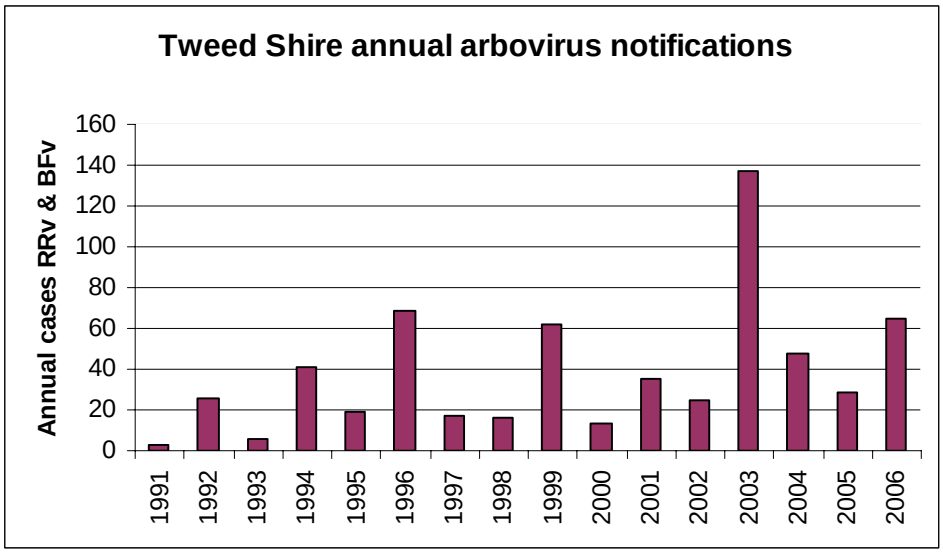
Mosquitos and biting midge are members of the insect order Diptera that contains all of the insects commonly called ‘flies”. A number of individual families (f.) of flies have adapted to existing through biting other animals (including humans) to obtain blood for either regular sustenance and/or to provide high energy resources for producing large batches of eggs as part of their lifecycle. Some familiar examples of these dipteran families include mosquitoes (f. Culicidae), biting midge (f. Ceratopogonidae), stable flies (f. Muscidae), horse flies (f. Tabanidae) and black flies (f. Simuliidae). In Australia, it is mosquitoes that present the greatest risk of vector-borne disease transmission to humans.

It is the mosquito’s need to feed on blood on repeated occasions that create the opportunity for disease causing blood parasites, including several specialised viruses and protozoa, to be transmitted from human carriers to susceptible human hosts. In coastal Australia, several mosquito-borne viruses are of interest but with the most highly represented causing human disease being Ross River virus and Barmah Forest virus. Human malaria caused by transmission of the protozoa *Plasmodium* spp is generally not an issue in present day Australia. New South Wales Health states:

> Human infection with RR virus or BF virus may result in the clinical condition known as polyarthritis. The effects range from a symptomless condition, through a transient rash and mild illness with fever, to polyarthritis affecting chiefly the ankles, fingers, knees, and wrists, but other joints may be affected. The disease is not fatal. For RR virus, symptoms become evident from 3-21 days (average 9 days) after infection, and mild cases may recover in less than one month but many persist for months to years. Recent studies have indicated that the rash may be more florid with BF virus infections but that the arthritic symptoms are greater with RR virus infection. People of working age are most likely to be afflicted with the diseases, whilst symptoms are rare in children. A variety of blood tests are used to demonstrate the presence of specific antibodies to RR and BF virus. Blood samples should be taken during the acute and convalescent phases of the illness, and a fourfold rise in antibody levels will confirm the clinical diagnosis. Specific therapies do not exist to treat the disease; rather it is the symptoms that are alleviated. This includes various analgesics to reduce the pain and fevers, and anti-inflammatory agents for the arthritic symptoms. (Russell and Doggett)

Graph 1 is the yearly record of Ross River virus and Barmah Forest virus notifications in the Tweed Shire. It shows the typically cyclic rise and fall of disease across a number of years. Within each year, most notifications are recorded between March and May. This reflects somewhat the increased mosquito activity resulting from late summer rainfall.

Graph 1: (source Tweed Shire Council)



It is important to note that notifications of mosquito-borne disease are a significant under representation of the actual mosquito-borne infections that occur in the human population. Only infections confirmed by positive blood tests of patients are included in notifications. Cases that are diagnosed by clinical symptoms only or those who do not present at all to a physician are not included in notification data. Furthermore, many infections (>80% generally) in humans are unapparent (i.e. without symptoms) and go unreported. The significance of these however is that the transmission cycle of virus in human-mosquito-human continues to propagate (even sub-clinically) increasing the probability of clinical disease in subsequent infections in other people.

2.2.2 Relevant Mosquito Species

In Australia more than 270 species of mosquito have been described. Many of these species have no involvement with disease transmission to humans. However medical research has identified many species that are implicated in human disease transmission. A number of important species that are abundant to coastal Australia have been shown to be competent vectors of Ross River virus and Barmah Forest virus. The relevant species, for the purposes of this report, are:

- *Aedes (Ochlerotatus) vigilax* (Skuse): The “Salt-marsh Mosquito” breeds in temporary sea-water to brackish ground pools following inundation of coastal wetland by spring tides typically in salt-marsh habitat. Desiccation resistant eggs are deposited by female *Ae vigilax* on drying muddy substrate she instinctive knows will be re-flooded by following tidal or rain-water inundation. Conditioned eggs hatch *en masse* over a wide area in response to tidal flooding and mosquito larvae occupy the temporary

pools and feed on organic matter. Under ideal summer conditions, larvae develop, pupate and adult mosquitoes emerge also *en masse* within 5-7 days of hatching. After a short period when mating and some autoginous egg laying occurs, female *Ae vigilax* begin to disperse from saline breeding sites in search for blood meal. Dispersal over tens of kilometers is common and in high numbers, a pest range of up to 15 km is achievable. Following successful blood feeding and digestion over which time a batch of up to 150-200 eggs are produced, the female seeks suitable habitat to deposit them. The cycle is repeated for the life of the mosquito. Life expectancy is highly variable subject to environmental conditions but may be from a few days to a few weeks. The longer the insect survives, the greater the risk it has acquired virus in a blood meal and is able to transmit to susceptible humans on a subsequent blood feeding. *Ae vigilax* is a highly aggressive biter and is active at dawn, dusk or all day if overcast. In Tweed Sire, it is responsible for almost all complaints from the public received by Council.

- *Culex (Culex) annulirostris* Skuse: This species breeds in fresh water ground pools in grassy pasture/ fields and wetlands. Its eggs are not desiccation resistant and needs existing water on which to lay between 50 – 200 eggs per batch. Non-synchronous breeding is ongoing while suitable conditions exist with continuous presence of all life stages and production of adult mosquitoes. Adult *Cx annulirostris* disperse widely and travel up to 15-20 km in search of blood meal and suitable breeding habitat. This species has a dawn and dusk peak biting period extending well into the night. Where populations are high, biting activity can be highly pestiferous.

- *Verrallina funerea* (Theobald): This species breeds in ground pools of fresh to brackish water typically in *Casuarina* and *Melaleuca* wetland habitat adjoining estuarine environment. Desiccation resistant eggs are deposited around the margins drying ground pools where they mature and hatch in response to subsequent inundation. Adult mosquitoes can emerge in less than one week. *Ve funerea* does not generally disperse far from the vegetated harborage associated with its breeding habitat. It is reluctant to fly over open country. Within its vegetated harborage however it can attack humans and bite in large numbers with such intensity as to make it impossible to remain in these areas without some form of personal mosquito protection.

Biting midge are not considered responsible for direct disease transmission to humans. There are however indirect health impacts caused by the sometimes

intense biting of these insects around estuarine habitat. Both mosquitoes and biting midge secrete saliva containing an anti-coagulant to prevent blood clotting when feeding. The saliva may produce an allergic response in humans (and other animals) sensitive to antigens. Due to the lacerating action of biting midge mouth parts, allowing a relatively large wound to pool blood from which the insect draws its feed, increased action of biting midge saliva often leads to an intense allergic reaction and irritation. The subsequent itch can be very severe. Uncontrolled scratching of bite wounds can lead to secondary infection. This is a particular problem in children and may require medical intervention to treat both the allergy and infections.

2.2.2 Identified Hazards

For this report the identifiable hazards associated with mosquitoes and biting midge are:

- Mosquito-borne disease transmission of Ross River virus and Barmah Forest virus.
- Intense biting activity of mosquitoes and biting midge with potential to generate complaints and negative impacts on a health living environment for humans.
- Indirect health impacts caused by allergic conditions and secondary infections due to exposure to intensive biting midge attack.

2.3 The Context of Cobaki Lakes Relative to Hazards

Between June and August 2007 several site inspections of the Cobaki Lakes site were undertaken to evaluate the presence, extent and mosquito production potential of habitat contained on this land. In addition to physical site inspections by the author, consultation and joint inspection with Mr Clive Easton, Entomologist Tweed Shire Council was undertaken to gather direct site history and experience of mosquito control activities and issues.

2.3.1 Mosquito breeding habitat

Aedes vigilax

The south eastern portion of the site is adjacent to Cobaki Creek and contains low lying pasture created decades ago by clearing of natural *Casuarina* forest. In order to allow drainage of this low lying clearing, several drains were constructed allowing connection with Cobaki Creek. To prevent tidal ingress to the cleared land, tide control devices (flaps) were installed on the main drain (Dunns drain). From time to time the network of constructed drains was not effectively managed to prevent frequent tidal ingress to the cleared land. As a consequence of a long period of more or less regular tidal ingress through constructed drains flooding cleared pasture land, conditions existed that eventually allowed colonisation by salt-marsh vegetation species. Plate 1 shows areas of salt-marsh vegetation

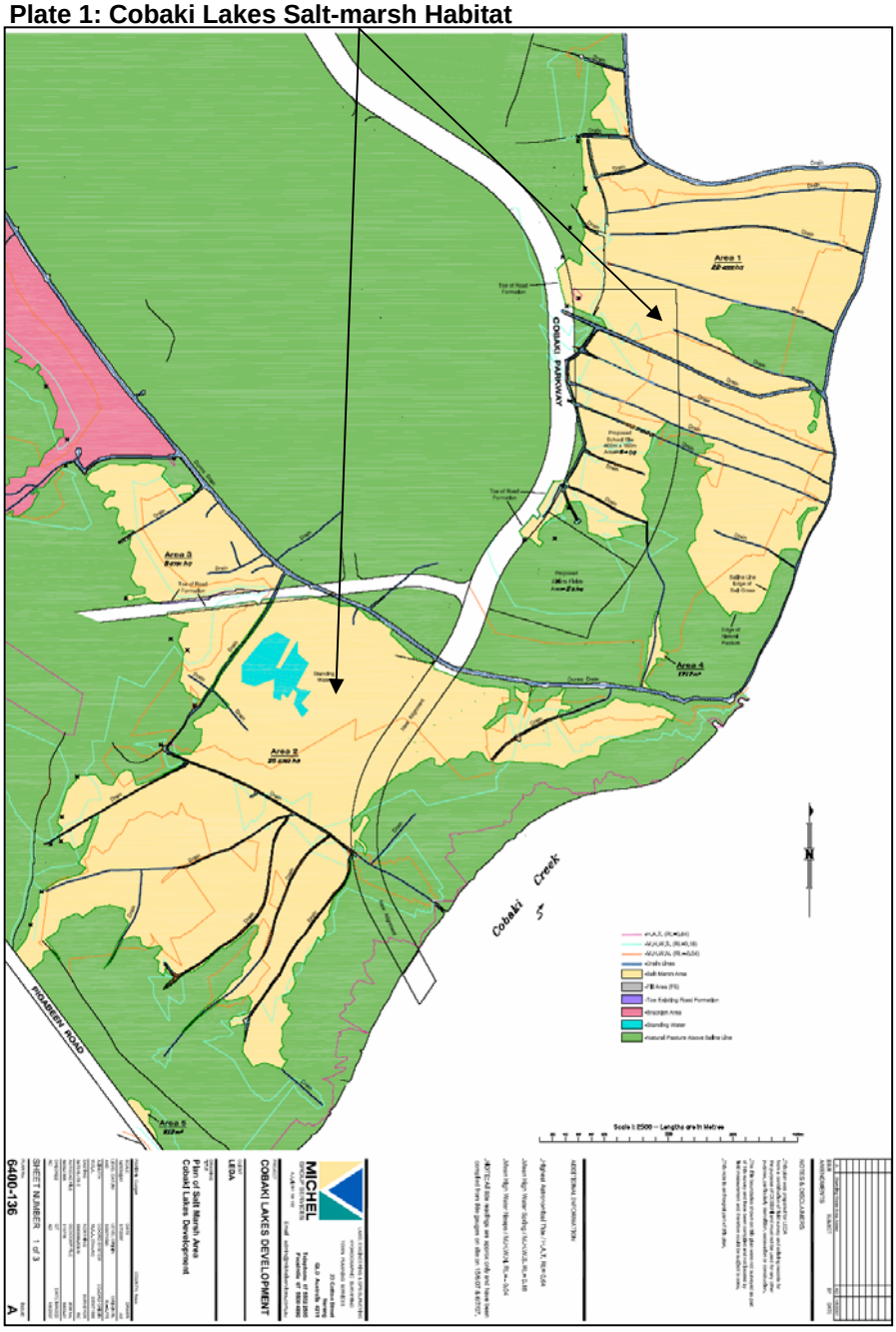
identified on the site. Within this identified habitat much of the land form provides for temporary retention of ground pools following tidal or rainfall inundation of the site. The temporary ground pools are suitable habitat for breeding of *Aedes vigilax*.

Field inspections undertaken following rainfall and tidal inundations of the salt-marsh zones of the site between June and August 2007 confirmed the presence of *Ae vigilax* larvae in temporary saline ground pools within the site. The density of *Ae vigilax* was variable across the site and ranged between one larva per 10 standard water samples (250ml dipper) to 20 larvae per sample. Sampling of larvae in this location by Tweed Shire Council's Entomologist under more productive summer conditions produced larvae densities exceeding 2000 larvae per square meter from time to time. This is consistent with frequent observations of *Ae vigilax* breeding in other salt-marsh locations in Southeast Queensland. The area of *Ae vigilax* breeding on the Cobaki Lakes site, from calculations of the mapped salt-marsh habitat, is 51.4 ha.

Tweed Shire Council estimates that the *Ae vigilax* breeding habitat on Cobaki Lakes represents approximately 80% of such breeding habitat within the northern Tweed including the balance of the Cobaki Broadwater. In addition to *Ae vigilax* breeding on the Cobaki Lakes site being the largest in the area, the breeding productivity of this site is also strongly boosted by the high level of suitability of the habitat due to the action of cattle grazing on the site. Cattle tend to leave many hoof prints in the habitat creating additional ground pools (a single hoof print may contain 100 ++ larvae) as well as high organic content from droppings and vegetation disturbance. It is due to the large area of the Cobaki lakes site and high production of *Ae vigilax* that Tweed Shire Council has previously conducted mosquito control treatments on this site to alleviate mosquito exposure to residents of northern Tweed Shire.

Council has previously provided an aerial spraying program using larvicide to target *Ae vigilax* larvae following site inundation. Aerial application of very short-term acting mosquito larvicide is widely used to control *Ae vigilax* in Queensland, Western Australia and Victoria due to the need to achieve control over extensive areas of salt-marsh (thousands of Ha) within a narrow time window to intercept a rapidly developing synchronous breeding cohort. More recently, fixed wing aerial application of larvicide by Tweed Shire at Cobaki has been curtailed in the air traffic control area of the Gold Coast International Airport due to air space management constraints. Ground based application of larvicides is also available. However the size of the Cobaki Lakes Site overextends the resources of Tweed Shire for regular operations at this location.

Plate 1: Cobaki Lakes Salt-marsh Habitat

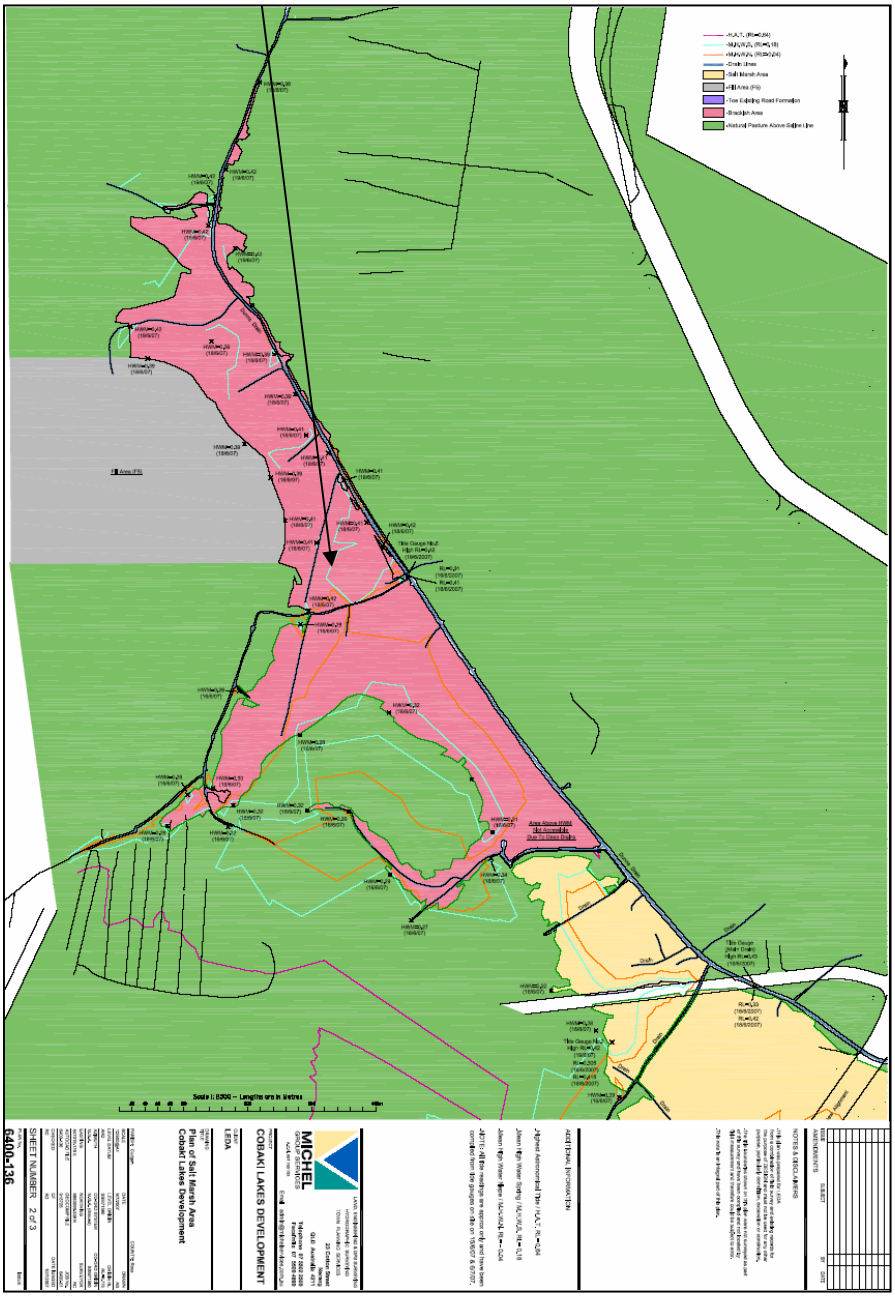


Culex annulirostris

Culex annulirostris breeding habitat consists of freshwater to slightly brackish ground pools typically in grassy pasture like habitat. For the Cobaki Lakes site, many small isolated grassy pools exist following rainfall. A large area of brackish to fresh habitat identified on the flowing map (Plane 2) provides a much more extensive and semi-permanent habitat suitable for production of this species.

Field sampling of the margins of this area discovered moderate production of *Cx annulirostris* at the time. Under favourable seasonal conditions this site may produce very high populations of *Cx annulirostris* (and other freshwater breeding species).

Plate 2: Fresh/Brackish Habitat



2.4 Identification of Risk and Prioritisation

Risk is a function of hazards presented in a given context. The hazards identified by this study include:

- Mosquito-borne disease transmission of Ross River virus and Barmah Forest virus.
- Intense biting activity of mosquitoes and biting midge with potential to generate complaints and negative impacts on a healthy living environment for humans.
- Indirect health impacts caused by allergic conditions and secondary infections due to exposure to intensive biting midge attack.

The context of the Cobaki Lakes development includes:

- The site contains more than 50 ha of highly productive breeding habitat for *Aedes vigilax*.
- The salt-marsh on the site is generally in very poor condition due to the action of cattle causing significant erosion and slumping that is increasing the size and number of ground pools suitable for *Ae vigilax* breeding.
- The site contains a further 10 ha of fresh/brackish wetlands habitat suitable for *Culex annulirostris* breeding.
- The *Ae vigilax* breeding habitat on Cobaki Lakes represents around 80% of such habitat in the northern Tweed.
- *Ae vigilax* and *Cx annulirostris* disperse over distances that overlap with all of the northern Tweed Shire.
- *Ae vigilax* and *Cx annulirostris* are competent vectors of Ross River virus and Barmah Forest virus.
- The New South Wales Government identifies mosquito-borne disease as an issue that requires management.
- Notwithstanding the existing 2007 residential population of the northern Tweed Shire is exposed to vector and biting nuisance species breeding within the Cobaki Lakes site, more than an additional 5,000 residences are planned in close proximity to this breeding habitat representing a highly significant increase for human exposure to mosquito-borne disease.
- Biting midge are not likely to significantly expose future residents to nuisance biting due to proposed separation of habitat and residential zones exceeding biting midge dispersal range.

A prioritised characterisation of mosquito-borne risk for the Cobaki Lakes development therefore lists:

- A significant public health risk caused by *Aedes vigilax* breeding on site exposing existing and future northern Tweed residential populations, recreational visitors and businesses to Ross River virus, Barmah Forest virus with persistent and aggravated biting nuisance.
- A significant public health risk caused by *Culex annulirostris* breeding on site exposing existing and future northern Tweed residential populations,

recreational visitors and businesses to Ross River virus, Barmah Forest virus and occasional biting nuisance.

2.5 Control of High Priority Risks

Management of the public health risks associated with mosquito-borne disease is best achieved using a number of integrated strategies each aimed at minimising exposure of humans to mosquito biting. By controlling human exposure to mosquito biting, disease transmission and biting nuisance will be managed.

Principles of mosquito management (Vic Govt 2004)

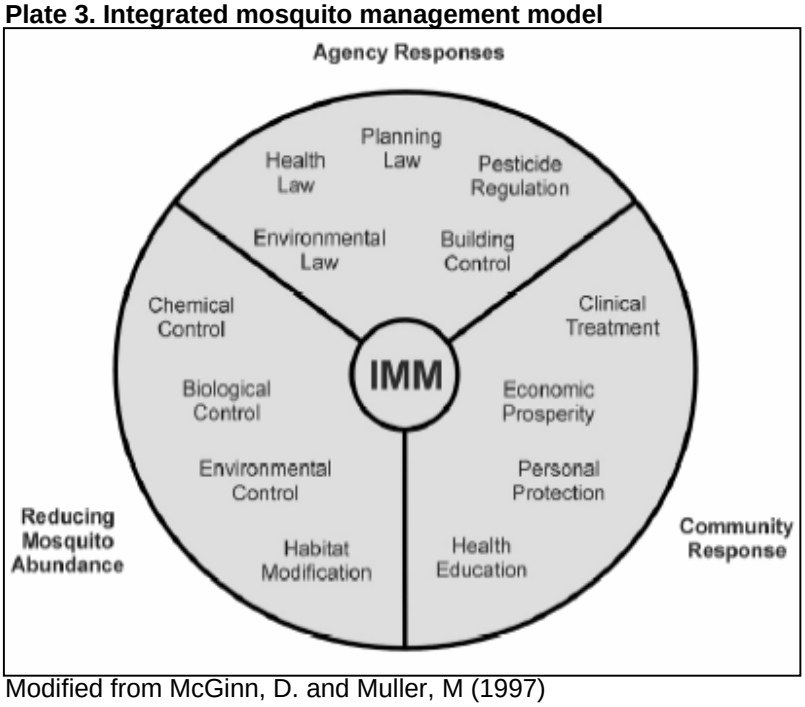
The following list identifies some emerging principles of Integrated Mosquito Management (IMM). Mosquito management attempts to solve existing problems and to prevent or mitigate future problems. IMM includes community involvement and recognises the importance of stakeholder coordination. It locates the use of physical, chemical and biological methods within a broader context of educational and planning strategies.

- Mosquito management involves health, environmental and socio-economic values.
- While disease control is the primary focus, reduction in nuisance value of mosquitoes is a legitimate aspect of improved community well being.
- Mosquitoes are an integral part of the ecosystem and their treatment may have positive and negative environmental impacts.
- Effective mosquito management requires a holistic approach and the cooperation and coordination of all stakeholders.
- Integrated mosquito management includes mosquito reduction, personal protection, community education and land use planning.
- Coordinated programs and on-going monitoring are necessary for effective mosquito management in the long term.
- Treatment of mosquito larvae or adults is an on-going activity.
- Treating larvae is generally more effective and targeted than treating adult mosquitoes.

2.5.2 Promoting integrated mosquito management

Some of the roles, powers and actions of agencies and the community in the IMM process are portrayed in Plate 3.

Plate 3. Integrated mosquito management model



Modified from McGinn, D. and Muller, M (1997)

Notwithstanding the desirability to address each of the elements of the Integrated Mosquito Management model in the broadest context, the developer only has the ability to address issues of mosquito management in the context of an owner on whose land mosquitoes are breeding. The primary focus of a site based mosquito management strategy for the developer is therefore to attempt reduction in mosquito abundance on the site.

A number of constraints and opportunities exist that must be considered as part of developing a site based mosquito management program for Cobaki Lakes. These issues include:

- The site is currently producing very high populations of mosquitoes that effect existing northern Tweed residents, recreational visitors and businesses now.
- There is limited opportunity for Tweed Shire Council to continue to provide an operational mosquito control program on the site indefinitely.
- Short-term opportunity exists for reducing mosquito abundance by Leda Holdings restricting cattle grazing away from *Aedes vigilax* breeding habitat and providing a self-funding mosquito control operation.
- Such a self-funded mosquito control operation is not financially sustainable beyond the current owners responsibility for the land once on-sold or otherwise divested.
- Long-term control of mosquitoes in salt-marsh and fresh/brackish wetlands based on environmental control should be considered.
- For the fresh/brackish wetland habitat producing *Culex annulirostris*, re-engineering of the landform to create urban water bodies also with

stormwater management and water quality improvement functions would be typical. This provides opportunity to include mosquito minimisation within the design criteria for such urban water bodies.

- For salt-marsh habitat producing *Aedes vigilax*, environmentally sensitive modification of the existing habitat is recommended that produces an outcome that discriminates against mosquito breeding but otherwise maintains or enhances salt-marsh environmental functio and value.
- A salt-marsh rehabilitation plan is recommended to guide these modifications and ensure high quality environmental outcomes are achieved while minimising mosquito production.

A site based mosquito management strategy is therefore divided into a short-term operational program that would be expected to continue for less than 5 years while a salt-marsh rehabilitation program is undertaken.

3.0 Proposed Concept for Salt-marsh Rehabilitation and Stormwater Management with Implications for Mosquito Management.

A Salt-marsh Rehabilitation Plan has been developed for the Cobaki Lakes site by James Warren and Associates Pty Ltd (JWA 2008). The JWA Salt-marsh Rehabilitation Plan references and is indeed integrated with the proposed Storm Water Concept Plan for Cobaki Lakes produced by Gilbert and Sutherland Pty Ltd (2008). Both of these plans (read together) succeed previous plans (Wright 2001) for salt-marsh rehabilitation. The current approach is multi-disciplinary and is based on contemporary methods of salt-marsh management to achieve rehabilitation, satisfactory storm water quality standards and effective long-term mosquito management.

The salt-marsh rehabilitation and storm water management concept is intended to be adaptive and evolve in operational practice in response to ongoing monitoring of its performance in achieving rehabilitation and water quality objectives and standards as well as achieving progressive reduction in mosquito production. As such manipulation of water entering the salt-marsh both from tidal source and stormwater will stimulate production of salt-marsh mosquito species in ground pools to a variable extent. Physical manipulation of salt-marsh habitat that occurs within the rehabilitation and stormwater management concepts will also have an influence on availability of suitable salt-marsh mosquito breeding habitat. Concurrent with the adaptation of the rehabilitation and stormwater management processes over time will be an adaptable Site Based Mosquito Management Program.

4.0 Conceptual Site Based Salt-marsh Mosquito Management Strategy.

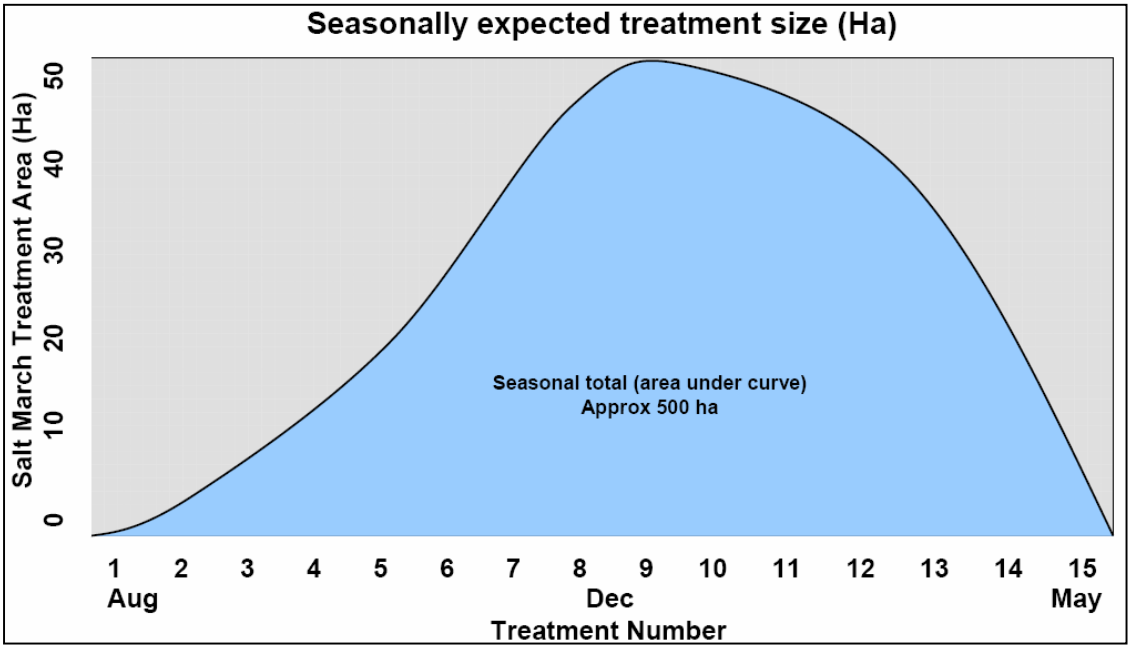
4.1 Current Mosquito Management Requirements

Currently around 50 ha of salt-marsh mosquito breeding habitat exists on the Cobaki Lakes site. This habitat is subject to flooding by tidal inundation via overtopping of the adjoining bank of Cobaki Creek and the existing tide control flap to Dunns Drain. Rainfall events exceeding (generally) 10-15mm will also flood all or part of the salt-marsh mosquito breeding habitat.

During the period of highest production of *Aedes vigilax* (between August and May each year), spring tides are expected to exceed the overtopping elevation on between 10 and 15 occasions. Typically the seasonal production of *Ae vigilax* in salt-marsh follows a normal distribution (sometimes scued somewhat towards Feb-March) in response to favourable tide and rainfall events and temperature.

For the purpose of considering control of salt-marsh mosquitoes by application of larvicide, Plate 4 indicates a typically expected seasonal demand for treatment over the mapped 50 ha of breeding habitat.

Plate 4: Typical Salt-marsh Mosquito Control Treatment Area (for a given 50ha)



Under the existing site conditions, it is expected that up to 500 ha of salt-marsh mosquito production a year would need to be managed within the anticipated15 flooding events.

It is expected that the production of salt-marsh mosquitoes will be managed in the longer term by successful implementation of salt-marsh rehabilitation and

stormwater management plans (JWA 2008 and Gilbert and Sutherland 2008). The salt-marsh rehabilitation processes and stormwater management adaptation and refinement are anticipated to take up to 5 years to achieve the outcomes required including long-term reduction in mosquito production. After this time, it is expected that reliance on application of mosquito control agents will be minimal if required at all.

The Site Based Salt-marsh Mosquito Management Strategy is therefore initially proposed to deliver the following functions.

4.1 Monitoring Program

The short and long term effectiveness of any control actions against mosquitoes should be measured to provide an information base on which to further develop and modify the program and be able to report on achievements on reducing mosquito-borne disease and nuisance risks. The monitoring program should be designed to gauge seasonal mosquito production on the site by conducting larvae surveys following inundation and following any control actions to measure their efficacy. As such it provides for the triggering of timely control actions to maximise their efficiency and efficacy. In the longer term, the competent scientific reporting and publishing of mosquito activity responding to progressive implementation of short-term and long-term controls would provide a significant information resource that would provide benefits in other mosquito management planning scenarios.

4.2 Mosquito Control Operational Actions

4.2.1 Cattle Management

The existing cattle activity on the salt-marsh enhances mosquito productivity in this area. Restricting cattle movement away from mosquito breeding sites including salt-marsh and fresh/brackish wetland would be highly beneficial to mosquito reduction. The permanent removal of cattle would be absolutely necessary to prevent destruction of salt-marsh rehabilitation works for long-term mosquito reduction.

4.2.2 Short-term Application of Mosquito Larvicide

Application of mosquito larvicides is the central strategy in the majority of mosquito management programs that include control of salt-marsh breeding mosquitoes in Australia. One larvicide considered to have the highest margin of non-target species safety is *Bacillus thuringiensis israelensis* (*B.t.i.*). Various commercial formulations of *B.t.i*. provide the mainstream method of controlling mosquito larvae within Australia.

The proposed method of larvicide application is ground based broadcast of liquid or solid formulations using very low ground pressure vehicle. *B.t.i.* formulations are short-acting, typically detectable (by bioassay) for less than 48 hours.

5.0 Urbane Constructed Wetlands in Fresh/Brackish Habitat

The Stormwater Concept Plan (Gilbert and Sutherland 2008) provides information on the use of stormwater management devices, processes and design outcomes. Concepts for stormwater management have potential to increase mosquito production if mosquito management is not considered as a design outcome also. The following comments are intended to guide the implementation of the Stormwater Concept Plan to achieve minimisation of mosquito-borne disease and nuisance risk. The Stormwater Concept Plan generally includes relevant devices and processes including.

- Grass swale drains and buffer strips along road verges and through drainage easements
- Detention ponds to capture allotment runoff for flow attenuation
- Wetland filters prior to final discharge for storm-water polishing
- Porous pavements, rainwater tanks, infiltration devices, and gross pollutant traps

From a mosquito management perspective, such stormwater management systems may allow designs that tend to increase opportunities for mosquitoes to breed. If not designed and managed effectively, such wetlands can become a source for unacceptable mosquito production. The basic generic design features that reduce opportunities for mosquitoes in constructed wetlands (and also comply with The Constructed Wetland Manual Vol 1 Chap 13), include:

- The batter around the constructed wetlands should be as steep as practical (within the design standards for public safety) to minimise shallow water (< 500mm) suited to mosquito breeding. If fencing is not used for public safety, a batter not greater than 1:6 is recommended.
- Normal water levels within the wetland should maintain at a minimum of 500mm water depth except for the margins.
- Improve opportunities for wind action to keep the water surface disturbed to reduce availability to mosquito larvae (require contact with stable surface film for respiration). Therefore basin margins should not be planted with shrubs or trees.
- Aquatic macrophytes should not be planted in more than 60% of shallow water (<500mm) around the margin. They should be clumped with separations of open water allowing wind disturbance on the water surface.

6.0 Conclusions

The presence of large scale breeding habitat for both *Aedes vigilax* and *Culex annulirostris* on the Cobaki Lakes site presents a significant public health risk from transmission of Ross River virus and Barmah Forest virus in the existing surroundings and for the planned nearby residential community. This public health risk should be managed by controlling mosquito breeding in the identified salt-marsh and freshwater mosquito breeding sites now and into the future with an integrated mosquito management program.

Tweed Shire has previously undertaken mosquito control treatments by aerial and ground based application of mosquito larvicides. The immediate ability to carry on aerial treatments is doubtful due to increased statutory restrictions on these operations near urban areas and Air Traffic Control limitations associated with the Gold Coast International Airport. Ground applications of larvicides are possible and effective using very low ground pressure vehicles and recommended in a short-term recurrent program to control the identified public health risks while salt-marsh rehabilitation and stormwater management strategies are implemented.

By properly implementing the Mosquito Management Plan in conjunction with the Salt-Marsh Rehabilitation Plan and the Stormwater Concept Plan, the immediate and future Public Health risk to communities surrounding Cobaki Lakes and the planned community within it will be significantly solved.

It would be appropriate for Leda Manorstead Pty Ltd to adopt and provide budget for the Mosquito Management Plan over the 5 year anticipated need for conventional mosquito control operations. Following this time, shared responsibility of continued salt-marsh management and stormwater management with Tweed Shire is anticipated. The Mosquito Management Plan has been developed in consultation with the Tweed Shire Council's Medical Entomologist who will play an active role overseeing the implementation of the Plan and monitoring its performance.

Darryl McGinn
Mosquito Consulting Services Pty Ltd

References:

Dale, P.E. and Knight, J.M. (1996) Managing Salt Marshes for Mosquito Control: Impacts of Runnelling, Open Marsh Water Management and Grid-ditching in Sub-tropical Australia. *Wetland Ecology and Management.* 14:3 pp 211-220.

Department of Land and Water Conservation New South Wales, 1998. The Constructed Wetlands Manual Volume 1, Chapter 13 pp 181-191.

Gilbert and Sutherland (2008) Stormwater Concept Plan. Report to Lead Manorstead Pty Ltd.

JWA (2008) SaltMarsh Rehabilitation Plan Cobaki Lakes. Report to Leda Manorstead Pty Ltd, James Warren and Associates Pty Ltd

McGinn, D. and Muller, M (1997) Saltmarsh Mosquito Control – towards best practice*. Arbovirus Research in Australia.* 7:194-197

Russell, R.C. and Doggett, S.L. Ross River and Barmah Forest. Department of Medical Entomology. University of Sydney. http://medent.usyd.edu.au/fact/ross%20river%20&%20barmah%20forest.htm

Wright, A.E. (2001) Cobaki Lakes Development, Anglican Catholic School Mosquito Management Options. Report to Leda Development Pty Ltd.

Author's Qualifications:

Darryl McGinn

Bachelor of Applied Science (Environmental Health)
Queensland University of Technology 1989.

Master of Scientific Studies (Entomology)
The University of Queensland 1996.

Currently undertaking PhD
School of Public Health
Griffith University Queensland.