

Chironomid midge and mosquito risk assessment guide for constructed water bodies



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Acknowledgments

This document has been developed by representatives from the Midge Research Group of Western Australia, including people with expertise in midge and mosquito management, as well as water body design and maintenance. In particular the contribution of the following people is gratefully acknowledged.

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This document is continually being reviewed and as such we welcome your feedback. Comments can be sent to the City of Cockburn at midge@cockburn.wa.gov.au. Additional copies of this document can be downloaded from <http://www.cockburn.wa.gov.au/midges/index.html>

Foreword

This risk assessment guide has been developed to provide assistance to Approving Agencies, Developers and Landscape Designers in assessing design characteristics of proposed and existing Constructed Water Bodies. This document has been endorsed by the Department of Water, Department of Health and the Water Corporation. It is intended to provide a balance to minimising the potential for midge and mosquito breeding whilst at the same time endeavouring to allow flexibility in design and construction options. The guide provides a risk rating to various design parameters and users should select the most appropriate description of the proposed water body.

The guide applies to constructed water bodies proposed for the temperate south-west of Western Australia, where moderate annual rainfall falls primarily in the winter months. It may be less appropriate to the north of WA (because of the heavy wet season rainfall and associated problems of flood management) or to other parts of Australia, although many of the principles may still be relevant.

For the purpose of this document Constructed Water Bodies refers to those water bodies which are artificial in construction whether they are for aesthetic, stormwater management, irrigation or environmental management purposes. It does not include vegetated swales or 'living streams', sewage lagoons or effluent re-use infrastructure, although many of the same design principles may be relevant.

The use of this document in no way provides a guarantee that nuisance problems will not arise, merely that they are less likely where lower risk options are selected. In addition its use in no way precludes any other legislative requirements relating to the development of water bodies.

In particular, for matters relating to stormwater management, the Department of Water recommends that this document should be read in conjunction with the Department of Water's *Stormwater Management Manual for Western Australia (2004)* and the *Decision Process for Stormwater Management in WA (2005)*. These documents promote management of stormwater at source via overland flow paths over vegetated surfaces (swales) and living streams, allowing infiltration and recharge of Perth's groundwater. Further advice on stormwater management and the appropriateness of constructed water bodies for specific catchments can be sought from the Department of Water.

Assessing the Proposed Constructed Water Body

Design elements which may contribute to the number of nuisance midge and mosquitoes have been selected and assigned various risk ratings. Where possible, characteristics with a lower risk rating should be incorporated into a proposed constructed water body. In order to obtain a total rating score add up all the selected risk ratings ie risk rating 2 equals a score of 2 etc. The total score should be between 13 and 47.

Score between 13 and 24: Low risk water body which is unlikely to produce midge or mosquitoes in sufficient numbers so as to create a nuisance or pose a health risk. It is likely that minimal monitoring and maintenance would be required. It is recommended that all future constructed water bodies fall within this category.

Score between 25 and 36: Medium risk. Increased probability of midge or mosquito breeding so as to create a problem. Requires improved monitoring and ongoing maintenance in order to prevent problems occurring. Not recommended for future constructed water bodies.

Score between 37 and 47: High risk. Strong probability of water body experiencing problems with nuisance midge/mosquitoes or both. Would require extensive monitoring and maintenance programs. It is recommended that these types of constructed water bodies should not be approved or built in the future.

Assessing an Existing Water Body

The primary purpose of the risk assessment guide is for use in assessing design characteristics for new water bodies. However the guide can also be applied to existing water bodies where there are midge and/or mosquito problems. The determination of high-scoring parameters may allow modifications to be made to the design of the water body (e.g. removal of emergent vegetation, addition of mechanical aeration, installation of a pre-treatment bed) to lower the risk rating and reduce the insect productivity of the water body. However the original design purpose should also be considered as any modifications may affect the water body's functionality e.g. many water bodies were designed primarily for drainage but over time became the habitat for many different species. This environmental benefit is secondary to the primary purpose, however some community members or groups may be opposed to any action which they believe will adversely impact the wildlife. The risks and outcomes from any changes should be carefully assessed and discussed with all relevant stakeholders. For water bodies which have stormwater drainage as a function, reference should be made to the Department of Water's *Stormwater Management Manual for Western Australia* (2004).

Conclusion

In addition to the selected criteria other elements such as public safety issues, including fencing and warning signs, need to be considered and adequately addressed. A well documented environmental management plan should be in place and provision should be made to ensure there are adequate financial resources available for personnel and machinery for maintenance purposes.

Further explanation on the different criterion and reasons for the assigned risk ratings can be found in the supplement section: Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water Bodies - Guidance Notes.

Risk Matrix

Hydrology of the Water Body:

Risk Rating 1	Risk Rating 2	Risk Rating 3
Water level fluctuates and water body dries out	Water body does not dry out but water level remains constant	Water body does not dry out and water level fluctuates

Location of the Water Body to Residential Areas:

Risk Rating 1	Risk Rating 3	Risk Rating 5	Risk Rating 7
Nearest resident is located at least 200m from waters edge	Nearest resident is located between 100m and 200m from waters edge	Nearest resident is located between 50m and 100m from waters edge	Nearest resident is located less than 50m from waters edge

Form of the Water Body

Risk Rating 1	Risk Rating 2	Risk Rating 3	Risk Rating 4
80-100% of the water body's edge is hard vertical edge thereby maximising the effect of wave action	50-80% of the water body's edge is hard vertical edge and located across prevailing wind axis	50-80% of the water body's edge is hard vertical edge but is randomly located	Less than 50% of the water body's edge is hard vertical edge

Risk Rating 1	Risk Rating 2
Shape of the water body is simple in order to facilitate good water circulation	Shape of the water body is intricate or includes angles which may restrict water circulation

Wind Related Parameters

Risk Rating 1	Risk Rating 2
The long axis of the water body is in line with known prevailing wind directions or is of a circular nature	The long axis of the water body is perpendicular to known prevailing wind direction

Risk Rating 1	Risk Rating 2
Surrounding land level with water body preventing surface runoff entering and maximising potential wind action	Constructed wetland located in a depression so that surrounding land slopes down to the waters edge

Depth of the Water Body

Risk Rating 1	Risk Rating 2	Risk Rating 4	Risk Rating 5	Risk Rating 6
Seasonal water bodies which dry out	Between 60cm and 2m	Between 30cm and 60cm	Greater than 2m	Less than 30cm

NB: Depth is to be the average predominant depth typical for the month of November with the exception of seasonal water bodies which dry out.

Mechanical Circulation

Risk Rating 1	Risk Rating 2	Risk Rating 3
Volume of water body circulated every 24 hours or less	Volume of water body circulated every 24 hours or longer	No mechanical aeration provided or poor water circulation

NB: Water bodies with a non permanent water source to be allocated a risk rating of 1.

Aquatic Vegetation

Risk Rating 1	Risk Rating 2	Risk Rating 4	Risk Rating 4
Emergent vegetation in small stands parallel to predominant wind direction with measures taken to reduce vegetation colonisation of remaining water body	Emergent vegetation in small stands parallel to predominant wind direction	Aquatic vegetation planted in large dense stands randomly and in a manner so it is not restrained from colonising other parts of the water body	No aquatic vegetation

Terrestrial Vegetation

Risk Rating 1	Risk Rating 2	Risk Rating 3
Buffer vegetation mainly planted down wind of the water body or surrounding entire water body and with clear open space provide between buffer vegetation and nearest residence	Buffer vegetation mainly planted down wind of the water body. Vegetation grows right up to nearest residence and may act as a dispersal corridor	Vegetation randomly planted or in insufficient quantity to provide an effective buffer

In Flow Water Quality

Risk Rating 1	Risk Rating 3	Risk Rating 5	Risk Rating 7
In flow water has minimal levels of nutrients	In flow water has low levels of nutrients	In flow water has medium levels of nutrients	In flow water has high levels of nutrients

Engineering Considerations

Risk Rating 1	Risk Rating 2
Inbuilt ability to 'draw down' or lower the water level mechanically	No ability to lower the water level mechanically

NB: Water bodies with a non permanent water source to be allocated a risk rating of 1.

Risk Rating 1	Risk Rating 2
Sufficient access for personnel and machinery to undertake routine maintenance or implement control measures	Access for personnel and machinery restricted

Chironomid midge and mosquito risk assessment guide for constructed water bodies - Guidance Notes

These guidance notes have been developed as a supplement to the Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water Bodies. They are intended to provide additional information and explanation on the various criteria and rationale behind the associated risk ratings.

Chironomid midges and mosquitoes both cause significant nuisance, affecting lifestyle and amenity and having direct and indirect economic impacts. Mosquitoes can also be vectors of Ross River virus and other mosquito-borne diseases. Therefore it is important that careful consideration is given to whether or not a constructed water body is appropriate or necessary in the first place. If a water body is to be constructed, then it should be located, designed and managed to minimise the production of midges and mosquitoes and to limit the contact between them and people, while satisfying other safety considerations.

The costs to Local Government for water bodies experiencing problems with nuisance insects can be significant. These may include economic costs associated with complaint investigation, monitoring, regular maintenance, application of chemical controls, implementing post construction rectification work, as well as social costs such as public perception and public satisfaction levels.

It is recognised that there are a number of conflicts between water body design parameters directed to minimising midges as opposed to those for minimising mosquitoes. For example, midge managers promote the use of emergent vegetation for nutrient stripping because algal blooms provide food for midge larvae. Mosquito managers however, recognise the importance of limiting the density and area of emergent vegetation because it provides protected habitat for mosquito larvae and prevents predator access. Therefore, this risk assessment guide and guidance notes have been developed in an attempt to resolve the key considerations for achieving constructed water bodies that have minimal midge and mosquito production and that minimise the requirement for ongoing management.

In developing the risk ratings, the typical situation has been considered, whereas some scenarios may not fit the expected pattern. For example, inflow water via traditional piped stormwater systems would be expected to have a higher nutrient load than that from bore water. However this may not be the case if the ground water has been contaminated. In such cases, the risk rating for that criterion can be adjusted accordingly.

Explanations and guidance on the various criteria are provided below.

Hydrology of the Water Body:

In general, a seasonal water body will be preferable to a permanent water body because midge and mosquito breeding will cease once it has dried out. It is important that the base of the water body is evenly contoured to prevent pools occurring as the water body dries out, as these pools of water allow mosquito breeding. Seasonal drying will also allow maintenance staff to access the water body for vegetation harvesting if required.

However, disadvantages of a seasonal water regime are that the refilling of the water body will produce a flush of mosquitoes resulting from the hatching of desiccation-resistant eggs and a flush of midges responding to algal growth after the wetting of nutrient-rich sediments. Also, predator populations will be lost each time the water body dries.

The nutrient status of the inflow water is viewed as a critical parameter because of the link with algal blooms and midge production. Inflow water from traditional piped stormwater systems is typically higher in nutrients than bore water or ground water.

In permanent (non-drying) water bodies, constant water level is preferable to fluctuating water levels because one group of mosquitoes, the *Aedes* species, lay eggs around the margins of the water body which hatch when inundated by rising water levels. Whilst a water body which has dried out obviously has a fluctuating water level, the benefit gained whilst it is dry results in it being considered as if the water level was kept constant.

Location of the Water Body to Residential Areas:

Planning for a new development should allow for a buffer distance to minimise dispersal of midges and mosquitoes from the water body to surrounding residences. The greater the buffer distance, the less likely residents are to suffer nuisance or be exposed to mosquito-borne disease. A buffer will also allow the space for other control measures, such as screening vegetation, to be implemented. Situations which have residential properties adjacent to the waters edge should be avoided at all costs.



Photo 1: By locating the water body in the centre of the parkland, buffer distances to surrounding houses have been maximised. In addition space is available for planting screening vegetation between the water body and houses.

Form of the Water Body

Hard vertical edges (or a 200mm vertical lip) will maximise the effect of wave action and disrupt midge/mosquito survival. Therefore it is important that the long axis of the wetland is parallel to the prevailing wind direction. The prevailing wind direction should be taken as the one most common during spring/summer. The shape of the wetland should be simple rather than intricate in order to facilitate good water circulation and prevent algal growth.



Photo 2: Shows hard vertical edges as well as barriers for public safety.

Wind Related Parameters

Increased wave action on the water surface will reduce an insect's chance of survival. For this reason factors which help promote wave action are recommended. To maximise the affect from wind, the water body should be orientated so its long axis is in line with known prevailing wind directions. The land surrounding the water body should also be relatively flat and ideally at a similar level to the water. A further advantage of not having the wetland in a depression is it prevents surface runoff entering the water body.

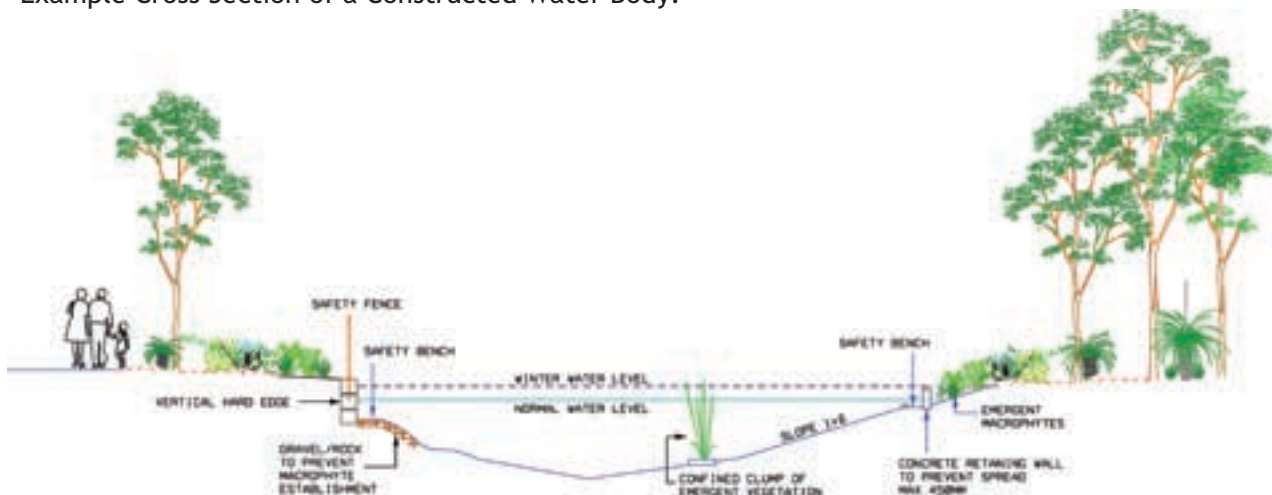


Photo 3: Shows surrounding land flat and level with the water thereby maximising the affect of wind action.

Depth of the Water Body

Shallow depth will result in higher water temperatures, faster midge/mosquito development and also encourage the proliferation of emergent vegetation. In general, the deeper the water body the better. However the depth should not exceed 2m to ensure sufficient light penetration for submerged plants (nutrient stripping) and to minimise the likelihood of stratification.

Example Cross Section of a Constructed Water Body:



Mechanical Circulation

Well circulated, oxygenated water bodies are less likely to produce algal blooms. As algal blooms provide a ready food supply for midge it is vital that they be prevented from forming where possible. The ability to oxygenate the water body will depend on its size and depth as well as the number and type of aerators. Whilst fountains are probably the most common form of aerator, other forms such as waterfall features may also be appropriate.



Photo 4: Showing no aeration of water body and subsequent algal bloom.

An added benefit of fountains is the surface disturbance of the water which can reduce insect survival. However in order for this to be effective the majority of the water must be being disturbed, particularly near the edges which typically have high insect activity. Therefore multiple smaller fountains widely dispersed will be preferable to single larger fountains. The running costs of smaller multiple fountains are also likely to be significantly lower than that for a single larger fountain. Obviously water bodies with lower running costs will be preferable to water bodies with high running costs.



Photo 5: Aeration of water body using a standard fountain.



Photo 6: Aeration of water body using a waterfall feature instead of a fountain.

Aquatic Vegetation

Aquatic vegetation is important for taking up nutrients within the water thereby reducing the potential for algal blooms which may in turn fuel midge populations. However, emergent, floating and submerged vegetation have the potential to colonise extensive areas, thereby providing good harbourage (protected habitat) for midges/mosquitoes and restricting access for predatory species. It is important to avoid planting areas of emergent vegetation around the shallow perimeter of a wetland. Aquatic vegetation should be limited to small stands, preferably in deeper water (>60cm). The stands should be parallel to the predominant wind direction to maximise the effect of wind action. Limestone or other hard substrates around the plantings can be used to limit outward colonisation. Wetland management must include the capacity and funding to undertake routine harvesting of vegetation by maintenance staff to limit midge/mosquito populations.



Photo 7: Sedge growth restricted to small pocket by concrete retaining wall



Photo 8: Unrestricted sedge growth which over time will dominate the remaining water body

Terrestrial Vegetation

Terrestrial vegetation planted around a water body provides a physical barrier between surrounding residences and the water body. This is advantageous for reducing the wind-assisted dispersal of midges towards lighting, however conversely it will provide a corridor for mosquitoes flying towards a potential blood meal. Therefore, terrestrial vegetation should be planted in a narrow band close to the water body on the down wind side in sufficient density to form an effective screen. However, clear open space should be provided between the vegetation screen and the residences to ensure that there is no continuous dispersal corridor for mosquitoes.



Photo 9: Screening vegetation planted on the down wind side of the water body.

Predatory Fish (Where permanent source of water will be present)

Whilst not included in the Risk Matrix, in order to ensure a predator population is built up as soon as possible, fish (preferably native species) can be introduced to the water body as soon as practicable. Predatory invertebrates will colonise the water body naturally.

The issue of whether to include this category in the Risk Matrix is a complicated one and raises issues regarding the type of fish to be introduced and the availability of native fish commercially. The introduced mosquito fish, *Gambusia* sp., occurs in many of WA's natural and constructed water bodies due to human intervention. While *Gambusia* sp. will feed on midge and mosquito larvae, they are also predators of other aquatic species. Therefore it is preferable to consider the introduction of local native fish in the first instance. The Department of Fisheries may be able to provide further advice as to what fish species are common to particular areas and may be able to provide information as to their availability commercially.

Inflow Water Quality



Photo 10: Inflow water flows through vegetated swale planted with sedges to remove nutrients from the water. There is also a concrete barrier separating the grass from the sedges restricting growth of both species and assisting in maintenance. However routine harvesting will still be required to control the growth of the sedges.

Water quality in a constructed water body must be of a good standard to avoid algal blooms, midge and mosquito production and excessive vegetation growth. In order to ensure the water quality remains acceptable, inflow water must also be of a good standard.

Where inflow water is via traditionally piped stormwater systems, a pre treatment bed should be installed to remove nitrogen, phosphorus and suspended solids prior to entry to the water body. The water in the pre treatment bed should be retained for as long as possible and allowed to drain naturally into the ground. However, if mosquito breeding occurs in the pre treatment bed, the addition of slow-release larvicides may be required.

The provision of a limestone base may be one method of binding phosphorous, which typically is the limiting nutrient for algal blooms, however this approach has not been rigorously trialled. It should also be remembered that eventually the limestone will become saturated and unable to bind further phosphorus. As a result, the limestone may need to be replaced or additional limestone added. Whilst this may be particularly expensive or difficult for existing water bodies, even for only a short term gain it is worth considering when constructing a new water body. The limestone may also assist in limiting colonisation of the water body by aquatic vegetation.

Engineering Considerations

Ideally, provision should be made for draining the water body to allow maintenance of pumps and equipment, vegetation harvesting and any other necessary work. In addition, mechanical draining of a water body may also be able to be used as a chemical free control measure against nuisance insects by preventing further larval growth and development.

The margins of the water body should be designed to allow access of personnel and machinery for vegetation harvesting, midge/mosquito monitoring and control activities. Access can be impeded by inappropriate fencing or surrounding residences, topography ie steep slopes, unstable grounds which do not support machinery or narrow access paths restricting entry of machinery to some areas.

The types of machinery required should also be carefully considered. For instance some larger water bodies may require the use of a small boat, so access for boat launching and retrieval should be considered. Likewise, the use of machinery such as backhoes and trucks may be used for vegetation harvesting. Backhoes have a limited reach so vegetation should not be planted too far in so as to be unreachable.

Environmental Management Plan

It is essential that a management plan for the water body is developed and implemented which clearly defines the monitoring and maintenance program, detailing the actions required and the estimated annual cost. It must also ensure that suitably trained and supervised personnel and funding are available over the long-term.

Environmental management plans and wetland management plans should be in accordance with the frameworks provided in *Environmental Guidance for Planning and Development Draft Guidance Statement No. 33* (EPA 2005).

The management plan should cover the following:

- A clear description of the designated role of the water body ie whether it is for drainage, aesthetic or environmental purposes. This may have implications for any additional work in the future.
- Routine maintenance program detailing type and frequency of required actions.
- Complaint investigation procedures (including non midge/mosquito complaints).
- Monitoring of limited environmental parameters, such as water temperature, nutrient levels etc to allow prediction of peak insect activity periods.
- Midge and mosquito monitoring (larval and adult trapping and responding to public complaints).
- Midge and mosquito control actions including treatment options, process involved and estimated costs.

- Vegetation control including harvesting, herbiciding and processes involved, frequency of required actions and estimated costs.
- Where water body is part of a new development, notifications should be placed on the property titles of all properties within 200m of the waters edge advising of the potential for midge/mosquito problems.
- Developers to provide prospective purchasers with information relating to ways to minimising nutrient runoff where stormwater drains into the water body such as water efficient gardens and not using phosphorus based fertilisers.
- Issuing of public warnings and other notices.
- Safety aspects, such as the need for railings, signage etc should also be considered. The issue of public safety has not been specifically addressed in this document. Safety issues need to be carefully considered when deciding to construct a new water body.
- A contingency plan should problems arise. The contingency plan should provide options which can be easily implemented. Provision should be made to ensure there is adequate space, access and funding for implementing of actions or decommissioning the water body if required.

Further Reading

1. Department of Water (2004) *Stormwater Management Manual for Western Australia*, Department of Water, Perth, Western Australia.
2. Department of Environment and Swan River Trust (2005) *Decision Process for Stormwater Management in WA*. Department of Environment and Swan River Trust, Perth, Western Australia.
3. Department of Water and Swan River Trust (in preparation). *River Science Issue 26: Constructed ephemeral wetlands on the Swan Coastal Plain - the design process*. Department of Water and Swan River Trust, Perth, Western Australia.
4. Department of Health (current edition). *Mosquito Management Manual*. Department of Health, Western Australia.
5. Environmental Protection Authority (2005). *Environmental Guidance for Planning and Development. Draft Guidance Statement No. 33*.

Further Information

Further information may be obtained by contacting the following groups or agencies.

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Phone: 6364 6500
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Department of Health

Mosquito Borne Disease Control
1A Brockway Road
Mt Claremont WA 6010

Phone: 9388 4999
www.health.wa.gov.au/envirohealth

Department of Water

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