Australia Pacific LNG Project

Narrows Crossing Pipeline Environmental Management Plan

Attachment 12 Mosquito Management Plan

Australia Pacific LNG Project

Appendix H - Mosquito and Midge Management Plan

LNG Facility

Disclaimer

Revision 1 dated 22 November 2010

APLN-000-EN-R01-D-10169

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Tables

1. Introduction

This Mosquito and Midge Management Plan (MMMP) has been developed to manage mosquitoes and midges for the purpose of public health and community well-being for the Australia Pacific LNG Project's LNG Facility. Mosquitoes pose a risk to human health as mosquitoes are vectors for many serious diseases, such as Ross River Virus and Barmah Forest Virus. Midges, although a nuisance, do not pose any serious risk to human health. For this reason and the fact that there are limited control measures for midges, this MMMP largely focuses on mosquito management.

This MMMP aims meet the goal of the Integrated Pest Management (IPM) of combining a variety of reasonable, practical, effective and economical pest control measures to reduce population numbers and disease risk of mosquitoes and midges, while having minimal impact on the environment.

This MMMP provides a framework for identifying and monitoring mosquito and midge populations as well as outlining procedures for implementing management strategies during the construction and operation phases of the Project.

2. Legal Requirements

Relevant legislation and policies associated with the management and control of mosquito and midge populations at Curtis Island include:

2.1 Public Health Act 2005/Public Health Regulation 2005

Division 2 of the *Public Health Regulation 2005* requires the owner, occupier of premises to prevent mosquito breeding on their premises and sets out the requirements for rainwater tanks to ensure the tanks do not breed mosquitoes.

2.2 Environmental Protection Act 1994

Section 319 of the *Environmental Protection Act 1994* (EP Act) defines a general environmental duty as: *"A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to minimise the harm."*

The EP Act further details the term environmental harm as:

"…any adverse effect, potential adverse effect, (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value.…"

This MMMP must demonstrate that reasonable and practicable measures are being taken to minimise environmental harm from control activities and ensure that general environmental duty is met.

2.3 Fisheries Act 1994

Any modification of mosquito breeding areas in tidal wetlands is required to be assessed against fisheries legislation. All marine plants (including mangroves, seagrasses and saltmarsh species) and declared fish habitat areas are protected by this legislation.

Runnelling programs that include the disturbance to marine plants or that are undertaken within declared fish habitat areas are considered development under the *Fisheries Act 1994* and the *Sustainable Planning Act 2009.*

An approval may also be required under the Fisheries Act 1994 for stocking of ponds with fish to increase predation of mosquito larvae.

2.4 Agricultural Chemicals Distribution Control Act 1966

The *Agricultural Chemicals Distribution Control Act 1966* regulates the distribution of agricultural chemicals and requires that mosquito control products applied by aerial spraying must be applied by a licensed pilot.

2.5 Chemical Usage (Agricultural and Veterinary) Control Act 1998

Under the Act, a licensed pilot must only use registered chemical products when controlling mosquitoes and to use the product in accordance with the label instructions.

2.6 Nature Conservation Act 1992

An approval may be required for undertaking mosquito control measures (e.g. runnelling and habitat modification) in areas protected by the *Nature Conservation Act 1992*.

2.7 Marine Parks Act 2004

A Marine Park Permit may be required under this Act if areas of a Marine Park will be used for the purpose of mosquito control activities.

2.8 Sustainable Planning Act 2009

Any disturbance classified as 'development' may require a permit. Runnelling is now covered under the self-assessable code for 'Minor impact works in a declared fish habitat area or involving the removal, destruction or damage of marine plants (MP06)'. When works can be done in accordance with this code, runnelling does not require a development approval. Where the proposed runnelling does not comply with the requirements of MP06, a development approval is required and, if in a declared fish habitat area, a resource allocation authority is also required.

The maintenance of approved runnels is covered under the self-assessable code for 'Maintenance works on existing lawful structures (other than powerlines and on-farm drains) in a declared fish habitat area or involving the removal, destruction or damage of marine plants (MP02)'. Where maintenance cannot be performed in accordance with MP02, a development approval is required.

2.9 Transport Infrastructure Act 1994

The *Transport Infrastructure Act 1994* now encompasses the provisions of the old Harbours Act which has relevance to any proposed habitat modification or control works proposed below the mean high water springs.

3. Mosquito and Midge Prevalence and Identification

3.1 Initial survey

IPM combines several pest management strategies to provide effective, economical control of pests while minimising damage to the environment.

The first step in effective IPM is to quantify the problem through identification of the species and population of the pest that is to be controlled.

Historically there has been no monitoring of mosquito or midge numbers or species at Curtis Island. Therefore, a consultant medical entomologist will be engaged to undertake an initial survey and monitoring program prior to the commencement of construction. This program will run for a minimum of four months during the wettest months of the year (December to March). The program will involve monitoring species' diversity and density of adult mosquitoes and midges near potential breeding sites.

The monitoring program will rank the degree of importance of each potential breeding site according to:

- Average number of mosquitoes and/or biting midges per trap per night.
- Species which bite humans.
- Species which are vectors of disease.

Once this initial survey monitoring program has been completed, broad thresholds of mosquito numbers for each species common to the site will be established to enable the effective implementation of management strategies.

3.2 Site considerations

3.2.1 Temperature

The egg, larvae and pupae stages of mosquito development are dependant on temperature. High temperatures will warm the water or substrate in breeding sites, resulting in shorter development periods for eggs, larvae and pupae. Although temperature plays a role in creating an environment ideal for mosquito breeding, rainfall and tidal information are important for identifying key breeding times.

Meteorological monitoring data from the Bureau of Meteorology (BOM) station at Gladstone Airport shows that the annual average maximum daily temperature recorded for the period 1993–2009 is 27.2°C, with an average minimum temperature of 18.0°C. The warmest months are January and February, with average maximum daily temperatures of 30.7°C and 30.5°C respectively and an average minimum daily temperature of 23.0°C. The coolest month is July with an average maximum daily temperature of 22.9°C and an average minimum daily temperature of 11.7°C.

3.2.2 Rainfall

Rainfall data is important to identify times when habitat creation can lead to an increase in mosquito populations. High rainfall assists in maintaining permanent mosquito breeding sites, such as pooling water, as well as creating extensive breeding sites in low lying grassy areas. Conversely, heavy rain can flush mosquito larvae out of breeding sites and drown pupae (QH, 2002).

Meteorological monitoring data from the BOM station at Radar Hill has been used to characterise rainfall in the Gladstone region. The monitoring station at Radar Hill has been operating since 1957 and provides the longest record of rainfall data for the Gladstone area. As well as relying on the BOM data, local site data should also be collected using a simple rainfall gauge. The minimum, average and maximum monthly rainfall during the 52 year period from December 1957 to August 2009 collected at the Radar Hill monitoring station is presented in Table 3.1 (BOM 2009). The annual average rainfall at Radar Hill is 873.2 mm/year. Consistent with a subtropical climate, the summer months are wetter and the winter months are drier. On average, the months of December to March account for 57.3% of the annual rainfall while the months of June through September total only 15.0%.

Table 3.1 Minimum, average and maximum, monthly rainfall at the Radar Hill monitoring station for the period 1957–2009.

Month	Minimum (mm)	Maximum (mm)	Average (mm)	Monthly rainfall distribution (%)
January	0.4	640.1	143.4	16.5
February	7.2	709.8	143.4	16.5
March	2.4	311.6	82.6	9.5
April	3.8	250.4	46.4	5.3
May	0.2	316.4	59.6	6.8
June	0	220.3	38.9	4.5
July	0	170.2	34.4	3.9
August	0	141.6	31.2	3.6
September	0	89.6	26.5	3.0
October	0.4	276.8	62.3	7.1
November	1.4	218.1	74.2	8.5
December	2.8	508.9	128.8	14.8

3.2.3 Tidal patterns

Following normal high tides there is usually a spike in salt marsh mosquito populations. In addition, cyclones and sub-tropical depressions can induce high tide and storm surge, which may trigger salt marsh mosquito breeding.

The closest tidal monitoring site to the proposed Australia Pacific LNG site is Fisherman's Landing. Amplification of less than a few percent is also observed in the hydrodynamic model at peak spring tide compared to Fisherman's Landing, approximately three kilometres away. There is a small but discernible difference (less than 10 minutes) in tidal phase difference between the proposed Australia Pacific LNG site and Fisherman's Landing. Tidal information is important in planning timing of surveys and proposed insecticide treatments.

During Mean Low Water Spring tides at the proposed Australia Pacific LNG site, mud flats are exposed for a distance of 200-300m seawards from the mangrove line. During Mean High Water Spring tides a high proportion of the existing coastal wetland behind the mangrove stands is inundated. Tidal planes for Fisherman's Landing are given in Table 3.2 (MSQ, 2009). These mudflats and coastal wetland provide intertidal mosquito breeding grounds.

Table 3.2 Tidal Planes for Gladstone region

Location	Datum	HAT	MHWS	MHWN	MSL	MLWN	MLWS
Fisherman's Landing	LAT (m)	5.12	4.20	3.30	2.41	1.66	0.76
	AHD (m)	2.69	1.77	0.87	-0.02	-0.77	-1.67

3.2.4 Wind

The flight activity of mosquitoes and midges can be reduced by strong winds and therefore the chance of being bitten is also reduced. Conversely, strong wind may carry large numbers of mosquitoes and midges away from their breeding sites to populated areas, which are normally out of pest range.

3.3 Likely midge breeding areas

Areas of mangroves and estuarine areas with sandy beaches are potential breeding grounds for midges. Midge population numbers peak monthly and are associated with tidal patterns and also peak seasonally with the summer months.

3.4 Likely mosquito species and breeding areas

This MMMP outlines the mosquito species likely to be significant for Curtis Island based on vector capability, nuisance value and seasonal variation. While there are likely to be many mosquito species present in the Gladstone area, there are some species that are of greater importance because of their ability to transmit disease or to be significant pests. The mosquito species likely to be significant for the Project, in terms of disease or nuisance value, are briefly described in the Section 3.4.1 and Section 3.4.2.

3.4.1 Intertidal wetlands mosquito species

Intertidal wetlands are located along the eastern boundary of the proposed LNG facility site and are also in close proximity north and south of the site. In particular the mangrove areas are likely to provide ideal grounds for breeding. Mosquito species that are associated with breeding in intertidal wetlands include:

1. ***Culex sitiens*** – can become a major pest species during summer months. This species may also be a competent vector of Ross River virus. *Culex sitiens* are found along most coast lines of Australia and have the ability to travel large distances. Breeding sites of *Cx. sitiens* are temporary brackish pools and salt marshes filled as a result of tidal inundation. *Culex sitiens* is often found living with *Oc. vigilax.*

2. ***Ochlerotatus vigilax*** *(previously known as Aedes vigilax)* - is the primary coastal vector of Ross River virus, Barmah Forest virus and other arboviruses in Queensland. This species is widely distributed along the coast and will feed on humans and animals during the day or night and can travel up to 40km from breeding sites. Peak feeding activity is during dawn and dusk.

   Breeding sites of *Oc. vigilax* include a variety of saline habitats, including salt marshes, mudflats and temporary brackish pools. The eggs of *Oc. vigilax* hatch in response to inundation from high tides and heavy rainfall and population fluctuations are therefore associated with tide cycles.

   Ochlerotatus alternans can reach reasonably high pest levels following extended periods of rain. Breeding can occur in temporary brackish pools and marshes on the coast along with *Oc. vigilax* and further inland in freshwater areas with *Oc. vittiger.*

   Ochlerotatus alternans are very aggressive biters, especially in and around mangroves and will attack throughout the day and night and can travel 5-8km from breeding sites in search of a blood meal. This species may continue to be a pest from one to three weeks after breeding areas are inundated.

3. ***Verrallina funerea*** (previously known as *Aedes funereus*) may be a major pest where residential housing is in very close proximity to breeding sites. This species can breed in both fresh and slightly brackish water. *Verallina funerea* is a very aggressive and painful biter. This species travels very small distances from its breeding ground and is thus not considered a major pest for areas not adjacent or in close proximity to their coastal breeding areas.

4. ***Ochlerotatus procax*** (previously known as *Aedes procax*) is a common species in coastal areas and breeds in bushland ground pools. This species can be a minor pest in its breeding area.

Source: (AMCA Inc,1998, DME, 2010a and LGAQ, 2002).

Control measures best suited to the reduction of species, within intertidal wetlands are larviciding and habitat modification. These control measures are further discussed in Section 5.

3.4.2 Freshwater habitat mosquito species

Potential on-site freshwater habitats for mosquitoes include:

- Sediment ponds
- Hydrotest water storage ponds
- Stormwater drainage systems
- Pooled water in bunded areas, containers or other vessels
- Low lying areas temporarily flooded by high rainfall or irrigation

- Areas created during construction works
- Landscaped areas.

A number of mosquito species can be associated with breeding in freshwater pools, and include:

1. ***Culex annulirostris*** - a major pest (nuisance) species and is a vector of Ross River virus, Barmah Forest virus, Japanese Encephalitis and Kunjin virus. This mosquito is widespread throughout Queensland. Preferred breeding areas include freshwater wetlands and low lying grassy areas that are commonly inundated following rain as well as irrigation areas having heavy organic effluent component. Peak feeding activity is predominantly at dusk (up to two hours following) and to a lesser degree at dawn. This breed feeds on animals and humans and have the capacity to travel 5–10 km from breeding sites.
2. ***Culex quinquefasciatus*** - is a medium-sized mosquito of brownish appearance. This species is generally active only during the warmer months but is a major pest (nuisance) species in urban areas following heavy rainfall. *Culex quinquefasciatus* will also breed in containers, troughs and drainage channels.
3. ***Ochlerotatus vittiger*** - is often a pest species following heavy rain. This species breeds prolifically following rain, with the preferred habitat being depressions filled by summer rain. *Ochlerotatus vittiger* is an aggressive biter readily feeding from humans during the day at regular peak feeding times. This species may continue to be a pest from 1-3 weeks after breeding areas are inundated.
4. ***Ochlerotatus notoscriptus*** - breeds in freshwater and feeds during the day in shaded areas as well as at night. *Ochlerotatus notoscriptus* is primarily considered a domestic species, breeding in artificial containers. Laboratory studies have shown this mosquito capable of carrying a number of arboviruses and it believed to be suitable vector for Barmah Forest and Ross River Virus.
5. ***Aedes aegypti*** - a container breeding species associated with human habitation with usual distribution in North Queensland. Biting is predominantly by day in shaded areas but may also occur early in the night. *Aedes aegypti* is a major vector for Dengue fever, Yellow fever and a potential vector of Murray Valley encephalitis and Ross River virus.

Source: (AMCA Inc,1998, DME, 2010b and LGAQ, 2002).

3.5 Treatment triggers

Triggers for treatment will largely depend upon the target environment (fresh or salt water), the terrain, accessibility and location of breeding sites, the mosquito species involved and weather conditions. Australia Pacific LNG's responsibilities are limited to the control of mosquitoes on-site and do not include other breeding grounds off-site (e.g. intertidal areas).

Considerations for intertidal species may include:

- Tides
- Heavy rainfall events
- Wind direction and velocity

- Larvae numbers.

Considerations for freshwater species may include:

- Rain events and duration
- Excessive irrigation/watering
- Larvae numbers.

It is difficult to predict a definitive level of rainfall or tidal event level that will necessitate a treatment. A number of variables such as duration and amount of rainfall received, the period since the last rainfall event, high tides, low pressure systems, wind strength and direction and storm surges may all combine in different combinations, with different outcomes. The variability of these elements precludes the ability to consistently place definitive measurement on such elements.

This MMMP will be updated following the completion of the initial survey monitoring program outlined in Section 2.1 and will aim at that stage to specify treatment thresholds. Guidance will also be sought from GRC for evaluation of trigger conditions and when it is considered that a major mosquito event is imminent.

4. Ongoing Surveillance Program

4.1 Mosquito and midge population monitoring

To determine the on-going prevalence and distribution of mosquito and larvae and to enable timely control activities the following monitoring will be undertaken during the peak breeding season (December to March).

1. Visual inspections – visual inspection of the site for pooled water and larvae.
2. Sampling of mosquito larvae - surveys of mosquito larvae will be conducted at sites in continuous rotation. Mosquito larvae will be surveyed by sampling using a scoop/ladle.

Standardised collecting techniques of sample adult and larval mosquitoes will be undertaken at fixed sites as detailed below in Table 4.1.

This on-going monitoring program will be reviewed following the outcomes of the initial survey outlined in Section 2.1.

Table 4.1 Ongoing monitoring program during peak breeding season

Monitoring Site	Method	Frequency
Bunds and containers around the site.	Visual inspection	Weekly
Ponds and basins	Visual inspection	Weekly
	Sampling of mosquito larvae	Monthly
Stormwater drainage systems.	Visual inspection	Weekly
	Sampling of mosquito larvae	Monthly
Irrigation areas	Visual inspection	Weekly following irrigation.
	Sampling of mosquito larvae	As required
Low lying grassed areas.	Visual inspection	Weekly following heavy rain events.
	Sampling of mosquito larvae	As required
Intertidal wetlands	Sampling of mosquito larvae	Monthly

In addition to this monitoring, close liaison with GRC and Queensland Health (QH) will occur to obtain results of any surveys undertaken and to be notified of major mosquito events in the Gladstone region.

4.2 Notification of vector borne disease

Illness symptoms in employees (such as temperature, fever, joint and muscle pain) that may indicate vector borne disease will be monitored, with illnesses assessed for cause where possible. A register will be maintained of any staff member infected by the following vector borne diseases:

- Arthropod Other
- Barmah Forest Virus
- Dengue Fever
- Japanese Encephalitis
- Malaria (unspecified and other)
- Malaria Falciparum
- Malaria Malariae
- Malaria Ovale
- Malaria Vivax
- Ross River Virus.

Data on vector borne diseases numbers for the region can be requested from QH if deemed necessary. However, these records are not always indicative of the mosquito problem as records only show those who have been diagnosed by a doctor and do not link the result to the area of transmission.

4.3 Community opinion/Complaint register

A complaint register will be maintained and each complaint investigated to assess mosquito and midge prevalence.

5. Management Plan

To achieve environmentally sustainable outcomes, the aim of this MMMP is to focus on indirect management controls; personal protection and design controls, with the use of direct management controls, such as chemicals, habitat modification and biological controls regarded as the least preferred methods.

A regional approach is also important and close consultation with GRC and QH and surrounding industries will be undertaken with attendance at Mosquito Forums held between these groups.

5.1 Goals

The objectives of this MMMP are aligned with the Gladstone Regional Council (GRC) Mosquito Management Plan and include:

- Ensuring that the goal of IPM is the basis of this MMMP.
- Complying with the Mosquito Management Code of Practice.
- Identifying suitable surveillance procedures and treatment efficacy.
- Identifying triggers for treatments and types of treatment options currently available.
- Developing control measures that are environmentally sound, effective and cost efficient.
- Participating in an integrated regional approach with GRC and other key stakeholders.
- Providing general information regarding mosquitoes including species habitats.
- Examining environmental considerations and ensuring compliance with legislative requirements.

5.2 Performance indicators

The performance indicators for this plan are:

- No outbreaks of mosquito borne disease within the project area.
- No environmental harm from mosquito and midge management controls.

5.3 Responsibilities

The persons responsible for compliance with this plan during the construction period and operational phase and their responsibilities are summarised below.

5.3.1 Construction phase

During the construction period, the Construction Contractor Site Manager will be the Responsible Person and will undertake the following:

- Ensure that the requirements of the MMMP are satisfied.
- Ensure that contractors and sub-contractors engaged in the construction of the LNG facility are advised of their responsibilities to undertake their activities in accordance with the MMMP.

- Ensure that contractors and sub-contractors engaged in the construction of the LNG facility are advised of their responsibilities regarding mosquito and midge management.
- Ensure that an auditing/monitoring program is implemented.
- Prepare incident reports and implement corrective actions.
- Ensure appropriate records are kept and maintained on-site.
- Retain a copy of the MMMP on-site for reference by appropriate personnel and provide a copy to contractors and sub-contractors.
- Recommend additions or changes to the MMMP based on experience gained from implementation of the MMMP.

5.3.2 Operational phase

During the operational phase and subsequent de-commissioning period, the Australia Pacific LNG Site Manager will be the Responsible Person and will undertake the following:

- Ensure that the requirements of the MMMP are satisfied.
- Ensure that the auditing/monitoring program is implemented.
- Prepare incident reports and implement corrective actions.
- Ensure appropriate records are kept and maintained on-site.
- Retain a copy of the MMMP on-site for reference by appropriate personnel.
- Recommend additions or changes to the MMMP based on experience gained from the implementation of the MMMP.

5.4 Training and awareness

Environmental management requirements including mosquito and midge management will be included in an induction and training program for all personnel employed/contracted on the site for the construction and operational phases. Environmental topics will be included in toolbox talks or other on-going worker training and awareness, as required. All project personnel will be made aware of environmental issues relating to mosquito and midge management and the MMMP.

A register of training for each employee will be maintained and reviewed as required.

5.5 Continual improvement

This MMMP will be reviewed annually to ensure industry standards are met and make any necessary changes to improve the outcome of this plan.

5.6 Management Strategies

The following list of management strategies are listed in order of preference, however, for effective mosquito and midge management an integrated approach is required with most likely a combination of the management strategies needing to be adopted.

5.6.1 Personal protection

Personal protection measures are the first line of defence against mosquito-borne diseases.

Strategies to be implemented to avoid and repel mosquitoes and midges include:

- Personnel will be educated on the mosquito and midge problem on-site and educated in management strategies and responsibilities for their own health (through induction, regular communication and posters throughout the construction site).
- Where practicable, personnel will avoid peak biting times; specifically at dusk.
- Where practicable, personnel will avoid dense vegetation near breeding sites for one or two weeks after the highest astronomical tides of the month or significant rain.
- Personnel will wear hats, socks, and loose fitting, light coloured clothing with long pants and long sleeves when outdoors. Head nets and gloves will also be worn, if required. Head nets with 1-1.5 meshes to the centimetre are recommended. Sleeves and collars will be kept buttoned and trousers tucked into boots. In severe cases clothing may be impregnated with permethrin.
- When required, personnel will use mosquito repellents. The main active ingredient in mosquito repellents is N,Ndiethyl- 3-methylbenzamide (deet) which has a broad spectrum of effectiveness against a variety of arthropods, including mosquitoes. Repellents have differing concentrations of deet with the concentration of deet needed depending on the individual.
- The workforce will be notified if there is a mosquito or biting midge problem and individuals will take appropriate personal protection.

5.6.2 Planning tools

Planning tools to be used for mosquito and midge management include:

- All on-site accommodation will be air-conditioned and screened. Screens will be the correct mesh size, fit tightly and be in good repair. As mosquitoes and midges follow people into buildings, all screen doors on buildings should open outward and have automatic closing devices. Where required, Bifenthrin barrier treatments around personnel areas will be implemented to reduce adult biting midge numbers.
- Yellow or red lights will be used in personnel areas, where possible, to prevent attracting midges. White lights will be used away from non-personnel areas to divert the midges.

5.6.3 Source reduction

For the purpose of this MMMP source reduction refers to the elimination and removal of potential breeding grounds, feeding opportunities and harbourage in areas associated with human habitation.

5.6.4 Container breeding

Management actions for container and vessel breeding include:

- The creation of areas and structures in which water could be retained for more than five days will be avoided (i.e. potential mosquito breeding habitat).

- The site will be inspected weekly for all containers and vessels capable of holding water (including bunded areas) to prevent water pooling. These areas will be drained and treated as required.

5.6.5 Ponds

On-site ponds will follow design goals to decrease opportunities for mosquitoes to breed. These design features include:

- Ponds will not be less than 60cm deep.
- Pond batter slopes will not be greater than 1:6.
- Pond design will not support rapid growth of emergent aquatic plants or the formulation of vegetation hummocks in periods of low water levels.
- Basins and swales will be designed to empty in less than seven days to prevent the completion of mosquito breeding cycles.
- Aquatic macrophytes will not be planted in more than 60% of shallow water (<600mm) around the margin. These will be clumped with separations of open water, which will allow wind disturbance on the water surface.
- Monitoring of ponds for weed infestations will occur and if required, weed eradication actions will be undertaken.
- Ponds will be inspected, as per the monitoring program in Table 4.1.

5.6.6 Drainage systems

Stormwater drains will be constructed in a manner that does not lead to the creation of new mosquito breeding sites. The design of drainage systems will consider the following design features:

- Drainage design will prevent the accumulation of silt and debris that may create pooling of water.
- Erosion control measures will be installed on drain batters to prevent silting.
- Any plant species selected to stabilise slopes will be suitable and not cause invasion of water bodies and create breeding grounds.
- All maintenance of drains will be carried-out in accordance with procedures which ensure that further habitats for mosquitoes or midges are not created by wheel ruts.
- Concrete channel ‘low flow’ drains within large earthen drains are preferred.
- Discharging water into mangrove and vegetated wetlands will be avoided, as this can help maintain permanent breeding sites. Discharged water may be enriched with nutrients which assist the growth of some types of vegetation, resulting in the restriction of the water flow and preventing natural predators reaching mosquito larvae.
- Drains will be maintained free of siltation and debris.
- Drains will be inspected as per the monitoring program in Table 4.1.

5.6.6.1 Sewerage systems and wastewater disposal

Sewerage systems and wastewater disposal will be managed in accordance with the following:

- Sewerage systems and wastewater disposal will be operated in a manner to avoid ponding of water.
- Irrigation rates will be effectively managed to prevent the creation of temporary pools.
- Temporarily flooded areas will be managed through filling depressions and draining pooling areas.

5.6.6.2 Construction

Construction activities may create mosquito/biting midge breeding sites. In order to minimise the problem the following actions will be followed:

- Access roads will be fitted with culverts where necessary, in order to prevent water ponding upstream, and thus prevent mosquito breeding.
- All materials taken on or off-site will be inspected for pooled water and drained and treated as required.
- Reinstated sites will be re-contoured to the original surface profiles to prevent ponding.
- Design landscaping and drainage so that no stagnant ponding occurs during and after construction.

5.7 Biological Controls

5.7.1 Fish stocking

Where design controls have not effectively managed mosquito populations, the introduction of native fish into water impoundments will be considered. The introduction of fish will increase predation of mosquito larvae. Determination of minimum required water levels and water quality is to occur for use of this management strategy. Also, prior to implementing this option consultation is required with the Department of Employment, Economic Development and Innovation (DEEDI) to ascertain if any approvals are required under the *Fisheries Act 1994*. Native fish suitable for mosquito control in engineered wetlands/ponds on Curtis Island include:

1. Eastern Rainbow Fish (*Melanotaenia splendida splendida)*
2. Empire gudgeon *(Hypseleotris compressa)*
3. Fly-specked hardyhead *(Craterocephalus stercusmuscarum fulvus)*
4. Pacific blue *(Pseudomugil signifier)*
5. Southern purple-spotted gidgeon *(Mogurnda adspersa)*

Source: QDPI (1999)

The following measures will be followed when using biological controls:

- Only fish approved by the DEEDI may be used.
- Detailed records of any introductions will be maintained.
- Water used to transport fish will be derived from a source free of exotic plants.
- Fish will be sourced from a reputable provider.

5.8 Habitat modification

For the purpose of this MMMP habitat modification refers to the manipulation of wetlands to reduce breeding sites.

Runnelling is the most commonly used means of modifying saltmarsh areas to reduce mosquito numbers. Runnelling is the linking of pools by shallow (less than 30cm) spoon-shaped channels (runnels) which increase tidal flushing and access by fish and other predatory species. Because there are potential environmental consequences from runnelling (disturbances to marine plans and the increased inundation of substrates), implementation of runnelling programs for this site is not preferred.

Permits are required from the DEEDI and DERM before any modification of wetland areas.

5.9 Chemical controls

If necessary, areas that cannot be managed with other management controls (planning or biological methods) will be treated as required with a control agent. The advantage of chemical control methods is that pesticides can be quickly applied with rapid results at relatively low cost. However, chemical usage will not be viewed as a long term control strategy as prolonged use can result in the development of resistance in mosquito populations and be detrimental to the environment.

Relatively few chemicals can be recommended for use in wetlands, whether natural or constructed (which usually flow into natural water systems), because of environmental concerns. The importance of pre-inspection activities is further reinforced when considering the selection of the most suitable treatment chemical. The effectiveness of the various 'acceptable' agents depends on appropriate formulations and local conditions and the target mosquito species is of critical concern.

Consultation will be undertaken with GRC and QH prior to the planning of and implementation of this management option.

5.9.1 Larviciding

5.9.1.1 Bacillus thuringiensis israelensis

The most commonly used agent and most environmentally acceptable larvicide is Bti (*Bacillus thuringiensis* subspecies *israelensis*) based products.

Bti is a highly selective biological larvicide and is composed of viable (Bti) (H-14 endospores and delta endotoxin crystals) and is considered the least toxic larvicide currently available on the market. This product is widely accepted for the use in environmentally sensitive areas because of its relative specificity for mosquitoes amongst invertebrates and negligible toxicity for vertebrates. It is also approved by Queensland Parks and Wildlife Services for use on lands under their jurisdiction. The general advantage of this larvicide is its effectiveness against the first three larval stages. Bti product is suitable for both ground and aerial application purposes. However Bti has little persistence and mosquito populations can rebound in 1-2 weeks.

5.9.1.2 Methoprene

S-Methoprene products come under the category of insect growth regulators. These products are considered extremely safe to the environment and like Bti are very target specific in their action. They act upon mosquito larva by mimicking naturally occurring insect growth regulators causing interference with normal mosquito development. Larvae are not killed, but adult emergence from the pupal stage is prevented. Slow-release formulations can provide control over some months.

One disadvantage of these products is the difficulty in determining the effectiveness of an application as larva will often continue to develop and die in late fourth instar stage or pupae stage. Should the application rate or method be shown to be ineffective and the larva continues to develop, re-treatment options become limited to the use of adulticiding.

5.9.1.3 Organophosphates

The organophosphates action on mosquito larva is a contact poison. It is less target-specific, killing a wide range of other non-target aquatic organisms. Research also indicates that the action of organophosphates has adverse affects on other organisms such as juvenile crustaceans (such as prawns, crabs). Above recommended dosage rates it can be highly toxic for many invertebrates; it has low mammalian toxicity, but is moderately to highly toxic for fish and birds.

Organophosphates do however have the advantage of being capable of killing all stages of larva effectively, as well as the pupal stage. Organophosphates may be invaluable in certain circumstances where treatment timing is incorrectly determined or in post-disaster activities.

It should be noted however that these types of chemicals should only be used after full assessment of potential adverse affects, consideration of the receiving environment and on-site risk/benefit analysis. It is important to note that the use of organophosphates in environmentally sensitive areas is unlikely to be approved.

5.9.2 Adulticiding

5.9.2.1 Pyrethrins and Synthetic Pyrethroids

The main advantage of pyrethrins and synthetic pyrethroids is they have a rapid knock down effect on adult mosquitoes. Synthetic pyrethroids are less irritating to humans than other adulticides and have a less offensive odour. Permethrin, a second generation pyrethroid has very low mammalian toxicity. However, they are toxic to fish, but with low use rates risk to welfare is minimal. The main disadvantage is the high cost compared to other adulticides.

Management Actions:

If chemical controls are to be used the following management actions will be adhered to:

- A suitably qualified consultant will be engaged to develop a treatment program that meets the Local Government Association of Queensland (LGAQ) Mosquito Management Code of Practice 2002.
- A licensed operator will be engaged to undertake the chemical treatment.
- Chemicals used will be registered and used in accordance with manufacturer's instruction.
- Treatments will not be undertaken prior to a breeding event.
- Areas identified for treatment will consider environmentally sensitive areas and buffer zones will be designated.
- A treatment register will be maintained and include:
  - Areas treated
  - Date and time of treatment
  - Equipment
  - Pilot/operator
  - Insecticide dose
  - Insecticide batch measure
  - Result

6. Plan Effectiveness

It is important to review the effectiveness of this MMMP and chosen management strategies through assessing the data collected from surveillance methods of surveys, vector borne disease data and complaints outlined in Section 4.

It is especially vital to establish the target population numbers prior to and following any chemical treatment to assess effectiveness to assist in determining reasons for treatment failure.

7. References

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