Queensland Health

Interim Queensland Japanese Encephalitis Virus Mosquito Surveillance and Control Plan

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Queensland Government

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Introduction

On March 4, 2022, Australia's Acting Chief Medical Officer declared the Japanese encephalitis virus (JEV) situation a Communicable Disease Incident of National Significance (CDINS). Human cases of Japanese encephalitis (JE) have been confirmed in Queensland, Victoria, New South Wales and South Australia. The Commonwealth Government is coordinating the response in collaboration with State and Territory Governments.

The first locally acquired human case of JE in Queensland associated with the current outbreak was notified on 3 March 2022.

Queensland Health is responsible for the surveillance of human JE notifications throughout the state and, in collaboration with key stakeholders, is committed to supporting vector and virus surveillance and control activities. Current mosquito and arbovirus surveillance and control systems in Queensland are inadequate for the JEV response.

The Joint National Japanese Encephalitis Virus Outbreak Response Plan (Department of Health and Aged Care and Department of Agriculture, Fisheries and Forestry) outlines a framework for national coordination and response arrangements for the management of JEV and guides the response in both the animal and human health sectors. A key component of the response is mosquito surveillance and control, as outlined in the draft National Japanese Encephalitis Virus Mosquito Surveillance and Control Plan ("the draft national guideline") developed by the National Arbovirus and Malaria Advisory Committee (NAMAC).

The draft national guideline presents a consistent and coordinated approach to mosquito-based surveillance and control of JEV and articulates immediate objectives to reduce the risk of JEV to public health and industry. It also outlines immediate priorities for mosquito based JEV response and highlights that longer-term management will be informed by emerging intelligence.

Purpose

This document outlines the key elements of mosquito surveillance and control actions for JEV in Queensland, in accordance with the draft National Guidelines. Operational deployment of mosquito surveillance requires a coordinated, multi-agency approach, and is resource intensive. In line with a national One Health approach, mosquito-animal-and human-based surveillance should be complementary.

The draft national guidelines prioritise mosquito surveillance at locations where JEV is detected or suspected in humans or animals (including piggeries). Accordingly, Queensland is committed to deploying mosquito surveillance and supporting control activities, in line with national guidance. However, as JEV is a recent and evolving situation in Australia, advice and guidance will advance as more is understood about JEV in the local context. Additional direction for the Interim Queensland Japanese Encephalitis Virus Mosquito Surveillance and Control Plan (The Plan) will be further informed by the endorsed version of the national guidelines, when available.

This document will:

- describe Queensland's current arbovirus surveillance systems and how they can be tailored and/or expanded to provide additional JEV mosquito surveillance
- describe the newly designed Queensland JEV Vector Surveillance Program to carry out JEV-focused mosquito surveillance across Queensland in immediate response to public health risks associated with recent JEV detections and gather intelligence on JEV epidemiology and ecology as it pertains to Queensland
- as an extension of the new surveillance program, describe aspects of a sustained, long-term JEV mosquito surveillance plan, to be carried out even in the absence of JEV detection. A long-term plan will be informed by intelligence gathered over time.

This document also provides a strategic approach to mosquito-based measures for Queensland, including guiding mosquito control actions to mitigate JEV transmission and address public health risks where JEV is detected. The Plan outlines the processes required for coordinated and consistent control measures, encouraging integration with existing guidance for mosquito management at piggeries.

Finally, this document identifies other critical aspects that are required for successful JEV mosquito surveillance and control: resources, training, data management and reporting. The Plan should be used to inform the development of local operational plans for the prevention and control of JEV and its vectors.

Objectives

The Interim Queensland Japanese Encephalitis Virus Mosquito Surveillance and Control Plan includes the following objectives:

Arbovirus and mosquito surveillance – Identifying and anticipating the potential risk of JEV and the impact of mosquitoes on the community to facilitate the prioritisation of strategies to reduce the risk to human health.

Prevention and control of mosquitoes and mosquito-borne disease threats (JEV) that have significant health impacts – Using surveillance data to pre-empt human JEV exposure.

Communication strategies between state and local government, and industry stakeholders – Promote enhanced coordination and information sharing between Queensland Health, Biosecurity Queensland, local government and Industry of mosquito surveillance and control activities for JEV.

Adoption of research and the collection of intelligence required to inform mosquito management strategies – Provide evidence that supports mosquito management in Queensland, including but not limited to, assessments of the effectiveness of surveillance and control, and the identification of key vectors and transmission cycles.

Scope and focus

The Plan outlines collaboration for JEV management between Queensland Health, other government agencies and non-government stakeholders to ensure relevance and consistency. Mosquito surveillance will be most informative when conducted in conjunction with, and complement, surveillance in humans and animals.

Animal surveillance includes surveillance in pigs (domestic and feral) and water birds and is coordinated by state and commonwealth animal health authorities. Mosquito surveillance at piggeries is included as part of The Plan. In some instances, mosquito surveillance may be deployed in unison or at the same locations as animal surveillance. Supported by robust coordination, this may provide critical ecological insight and/or inform requirements for longer term surveillance planning.

Surveillance in humans will inform mosquito surveillance and control effort. Positive JEV test results confirmed by the Public Health Virology Laboratory, at the Queensland Health Forensic and Scientific Services, are notified to the Queensland Notifiable Conditions Register (NoCS). Classification and enhanced surveillance data for notified JEV cases are collected by public health units. These data include demographic and clinical details, hospitalisation and vaccination history, disease outcome, and risk factors including travel history during an exposure period. Case interview data will provide suspected exposure locations at which mosquito surveillance may be deployed. The Plan does not include advice on the clinical management of people with JEV. Vaccination strategies to reduce the clinical impact of JEV are addressed elsewhere.

Queensland Health is not typically the lead agency in the deployment of operational mosquito control and the operational and technical aspects of vector control are out of scope for this document.

For the Plan to be operationalised, several enablers are required to support the deployment of mosquito surveillance and control in response to JEV. It is acknowledged that resourcing for equipment and staff is required to support field operations, supplemented by access to quality training resources and clarification of the roles and responsibilities of each stakeholder in JEV management. Further enablers to achieve the Plans' objectives include the development of agreements to underpin data sharing between organisations and consideration of legislative frameworks to support mosquito surveillance and control in response to JEV. Finally, the availability of sufficient laboratory diagnostic capability and continued engagement and collaboration among regional stakeholders are both critical to enable the Plan.

Legislative considerations

The relevant legislation used in disease surveillance and mosquito management in Queensland are:

- *Public Health Act 2005*
- *Public Health Regulation 2018*
- *Medicines and Poisons Act 2019*
- *Medicines and Poisons (Pest Management Activities) Regulation 2021.*

Mosquitoes are classified as a designated pest in the *Public Health Act 2005* which outlines the broad requirements of both local government and the State (Department of Health). The *Public Health Regulation 2018* describes measures to control mosquitoes (a designated pest) and prevent and control public health risks.

Background

What is JEV?

JEV is a flavivirus, belonging to a group of viruses that includes yellow fever, dengue, and Zika viruses. Most human infections with JEV are asymptomatic or cause only mild symptoms such as headache or fever. Rarely, the virus can cause JE, a potentially serious illness of the brain that can lead to long-term neurological complications and even death.

JEV is endemic in much of Asia and parts of the Pacific. Before 2022, two small outbreaks of JEV occurred in Queensland in the mid-1990s, in the Torres Strait/Cape York Peninsula region. A JEV vaccination program commenced in late 1995 for all residents of the outer Torres Strait islands. Other preventative measures included the movement of pigs away from communities and a reduction in mosquito breeding habitats.

How is JEV spread?

JEV is transmitted to humans through bites from infected mosquitoes, particularly those belonging to the genus *Culex*. The virus exists in a transmission cycle between mosquitoes, pigs and/or water birds. Humans, once infected, do not develop sufficient viraemia to infect feeding mosquitoes. JEV cannot be spread directly from human to human.

Pigs and some types of wild birds (wading birds, including herons and egrets) are considered amplifying hosts, as they allow the virus to multiply quickly to high levels, becoming a source of infection for mosquitoes.

JEV cannot be caught by eating animal products, including commercially produced pork and pork products.

JEV outbreak risk

The detection of JEV in eastern and northern states of Australia in 2022 indicates widespread JEV activity across Australia, and it is unknown how long JEV transmission has been occurring. Future patterns of spatial and temporal activity of JEV across Queensland are difficult to predict. Animal and mosquito surveillance across multiple seasons is required to provide insight into transmission cycles across the state.

Outbreak risk is influenced by environmental factors such as temperature, humidity and rainfall. For example, widespread flooding and rainfall in South East Queensland in 2022 have led to increased mosquito numbers (particularly of the assumed primary mosquito vector *Culex annulirostris*) and increased abundance and distribution of water bird species that serve as reservoirs and amplifiers for JEV.

Climatic and environmental heterogeneity across Queensland almost assuredly means that the epizootic potential across the state will not be uniform. Some locations, including the northern regions, may support the ongoing enzootic transmission of JEV across seasons whereas, in other locations, periodic outbreaks would be anticipated.

JEV exposure risk

JEV transmission to humans requires the presence of competent mosquito vectors at sufficient densities and reservoir host animal populations capable of amplifying the virus.

JEV exposure risk is likely geographically widespread but is not uniform across the state and requires local contextual consideration. Patterns of exposure risk based on geography may likely emerge as more is learned about the ecology of JEV transmission across Queensland regions.

The potential for increased exposure to JEV should be considered among:

- people who engage in outdoor activities (e.g., camping, fishing, hiking) near abundant mosquito populations, or productive mosquito habitats, particularly where amplifying hosts may be present
- people living on or near, or working at a piggery, particularly in regions where JEV has been detected
- people in proximity to wild pig and/or wading bird populations.

Stakeholders and communications

The major stakeholders directly involved the state-wide JEV response include:

- Queensland Health
- Hospital and Health Service Public Health Units
- Biosecurity Queensland (Department of Agriculture and Fisheries)
- Other Queensland animal industries, particularly the horse industry and horse owners
- Queensland Pork Industry including piggeries, veterinarians, pork processing plants, pig transporters and other industry service providers
- Australian Government Department of Agriculture, Fisheries and Forestry
- Workplace Health and Safety Queensland
- Local Government Association of Queensland
- Local Governments across Queensland.

Queensland Health (QH) and Biosecurity Queensland (BQ) work closely with relevant interstate and Commonwealth government agencies to support a consistent approach to JEV management across all jurisdictions. Specific advice regarding resourcing and the roles and responsibilities of key stakeholders is not yet determined. National guidelines, when available, will assist in clarifying roles at a local, state, national and industry level.

Processes are being established in Queensland to embed the governance around information sharing regarding piggeries where JEV has been detected. An expanded scope may include piggeries where JEV is suspected, pending guidance from the national plan, when endorsed. Agreements on the process are integral in providing consistent and timely communication between stakeholders to inform appropriate mosquito surveillance and control, and vaccine distribution.

Key government and industry stakeholders, including piggeries, should nominate a single point of contact. This is to limit duplication of advice and requests for information.

Assumptions

- The current geographical extent of JEV in Queensland is unknown.
- The major likely vector of JEV in Queensland is *Culex annulirostris*. There are likely other competent vectors of JEV in Queensland, but their role in field transmission is largely unknown.
- The origin of the virus in Australia is unknown, but JEV has likely been present in some parts of Australia since at least 2021.
- The mechanism of virus dissemination between transmission foci is unknown but may include the movement of infected mosquitoes or birds, or overlapping transmission cycles.
- Wild birds (particularly wading birds) and feral pigs are reservoirs of JEV in the natural environment.
- Detections of JEV in the commercial production of pigs may represent spillover events from natural reservoirs (wading birds and pigs).
- It is probable that JEV will become enzootic in some parts of northern tropical Australia. It is unknown if the virus will persist during winter in southern regions of Queensland.
- JEV transmission dynamics will differ across Queensland and be highly dependent upon short-term and long-term climatic and other environmental conditions.
- Adequate technical and laboratory diagnostic services will be available to provide timely species identification and testing for JEV presence in mosquitoes collected during surveillance activities. Timely delivery of laboratory results is critical for the success of a mosquito surveillance and control strategy.

Current Queensland arbovirus surveillance programs

As of March 2022, 2 formal arbovirus surveillance programs exist in Queensland.

Queensland Arbovirus Sentinel Surveillance Program (QASSP) The QASSP is carried out in remote regions of northern and western Queensland to routinely monitor for Murray Valley encephalitis virus (MVEV), West Nile virus (Kunjin strain; WNV_{KUN}), JEV, Ross River virus (RRV) and Barmah Forest virus (BFV) activity. The surveillance program commenced in 2016 and operates from January to

June. Program coordination and financial support are being provided by the Communicable Disease and Infection Management team within the Communicable Diseases Branch (CDB), Department of Health. Field activities are a collaborative effort by Public Health Units (PHU), Hospital and Health Services (HHS), local councils, and the Northern Australia Quarantine Strategy (NAQS).

Queensland Peri-Urban Alphavirus Surveillance Program (QPASP) The QPASP operates in partnership between local government councils and Queensland Health (QH). The program adds value to routine mosquito monitoring conducted by councils by surveying RRV and BFV in mosquito populations in or near urban or suburban areas, particularly in coastal Queensland. The program is financially supported by CDB with management including reporting functions and operational support being provided by Metro North PHU. before February 2022, this program did not target flaviviruses, including JEV.

Laboratory diagnostic analysis for both programs is performed by Forensic and Scientific Services (FSS) under a formalised agreement with CDB.

Both programs use a sugar-based surveillance method in which mosquitoes are collected in CO2-baited traps and allowed to feed on honey-soaked nucleic acid preservation cards, also known as Flinders Technology Associates (FTA) cards. The QASS program currently uses the Sentinel Mosquito Arbovirus Capture Kits (SMACKs), which are designed for deployment in remote locations where dry ice and power are unavailable and site accessibility is a challenge. SMACK traps are serviced fortnightly. The QPASP uses standard mosquito light traps, each deployed overnight. The FTA cards are submitted to FSS, via post or courier, for molecular detection of viral RNA expectorated by mosquitoes whilst feeding on the cards. Both programs have detected arboviruses across Queensland every year since they started in 2015.

Human case surveillance and animal surveillance

Infection with JEV and other arboviruses are notifiable conditions in Queensland. Human cases are recorded in the Queensland Health's Notifiable Conditions System (NoCS).

Biosecurity Queensland is responsible for arbovirus surveillance in pigs and other animals. Department of Agriculture Water and the Environment also conducts surveillance for arboviruses, including JEV, in both domestic and feral animals in northern Queensland as part of the Northern Australia Quarantine Strategy (NAQS). The National Arbovirus Monitoring Program is coordinated by Animal Health Australia and currently targets arboviruses such as bluetongue, Akabane and bovine ephemeral fever viruses.

Current mosquito control in Queensland

Local governments in Queensland administer and enforce the provisions of the *Public Health Act 2005* and *Public Health Regulation 2005*, which deal with public health risks from designated pests such as mosquitoes. The legislated role of local government is to manage and control mosquitoes within their local government areas.

Local government seeks to reduce the impact of mosquitoes on their local communities. The approach outlined below is dependent on resources being available to support the activities and can vary markedly between local governments.

Mosquito control to reduce the impact of mosquitoes on local communities is achieved by:

- surveillance of pest and vector mosquito species
- developing and reviewing local mosquito management plans and incorporating integrated mosquito management principles into the plans
- initiating and implementing sustainable mosquito management and control programs
- assisting in first port responses to incursions of exotic mosquitoes where relevant
- providing advice to residents to reduce the impact of mosquitoes on the community
- collaborating with other local governments, Queensland Health, other state government departments, research institutions and industry to develop an integrated mosquito management program for their local area
- enforcing relevant public health legislation related to mosquito breeding sites including rainwater tanks
- negotiating with developers to prevent or minimise the impact on the community of mosquitoes and other biting insects in new development locations
- responding to emergency incidents that increase the exposure of residents to mosquitoes.

Mosquito surveillance in response to JEV

Objectives of mosquito surveillance for JEV

In the context of JEV, there are 4 main objectives of mosquito surveillance:

1) Assess the public health risk.
2) Inform the assessment of industry and animal health risks (with assessment led by industry and animal health authorities).
3) Gather intelligence regarding the ecology of the virus and transmission dynamics which, in turn, will support (1) & (2).
4) Assess the impact of local mosquito management practices on vector abundance.

Ultimately, mosquito surveillance informs the risk of JEV to human and animal health so that mitigation measures can be enacted.

Importance of mosquito surveillance

Mosquito surveillance provides critical data to inform public health research and planning. Valuable information is collected via the following:

- Screening of mosquito samples collected during surveillance for JEV presence currently provides a near-'real-time' and unambiguous indication of JEV activity at a location.
    - This is in contrast with the detection of JEV in pigs following reproductive manifestations and confirmation of JEV infection in humans which are retrospective indicators of JEV activity.
    - Mosquito surveillance must be deployed where animal detections or human cases have occurred to assess contemporary risk.
- Mosquito surveillance can incriminate local vector species important for virus transmission- currently, *Cx. annulirostris* is implicated as the key vector but other species, such as *Cx. gelidus* may be involved.
- Vector species identified during surveillance activities can indicate that productive larval habitats are nearby which can become targets for control.
- Counts of mosquitoes collected can indicate vector abundance and guide the need for control measures or personal protective behaviour messaging.
- Temporal data sets from mosquito surveillance over time can suggest locations/times when surveillance can be most informative (i.e., optimise surveillance effort).

  Note: mosquito-based arbovirus surveillance can overcome many of the logistical and ethical challenges of animal surveillance, particularly in the context of wild animal surveillance.

Short-term JEV surveillance

In the short term, surveillance for JEV is triggered primarily by JEV detection in pigs or humans and is focused on outbreak investigation to prioritise and inform intervention strategies.

Objectives include:

- detect the current and prospective geographic distribution of JEV in the environment
- determine the locations most at risk of virus transmission in the affected environs
- identify the mosquito species involved in the transmission
- gather intelligence on the ecology of the virus and transmission dynamics
- detect and monitor JEV activity on premises with infected pigs/animals
- obtain genetic sequencing of viruses detected to provide key genotypic information
- support strategic control interventions and effective mosquito management to reduce human and animal health risks.

Notably, the draft national guideline promotes a consistent and coordinated approach to mosquito-based surveillance for JEV and prioritises mosquito surveillance at all piggeries where JEV is detected or suspected. Accordingly, Queensland is committed to deploying mosquito surveillance in line with this national guidance, wherever possible.

This section describes two components of short-term JEV mosquito surveillance: 1) expansion of existing arbovirus surveillance programs and 2) description of proposed, bespoke JEV mosquito surveillance plan.

Expansion of existing arbovirus surveillance programs to rapidly increase surveillance for JEV

As per the draft national guideline, existing surveillance programs should be adapted for JEV, where possible and practical. Accordingly, the following recommendations provide an avenue to add value to existing programs and provide immediate opportunities to enhance JEV surveillance. Whilst expansion of existing programs represents an efficient method to increase surveillance, additional field and laboratory resources will be required to operationalise this expansion.

Queensland Arbovirus Sentinel Surveillance Program (QASSP)

- Extend the seasonal operation of the Arbovirus Sentinel Surveillance Program (QASSP).

  Extension of this program from a six-month (January to June) program to operate year-round will ensure temporal monitoring in locations that are already identified as flavivirus targets.
- Expand the number of sites participating in the QASSP.

  Surveillance (via SMACK traps) will be extended to additional remote sites, particularly across northern Queensland.

Queensland Peri-Urban Alphavirus Surveillance Program (QPASP)

- Broaden the diagnostics of the Queensland Peri-Urban Alphavirus Surveillance Plan (QPASP) to include flaviviruses.

  Currently, FTA cards collected as part of the QPASP are screened for RRV and BFV only. This will be extended to include JEV screening.
- Extend the seasonal operation of the QPASP.

  Currently, the QPASP operates during the warmer months (approximately December to May). Some sites will see a continuation of surveillance into the winter months and beyond. This will likely occur in locations of interest (such as locations near pig-producing regions or wading bird habitats, particularly in the north).
- Expand the number of sites participating in the QPASP.

  This program operates in peri-urban locations along the east coast. The number of sites participating will be increased to include additional locations near the east coast (and elsewhere, where appropriate) where dry ice is accessible, and traps can be serviced daily is a suitable option in some instances. Identification of additional candidate sites will require an assessment of site suitability and regional capability. Note that this method is less preferable than testing mosquito pools but can be considered in some instances.

The Queensland JEV vector surveillance program

Bespoke surveillance for JEV is required in both the short and long term. This demands a new, dedicated JEV vector monitoring program. Importantly, current resourcing does not accommodate JEV-focused surveillance and additional funding to support such responsive JEV surveillance is required. This includes additional staff (including medical entomologists), training, equipment, vehicles and consumables for mosquito collection, identification and molecular diagnostics. Further medical entomology expertise will be required to interpret data describing ecology and transmission dynamics to inform the development of a long-term plan.

The new Queensland JEV Vector Surveillance Program is comprised of 2 major components:

1) an immediate public health assessment and response after notification of confirmed or suspected JEV activity and
2) intelligence gathering on drivers of JEV transmission critical for understanding transmission cycles and the development of a sustained surveillance strategy.

Immediate public health response

In the first instance, the targeted JEV surveillance program includes:

- Identification of locations with confirmed JEV transmission or with high-risk potential for JEV transmission. These locations may include, but are not limited to:
    - sites with human cases or the suspected exposure location where human cases have travelled
    - piggeries where infected pigs were identified
    - commercial piggeries within approximately 5 km of human populations at risk for JEV
    - areas that have had recent JEV detection in mosquitoes
    - towns or vulnerable populations in proximity to known or suspected exposure risk
    - locations with a history of the transmission of viruses related to JEV (like MVEV and WNV_{KUN}).

Once a target location is identified:

- the lead responsive surveillance agency will liaise with appropriate local partners (e.g., local government, industry (including land/piggery owners), Biosecurity Queensland) to determine the action required. The lead agency will likely be the Public Health Unit.
- a mosquito surveillance team will be appointed, and the required equipment will be procured
- where the target location is a piggery, landholder biosecurity requirements for personnel, vehicles, equipment etc. must be reviewed and observed.

Field surveillance at the target location may include:

- Deployment of CO_2-baited light traps in areas appropriate for trapping JEV vectors (primarily *Cx annulirostris*, but also targeting *Cx. quinquefasciatus*, *Cx. gelidus* and other potential vectors).
    - As a general guide (but depending on local conditions and resources):
        - most large piggeries should accommodate approx. 10 traps; smaller areas, or areas with less suitable harbourage may accommodate fewer
        - in locations where dry ice is not available, CO2 delivery will be via cylinders (and associated equipment) as an alternative source.

Traps should be deployed for at least 2 nights initially, wherever feasible.

- Transportation of the mosquitoes on dry ice to mosquito diagnostics laboratory for species identification and testing for JEV.
    - Where transport on dry ice is not feasible, other transport options can be considered (see transport guide).
    - For long distances, a dry ice courier service or other option which preserves the cold chain (e.g., liquid nitrogen dry shipper) may be employed. Alternative methods of virus/mosquito preservation may be considered in consultation with the laboratory.
    - All samples submitted to the laboratory must be accompanied by a completed sample submission form.
- As per the draft national guideline, mosquito traps should be redeployed at a location when JEV is detected in mosquitoes collected during the initial responsive trapping. Wherever possible, subsequent trap collections should be pooled by species before laboratory testing for the virus.

Note: For piggeries, biosecurity requirements outline requirements for entry and operations on agricultural premises. It is preferable that surveillance equipment is not used across different properties. Where this is not possible, traps must be cleaned and decontaminated as per industry standards.

Intelligence gathering

Surveillance for the purpose of 'Intelligence gathering' is also required to identify drivers of JEV transmission. This surveillance is critical for developing a sustained surveillance strategy, and objectives include:

- describing the geographical spread of JEV across Queensland
    - identifying differences in JEV distribution & activity between northern and southern Queensland, and across other geographic regions (for instance, far west versus closer to the coast)
    - surveying various environmental/climatic scenarios.
- characterisation of the contribution of various reservoir hosts to transmission across Queensland
    - identification of feral pig or ardeid bird reservoir hosts and locations where they may sustain virus transmission
    - blood meal analysis of captured mosquitoes to identify other vertebrate reservoirs of JEV
    - understanding the persistence of the virus in locations where amplifying hosts are present.

Such 'intelligence gathering' surveillance will require the deployment of mosquito surveillance beyond locations already implicated as target locations due to JEV detection in animals or human infection. Further, surveillance will need to be extended beyond the immediate response period following notification of a detection in animals or humans.

Long-term JEV surveillance

Long-term sustained JEV surveillance requires a comprehensive understanding of vector, virus, and reservoir host ecology. Long-term surveillance focuses on known risks. Data generated from initial JEV surveillance and scientific research, in addition to periodic review of the program, is necessary to create and optimise a long-term JEV surveillance plan.

Specific intelligence products that will inform long-term surveillance planning and design include:

- phenotypic description of genotype IV JEV strain in Queensland mosquito fauna, including vector competence characterisation
- the geographic extent of JEV activity across Queensland, including seasonal fluctuations in activity across regions
- geographic distribution and ecological characterisation of various vector mosquito species (e.g., *Cx. gelidus*)
- the role of feral pigs in virus ecology
- the role of wild birds in the maintenance and dispersal of the virus
- mosquito host blood feeding patterns with respect to reservoir hosts of the virus
- duration of persistence of active transmission events of JEV at piggeries.

Other aspects of a sustainable, long-term surveillance plan:

- fixed trapping schedules and locations
    - Trap locations will need to represent known locations of past and/or current likely transmission activity and be geographically dispersed across the state.
    - Trap locations will need to reflect the diversity of climatic and environmental conditions across the state.
    - Trap locations will include, but not be limited to, major pig-producing regions.
- capacity and flexibility to accommodate responsive or *ad hoc* surveillance when JEV is detected or suspected in other locations (e.g., as indicated by human or animal surveillance)
- inclusion of a variety of mosquito surveillance techniques (including alternative trap types which may target other candidate vectors) that are tailored to locations where trapping is conducted, for example:
    - in some locations, including judicious incorporation of sugar-based arbovirus surveillance techniques (or other novel techniques, as they become available) to complement mosquito-based surveillance collections
    - accommodating logistical constraints due to the requirement for trapping in remote locations - alternative forms of CO_2 (e.g., cylinders, portable dry ice makers) may be required where commercial dry ice is not available
    - passive mosquito traps where they may be more feasible than light traps.

The potential transition to a collaborative model of mosquito surveillance (particularly at piggery locations), will be informed by the content of the final National Japanese encephalitis Mosquito Surveillance and Control Plan.

An ongoing surveillance plan will require routine surveillance across a relatively large number of locations, with central coordination across HHS regions. Surveillance will need to be sustained for the foreseeable future, even during periods of limited evidence of JEV activity. A long-term, ongoing JEV mosquito surveillance plan will represent monitoring across a wide geographic area with a particular focus on

- pig-producing regions of Queensland
- locations representing foci of enzootic transmission (with likely emphasis on monitoring in the north across seasons but with the inclusion of potential southern foci)
- vulnerable towns or communities with an established risk of exposure
- other sites identified as indicators of general JEV activity across Queensland.

Control of mosquito vectors of JEV

Objectives

Vector control deployed in response to JEV or to mitigate likely JEV risk is intended to reduce mosquito populations in high-risk areas to:

1) reduce biting frequency and thus lessen the likelihood of JEV transmission to people
2) break zoonotic transmission cycles
3) suppress virus transmission in commercial, smallholder and pig keeper piggeries.

Developing a local mosquito control response

There is no universal prescription for mosquito control treatments following the detection of JEV. Local conditions and experience should always inform the development of a treatment/control plan in response to JEV detection. The local HHS or PHU will coordinate a mosquito control response, acknowledging that local processes will differ around the state. Considerations should be made to convene an Expert Advisory Group (EAG) to assess situations where JEV has been detected. This will ensure collaborative decision-making regarding the urgency of the deployment of mosquito surveillance and control measures. An EAG will include Queensland Health medical entomology expertise and, where appropriate, industry representatives, and allow for collaborative discussions across Biosecurity Queensland (BQ), Public Health Units (PHU), CDB, vector control experts and any relevant local or state Incident Management Team (IMT), where applicable. In some cases, information will be required from local government or industry authorities to inform the EAG decision-making. Importantly, input from agricultural chemical experts (Department of Agriculture, Forestry and Fisheries and industry) will inform the development of control response plans.

To ensure appropriate coordination of decision-making regarding response and control efforts, all collaborating agencies must ensure timely and open communication and information sharing to inform control and response activities.

Various considerations will determine the type, scope and timing of control interventions required in the event of detection of JEV. Further, the type of response and prioritisation of each location where JEV is detected or suspected needs to be considered on a case-by-case basis. Key considerations in formulating a control response include:

- prevailing, recent, and forecast environmental and weather conditions
- known mosquito species composition and abundance
- type of mosquito larval habitat identified & drainage/flow from these habitats
- local resources for control and site accessibility
- time elapsed since previous control applications or ongoing control plan
- the proximity of vulnerable human populations
- consideration of environmental health aspects e.g., chemical pollution.
- Consideration of agricultural chemical and food safety aspects to manage the risk of chemical residues in meat
- biosecurity requirements which outline requirements for entry and operations on agricultural premises.

Guidelines for control actions

Integrated mosquito management, i.e., combining environmental, biological and chemical control where appropriate, is the recommended strategy to manage mosquito vectors of JEV. Mosquito management may target freshwater larval habitats of vectors such as *Cx. annulirostris*, at piggeries, near residential areas, or anywhere else where people are at risk of being exposed to JEV.

With regards to mosquito management at piggeries, the Integrated Mosquito Management Principles for Piggeries document was developed by agriculture and health agencies and the pork industry to provide guidance for mosquito control at piggeries. It outlines basic principles of integrated mosquito management that apply to managing mosquitoes in a range of settings, while detailing specific insecticides labelled for use near pigs, including in response to JEV. Further advice regarding mosquito management around piggeries can be found at: https://www.farmbiosecurity.com.au/livestock/pigs/controlling-mosquitoes-around-piggeries/

Insecticide use for vector control in pig production is limited due to residue considerations.

Additional chemicals may be available for use in non-pig production environments. Pesticide applications could be made by local government vector control officers, animal production facility staff (e.g., on piggeries), or private pest management technicians.

Integrated mosquito management is made up of numerous components including chemical, environmental, and biological controls:

1. Adulticides are critical for breaking the virus transmission cycle by preventing mosquitoes from biting humans or pigs. This could include:
    a) Fogging. Note that adherence to directions on the label is critical, particularly with regard to usage near food-producing animals or aquatic life. Insecticidal fogs have no residual activity, so must be reapplied. Fogs containing pyrethroids (e.g., deltamethrin) are most commonly used, however only some pyrethrin fogs are registered for use in and around piggeries.
    b) Outdoor residual spray (ORS) applied to surfaces on buildings or vegetation. Follow all directions on the label. Depending on the product, ORS can have residual activity for up to 6 weeks. Persistent residual sprays should not be used near pig-producing facilities unless specifically registered with the Australian Veterinary Pesticides and Medicines Authority (APVMA) for this purpose. Inappropriate use of persistent chemicals poses a significant risk of non-permissible residues in food and may present a trade and/or food quality risk.
2. Larvicides are important for suppressing biting pressure by reducing the emergence of viable mosquito adults and can be applied to a range of aquatic larval habitats. Larvaciding can be particularly effective in reducing the number of mosquitoes produced from breeding sites attributable to animal wastewater.
    a) *Bacillus thuringiensis israelensis* (Bti) in wetlands and floodplains. Bti is most effective on younger larvae (1st or 2nd instar). Bti has short residual life (24 hours) but kills quickly so efficacy can be easily assessed. It is less effective in highly organic water.
    b) *Bacillus sphaericus* (Bs) is ideal for pools with high organic content (e.g., animal wastewater ponds, and septic tanks).
    c) S-methoprene in wetlands and floodplains. S-methoprene has a longer residual life (~30 days), but it takes several days to determine if treatment has been effective. S-methoprene is most effective on older larvae (3rd-instar).
3. Physical removal or modification of productive larval habitats can reduce the requirement for chemical control in some instances. Appropriate design, redesign and physical management of piggery sewage or wastewater systems can minimise the formation of mosquito breeding sites in ponds and effluent disposal. Where practical, removal of ground depressions that retain flood water can likewise eliminate productive habitats (excluding flood scenarios).
4. Ongoing surveillance during and after the implementation of control is critical:
    a) to determine the extent to where control is needed
    b) to assess the efficacy of control measures, where possible.

Personal protection should be recommended for humans in the form of repellents containing DEET, picaridin or oil of lemon eucalyptus, applied at regular intervals in accordance with label directions. Other personal protection measures include the use of long-sleeved, loose-fitting clothing and enclosed footwear, and the use of screens on doors and windows.

Any control measures applied outside piggeries by local government or other operators must be coordinated with those undertaken at piggeries. Control efforts across regions and regional boundaries need to be consistent and complementary.

Data management and reporting

Data describing mosquito surveillance efforts needs to be managed in a consistent and coordinated manner. A central repository of data for Queensland, populated by data from trained regional representatives, is essential to support coordinated data sharing and reporting at a national level, as outlined in the draft national guideline.

Consistent with a One Health approach, joint reporting processes across animal, mosquito and human surveillance must be developed. Open and timely communication will inform agile management of surveillance and control strategies.

Resourcing and training

Effective mosquito surveillance and control operations must be undertaken by skilled and competent staff to ensure consistency and quality of practices and standards. Insecticides should be applied by somebody with a pest management technician (PMT) license unless exemptions apply. Commercial pest control operators require a PMT license.

Sustained emphasis needs to be on training, supervision and skill development of staff involved in mosquito management operations. Training and skill development should be appropriate to the risks and requirements of each geographic region.

In the context of piggeries, mosquito control operators must be aware of the specific requirements pertaining to:

- application of chemicals in and around facilities where food-producing species are housed and handled
- biosecurity in and around pig-producing facilities.

Public health messaging regarding preventative measures

Queensland Health's Strategic Communications Branch leads JEV public health messaging. Messaging will be undertaken in line with the whole-of-government communications strategy.

PHU requests for local public health messaging should be conveyed via the Hospital and Health Service media team for the affected region. The HHS media team will contact the Media and Issues team in the Strategic Communication Branch to advise of the intention to communicate locally and share draft materials.

All local communications should highlight that mosquito protective behaviours apply to all of Queensland, all year round.

Approval and implementation

Document custodian:

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Version control

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