Land Transport Authority

We Keep Your World Moving

VECTOR CONTROL AT LTA SITES

GUIDEBOOK FOR BEST ENVIRONMENTAL PRACTICES

Published by the Land Transport Authority
Enquiries can be directed to LTA Construction Safety & Environmental Protection Division

ACKNOWLEDGEMENT

The Land Transport Authority (LTA) would like to thank the National Environment Agency (NEA) for their invaluable contribution and support in producing this guidebook.

Special thanks to all staff who have provided constructive feedback and suggestions.

Lastly, a big thank you to all our contractors for their continuous support and efforts in maintaining environmentally friendly sites.

Land Transport Authority

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ENVIRONMENTAL POLICY STATEMENT

LTA is committed to nurture its staff to care and protect our environment. We incorporate environmental protection in our strategic decisions and conduct our business in a manner that balances the environmental and economic needs of the communities in which we operate.

We will:

- Comply fully with all relevant environmental legislation and regulations and meet or exceed good environmental practices;
- Work with our partners i.e., transport operators, contractors, suppliers, interest groups and other government agencies in a concerted effort to operate in an environmentally responsible manner;
- Create a cleaner and greener environment by making continuous efforts to be energy-efficient and to practice Reduce, Reuse and Recycle; and
- Monitor, evaluate and continually improve our environmental management practices to ensure efficient use of the limited resources.

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CHAPTER 1

INTRODUCTION

1.1 VECTORS

Vectors are organisms that transmit diseases from one host to another but they do not cause diseases themselves.

Under the Control of Vector and Pesticide Act (CVPA), a vector is defined as:

"Any insect, including its egg, larva and pupa, and any rodent, including its young, carrying or causing, or capable of carrying or causing any disease to human beings."

In Singapore, the five main vectors are:


Mosquito[1]


Rodent[2]


Fly[3]


Cockroach[4]


Flea[5]

Source:

[1] *https://www.straitstimes.com/singapore/health/singapore-students-infected-with-chikungunya-fever-what-you-need-to-know-about-the*

[2] *http://img1.tradeget.com/pestmanagement/ QFHHCCQ41Rodent-Control.jpg*

[3] *http://freedomwellness.files. wordpress.com/2009/06/housefly.jpg*

[4] *http://www.landcareresearch. co.nz/research/biosystematics/ invertebrates/invertid/images/ AmericanCockroach1.jpg*

[5] *http://www.lushlawn.net/images/flea.jpg*

1.2 VECTOR-RELATED DISEASES

The following table shows the diseases transmitted by each vector.

Vector	Diseases
Mosquito	Dengue Fever Chikungunya Zika Malaria Japanese Encephalitis Filariasis
Rodent	Rat-bite Fever Leptospirosis Murine Typhus
Fly	Cholera Typhoid and Para Typhoid Salmonellosis Dysentery
Cockroach	Cholera Food-borne Diseases
Rat Flea	Plague

Source: National Environment Agency (NEA)

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CHAPTER 2

LEGISLATION AND LTA SPECIFICATIONS

2.1 CONTROL OF VECTORS AND PESTICIDES ACT

2.1.1 Prohibition on Breeding of Vectors

Under Section 15, the Act states that *"No person shall create or cause or permit to be created any condition favourable to the propagation or harbouring of vectors."*

Sites with poor housekeeping create conditions favourable to mosquito breeding and rodent infestation

2.1.2 Penalties for Breeding of Vectors

Fine

The maximum fine for vector breeding detected will be up to $50,000 or imprisonment for up to 6 months or both.

Stop Work Order (SWO)

NEA may also issue SWOs to errant contractors with poorly maintained sites. During the SWO period, only corrective actions, e.g. housekeeping and vector control measures, are permitted to be carried out.

The duration of a SWO varies, it will only be lifted if site conditions have improved to NEA's satisfaction.

Do You Know?

Construction sites issued with SWO will be published on NEA's website for six months from the issuance date.

2.1.3 Control of Pesticides and Repellents

Section 5 of the Act stipulates that all public health pesticide products and repellents intended for use against vectors in Singapore are to be registered with NEA. It is further highlighted in the ***"Guidebook to the Registration of Public Health Pesticides and Repellents against Vectors"*** that there are 2 categories of registered pesticides and repellents - ***"For General Use"*** or ***"For Restricted Use"***.

The products classified as ***"For Restricted Use"*** shall only be handled and applied by NEA-registered Pest Control Operators (PCOs) because of their high toxicity. The contractors' in-house vector control team shall not use such chemicals.

The latest list can be downloaded from the NEA website under ***"Registration of Control of Public Health Pesticides and Repellents against Vectors"***.

Bentacide 250EC is a larvicide labelled ***"For Restricted Use"***, and can only be applied by PCOs

2.2 LTA SPECIFICATIONS

Contractors shall refer to the ***General Specifications (GS) Appendix A*** in their contract for LTA's requirements in vector control.

The following sections will cover the salient points.

2.2.1 Vector Control Personnel

Contractor shall provide competent personnel for vector control and surveillance on site, and these include:

	1) Forming an in-house vector control team to conduct **search and destroy** activities; monitor and maintain Gravitraps daily by using the Zoning Method.
	2) Engaging an external **NEA-licensed PCO** to carry out vector control and surveillance at least once a week to supplement the in-house vector control effort. The list of registered PCOs can be found on NEA's website.

**Note: "search and destroy" refers to the search for and destruction of potential mosquito breeding grounds. This includes clearing of stagnant water, removal of unwanted water-bearing receptacles, and eliminating conditions that are prone to water stagnation.*

2.2.2 Vector Control Plan

Upon contract award, Contractor shall submit a site-specific **Vector Control Plan**, encompassing the following sections:

- **Pre-existing Conditions**

Once Contractor has taken over the site, it is essential to conduct a pre-construction survey to establish a vector baseline in the vicinity. This is to identify high-risk areas for breeding of vectors and eliminate any pre-existing vector issues before the start of work. Please refer to LTA's ***Procedure for Pre-Construction Vector Baseline Survey*** for more details.

- **Zoning Method**

Contractor shall divide the site into a maximum of **3 zones**, and conduct search and destroy activity at one zone per day for a more concentrated effort to eliminate mosquito breeding on site.

Divide site into three zones for daily vector control activities

Focusing on one zone per day, each zone will be combed at least twice a week.

SAMPLE VECTOR CONTROL PROGRAMME

Location	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Zone A and Site Office							
Zone B							
Zone C							

Legend: In-house Vector Control Team
PCO

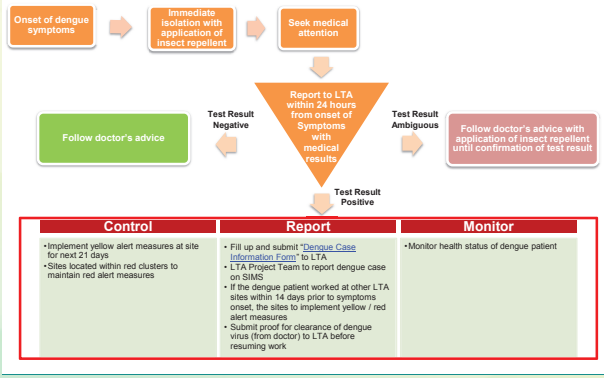
- **Dengue Contingency Plan**

Contractor shall adopt the ***"LTA Dengue Contingency Plan"***, and implement the control measures required. All suspected Dengue or Zika cases shall be reported to LTA, following the procedure stated in the response flow chart.

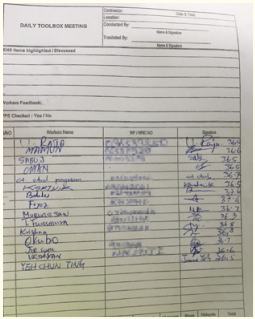
LTA Dengue Contingency Plan

Site Condition / Action Required	LTA Sites located within Dengue Clusters based on NEA Dengue Community Alert			LTA Sites with ≥10 Dengue Cases within 2 Consecutive weeks
	Green (No Active Cluster)	Yellow (Cluster of <10 cases)	Red (Cluster of ≥10 cases)	
Housekeeping	Daily	Daily	Twice Daily	Twice Daily
Search & Destroy by in-house vector team (3-zone method)	One zone daily	One zone daily	Daily for all zones	Daily for all zones
Mass carpet combing for the entire site	Weekly	Weekly	Twice weekly	Daily (till no new reported cases)
Pest Control Operator (PCO) visit for the entire site	Weekly	Twice weekly	Twice weekly	Daily (till no new reported cases)
Trimming of overgrown grass	Weekly	Weekly	Weekly	Weekly
Monitoring of mosquito population using Gravitrap	Weekly	Weekly	Twice weekly	Twice weekly
Monitoring & reporting of Dengue symptoms	-	Suspected patient to report	Compulsory daily temperature check*	Compulsory daily temperature check* and daily reporting to LTA
Applying of insect repellent (3 times daily)	-	Compulsory	Compulsory	Compulsory

* This applies to all personnel entering the site including LTA staff, QPS, Sub-contractors, suppliers and consultants etc.



Contractor checking temperature for LTA staff



Staff's body temperature readings are recorded

2.2.3 Vector Control Time-out

In the event that mosquito breeding is discovered on site by NEA, the contractor shall conduct a time-out. During the time-out, the contractor shall stop all works and gather all workers to carry out a detailed search and destroy i.e. carpet combing to eliminate any potential breeding grounds.

Besides carpet combing, the contractor shall also review the incident and identify reasons why breeding was not detected during routine inspections. An environmental incident report shall be submitted following the requirements in ***GS Appendix A***.

Contractors can refer to the guidelines below on conducting an effective **carpet combing** exercise.

1. Have a plan

To provide overall guidance in conducting the exercise and ensure all logistics/manpower are catered for

Divide site into zones to allow concurrent combing to take place. Ensure the entire site is to covered.

Allocate sufficient manpower to each zone.

Prepare equipments for each team.

Essential items include:
Trash bags, Torchlight, Gloves, Note pad and/or camera, Broom, Ladder

2. Conduct briefing

To raise awareness in dengue and for effective communication of plan

Communicate on the dangers of dengue and prevention methods

Brief on Carpet Combing Plan
This includes:

- Location the teams are covering
- Duration of the exercise
- Role of each team member
- Highlight hard-to-reach areas

Ensure application of insect repellent before combing site

3. Carpet Combing Exercise

To remove potential breeding grounds and record findings

Team members may wish to stand in a line and sweep the site from one end to the other.

Remove all breeding ground.
Ensure all hard to reach areas are being covered.

For areas that are out of reach, record it down (by photographs or note taking) for further actions

If breeding is found, Take a picture of it and highlight it to the leader of the team.

Leader to document it.
After which, larvae is to be killed using larvicide before disposal.

4. Debrief

To consolidate all findings and good practices

Gather all findings during the exercise

ECO to conclude with findings and lessons learnt

Document findings and good practices of carpet combing exercise to be submitted to Project & Construction Safety Division for sharing purposes

CHAPTER 3

COMMON BREEDING HABITATS

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3.1 SITE BOUNDARY / PERIMETER AREA

3.1.1 Water-filled Barricades

Water-filled barricades placed outside the site are often neglected during vector control inspections. Openings in these barricades can collect water and lead to mosquito breeding.

If the barricades are damaged beyond repair, contractor shall replace them.

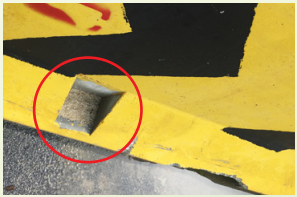
Potential mosquito breeding in uncapped or damaged water-filled barricades

Openings of barricades are capped or covered

3.1.2 Concrete Barriers

Concrete barriers come with openings for anchorage and / or installation of railing. These openings are prone to be littered with discarded water-bearing receptacles that result in water collection.

Discarded receptacles left in concrete barrier can collect water



Openings in concrete barriers covered or filled up

3.1.3 Hoarding

Water may accumulate along hoarding / perimeter noise barrier due to ineffective drainage or poor housekeeping.

Water stagnation beside hoarding

Contractors are also recommended to take care of the area next to site boundary and eliminate potential breeding grounds.

Gaps sealed up to prevent water stagnantion

Ground depression is filled up to prevent water ponding

Worker doing housekeeping at site boundary

3.2 MATERIAL STORAGE AREA

3.2.1 Water-bearing Receptacles

Loose Material

Loose material such as fittings, joints, and flanges etc. can collect water if not properly stored.

Water stagnation due to improper storage of materials

Loose items are placed properly to avoid water collection

Loose items and spare parts are stored under shelter area, or in a manner that do not collect water

Bulky Items

Large and bulky materials can collect water in their voids.

Water stagnation in voids of bulky materials

Empty space filled up with gravel and sand to prevent collection of water

3.2.2 Inadequate Access

Storage areas are often cluttered with no space between materials. This hinders the vector control team from performing regular checks and administering vector control measures required due to safety concerns.

Lack of access at storage area

Lack of access at storage area

Proper and adequate access provided to allow for checks and control measures

3.2.3 Canvas Sheets

Commonly used on construction sites, canvas sheets are one of the top mosquito breeding habitats when not being handled properly.

Stagnant water on canvas sheets

Canvas sheets should be pulled taut to prevent collection of water. For canvas sheets used as cover for material storage and are prone to collecting water, daily inspection shall be carried out to ensure that stagnant water is promptly removed.

Canvas sheets are pulled taut and the bottom is cut/folded in to avoid water collection

3.2.4 Plastic Sheets

Plastic sheets are generally used for material packaging, and can easily trap water. Contractor shall remove plastic sheets and store the materials under shelter or in a manner that does not collect water.

Stagnant water on plastic wrapper

3.2.5 Tunnel Segment Rings

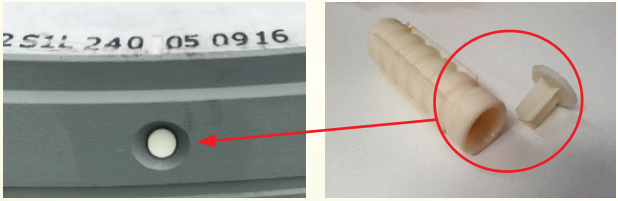
The bolt socket holes and lifting/grouting socket holes of tunnel segment rings can collect rainwater.

Stagnant water in bolt opening of tunnel segment rings

The openings can be temporarily covered by sponge plugs and / or tape.

Openings on tunnel segment rings are covered

Bolt socket with end caps are also commercially available which can be pre-installed during fabrication to prevent water collection.



Customised bolt cover installed at pre-cast fabrication yard

3.2.6 Chemical Drums

The top of chemical drums usually come with grooves which can collect stagnant water if the containers are stored in open areas.

Such containers should be stored under shelter to prevent the collection of rainwater. Otherwise, frequent checks shall be carried out to ensure stagnant water is cleared.

Stagnant water on top of PVC drums

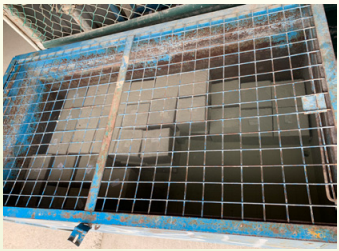
Larvae found on top of a chemical drum

Chemical and material containers are stored under shelter

3.2.7 Test Cube Tank

Concrete cubes are required to be cured in water tank for 28 days before being sent for compression strength test.

Stagnant water in test cube tank is a potential breeding ground if left unattended.



Water should be replaced frequently, and in addition, contractors can cover tank with a netting to prevent mosquitoes from entering.

Stagnant water in a test cube tank

Netting on test cube tanks

3.3 CONSTRUCTION AREA

3.3.1 Uneven Surface / Ground Depression

Uneven surfaces or ground depressions are often observed on site.

Water ponding due to uneven surface / ground depression

Ground depressions should be levelled to prevent water stagnation. It is also important to ensure that the levelled ground has a proper gradient for water to be drained.

Site entrance is paved to avoid ground depression

Milled waste is used to level the ground

Ground should be levelled before laying steel plates

3.3.2 Walers and Struts

Walers and struts are likely to contain stagnant water, and are difficult to maintain due to the constraint of access.

✗ Stagnant water on walers and struts

Contractors can drill holes to drain rainwater. Alternatively, gaps can be filled with fine gravel and sand to prevent water from collecting.

✓ Holes in walers to drain stagnant water

✓ Empty space in walers / struts filled up with sand

3.3.3 Machinery and Equipment

While it may not be possible to store all machinery and equipment under shelter, contractors shall practise good housekeeping and ensure proper storage of equipment.

✗ Larvae found in the standpipe of a pump that is not in use

✗ Stagnant water in lifting bucket that is not in use

✓ Opening on pump is covered

✓ Lifting bucket turned upside down when not in use

3.3.4 Trenches

Areas excavated for trial trenches, utility diversions and other temporary works generally have water ponding issues as water cannot be drained.

Water ponding in trenches

Water shall be frequently pumped out, and larvicide shall be applied to prevent mosquito breeding.

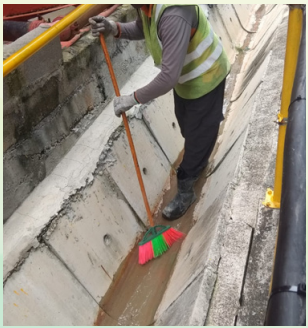
Deploy pump to clear water promptly

3.3.5 Site Drainage

Internal drains shall be properly constructed with the right gradient to allow effective drainage. Silt and debris in drains shall be regularly cleared to ensure the flow is not obstructed.

✗ Water stagnation in site drain due to silt buildup

✗ Water stagnation due to poor gradient



✓ Worker clearing silt in the drain to ensure water flow

Scupper drain with stagnant water due to flow obstruction

Properly maintained scupper drain and free from obstructions

3.3.6 Trackwork

Stagnant water in trackwork shall be promptly cleared, and larvicide shall be applied to prevent mosquito breeding.

Stagnant water at train tracks under construction

3.3.7 Recess on Concrete Surface

Small surfaces with recess should be filled up with sand to prevent collection of water. While for larger surface areas, small pumps shall be deployed to clear the water, followed by application of larvicides.

Stagnant water on recessed concrete surface

Lifting point is filled up to prevent water stagnation

3.3.8 End of Pipes / Hoses

Stagnant water in the standpipe of a water pump

Stagnant water in GI pipe due to missing cap

Whenever possible, end(s) of pipe or water hoses shall be covered if not in use.

End of water hoses covered

End of GI pipe covered or sealed up

3.3.9 Sheet Piles

It is common to have water ponding between the gaps of sheet piles, and sometimes trapped in backfill material. The ground shall be properly levelled to drain the water effectively.

✗ Water stagnation in gaps of sheet piles

✓ Gaps of sheet piles are filled with lean concrete

3.3.10 Toe Boards

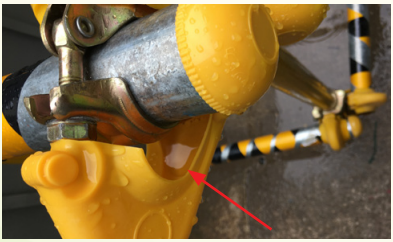
Toe boards, when installed vertically, tend to collect water. Such gaps can be filled up with fine gravel and sand to prevent water stagnation.

Stagnant water on toe board

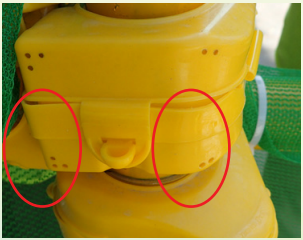
Toe board gap filled up with sand

3.3.11 Scaffold Clamp Covers

Scaffold clamp covers can collect stagnant water and lead to mosquito breeding.



Stagnant water in GI pipe clamp cover



Clamp cover designed to drain the water

Hole drilled to drain the water

3.3.12 Discarded Receptacles

Regular housekeeping shall be carried out to clear discarded water receptacles

3.3.13 Waste Bins / Skips

Skips used for waste storage are potential breeding grounds if they are not regularly emptied or properly managed.

Waste skip with stagnant water identified at the corners

Waste skip was tilted with an angle to allow easier monitoring of stagnant water

Platform provided at waste skip allows easy checking of stagnant water

3.3.14 Hollow blocks

Hollow blocks, when bottom ends are closed, tend to collect water. The openings of hollow blocks shall be filled up or patched up to avoid water stagnation.

Openings on hollow blocks

Openings on hollow blocks are filled or patched up

3.3.15 Water Treatment and Storage Tanks

Water tanks that are not in use are usually kept outdoors. They can collect rainwater and are often neglected during inspections.

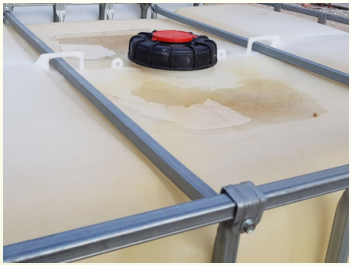
Stagnant water at the bottom of the tank that is no longer in use

Stagnant water in tank that is no longer in use

Netting provided for water tanks to deter entry of mosquitoes

3.3.16 Recharge Well

IBC tanks used as recharge wells can be a potential breeding ground, as rain water is collected on top of the tank. Due to limited access to the tanks, they are often left unchecked.



Top of recharge well may have stagnant water

These tanks are recommended to be covered with a pitched roof to prevent water stagnation, and the caps of the IBC tank shall be properly secured to prevent mosquito from entering the tank.

Pitched roof installed for recharge well

3.4 SITE OFFICE, CANTEEN AND REST AREA

3.4.1 Site Container Office

Containers with missing or poorly maintained pitched roofs are prone to collect rainwater.

Missing or damaged roofing for containers

For newly arrived containers that are not installed with pitched roofs, contractors must carry out inspections and clear stagnant water at least once a week.

No material or machinery parts shall be stored above, below or behind containers, as they may trap water and become mosquito breeding grounds.

Random construction materials or discarded items shall be removed

Workers perform inspections for containers

Condensate from air-conditioning is collected using PVC tube and into a bucket placed below. However, this may lead to mosquito breeding if the water is not cleared in time. It is recommended to fit a pipe to channel the condensate to a nearby drain directly.

AC condensate is channelled to the drain through a tube

3.4.2 Trees / Plants

Aedes mosquitoes are attracted to stagnant water in tree holes.

Tree holes are susceptible to mosquito breeding

To avoid breeding in plants, contractors shall perform more inspections and maintenance to reduce water stagnation.

Pipette is used to check hard-to-reach parts of a tree for larvae

Top of tree stump is sealed to prevent mosquito breeding

For trees that need to be cleared due to construction needs, tree stumps have to be thoroughly removed, else the holes shall be patched up.

3.4.3 Workers' Rest Areas

Daily housekeeping and regular carpet combing shall be carried out at workers' rest areas. Unwanted items are to be disposed of and workers' belongings are to be properly stored.

Stagnant water in water dispenser that is not in use

Water dispenser bottles are left without cap

Larvae found in a pail

Stagnant water in flower pot without drainage hole

Waste bins with overflowing food waste

Washing area with spilled food waste

Empty water containers are covered

Rack provided to store empty water containers properly

Designated PPE storage area under shelter

Good houskeeping at workers' rest area

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CHAPTER 4

CONTROL MEASURES FOR MOSQUITOES

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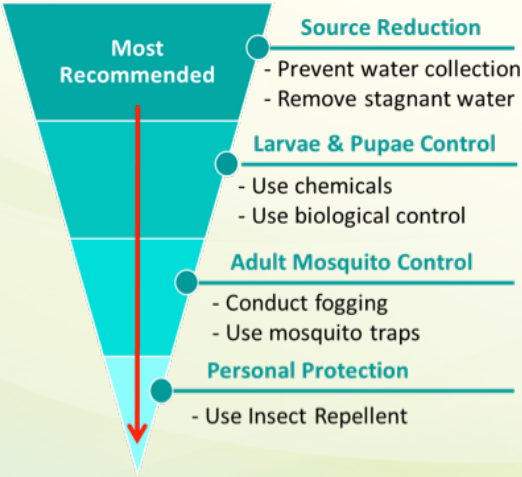
4.1 OVERVIEW

There are various control measures to prevent mosquito breeding and transmission of mosquito-borne diseases. The hierarchy of the measures that can be deployed is as shown below, with source reduction being the most effective.



Hierarchy of Mosquito Control Measures

4.2 SOURCE REDUCTION

Good housekeeping prevents mosquito breeding as the occurrence of stagnant water is reduced. Below are some examples of effective source reduction for mosquito control.

Provide well-maintained pitched roof

Clear discarded items through daily housekeeping

Store materials in ways that prevent water collection

Level up ground depression

Ensure effective drainage flow

Trim excessive vegetation regularly

Do You Know?

- Mosquitoes can breed in a puddle of water the size of a 20 cent coin.
- On average, a mosquito can lay about 100 eggs or more after a full blood meal.
- Eggs of *Aedes* mosquitoes can survive in dry conditions for 6 months to a year. Once they are exposed to water, they will hatch to become larvae and continue their life cycle.

4.3 LARVAE AND PUPAE CONTROL

For areas with stagnant water that cannot be permanently removed, larvae and pupae control shall be carried out to prevent mosquito breeding.

4.3.1 Physical Control

Application of Anti-Mosquito (AM) oil is one of the most commonly used control measures on site.

Worker sprays AM oil in tank with stagnant water

Do You Know?

AM oil forms an oil film on the water surface, which blocks the oxygen supply to the mosquito larvae / pupae. This suffocates them as their siphons are unable to penetrate through the oil film for air.

For AM oil to be effective, it should be:

- Applied at least once a week
- Reapplied immediately after rain as the oil would have been washed away
- Covering the entire surface of the stagnant water

MMF block for physical control of mosquito breeding

The Mono-Molecular Film (MMF) block follows a similar mechanism by forming a thin layer of film upon contact with water, suffocating the larvae and pupae. It reduces the surface tension of water, which also makes it difficult for female mosquitoes to stay on the water surface and lay their eggs.

4.3.2 Chemical Larvicides

Temephos Sand Granule

Temephos sand granule, also known as “Abate”, are commonly used on site for vector control.

The active larviciding ingredient is coated on the granule surfaces, and disperses when it is applied to water bodies. There will not be any physical change to the sand granule after all the active ingredient is depleted.

Abate sand granule

Abate should be replaced regularly according to the product’s instruction.

To ensure timely replacement of the abate, contractors are recommended to put a tag to indicate the date of application and the date for replacement.

Relief T

Relief T is a slow-releasing larvicide in a tablet form with the active ingredient, Temephos. It is usually submerged in sump pits and sedimentation tanks to prevent mosquito breeding. Relief T tablets should be replenished after it has been fully dissolved.

Relief T placed in a net for easy deployment

4.3.3 Biological Larvicides

Bacillus Thuringiensis Israelensis (BTI)

BTI is a group of bacteria used as biological control agents against mosquito larvae. It infects the larvae, resulting in a chronic infection that kills them.

BTI Dunks are readily available off the shelf

BTI products are usually in the form of a solid dunk, which will slowly release biological larvicide when applied to water bodies.

Most BTI products are for general use and are considered more environmentally friendly as compared to AM oil and chemical larvicides. They are recommended for use especially in ecological sensitive areas as they are harmless to fish, birds and other animals.

Do You Know?

Contractors can engage PCOs to carry out BTI misting where BTI mist droplets are dispersed to hard-to-reach areas like tree holes, fallen leaves, ground depressions and roof gutters.

4.4 ADULT MOSQUITO CONTROL

Adult mosquito control is carried out through fogging, misting or applying residual spray. This shall only be conducted by PCOs as it involves the use of restricted pesticides and specialised equipment.

4.4.1 Thermal Fogging

In thermal fogging, heat is used to vaporise and disperse pesticides. Adult mosquitoes present in the area are killed through direct contact with the fog.

However, **regular fogging is not encouraged** as it may build up the mosquitoes' resistance against these pesticides chemicals over time. It should only be carried out when there is a Dengue outbreak in the vicinity of the construction site, or when high mosquito population is detected.

PCO is to conduct thermal fogging on site only when necessary

For thermal fogging to be effective, it should be:

- Applied in the early morning or late afternoon when *Aedes* mosquitoes are most active
- Conducted by PCOs with sufficient manpower and fogging guns on site
- Started by circling the site boundary before moving gradually into the site

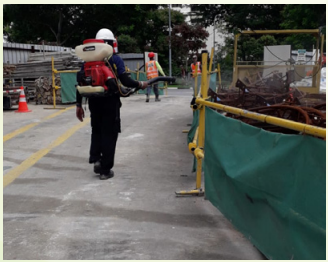
Do You Know?

Thermal fogging is only effective if the chemical has direct contact with mosquitoes. It does not have any residual effect to kill mosquitoes after the fog has dispersed.

4.4.2 Misting

Similar to thermal fogging, misting kills adult mosquitoes upon contact. It requires dilution of pesticide with water in a prescribed ratio, after which the mixed solution is pressurized into small particles and sprayed through the nozzle of the misting equipment. The particle size can be adjusted for different applications.

Misting can be used for both outdoor and indoor applications.



PCO conducting misting on site

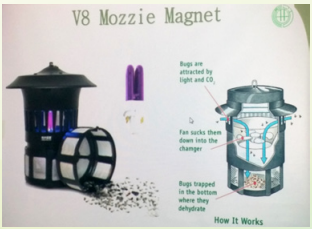
4.4.3 Mosquito Traps

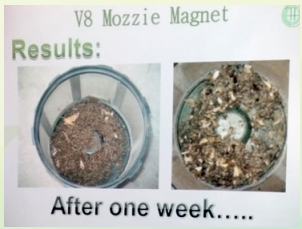
Mosquito traps are commercially available to lure and trap adult mosquitoes. These traps attract female mosquitoes through various mechanisms.

Some use ultraviolet light to attract mosquitoes into an electrocuting trap, while some emit carbon dioxide and mild heat to attract mosquitoes before they are trapped to die of dehydration.

They are usually placed at locations where workers frequently gather, such as canteens and worker rest areas, or near forested boundaries where there are more mosquito breeding habitats.

Mosquito trap releasing CO_2 is deployed on site, especially where high mosquito population is detected





Mosquito magnet attracts mosquitoes by light and CO_2, and sucks mosquitoes into the chamber where they dehydrate to die

4.5 PERSONAL PROTECTION

4.5.1 Application of Insect Repellent

Besides wearing long sleeved clothing to prevent mosquito bites, it is advisable to apply insect repellent on all exposed parts of the body as well as on the clothing. The repellent should be reapplied throughout the day for effective protection.

DEET and Picaridin are the two active ingredients found in insect repellents, and have been scientifically proven to be effective against mosquitoes.

Workers applying insect repellent before start of work

Do You Know?

The effective duration of mosquito repellent is determined by the percentage of DEET it contains. The higher the DEET concentration, the longer it would last.

4.5.2 Repellent-treated Safety Vest

Repellent-treated safety vests are manufactured using active ingredients found in insecticides, along with special release-control agents. These vests repel mosquitoes, and prevent the user from being bitten.

Repellent-treated safety vest provided to general workers

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CHAPTER 5

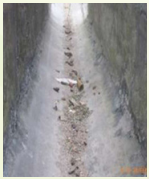
CONTROL MEASURES FOR OTHER VECTORS

Land Transport Authority

5.1 OVERVIEW

Rodents, cockroaches and flies are pests commonly found in urban environment, especially when there are nearby food establishments or waste handling facilities. They are most likely to thrive at places where food, harbourage and water are easily available. This includes canteens, worker rest areas, and storage areas.

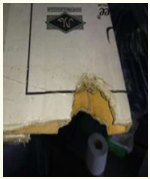
Rodent infestation can be recognised by the following signs:



Rodent Droppings

Burrows / runways

Smear marks



Gnawing marks

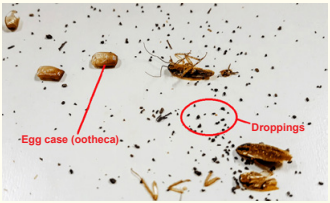
Source: NEA

Do You Know?

Construction sites found with a significant amount of rodent droppings can be fined for rodent infestation.

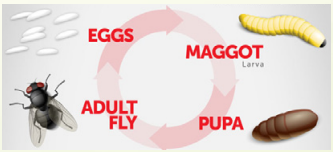
Cockroach infestation is indicated by:

- Cockroach droppings
- Cockroach egg cases
- Odour
- Live cockroaches



Signs of Cockroach infestatio[7]

Breeding of flies is indicated by the presence of adult flies and maggots.



Fly life circle[8]

Fly Infestation due to improper handling of food (waste)[8]

Source:
[7] *https://killem.com.sg/blog/category/cockroaches/*
[8] *http://www.rentokil.com.sg/assets/content/flies/fly-infographic)*

5.2 SOURCE REDUCTION

Source reduction, through elimination of favourable conditions, is still the main form of vector control.

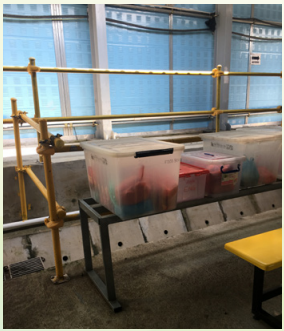
5.2.1 Elimination of Food Sources

As rodents, flies and cockroaches are mainly attracted to food and decaying organic waste, it is important to eliminate their food sources by properly storing food and managing food waste on site.

Proper Food Storage

Contractor shall properly store food in containers with close-fitting lids at designated food storage area at least 60cm above ground.

✔ Food containers are provided for workers and cleaned daily



Proper Food Waste Management

Contractor shall provide adequate lidded refuse bins at designated dining or resting areas to contain all food waste.

Such bins shall be covered tightly at all times and be cleared and cleaned daily. Spilled food waste shall be cleaned immediately.

Spilled food waste should be cleared immediately

Poorly maintained food waste bin

Food waste bins are properly covered and well maintained

5.2.2 Elimination of Shelter and Harbourage

As rodents, flies and cockroaches are likely to thrive in areas with harbourage, it is important to make such places less conducive for their survival.

In construction sites, common breeding grounds for these vectors include stacks of plywood, beams, concrete barriers, container site offices, piles of rubbish, unwanted cardboard boxes, cable reels, fallen trees and overgrown vegetation etc. Contractors shall practice the following control measures to eliminate harborage and prevent infestation:

- Dispose unwanted boxes, crates, piles of newspapers and other articles
- Store material properly and inspect the storage area regularly
- Seal any holes or crevices in the ceilings, walls, floors and hoardings
- Ensure that floor traps and downpipe are properly covered with grating
- Cover entrance points by installing air curtains or plastic screens, or installing self-closing doors

Regular grass cutting

Sealing up bottom of container office

Worker inspecting the space below container office and ensure it is free of rubbish to prevent vector harbourage

5.3 TRAPS

Fly trap stickers and electrical fly traps can be used to capture flies at canteens or rest areas..

Electrical fly traps are used at site canteen as fly control measures.

5.4 PCO INTERVENTION

If infestation is found within the site, contractors should quickly engage PCOs to set up traps and apply pesticides to kill these vectors.

Rodent traps and feed baits can be introduced by PCO to trap and poison rodents on site. These traps should be strategically placed at areas where rodents are likely to appear, such as worker's rest areas, material storage areas and near vegetated grounds. Physical vector control measures are preferred as there are risks of possible food contamination and health effects when pesticides are used.

The PCOs can also apply rodenticides during their inspections to aid in rodent control.

Rodent trap placed near site boundary

Rodenticide deployed by PCO

Glue board deployed by PCO for rodent trapping

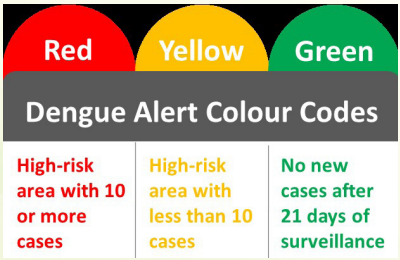
CHAPTER 6

MONITORING AND EDUCATION

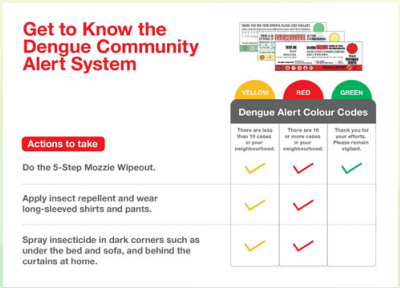
Land Transport Authority

6.1 DENGUE CLUSTER STATUS

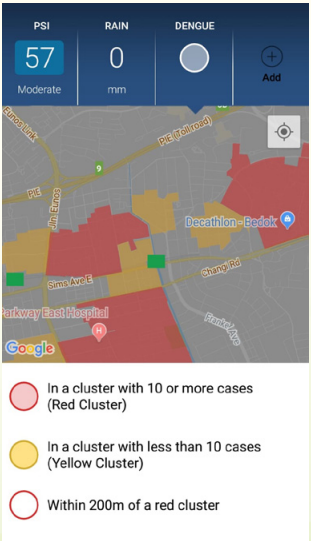
NEA launched the Dengue Communtiy Alert System to highlight areas with active transmission of the Dengue virus. Different colour-coded (red, yellow or green) banners are also displayed in the neighbourhood to alert the residents.



NEA's colour-coded Dengue Community Alert System and the respective banners



Contractors should monitor daily if there are any active Dengue clusters near the site. The information can be found on NEA's website or the myENV app, which are updated daily.

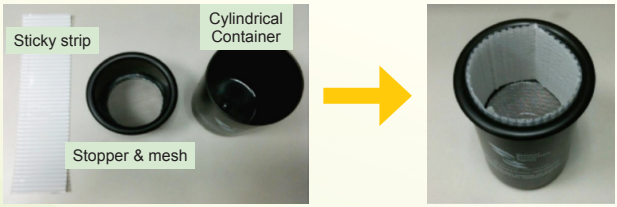


Screenshot of Dengue status on myENV app

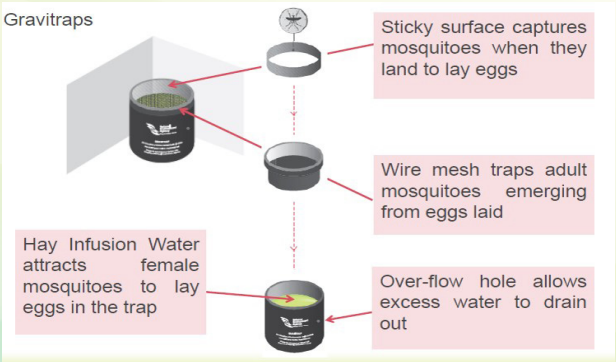
Users can also subscribe for the Dengue alerts on the myENV app by setting their preferred locations.

6.2 GRAVITRAP

The Gravitrap is designed to capture both gravid female mosquitoes and their eggs. Contractor shall regularly monitor the mosquito population on site by using well-maintained Gravitraps.



Components of Gravitrap



Setting up Gravitrap (Source: NEA)

For the Gravitrap to be effective, it should be:

- Filled with water until the over-flow hole level
- Placed in an area with good housekeeping, under shade and on a levelled ground
- Maintained weekly to ensure the water is sufficient and the sticky tape is functional
- Covered or kept away during thermal fogging or misting to prevent introduction of chemical particles into the trap

✗ Gravitrap not placed under shelter

✗ Poorly maintained gravitrap

Well maintained gravitrap with pictorial instructions

Provision of tag to record checks and maintenance

6.3 INSPECTIONS

Regular inspections shall be carried out to reduce potential sources of breeding and infestation.




Environmental inspection carried out by ECO, in-house vector control team and construction team

Contractor shall also develop a site-specific inspection checklist to suit their own needs.

Checklist for
Mosquito Breeding Sites
in Construction Sites

Location:	
Date:	
Inspected by:	

Items	Description	Checked	Findings		Actions Taken		Remarks
			Stagnant water	Mosquito breeding	Clear stagnant water	Apply chemical	
1	**Construction Area**						
a	Puddles on ground and concrete floor at all levels						
b	Building materials - zinc sheets, form work, steel bars, metal beams, pipings, uninstalled toilets, etc including canvas sheets						
c	Demolition debris						
d	Equipment and machineries, including excavators, etc						
e	Water storage/ filtration/ sedimentation tanks, drums, containers						
f	Barriers						
g	Trenches						
h	Bulk waste containers, skips & refuse bins						
i	Sump pits/ silt traps						
j	Drains/ temporary channels constructed for drainage						
k	Vehicle wash bays						
l	Lift wells						
m	Planter boxes						
n	Discarded items & receptacles						
2	**Storage Yard**						
a	Puddles on ground and concrete floors						
b	Freight containers i) Container and canvas roof, including secondary roof ii) Ground below containers						
c	Building materials - zinc sheets, form work, steel bars, metal beams, pipings, uninstalled toilets, etc including canvas sheets						
d	Equipment and machineries						
e	Concrete test cube tanks						
f	Tool boxes						
g	Paint tins/ cans						
h	Discarded items & receptacles						
3	**Container Office**						
a	Freight containers i) Container and canvas roof, including secondary roof ii) Ground below containers						
b	Air-conditioner drip trays						
c	Any other water bearing receptacles						
4	**Living Quarters**						
a	Freight containers i) Container and canvas roof, including secondary roof ii) Ground below containers						
b	Plastic containers/ cooking pots & pans/ domestic containers						
c	Discarded items & receptacles						
5	**Toilet & Bathroom**						
a	Concrete floor						
b	Pails (including rim of overturned pails)/ plastic containers						
c	Toilet cisterns & unused toilet bowls						
d	Bathing point concrete tanks						
e	Drainholes of unused sinks						
f	Gully/ floor traps						
6	**Cooking & Washing Area**						
a	Cooking pots & pans/ domestic containers						
b	Discarded items & receptacles						

6.4 TRAINING AND AWARENESS

6.4.1 Training

Personnel involved in vector surveillance and control shall attend relevant trainings, such as:

- Joint ITE-NEA Certificate in Pest Management/ Control for ECO or in-house pest control team
- Training conducted by PCO on the proper usage of vector control chemicals and equipment
- In-house trainings on understanding vector-borne diseases, identifying potential vector breeding grounds and measures to prevent the propagation of vectors for general workers

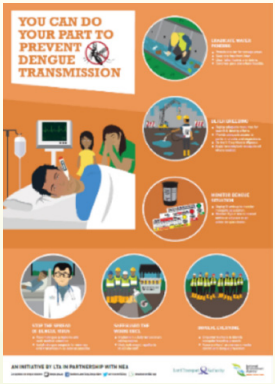
ECO carrying out in-house training

Vector control training by PCO

6.4.2 Awareness

Display of Dengue Prevention and Vector Control Information

Contractor should also put up promotional material, such as posters and banners, that deliver Dengue prevention and vector control messages on site and at workers' rest area to raise awareness.



LTA-NEA Dengue Prevention Poster

Promotional banner is displayed on site to remind workers to remove potential mosquito breeding grounds.

Posters on Dengue prevention & vector control displayed on site

Promotional Activities

Contractor should organise promotional activities, such as awareness talks during toolbox meetings, campaigns and NEA Dengue prevention roadshows, to raise awareness among workers.

X-Dengue Campaign organised by contractor to raise vector control and dengue prevention awareness

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CHAPTER 7

MORPHOLOGY

Land Transport Authority

7.1 MOSQUITO SPECIES

In Singapore, more than 140 species of mosquitoes have been identified. The three genera that are of concern are *Aedes*, *Culex* and *Anopheles*.

	Aedes[1]	*Culex*[8]	*Anopheles*[8]
			
Colour	Black and white stripes	Greyish brown	Brown with speckled wings
Breeding Habitats	Clean stagnant water indoors or outdoors	Organically-polluted stagnant water or clear water	Seepage or brackish water
Feeding Time	Day time, especially dawn and dusk	Night time	Night time
Diseases	Dengue fever, Zika, Chikungunya, Yellow fever	Japanese Encephalitis, Lymphatic Filariasis, West Nile Fever	Malaria

Source:

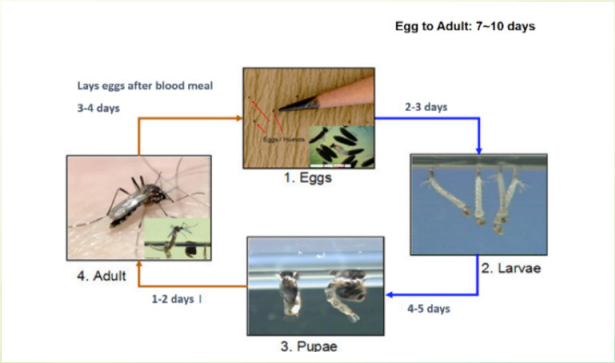
[8] *www.nea.gov.sg/corporate-functions/resources/research/wolbachia-aedes-mosquito-suppression-strategy/not-all-mosquitoes-transmit-dengue*

7.2 MOSQUITO LIFE CYCLE

All mosquito species go through four distinct stages during their life cycle:

- Egg
- Larva
- Pupa
- Adult

The complete life cycle of mosquitoes from egg to adult usually takes 7 to 10 days. *Aedes* mosquitoes in Singapore could survive for about 2 to 3 weeks in the natural environment.



Mosquito Life Cycle[9]

Source:
[9] *Centers for Disease Control and Prevention*

7.3 COMMON MOSQUITO-BORNE DISEASES IN SINGAPORE

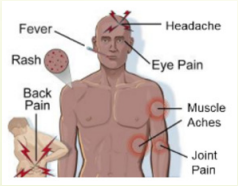
7.3.1 Dengue Fever / Dengue Haemorrhagic Fever

Dengue fever is an infectious tropical disease caused by the Dengue virus, transmitted by female *Aedes* mosquitoes.

Dengue has 4 serotypes, and the recovery from infection by one serotype provides lifelong immunity against that particular virus. However, there is no cross-immunity to the other serotypes after recovery.

Dengue should be suspected when a high fever is accompanied by the following symptoms:

- Severe headache
- Pain behind the eyes
- Muscle and joint pains
- Nausea and vomiting
- Swollen glands or
- Rash



Symptoms of Dengue Fever[10]

Symptoms usually last for 2 to 7 days, after an incubation period of 4 to 10 days after the bite from an infected mosquito.

Source:
[10] *https://chemoaquatech.wordpress.com/dengue-and-dengue-haemorrhagic-fever*

Dengue haemorrhagic fever is a more severe form of Dengue fever, and an infected person may have the following symptoms:

- Bleeding from nose, mouth and gum
- Blood clotting
- Patches of blood on skin and bruises may appear
- Dengue Shock Syndrome – a critical state of shock due to circulatory failure

7.3.2 Zika

The Zika virus is transmitted primarily by *Aedes* mosquitoes. People with Zika virus disease has similar symptoms as Dengue, but milder, such as fever, skin rashes, conjunctivitis, muscle and joint pain, malaise and headache. Only about one in five people infected with Zika will show symptoms. An infection during pregnancy can sometimes cause serious complications in a small number of unborn children.

7.3.3 Chikungunya

Chikungunya is a viral disease transmitted to humans by infected *Aedes* mosquitoes. It causes fever and severe joint pain, and other symptoms include muscle pain, headache, nausea, fatigue and rash.

7.3.4 Malaria

Malaria is transmitted by *Anopheles* mosquitoes. Symptoms include fever, chills, nausea, headache, and sweating / perspiring. More severe symptoms of malaria will lead to renal and liver failure, shock and coma.

REFERENCES

Legislation

1. Control of Vectors and Pesticides Act

LTA Specifications

2. LTA General Specifications Appendix A

Guidelines

1. Guidebook to the Registration of Public Health Pesticides and Repellents against Vectors
2. Guidebook on Prevention of Mosquito Breeding - Common Mosquito Breeding Places: Construction Sites, NEA
3. Information shared by NEA and Inter-Agency Dengue Task Force

Online Resources

1. https://www.straitstimes.com/singapore/health/singapore-students-infected-with-chikungunya-fever-what-you-need-to-know-about-the
2. http://img1.tradeget.com/pestmanagement/ QFHHCCQ41Rodent-Control.jpg
3. http://freedomwellness.files.wordpress.com/2009/06/housefly.jpg
4. http://www.landcareresearch.co.nz/research/biosystematics/invertebrates/invertid/images/ AmericanCockroach1.jpg
5. http://www.lushlawn. net/images/flea.jpg
6. https://killem.com.sg/blog/category/cockroaches/
7. http://www.rentokil.com.sg/assets/content/flies/fly-infographic
8. www.nea.gov.sg/corporate-functions/resources/research/wolbachia-aedes-mosquito-suppression-strategy/not-all-mosquitoes-transmit-dengue
9. Mosquito Life Cycle, Centers for Disease Control and Prevention
10. https://chemoaquatech.wordpress.com/dengue-and-dengue-haemorrhagic-fever