

Mosquito Management Plan 2024-2027



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1. Introduction

The City of Armadale (the City) is located in the south-eastern suburbs of Perth, WA, approximately 28 km from the Perth Central Business District (CBD). The City covers an area of 560 square kilometres and consists of 19 suburbs and localities with vineyards and orchards, green open spaces and the backdrop of the Darling Range. The population is approximately 100,768 and it is the fourth fastest growing local government in WA. The diverse range of environments including bushlands, freshwater bodies and wetlands provide for mosquito breeding habitats. The development of residential, recreational, and urban areas in close proximity to these breeding sites can increase human exposure to mosquitoes.

Mosquitoes are one of the most significant groups of insects with the potential to cause nuisance and transmit diseases to humans. The incidence of diseases such as Ross River virus (RRV) and Barmah Forest virus (BFV) throughout southern WA presents a serious risk to public health. Whilst not all mosquito species are vectors of disease, they can be aggressive biters. This has a significant impact on quality of life and on the ability of residents and visitors to enjoy the amenities and natural beauty of the area.

It is not realistically possible or environmentally sustainable to eradicate mosquitoes as they are an important part of the ecosystem providing food for birds, bats, amphibians, fish and insects. However, it is possible to achieve a reduction in mosquito populations, to minimise nuisance and prevent mosquito borne disease with an effective integrated management plan. This approach to mosquito management creates an effective and environmentally sensitive solution that is sustainable.

This management plan presents an integrated management approach to help control and reduce the impact of mosquitoes on both the residents and visitors of the City. The plan clearly defines the common mosquito breeding areas, provides suitable control options, and outlines key ongoing monitoring, surveillance, and evaluation methods to assess overall effectiveness. It is a continually evolving document that takes into consideration the relevant statutory obligations, policies, guidelines, current practices, the community, and the environment. The City also collaborates with key stakeholders and neighbouring local governments, employing a partnership strategy in order to deliver positive public health outcomes.

Acknowledgement of Country

As part of the City of Armadale, we would like to acknowledge that the land we meet on is the traditional lands for the Noongar people, and that we respect their spiritual relationship with their country. We would like to acknowledge the Noongar people as the custodians of the Perth region and recognise that their culture and heritage is still important to the Noongar people today.

2. Objectives

The purpose of the City's Mosquito Management Plan (MMP) is to provide a coordinated approach for managing the public health risk from mosquitoes within the City. The MMP establishes local priorities and sets out actions that aims to minimise the impacts of nuisance and potential disease vector mosquito species and mosquito-borne diseases that can potentially affect the City's residents and visitors.

The objectives of this MMP are:

1. To identify breeding areas and potential breeding sites.
2. To inform, guide and assist developers, consultants, landowners, residents, City staff and the general public of the City's mosquito management actions and guidelines.
3. To create an integrated control framework using physical, chemical, biological, and cultural methods to protect against mosquito resistance.
4. To conduct community educational programs and promote the Department of Health's mosquito campaigns.
5. To strategically guide the financial direction of mosquito management.
6. To review the effectiveness of this plan and identify any opportunities for further improvement.



3. Strategic Implications

The City's *Strategic Community Plan 2020-2030* governs all of the work that the City undertakes, either through direct service delivery, partnership arrangements or advocacy on behalf of our community to achieve the vision of Armadale, **Where City meets Country**.

This MMP strives to address or partially address the following strategic directions:

1. Aspiration – Community

Outcome: Improve Community Wellbeing

Objective: Facilitate the delivery of health and wellbeing programs and services within the community.

2. Aspiration – Environment

Outcome: Protection and Restoration of the Natural Environment, and the Reduction of Environmental Impacts

Objective: Biodiversity is managed to preserve and improve ecosystem health.

Objective: Ensure that the health of the City's natural environment is regularly monitored, and the effectiveness of environmental programs are periodically assessed.



4. Statutory Management and Legislation

Public Health Act 2016

The *Public Health Act 2016* aims to protect, promote and improve the health and wellbeing of the public of WA and to reduce the incidence of preventable illness. Under this Act, the local government is responsible for:

- Initiating, supporting and managing public health planning for its district.
- Administering and enforcing this Act.
- Developing and implementing policies and programmes to achieve the objects of this Act within its district.

The *Health (Miscellaneous Provisions) Act 1911* and subsidiary legislation will continue to be the City's primary enforcement tool, until the *Public Health Act 2016* is fully implemented.

Health (Miscellaneous Provisions) Act 1911

Under the *Health (Miscellaneous Provisions) Act 1911* and subsidiary legislation, local government has the following responsibilities in relation to mosquito management:

- Prepare and implement management programs for the control of pests and disease-vectors (including mosquitoes).
- Ensure that pests or disease-vectors breeding on 'non-private' land, which have an impact on residential areas are actively monitored and effectively managed.

Health (Pesticides) Regulations 2011

The *Health (Pesticides) Regulations 2011* uses a risk-based approach to regulate the use of pesticides in Western Australia. These regulations should be considered when employing any chemical treatments to manage mosquitoes.

City of Armadale Health Local Law 2002

Part 6 – Pest Control, Division 2 of the *City of Armadale Health Local Law 2002* measures to be taken by the landowners and occupiers to prevent mosquito breeding on private property.

Environmental Protection and Biodiversity Conservation Act 1999

The *Environmental Protection and Biodiversity Conservation Act 1999* requires that any action likely to cause a significant impact on a matter of environmental significance (including significant wetlands), must be referred to the Commonwealth Minister for the Environment, for a determination. The City has a number of significant wetlands that are potential breeding sites for mosquitoes such as Piara Nature Reserve and Forrestdale Lake which are managed by DBCA (Department of Biodiversity, Conservation and Attractions). The City is required to consult with Department of Health (DoH) if high mosquito numbers are obtained from ongoing monitoring and surveillance of these sites. Should DoH deem treatment necessary, approval from DBCA must be sought prior to any treatment.

Aboriginal Heritage Act 1972

The *Aboriginal Heritage Act 1972* provides for the recognition, protection and preservation of Aboriginal sites and cultural heritage in Western Australia. Proposals to undertake physical modification of mosquito breeding sites within the natural environment must include consideration of Aboriginal heritage issues.

5. Mosquito Biology and Ecology

Mosquitoes undergo four development stages – egg, larva, pupa and adult as shown in Figures 1 and 2. This whole cycle from hatching egg to flying adult can take as little as 5-7 days in summer. During colder months the life cycle may take several weeks.

5.1 Life Cycle

Egg stage – Eggs are laid on or near the surface of water. Some mosquitoes lay their eggs separately while others lay eggs in rafts of 200 or more. Eggs hatch into larvae within 2 to 3 days.

Larval stage – Mosquito larvae can be found in different water bodies (fresh, stagnant, and saltwater). Most have siphon tubes for breathing and hang suspended from the surface of the water.

They mainly feed on microorganisms and decaying organic matter. Larvae go through four growing stages, called instars and then transition into the next stage.

Pupal stage – The pupal stage is a mobile but resting and non-feeding phase. It takes about two days before the adult is formed.

Adult stage – The newly emerged adult rests on the water surface for a short time to allow its body parts to harden. The wings have to spread out and dry before it can fly. Males generally emerge before females and have a shorter lifespan. Adult Mosquitoes will survive for about 3 to 4 weeks. Some species are known to travel 3km or more from a breeding site in search of a blood meal. As a result, residents living at a distance from the breeding sites (as well as those close by) may be affected.

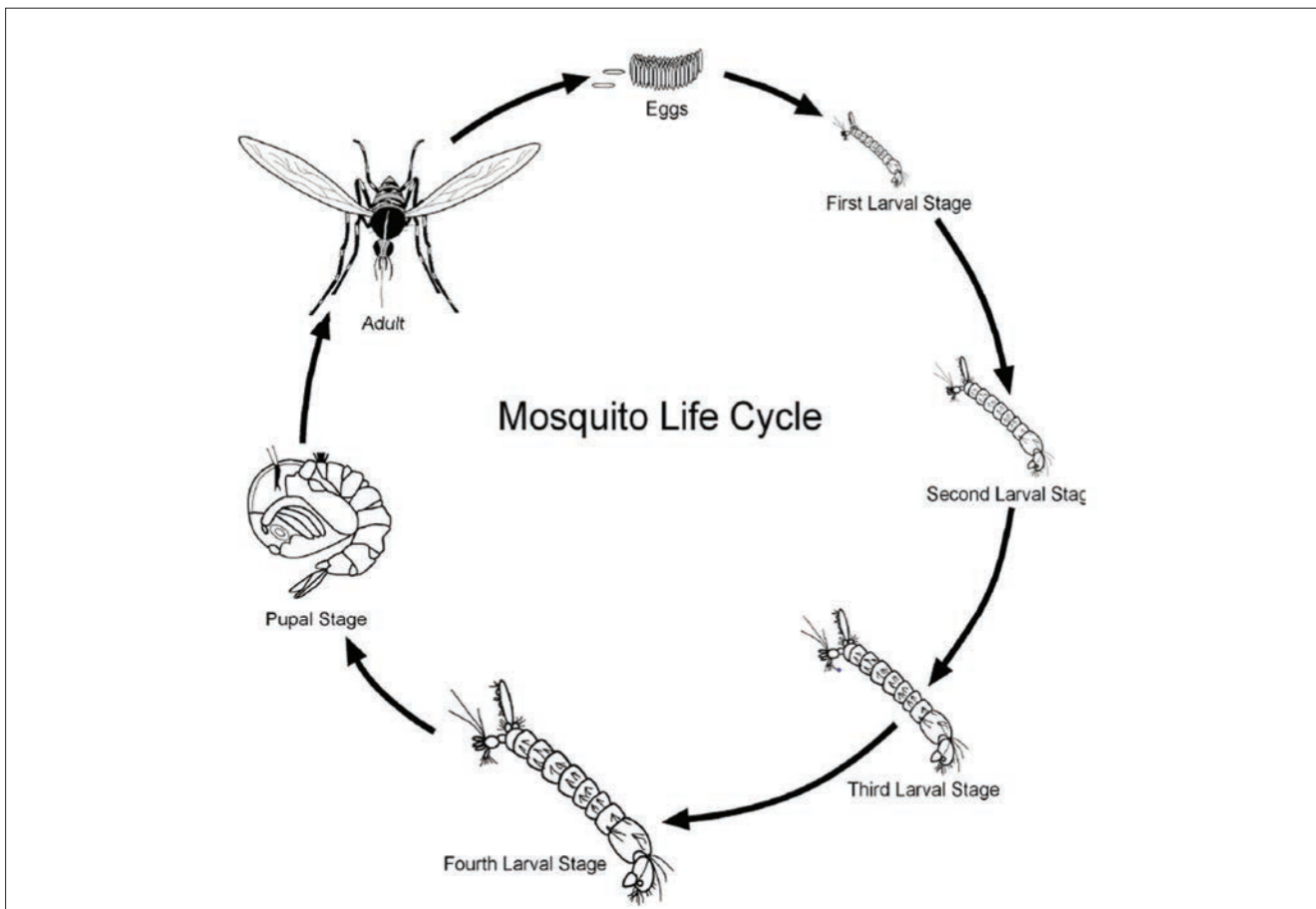


Figure 1: The typical life cycle of mosquitoes



Figure 2: Five stages of Aquatic Immature Mosquitoes (From left to right: 2nd Instar, 3rd Instar, Pupa, 4th Instar and 1st Instar) Source (Webb 2016)

5.2 Environmental Factors

The City experiences a Mediterranean climate with hot dry summers and mild wet winters, with moderate to high seasonal rainfall. Mosquito populations will fluctuate from year to year and seasonally in response to these changing environmental conditions. These weather factors play an important role in mosquito management and need to be considered during the implementation of the program.

Based on the City's historical weather data, the mean annual rainfall is 866.66mm, the majority of which falls between May and August. Average maximum temperatures usually peak between January to February, where mean temperatures are above 33°C. The lowest mean maximum temperature of 19°C occurs between June to August. These rainfall and temperature conditions can influence breeding lifecycles; often dictating how long-standing water will support breeding, how quickly the breeding cycle will be completed and how active the emergent adults will become. After the emergence of the adults, temperature, humidity, wind speed and direction can affect dispersal.

Weather variables are recorded when undertaking monitoring and surveillance. This helps develop an understanding of the natural mosquito populations and predict changes for future management strategies.

5.3 Breeding Sites

Mosquitoes can breed in any form of standing water. Different species of mosquitoes will breed in different environments such as natural and man-made water bodies, fresh to brackish or even saltwater. Urban development and infrastructure may also contribute to breeding in storm water systems, roadside drains and constructed wetlands.

Extensive mosquito monitoring will be undertaken to determine a list of priority treatment areas within the City. The City will also use information from mosquito complaint investigations to inform priority treatment areas. The common breeding sites currently monitored by the City is shown in Appendix 1.

Residential backyard breeding in gutters, stagnant pools and ponds, and water-holding containers such as bird baths and pet bowls can also contribute to mosquito breeding. The management of mosquitoes on private property is the responsibility of owners and occupiers.

Mosquito Breeding in State Government Owned/Managed Land

Council at its meeting on 26 June 2023 endorsed the City’s proposal to amend its MMP to include some State Government owned land following community concerns relating to mosquitoes potentially breeding in nearby wetlands such as Piara Nature Reserve.

Harrisdale Swamp and Anstey-Keane bushland will be considered for the next treatment sites, but further assessment is required before conducting any long-term treatment. Although the DoH has identified Forrestdale Lake as a likely breeding site, it is a RAMSAR conservation wetland, therefore further negotiations with DBCA on possible monitoring and treatment would be required.

5.4 Nuisance and Disease Risk

Disease Risk

Mosquito-borne diseases are caused by the transmission of viruses through the bite of an infected mosquito to a person. The main viruses transmitted by mosquitoes in WA are:

- **Ross River virus (RRV)** – this is the most common virus transmitted by mosquitoes in WA. Symptoms of RRV disease include joint pain and swelling, sore muscles, rash, fever and fatigue. Symptoms may persist for several weeks to months.
- **Barmah Forest virus (BFV)** – BFV disease has similar symptoms to RRV disease but is not as common.
- **Murray Valley encephalitis (MVE)** – MVE is a rare but potentially fatal disease that occurs mainly in the northern two thirds of WA. Symptoms include fever, drowsiness, confusion, headaches and stiff neck, nausea and vomiting, muscle tremors and dizziness. In severe cases brain damage, paralysis or death may result.
- **West Nile virus (Kunjin subtype) (WNV_{KUN})** – This has previously been known as Kunjin virus or KUNV. While the symptoms of this rare but serious disease can be similar to MVE, illness is generally milder and not life threatening.

As shown in Table 3 mosquito species prevalent in the City are carriers of these diseases, with the most common disease in the region being RRV. DoH has analysed human case data over 10 years to assess the risk of mosquito-borne disease in the State. The data indicates that the City’s average attack rate (cases per 100,000 population) for RRV is significantly lower than the rest of the State. This ranks the City at a lower risk rating for RRV at 110 out of 138 local governments. This is also shown in the City’s historical data where RRV cases have been considerably low. However, there was a significant increase of 19 total cases in the 2021/22 monitoring season, all of which were likely to have been acquired within the City. Significant further urban development is planned for the City, potentially placing recreational and residential uses in proximity to mosquito breeding sites with a corresponding increased risk of human exposure to mosquito bites and mosquito-borne diseases.

Mosquito-borne diseases have a significant impact on the health, social and financial well-being of residents and visitors to the region. There are no specific cures or registered vaccines for any of these diseases, so managing mosquitoes and human/mosquito interaction via an integrated mosquito management program is the only way to reduce the risk of mosquito-borne disease transmission.

Nuisance

As well as being a disease risk, mosquitoes can also be serious pests. Some mosquito species in the City are known to be aggressive biters, causing discomfort and pain to residents and visitors, significantly impacting their lifestyle and outdoor amenity.





In the last 5 years, the City has received an average of 18 complaints per season. The highest number of complaints were received during FY20/21 and FY21/22 with 27 and 26 complaints respectively. There is a community expectation for the City to manage mosquitoes at an acceptable level to reduce their impact whilst recreating in public open spaces and/or their own properties.

5.5 Species of Interest



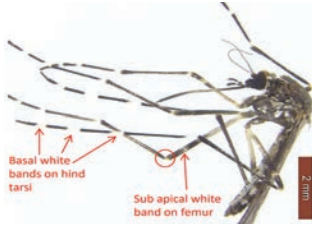
There are approximately 100 species of mosquitoes in WA. Different species have different breeding habitats, active periods, dispersal capabilities and associated nuisance or disease risk.

An understanding of these species can allow for targeted larval investigations and control at the breeding site. The most common mosquitoes in WA and those confirmed as breeding within the City are referred in Table 1.

Table 1: Species of Interest

Species	Breeding Habitat	Active Season	Dispersal Capabilities	Vector Risk	Pest
Culex annulirostris 	<ul style="list-style-type: none"> • Permanent/semi-permanent freshwater bodies • Prefers heavily vegetated sites 	<ul style="list-style-type: none"> • November-March • Dawn, dusk and night 	10km	MVEV WNV _{KUN} RRV BFV	P
Aedes notoscriptus 	<ul style="list-style-type: none"> • Clean water within the domestic environment; artificial containers • Prefers shade 	<ul style="list-style-type: none"> • All year/wet months • Dawn and dusk; occasionally at night and daytime 	0.4km	RRV	P
Culex quinquefasciatus 	<ul style="list-style-type: none"> • Clean or polluted water • Domestic environment, artificial containers 	<ul style="list-style-type: none"> • All year, peak in winter months • Dawn, dusk and night 	Limited	None	P
Anopheles annulipes 	<ul style="list-style-type: none"> • Permanent and semi-permanent fresh water 	<ul style="list-style-type: none"> • All year, peak in wet season • Active at night; occasionally in day times 	Unknown	None	–

6. Baseline Survey/Existing Data

Species	Breeding Habitat	Active Season	Dispersal Capabilities	Vector Risk	Pest
Aedes camptorhynchus 	<ul style="list-style-type: none"> Brackish to fresh ground pools Tidal saltmarsh areas 	<ul style="list-style-type: none"> Winter, spring and early summer 	3-5km from breeding site	RRV BFV	P
Culex globocoxitus 	<ul style="list-style-type: none"> Open swamps Brackish water 	<ul style="list-style-type: none"> All year, peak in July to November 	Unknown	None	Adults do not generally bite humans
Aedes alboannulatus 	<ul style="list-style-type: none"> Temporary rain filled ground or rock pools Open or sunlit areas Forest areas 	<ul style="list-style-type: none"> May to October 	Low	None	–

Baseline data has been collected from set locations across the City since 2020. Environmental factors, including rainfall, tide and temperature, were correlated with mosquito surveillance results to determine the natural triggers for breeding at various sites. An adult trapping program has been established using this data, with EVS/CO₂ traps being set regularly through the spring, summer and early autumn months. Figure 3 shows the location of the 9 established EVS/CO₂ traps across the City.

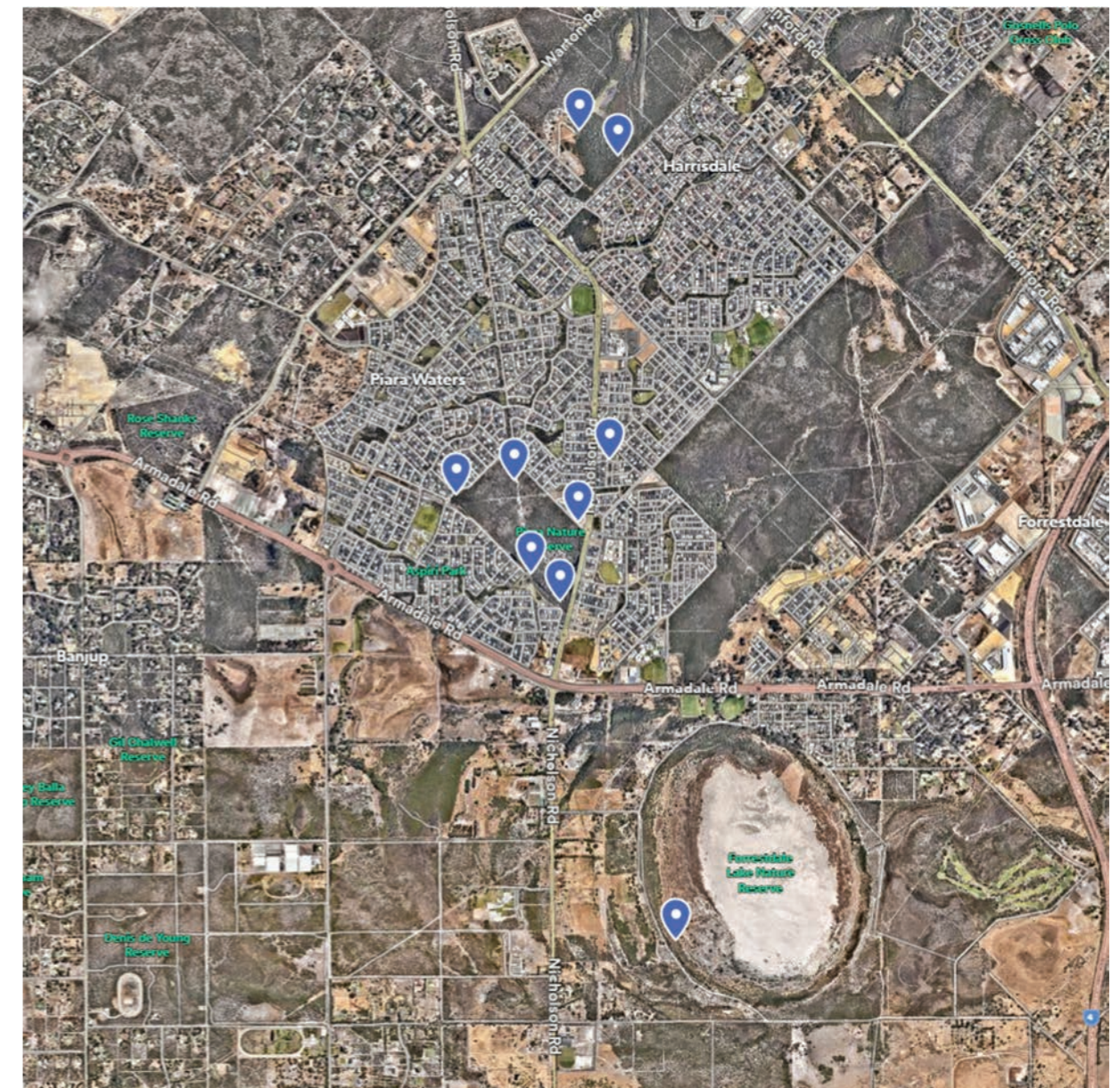


Figure 3: Adult Trap Locations

Adult trapping results from the core trap site locations between 2020 to 2024 can be seen in Table 2. Over this period, the results show a consistent increase in numbers from September before beginning to decline in February/March with low numbers in the winter months. Site 1 collected the largest number of adult mosquitoes for most months of the year, being substantially higher than the other sampling locations.

Table 2: Baseline Adult Trapping Result

Date	Site 1	Site 2	Site 3	Site 4
	5 PNR Sites – Cnr Nicholson Rd and Piara Drive, Back of PNW – 3 Kitley Way, Moraba Park along Claystone Loop, Back of PNW dips site Rossiter Ave, Back of PNW Parallel to Piara Dr (opp 81 Piara Dr inside the park)	Piara Waters – Sandstone Park	2 Harrisdale Swamp sites – Across 51 Wright Rd, opp Oakleigh Pass	Forrestdale – Forrestdale Lake
20/01/2020	32	N/A	0	N/A
21/01/2020	0	N/A	0	4
29/01/2020	8	N/A	0	N/A
17/02/2020	17	N/A	0	N/A
21/09/2020	31	N/A	0	N/A
5/10/2020	27	N/A	0	N/A
4/11/2020	522	N/A	0	N/A
16/11/2020	267	N/A	0	N/A
1/12/2020	598	N/A	0	N/A
7/12/2020	2184	N/A	0	N/A
21/01/2021	83	N/A	0	N/A
27/01/2021	294	N/A	0	N/A
22/02/2021	36	N/A	0	N/A
15/03/2021	214	N/A	0	N/A
16/03/2021	274	N/A	0	N/A
30/11/2021	245	N/A	0	N/A
20/12/2021	217	N/A	167	N/A
3/02/2022	184	76	94	N/A
15/03/2022	12	25	25	N/A
12/04/2022	19	N/A	45	N/A
20/09/2022	21	N/A	65	N/A
17/10/2022	112	42	68	345
21/11/2022	209	63	115	N/A
13/12/2022	114	N/A	104	N/A
17/01/2023	263	N/A	61	26
7/02/2023	131	38	27	N/A
20/03/2023	37	23	41	2
18/04/2023	25	27	47	N/A
26/09/2023	377	163	289	632
16/10/2023	157	148	81	N/A
20/11/2023	225	0	27	N/A
11/12/2023	785	88	104	N/A
15/01/2024	128	2	2	3
12/02/2024	11	5	0	N/A
20/03/2024	49	(Trap failed) 0	0	N/A
Total	7908	700	1362	1012

The composition of all adult traps was similar throughout the trapping season with a dominance of *Culex annulirostris*, *Culex globocoxitus*, *Culex quinquefasciatus*, *Culex australicus*, *Aedes notoscriptus* and *Anopheles annulipes s.l.* Table 3 shows a full list (in descending order of dominance) of adult mosquitoes collected across the sites from 2014 to 2024 and their associated disease risks.

Table 3: List of Adult Mosquito Species Identified

Adult mosquito species	Total Abundance from 2014-2024	Disease Risks
<i>Aedes notoscriptus</i>	15688	RRV
<i>Culex quinquefasciatus</i>	11228	RRV, MVE
<i>Culex annulirostris</i>	9817	MVEV, WNV _{KUN} , RRV, BFV
<i>Culex australicus</i>	4624	None
<i>Culex globocoxitus</i>	4480	None
<i>Anopheles annulipes s.l.</i>	2088	None
<i>Aedes alboannulatus</i>	901	None
<i>Aedes camptorhynchus</i>	392	RRV, BFV
<i>Culiseta atra</i>	215	None
<i>Aedes clelandi</i>	105	None
<i>Aedes hesperonotius</i>	86	None
<i>Coquillettidia sp nr linealis</i>	51	RRV
<i>Aedes ratcliffei</i>	26	None
<i>Aedes tremulus</i>	6	Unclear
<i>Aedes vigilax</i>	4	RRV
<i>Aedes turneri</i>	1	None

Larval monitoring has been carried out across the City since 2006 to gather baseline data on the density and species present. The frequency of larval monitoring has been based on weather conditions/breeding triggers, but generally occurred on a weekly to fortnightly basis throughout spring, summer, and early autumn. Over late autumn and winter, larval monitoring occurred on a monthly basis. The main larval dipping sites have been established across the city, as identified in Appendix 1.

In summary, *Culex annulirostris*, *Culex quinquefasciatus*, and *Aedes notoscriptus* were the three most dominant species trapped throughout the City over the years of adult monitoring. Similarly, *Culex quinquefasciatus*, and *Aedes notoscriptus* were also the dominant species collected during larval monitoring. All three species are capable of transmitting RRV and BFV.



7. Mosquito Management Strategies

There are four mosquito management strategies that the City uses in the development of its integrated MMP: physical, chemical, cultural and biological. Avoiding the reliance on a single strategy helps prevent many of the problems inherent with long-term control, such as the development of chemical resistance.

7.1 Physical Control

Physical control methods are used to reduce the potential for mosquito breeding and harbourage by modifying the natural or built environment. Breeding sites are reduced by decreasing the amount of vegetation within drains, marsh or other known breeding sites.

As a part of the MMP potential physical control measures are identified and reported to the relevant City Departments to undertake the works, including but not limited to:

- Maintenance of stormwater drains to facilitate draining and prevent water pooling;
- Maintenance of City managed waterbodies to limit and thin vegetation growth (excluding conservation areas); and
- Filling in small depressions e.g., uneven land clearing, wheel ruts, etc.

The City's Town Planning Scheme also identifies parcels of land that require a Structure Plan to be prepared to guide subdivision and development which includes areas that may have the potential to be affected by mosquito breeding due to proximity to wetlands/waterways. As a part of the subdivision process, developers are often required to prepare and implement a Mosquito Management Plan to the satisfaction of the City, with the majority being in the City's growth areas.

7.2 Chemical Control

Chemical treatment will be applied by the City only if significant number of pest or disease vector species are identified and if physical and/or biological control of the site is not possible. For environmentally sensitive areas, approvals will be required from relevant regulatory bodies before chemical treatment is applied.

Larvicides

It is more efficient to treat the mosquitoes as larvae, while they are contained within an aquatic environment, rather than as flying adults. Larvicides kill mosquito larvae and/or prevent the larvae developing into adult mosquitoes. They are also target-specific when applied at the label rate, reducing the impact on the environment. Larvicides will be applied as per standard operating procedures and manufacturer's recommended larvicides application rates by operators trained in mosquito management. For small breeding sites, larvicide will be applied using a handheld spreader or using a backpack spreader.

The following larvicides are currently used as part of the City's MMP:

S-methoprene is an insect growth regulator that is absorbed by larvae and prevents them from developing into normal pupae. The City currently uses this larvicide in the form of Prolink XR briquettes and Prolink pellets. The slow releasing briquettes provide control for up to 150 days. The pellets are used for smaller treatment areas such as water holding containers and are effective for 30 days.

Bacillus thuringiensis israelensis (Bti) contains spores and endotoxins of naturally occurring bacterium. These spores and endotoxins are ingested by mosquito larvae, resulting in death within 24 hours. Bti is toxic only to the larvae of certain dipteran (true flies). It does not harm other aquatic, marine or terrestrial fauna.

Bacillus thuringiensis israelensis (Bti) and S-methoprene – The City also uses Vecto Prime FG which combines Bti and (S)-methoprene in each micro particle. This dual mode action enables treatment at all larval stages allowing application flexibility for early or late instars.

The high potency and dual actions reduce the number and volume of product required. Vecto Prime FG is thus the preferred larvicide used by the City when there is major breeding. To prevent potential resistance issues of continuously using both Bti and *S-methoprene*, the City will rotate between using larvicide products containing either Bti or *S-methoprene* as the active constituent. The City will not rely on Vecto Prime FG and only use this larvicide when major breeding is identified, and instant kill is required.

Adulticides

Adulticides used in fogging activities are designed to kill adult mosquitoes. However, they will kill other flying insects (e.g. bees, dragon flies etc) and can be lethal to fish. For these reasons, fogging is only used by the City if there is an imminent public health risk associated with mosquito-borne disease transmission. The City has not had to used fogging since implementing its MMP.

7.3 Cultural Control

Cultural control is critical to successful mosquito management. The main objectives are to prevent backyard breeding and to reduce the incidence of residents bitten by mosquitoes. This is achieved through community education programs and increasing awareness of the nuisance and health risks associated with mosquitoes. Residents are encouraged to raise their mosquito concerns with the City so an investigation can be instigated, and appropriate management action taken. Service request investigations are an opportunity for officers to provide information directly to residents on how they can control mosquitoes on their property.

The City also educates the community on mosquitoes and mosquito-borne diseases at City supported events such as the "Let's Connect Expo" and "Movies in March" by promoting the City's Mosquito Management Program and DoH's 'Fight the Bite' campaign. The public are encouraged to take measures to limit the impact mosquitoes and mosquito-borne disease may have on their health and lifestyle.

Information on mosquito abundance, mosquito-borne disease and mosquito management activities are also provided through the City's social media platforms and the City's website.

Increasing community awareness for future developments is also important. During the subdivision approval process, should it be identified that there is potential for residents to be affected by mosquito activity and if the Western Australian Planning Commission agree, a notification, pursuant to Section 165 of the *Planning and Development Act 2005*, can be placed on the certificate of title of the proposed lot(s) advising of the potential hazard.

7.4 Biological Control

Biological control is the most natural option and it is achieved by maintaining healthy, self-sustaining ecosystems to promote natural predation of mosquitoes. To promote healthier aquatic systems, the City reduces the use of nutrient rich fertilisers in public parks that run into wetlands, therefore assisting in managing the nutrient levels in the water.

8. Ongoing Monitoring and Surveillance

Ongoing monitoring and surveillance are vital to ensure suitable control methods are applied in a timely manner and to assess the effectiveness of the control program.

8.1 Adult Trapping

Adult EVS/CO₂ (encephalitis virus surveillance/carbon dioxide) traps are used to monitor populations of adult mosquitoes. The mosquitoes caught in the traps are counted and identified to species. Adult trapping is important to monitor mosquito abundance, as well as to identify problem species and allow targeted larval investigations and control actions.

Routine adult trapping is undertaken monthly during the mosquito season (September to April). The frequency may increase to fortnightly and or extend outside this season subject to environmental triggers or resident complaints that indicate an increase in mosquito breeding and nuisance risk. A minimum of 50 mosquitoes must be captured in a single trap to be considered a public nuisance. The area around the trap location is surveyed for mosquito breeding and treated as required. Additionally appropriate mosquito control will be implemented by the City if trap results exceed the threshold level as determined below:

- ≥ 20 adults *Aedes vigilax* per trap
- ≥ 30 *Aedes camptorhynchus* per trap
- > 30 *Aedes notoscriptus* per trap
- Over 100 *Culex annulirostris* per trap

Trapping is also conducted after larvicide treatments to determine the effectiveness of the treatment. All information on mosquito abundances and species are recorded on DoH's Atlas of Environmental Health application.

8.2 Larval Monitoring

Mosquito breeding only occurs when the water level is below 300mm and the minimum daily temperature is $> 20^{\circ}\text{C}$, triggering the need for larval monitoring to begin. Between September and April, larval monitoring is conducted on a regular basis at known or potential breeding sites. Drains owned by Water Corporation are inaccessible and are therefore not monitored or treated.

At each potential breeding site, several dippers are conducted to determine the larval density per square meter (larvae per m²). Appropriate larval control is implemented if larval dipping exceeds the threshold level of approximately 10 larvae in 5 consistent dippers, equivalent to 1000 larvae per m². Post-treatment larval monitoring is conducted to ensure treatment is successful. Samples are also collected and sent to a laboratory to be counted for abundances and identified for species.

9. Public Education

As part of the community education and awareness program, the City's Health Service undertake the following activities:

- Carry out face-to-face community engagement at City run and/or supported events educating patrons on mosquitoes and mosquito-borne diseases and promote the City's MMP.
- Actively promote DoH's 'Fight the Bite' campaign on social media, at events and on the City's website.
- Respond to general enquiries.
- Provide guidance while investigating complaints and while completing the RRV follow up questionnaires as notified by DoH.



10. Stakeholders

10.1 Internal Stakeholders

The City's Planning Officers will refer development applications to Health Services for comment and assessment prior to any decision being made about the appropriateness of the proposed land use.

The City's Engineering/Technical Services are responsible in ensuring that the new subdivision infrastructure and City built infrastructure are designed and managed to minimize mosquito breeding areas. All proposed civil applications will be referred to Health Services for comment and assessment.

The City's Parks and Reserves Department will assist with the removal of mosquito breeding items such as slashing of vegetation found within parks and reserves as requested by Health services.

The City's Community Services will assist Health Services with community engagement efforts via variety of social media channels to raise awareness of mosquito-borne disease, personal prevention strategies and the Fight the Bite Campaign.

The City's Health Services will liaise with these internal departments when required in order to implement key management actions as summarised in the action plan in Appendix 2.

10.2 External Stakeholders

External Stakeholders play a crucial role in ensuring the City's MMP is effective particularly where mosquitoes may cross borders between neighbouring Local Governments. Additionally, external stakeholders may be responsible for mosquito management for environmentally sensitive land or crown land within the City's jurisdiction that are breeding mosquitoes. Key stakeholders include:

- Department of Health
- Department of Biodiversity, Conservation and Attractions
- Western Australian Planning Commission (WAPC)
- Department of Planning, Land and Heritage
- Department of Water and Environmental Regulation
- Local Community
- Contiguous Local Authorities Group (CLAG) Stakeholders – City of Cockburn, City of Kwinana, Shire of Serpentine Jarrahdale

Council at its meeting on 26 June 2023 supported the City making an application to join the CLAG and authorised the CEO to enter into a Memorandum of Understanding (MOU). Through CLAG funding, DoH will provide a 50% contribution towards chemicals, mosquito management equipment, physical control strategies, cultural control strategies and training and development.

11. New Developments

With the City's growth expected to increase by an estimated 45,000 by 2046, land use, subdivision and rezoning could play a role in increasing the risk presented to future residents/visitors. At a strategic level, allowing development of land in close proximity to known mosquito breeding habitats should be given due consideration because of an increased risk of acquiring RRV/BFV (where vector species are present) and/or nuisance.

The WAPC has the power to impose a memorial on newly created land titles through the process of subdivision on lots, notifying prospective purchasers that could potentially be affected by a relatively permanent hazard. Proposals may not be supported where it can be demonstrated that management of the risk cannot be achieved through environmentally sensitive methods. In cases where the development is proposed to be near existing natural wetlands or an artificial water body created, the proponent may be required to submit to the Environmental Protection Authority (EPA) for assessment.

Lot notification on titles is also recommended at the subdivision stage based on the structure plan, assessment of the area and previous history of mosquito trapping data and complaints. WAPC can then impose conditions on subdivision approvals based on these risks and the City's recommendations.

Conditions dealing with risk associated with mosquitoes can include specific requirements such as the proponent being required to prepare a MMP and/or make financial contributions to the local government MMP.

Under the City's Town Planning Scheme, a MMP is often required to be submitted as part of a structure plan to guide subdivision and development for land that could have the potential to be affected by mosquito breeding due to proximity to wetland or waterways. The City may require large multi-lot developments in "special control areas" to submit a MMP in the early development stages through planning conditions on development approvals. Single site developments (large DA's/JDAP's) may also be required to develop a MMP based on the location. The City's Health Service will review the MMP and issue approvals to the developer.



12. Record Keeping

It is critical that good record keeping practices are maintained. The records and documentation that are kept on the City's record management system include:

- Annual complaint register.
- Mosquito-borne disease notifications and follow-up documentation.
- Adult and complaint trapping results.
- Larval survey results.
- Media releases issued by the City.
- Chemical/bio-larvicide treatment logs and post treatment surveys.
- Job Safety Analysis and Safe Work Procedures.
- Chemical product labels and MSDS.
- Reports.

A centralised recording system ensures current staff and any future employee/s involved with delivering the MMP have access to background knowledge.

13. Budget and Resource Requirements

Operating and implementing a mosquito management program can have a significant impact on human and operational resources. Budget requirements will fluctuate depending on the severity of the mosquito-breeding season, which is largely dependent on environmental variables. A sustainable budget is required in order to ensure the continued improvement and implementation of an effective mosquito management program.

Council at its meeting on 26 June 2023 supported the City's proposal for annual funding of up to \$64,000, an additional 1.0FTE Environmental Health Technician/Mosquito Management Officer and the purchase of a dedicated 4WD vehicle to help implement the MMP.

14. Training and Staff Development

It is essential that all personnel involved in the operational aspects of the MMP are suitably qualified, trained and/or supervised. Skills and competencies required to deliver the requirements of the MMP safely and effectively include:

- Basic mosquito ecology.
- Principles of integrated mosquito management.
- Ongoing surveillance/monitoring techniques.
- Collection, recording and identification of mosquito samples.
- Standard operating procedures for equipment.
- Calibration techniques.
- Safe storage, handling and application of chemicals/larvicides in accordance with the product manufacturers labelling specifications and MSDS.
- Use of appropriate PPE in accordance with product labelling, MSDS and environmental conditions.
- Correct disposal/handling of product waste.
- Information technologies/geographical information systems.
- Budget management and procurement procedures.
- First aid.

DoH offers a mosquito management course every two years to provide required mosquito management training. The City will arrange for staff to undertake professional development on an ongoing basis when training is available.

All City staff involved in the planning/development process and whose decision-making may have an impact on the MMP will be briefed on its objectives and implementation. City staff will also be provided with standard operating procedures and the necessary information required including the safe storage, handling and application of chemicals and the appropriate use of personal protective equipment.

15. Procedure Manual

Mosquito control procedures have been developed to support the operational requirements of the MMP to guide staff on the required processes. The procedure manual is a working document and will be reviewed and updated on a regular basis due to the constant changes in mosquito seasons. The following standard operating procedures have been included in the procedure manual:

- Species Identification.
- Chemical and/or biological control.
- Setting adult traps, collection and recording data.
- Larval monitoring, collection and recording data.
- Job Safety Analysis (JSA) Authorisation Sheet.
- Mosquito Control suppliers and contacts.



16. Review of the Mosquito Management Plan

This plan will be reviewed on an annual basis, with a full review every three years to reflect any legislative changes and new developments and management strategies. It is also important to assess effectiveness of the overall control program to allow for continuous improvement. An ongoing surveillance program will assess whether the mosquito populations are being reduced and if the control program is achieving reductions in pest problems or mosquito borne diseases. Statistical data on trapped adult species, confirmed breeding sites and resident complaints will be used for this assessment process. DoH will also be consulted as part of the review for any improvements or recommendations.

An annual report will be prepared at the end of the financial year to summarise the mosquito management actions that have been implemented throughout the previous mosquito season. The report will highlight key findings and recommendations for the following monitoring period and revisions (if required) for the Mosquito Management Plan.

17. References

Department of Health. (2007). *Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water bodies*. <https://www.health.wa.gov.au/~media/Files/Corporate/general-documents/Mosquitoes/PDF/Chironomid-midge.pdf>

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City of Kwinana. (2020). City of Kwinana Integrated Strategic Mosquito and Midge Management Plan

Bureau of Meteorology. (n.d.). Climate Data Online. <http://www.bom.gov.au/climate/data/>

18. Appendices

Appendix 1 – City of Armadale Known Larval Breeding Sites

Site 1 – Piara Nature Reserve – Along Nicholson Rd



Site 3 – Sandstone Park



Site 2 – Piara Nature Reserve Site – PNR below Power A Frame along Fairweather Dr



Site 4 – Gilam Park



Site 5 – Hesketh Park



Site 6 – Benbecula Park



Site 9 – Clam Clay Reserve



Site 10 – Westfield Heron Reserve

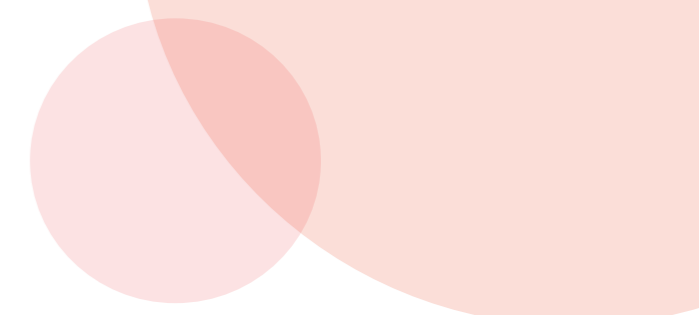


Site 7 – Cnr Churchman Brook Rd & Watereheel Rd N



Site 8 – Sheaf Park





Appendix 2 – City of Armadale Management Acton Plan

No	Task	Frequency	Trigger/ When	Action	Expected Outcome
1	Larval Monitoring	Monthly, as required or when public complaints are received	Evidence of larval breeding	Larviciding	Reduce larval and adult mosquito abundances
2	Adult vector monitoring	Monthly (September – April), As required or when public complaints are received	Evidence of adult mosquito nuisance level based on species identified per trap: <ul style="list-style-type: none"> • ≥ 20 <i>Aedes vigilax</i> • ≥ 30 <i>Aedes camptorhynchus</i> • > 30 <i>Aedes notoscriptus</i> • >100 <i>Culex annulirostris</i> 	Larviciding of breeding area, community education	Reduce larval and adult mosquito abundances, Increase community education and awareness on backyard breeding, reduction in breeding sites and mosquito abundances
3	Baiting	As required or when public complaints are received	Evidence of larval breeding	Larviciding	Reduce larval and adult mosquito abundances
4	Complaint Investigation	When public complaints are received	Evidence of larval breeding/adult mosquito nuisance level	Commence investigation, conduct larval dipping, adult trapping. Larviciding when there is presence of larval breeding, community education 'Fight the Bite Campaign' for source reduction	Increase in community education and awareness on backyard breeding, reduction in breeding sites and mosquito abundances
5	Monitoring of Vegetation, disused tyres and drains	Monthly, completed in conjunction with larvae monitoring, As required or when public complaints are received	Stagnant water/ponding caused by dense vegetation	Organise with Parks – Removal of silt, tyres and vegetation from stormwater drains	Reduce breeding sites and as a result decrease in trap numbers

No	Task	Frequency	Trigger/ When	Action	Expected Outcome
6	Staking and Monitoring existing stakes - briquettes	Monthly	Evidence of larval breeding, breakdown of briquettes/floatation device	Re-staking of briquettes	Reduce larval and adult mosquito abundances
7	Public awareness and communications program	Movies in March, Let's Connect Expo, As required	Evidence of extensive mosquito problem	Utilise DoH FTB Campaign. Participate in public events	Community education and awareness on backyard breeding, reduction in breeding sites and mosquito abundance
8	Locate all breeding sites on vector control maps	Ongoing	Evidence of breeding sites through surveillance	Update Maps	Updated vector mapping
9	New development applications	Ongoing	Evidence of potential or historical breeding and vector mapping	Notification on title for subdivisions and conditions on mosquito management	Public awareness and Mosquito Management
10	Staff Training	As required	New Environmental Health Technician	Training on mosquito management and control	Ability to conduct mosquito control, management and mosquito compliance investigations
11	Annual Review and Report	Yearly	Conclusion of each mosquito season	Highlight monitoring efforts, key findings and recommendations for the following monitoring period and revisions (if required) for the Mosquito Management Plan	The Annual Mosquito Report is to be included in the City of Armadale's Manager's report



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