North Bay Parry Sound District Health Unit
Bureau de santé du district de North Bay-Parry Sound

345 Oak Street West, North Bay, ON P1B 2T2 TEL: 705 474 1400
70 Joseph Street, Unit 302, Parry Sound, ON P2A 2G5 TEL: 705 746 5801

myhealthunit.ca
TOLL FREE: 1 800 563 2808

North Bay Parry Sound District Vector-Borne Diseases Surveillance and Protection Plan

2023

North Bay Parry Sound District Health Unit
Vector-Borne Diseases Surveillance and Protection Plan

Production Team

Prepared by

John Mitchell, Quality, Research and Evaluation Analyst, Planning and Evaluation
Robert A-Muhong, Manager, Environmental Health
Brent Allen, Senior Public Health Inspector, Environmental Health
Kendra Carswell, Public Health Nurse Specialist, Communicable Disease Control

For more information contact:

Robert A-Muhong, Manager, Environmental Health

Please use the following citation when referencing this report

North Bay Parry Sound District Health Unit (2023). *Vector-Borne Diseases Surveillance and Protection Plan.* North Bay, ON: North Bay Parry Sound District Health Unit.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction

The Vector Borne Diseases (VBD) Surveillance and Protection Plan includes information and activities on the following VBD of importance to the North Bay Parry Sound District Health Unit: West Nile Virus (WNV), Eastern Equine Encephalitis Virus (EEEV), Lyme disease (LD), Anaplasmosis, Babesiosis, and Powassan Virus. Data were last collected in the Health Unit area in 2022 for WNV, EEEV and LD. The data collected along with the data from past years helped inform the development of this plan. The health unit has committed to a cycle that will see adult mosquito collection occur every three years, with 2023 being the first year with no adult mosquito collection during the surveillance season.

The Health Unit's VBD Surveillance and Protection Plan includes an outline of the following activities:

West Nile and Eastern Equine Encephalitis virus

The health unit's approach to WNV and EEEV control will continue to emphasize personal protective measures and source reduction. The goal of the VBD Surveillance and Protection Plan is to minimize the impact of WNV and EEEV through district-wide surveillance that directs integrated pest management-based mosquito control activities at a level commensurate with the risk of human illness. This means an emphasis on surveillance, public education, and source reduction. If the level of WNV and / or EEEV in the district increases, then surveillance, education, and control measures will be intensified. Larval mosquito control, such as larviciding, may be considered. Adult mosquito control will only be considered should surveillance findings indicate a significant risk to human health despite the implementation of other control measures.

Source reduction will focus on *Culex pipiens* and *Culex restuans* mosquitoes, the main amplification vectors of WNV in Ontario, and *Culiseta melanura*, the main amplification vector of EEEV in Ontario. Adult surveillance, along with the health unit's messaging of using personal protection measures and source reduction, will be used to enhance mosquito control and education efforts in high-risk areas to interrupt the amplification of WNV and EEEV before they have a significant impact on human health.

Lyme Disease and Other Tick-Borne Diseases

Lyme disease is both a Reportable Disease and a Communicable Disease under the Health Protection and Promotion Act, Regulation 569 as of July 24, 2023. Lyme disease falls within the Environmental Health Program Standards (Health Hazard Prevention and Management – Disease Prevention/Health Protection) in the Ontario Public Health Standards, 2018. On July 1, 2023, Ontario's Ministry of Health made the tick-borne diseases Anaplasmosis, Babesiosis, and Powassan Virus reportable as Diseases of Public Health Significance.

Since the Health Unit is not an area of high risk of exposure to *Ixodes scapularis* (the blacklegged tick, which is the main vector of tick-borne diseases in North America), passive surveillance has been conducted since 2007, where the public is informed to contact the health unit to submit any human acquired ticks they have found and will continue in this format unless the situation changes.

Public Education and Community Outreach

The VBD communication plan will take a passive approach for WNV and a more informative approach for LD and other tick-borne diseases. Should there be any VBD increase in our district, a news release will focus on two main messages targeted to the public, personal protection, and source reduction. This offers a common-sense approach to minimizing the risk associated with WNV, EEEV, and LD and other tick-borne diseases. The Health Unit will consider relaying provincial and federal campaigns, when

available, by linking to them on our website, delivering promotional material, advertising in local newspapers, on social media, and on community information boards, etc.

Human Surveillance and Health Care Provider Education
Physicians and other health care providers will report WNV and EEEV suspect, probable, and confirmed human cases, as per any reportable diseases, to the local medical officer of health (MOH) and the local MOH will report to PHO. The link between physicians, health care providers and PHO plays a critical role in the detection, prevention and clinical management of mosquito-borne diseases.

Adult Mosquito Surveillance
The health unit has committed to a cycle that will see adult mosquito collection occur every three years, with 2023 being the first year with no adult mosquito collection during the surveillance season. During a surveillance season, the Health Unit will monitor mosquitoes across the area by collecting only adult mosquitoes to determine the distribution, density, and species. Adult mosquito traps will be set up throughout the district. Mosquito surveillance data will be used in decision-making about public education and mosquito reduction activities.

Larval and Adult Mosquito Reduction and Control
The MOHLTC has provided health units with a table outlining the action response levels where larviciding or adulticiding may be an appropriate intervention following a comprehensive risk assessment. The action levels are contained in O. Reg. 199/03 (see appendix). It is expected that a decision to implement mosquito control measures will be guided by this plan and the provisions of O. Reg. 199/03. With respect to larviciding, PHO will absorb the costs of all larviciding and adulticiding materials and application work, should it be deemed necessary.

Equine Surveillance
Equine WNV and EEEV cases will be reported to PHO by the Ontario Ministry of Agriculture and Food and Rural Affairs (OMAFRA). The Canadian Food Inspection Agency (CFIA) has made WNV in horses an immediately notifiable disease under its legislation, which requires diagnostic laboratories to report positive test results on a weekly basis. This information is forwarded to OMAFRA and placed on their web site for public reference. OMAFRA will also notify Public Health Units of positive cases in their respective jurisdictions.

Data Collection and Analysis
The Ontario Public Health Standards (2018) states that '*the board of health shall develop a local vector-borne management strategy based on surveillance data and emerging trends in accordance with the Infectious Diseases Protocol, 2023.* Therefore, the Health Unit will continue to collect data to better understand mosquito development in the area and how WNV vectors persist in our environment.

SECTION 1 - WEST NILE VIRUS

1.0 Introduction

West Nile virus (WNV) is a mosquito-borne flavivirus that first made its appearance in North America in 1999. It is a human, horse and bird neuropathogen that can result in encephalitis, meningitis and even death.

The extent to which WNV causes illness in the district on a consistent basis in the future will determine the need for an ongoing WNV program as part of the overall Vector-Borne Diseases (VBD) program. However, no program will be able to prevent every human case of WNV illness.

Background

Evidence suggests that WNV remains in an area over the winter in infected female adult mosquitoes and/or birds. Hence, a small number of infected mosquitoes and/or birds are present within the region during the early spring months. At this time, the virus begins its amplification cycle. As mosquitoes feed on birds, the virus is transmitted back and forth between the vector (mosquitoes) and the reservoir host populations (birds) allowing an increasing number of birds and mosquitoes to become infected. If environmental conditions are optimum for transmission, the virus amplifies. At this point in the amplification cycle, the virus bridges out of the amplification, bird-mosquito cycle via bridge vectors. Bridge vectors are mosquito species that readily feed on humans and other mammals in addition to birds. It is at this point in the season that transmission to humans may occur.

1.1 Surveillance

1.1.1 Human Surveillance

Objective: To reduce the risks of exposure in humans to the illness caused by WNV.

Reportable Disease Requirements in Ontario:

WNV Illness is a Diseases of Public Significance under the Health Protection and Promotion Act, Regulation 569 (June 16, 2022), Strengthening Quality and Accountability for Patients Act, 2017 (May 1, 2018), and Control of West Nile virus, Regulation 199/03 (as of Dec 14, 2017). WNV falls within the Infectious and Communicable Diseases Prevention and Control Program Standards (Infectious Diseases Protocol, 2023) in the Ontario Public Health Standards, 2018.

The following provides reporting responsibilities by selected agencies:

Physician/Health Care Professional:

- Reports human WNV suspect, probable, and confirmed cases, as per any reportable disease, to the local Medical Officer of Health

Local Medical Officer of Health

- Is required to determine whether action is required by a municipality to decrease the risk of WNV to persons either inside or outside the geographical boundaries of the area served by the MOH, based on a local risk assessment.
- This risk assessment may provide the need to collect adult mosquitoes to determine the presence of species of concern.
- Report all information on human WNV probable and confirmed cases to the Ministry of Health and PHO.

Planned Activities:

- Updates to area physicians and other health care providers will be carried out during the season when deemed necessary. This will be done through a mail out to physicians/health care providers.
- Health Unit staff will investigate all suspected, probable, and confirmed cases as per PHO protocols and Health Unit policies and procedures.
- Cases that meet the probable or confirmed case definition will be reported through the integrated Public Health Information System (iPHIS) for the reporting and surveillance of Diseases of Public Health Significance (DOPHS) in Ontario.
- Health Unit policies and procedures will be updated according to current protocols and operational requirements.

Please see Appendix 4 for Case Definitions.

1.1.2 Mosquito Surveillance

Objective: The health unit has committed to a cycle that will see adult mosquito collection occur every three years, with 2023 being the first year with no adult mosquito collection. When collection occurs, the objective is to collect and identify species of concern for the transmission of WNV and to monitor the location and number of species present.

Viral Testing:

When adult mosquito collection occurs, the following table lists WNV vector species of concern in Ontario will be used as the order of preference when considering what species to test in the event that a trap contains more than three different vectors. Note that *Culex pipiens* and *Culex restuans* should be grouped into *Culex pipiens*/*restuans*. The testing order of preference is as follows:

Culex pipiens/restuans (WNV)
Culex salinarius (WNV and EEEV)
Ochlerotatus japonicus (WNV)
Culex tarsalis (WNV)
Aedes vexans (WNV and EEEV)
Ochlerotatus triseriatus (WNV)
Anopheles punctipennis(WNV)
Ochlerotatus trivittatus (WNV)
Anopheles walkeri (WNV)
Ochlerotatus stimulans (WNV)
Anopheles quadrimaculatus (WNV)
Ochlerotatus canadensis (WNV and EEEV)
*Culiseta melanura (EEEV)
**Aedes albopictus/Aedes aegypti (WNV and EEEV)

* Since this species is found in low numbers and is the main enzootic vector for EEEV, it is to be tested for EEEV as part of the three pool limit
** Since this species may sporadically occur in very low numbers and is a highly competent vector, it is suggested that it be tested for WNV as part of the three-pool limit.

This list is prepared based on analysis of entomological data of Ontario and other variables. Changes to this list will be made as required, based on new information and analysis of entomological data.

All information for viral testing comes from the MOHLTC 2023 Surveillance and Preparedness Plan

Planned Activities:

- The new three-year surveillance cycle will start in 2023, where no adult mosquitoes will be collected. Adult mosquito collection will start again in 2025.
- Source reduction messaging and personal protection measures will be communicated to the public, if necessary.
- A communication plan will be followed where communication media from the ministry will be disseminated in our district along with timely communication from the health unit.

1.1.3 Equine (Horse) Surveillance

Objective: To monitor positive WNV cases in the horse population in order to identify the presence of WNV as an indicator of potential human exposure.

Background:

It is known that WNV in horses often occurs concurrently, or at times, just prior to confirmation of human infection. It is thought that the high intensity of mosquito exposure frequently experienced by horses makes them a useful sentinel species. The 1999 New York experience demonstrated equine cases in advance of human cases and in low populated areas where there was no other non-human evidence. Thus, equine surveillance may be important as an indicator of WNV activity and of human risk. It is recognized that the cost of testing is usually borne by the horse owner and, that together with the increasing vaccination of horses against WNV infection, may limit the usefulness of equine surveillance.

Equine Vaccine:

An equine vaccination product is available from veterinary practitioners in North America. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) promote the WNV vaccination of horses to veterinarians and the equine industry in Ontario. While there is no federal policy for action on equine WNV, laboratories must notify the Canadian Food Inspection Agency (CFIA) of any positive test result for equine WNV.

Planned Activities:

- The Health Unit will continue to communicate with large animal veterinarians in the district to receive reports of equine cases.
- Any reported cases of horses testing positive for WNV in the Health Unit area will result in increased in messaging pertaining to source reduction to eliminate adult mosquitoes.

SECTION 2 – EASTERN EQUINE ENCEPHALITIS

2.0 Introduction

Eastern Equine Encephalitis virus (EEEV) is an arbovirus and has made its way into southern and eastern Canada. Disease in birds and horses is the primary indicator of EEEV transmission in Canada.

Background:
Eastern Equine Encephalitis virus was detected, for the first time, in the mosquito population in Canada (2 positive *Culiseta (Cs.) melanura* and 2 positive *Aedes (Ae.) vexans*) in 2009. These were detected within the Simcoe Muskoka District Health unit area, on First Nations land (investigated by the First Nations Inuit Health Branch), which borders the Health Unit area to the south. Then in 2010, a mosquito pool tested positive for EEEV in the Parry Sound area of the Health Unit, marking the first time this has occurred in a public health unit area in Canada. Although it is known as a competent amplification vector, *Cs. melanura* can also be considered a bridge vector, potentially transmitting EEEV to horses and humans. Birds are still considered the primary means by which EEEV disperses through the population. Historically, up to 2023, there have been only three reported human cases of EEEV in Ontario; however, detection in mosquitoes and horses in 2009 signified the need for enhanced provincial surveillance.

Eastern Equine Encephalitis has established itself in Ontario. The extent to which EEEV causes illness in the district on a consistent basis in the future will determine the need for, and scale of, an ongoing EEEV program as part of the overall VBD program. However, no program will be able to prevent every human case of EEEV illness.

2.1 Surveillance

2.1.1 Human Surveillance

Objective: To reduce the risk of human exposure to the illness caused by EEEV.

Reportable Disease Requirements in Ontario:
All reportable diseases are to be reported to Public Health Ontario (PHO). According to their guidelines, while not specifically listed as a Disease of Public Health Significance (DOPHS) in Ontario, EEEV falls under the broader category of Encephalitis, including primary viral (including WNV) in the DOPHS list, meaning that surveillance guidelines for humans would be similar to those for WNV.

The following provides reporting responsibilities by selected agencies:

Physician/Health Care Professional:

- Reports human EEEV suspected, probable, and confirmed cases, as per any reportable disease, to the local Medical Officer of Health

Local Medical Officer of Health

- Is required to determine whether action is required by a municipality to decrease the risk of WNV to persons either inside or outside the geographical boundaries of the area served by the MOH, based on a local risk assessment.
- This risk assessment may provide the need to collect adult mosquitoes to determine the presence of species of concern.
- Report all information on human WNV probable and confirmed cases to the Ministry of Health and PHO.

Planned Activities:

- Updates to area physicians and other health care providers will be carried out during the season when deemed necessary. This will be done through a mail out to physicians/health care providers.
- Health Unit staff will investigate all suspected, probable, and confirmed cases as per PHO protocols and Health Unit policies and procedures.
- Cases that meet the probable or confirmed case definition will be reported through iPHIS.
- Health Unit policies and procedures will be updated accordingly.

Please see Appendix 4 for Case Definitions.

2.1.2 Mosquito Surveillance

Objective: The health unit has committed to a cycle that will see adult mosquito collection occur every three years, with 2023 being the first year where there will be no adult mosquito collection. When collection occurs, the objective is to collect and identify species of concern for the transmission of EEEV and to monitor the location and number of species present.

Viral Testing:
When adult mosquito collection occurs, the following table, supplied by PHO, recommends that health units use the WNV testing order of preference that is listed in the Ministry of Health's 2023 *West Nile virus Preparedness and Prevention Plan*. Health units can still opt to keep the EEEV order of testing if they feel they have a compelling reason to continue in their jurisdiction.

Planned Activities:

- The new three-year surveillance cycle will start in 2023. Adult mosquito collection will start again in 2025.
- Source reduction messaging and personal protection measures will be communicated to the public, if necessary.
- A communication plan will be followed where communication media from the ministry will be disseminated in our district along with timely communication from the health unit.

2.1.3 Equine (Horse) Surveillance

Objective: To monitor EEEV cases in horses in Ontario to identify the presence of EEEV as an indicator of potential human exposure.

Background:
It is known that EEEV in horses can occur concurrently, or sometimes just prior to, confirmation of human infection. It is thought that the high intensity of mosquito exposure frequently experienced by horses makes them a useful sentinel species. Eighty to ninety percent of infected horses develop acute and lethal disease with survivors developing neurologic signs. There are vaccines available to prevent EEEV. Thus, equine surveillance may be important, particularly in rural settings, as an indicator of EEEV activity and of human risk.

Equine Vaccine:
An equine vaccination product is available from veterinary practitioners in North America. The Ontario Ministry of Agriculture, Food and Rural Affairs promote the EEEV vaccination of horses to veterinarians and the equine industry in Ontario. Equine practitioners can send serum or tissue samples to the Animal Health Laboratory in Guelph, or to other private veterinary diagnostic laboratories, for analysis. While there is no federal policy for action on EEEV, laboratories must notify the CFIA of any positive test result for EEEV.

Planned Activities:

- The Health Unit will continue to communicate with large animal veterinarians in the district to receive reports of equine cases.
- Any reported cases of horses testing positive for WNV in the Health Unit area will result in increased in messaging regarding source reduction to eliminate adult mosquitoes.

SECTION 3 – LARVAL AND ADULT MOSQUITO REDUCTION

3.0 Larval Mosquito Reduction

Objective: To reduce the abundance of adult mosquitoes that transmit any Vector-Borne Diseases using Integrated Mosquito Management (IMM) practices.

Background:
All mosquitoes begin their life in water. This offers an opportunity to control mosquitoes in an efficient way before the adult mosquitoes emerge and become widely dispersed.

Culex pipiens and *Culex restuans* are the most important mosquito species in the transmission of WNV. They are known to be one of the most common mosquitoes found in urban and suburban areas. They can develop quickly and use standing or slow-moving water containing decaying organic materials to lay their eggs. Prime development sites include roadside catch basins, ditches, discarded tires left outdoors, poorly maintained bird baths, clogged rain gutters and eaves troughs, puddles in unused swimming and plastic wading pools, containers left outdoors to collect water, and other collections of standing water that last for a week or more.

Development of these mosquitoes can be prevented by either eliminating standing water (source reduction), changing the environment to be less hospitable for mosquito breeding, or treating the water with larvicide to prevent mosquitoes from developing. Habitat modification can include changing the physical environment or introducing predators. An integrated mosquito management approach is recommended which makes use of a range of larval control strategies as appropriate to the situation.

Decision-Making and Consultation:
The decision to employ mosquito larviciding is established through Regulation 199/03. The determination of where to apply the larviciding requires a local risk assessment. The assessment should weigh the level of risk to public health from the mosquito-borne virus based on the most current, available evidence of local WNV and / or EEEV activity in the human population and in non-human species (mosquito pools and/or equines). All factors, plus considering all other control measures, are incorporated into weighing the expected benefits and risks of pesticide use. The risk assessment should also consider all the existing non-pesticide means of mosquito reduction and the measures available to prevent or reduce disease transmission such as personal protective measures against biting mosquitoes. It is recommended that Health Units consult the Ministry of Health's West Nile Virus Preparedness and Prevention Plan (2023) for guidance on risk assessments.

The local Medical Officer of Health / or appointed delegate is the appropriate official to decide after receiving the aforementioned information from health unit staff and other municipal or regional agencies and, if necessary, from consultation with provincial, federal, or private sector expert authorities.

Planned Activities:

- Larval surveillance is no longer conducted by the health unit.
- Public education will ask residents and property owners to eliminate mosquito breeding sites on private property should the risk of WNV and / or EEEV become high in the Health Unit area.
- The Health Unit will assist local municipalities in the development of and implementation of plans for potential larviciding mosquito control programs should the need arise.

3.1 Adult Mosquito Reduction

Objective: To reduce the abundance of adult mosquitoes in areas of elevated risk to human health from Vector-Borne Diseases (VBD) through the judicious use of pesticides.

Background:

The application of chemicals to kill adult mosquitoes by ground or aerial application is called adulticiding. Adulticide is typically applied as an Ultra-Low Volume (ULV) spray where small amounts of insecticide are dispersed either by truck-mounted equipment or from fixed-wing or rotary aircraft. For good adult mosquito reduction, the fine ULV droplets must drift through the habitat and impinge on flying mosquitoes. Adulticiding is usually the least efficient mosquito control technique – adult mosquitoes are widely dispersed and the pesticide must make contact with the mosquito in order to kill it. Nevertheless, adulticiding, based on surveillance data, is an extremely important part of any Integrated Mosquito Management program (IMM). If an outbreak of a VBD in the human population is occurring or imminent, it means that large numbers of VBD infected adult mosquitoes are present. Mosquito reduction only results in a short-term mitigation of outbreak risk. It is recommended that Health Units consult the Ministry of Health's West Nile Virus Preparedness and Prevention Plan and Public Health Ontario's Guide for Public Health Units: Considerations for Adult Mosquito Control documents for guidance on risk assessments. Adulticiding is considered a last resort, when all other reduction measures have been implemented with no effect, as an adult mosquito control measure.

PHO will retain the services of a licensed applicator to adulticide using truck mounted equipment in response to a significant risk to human health. Aerial application is not being considered currently. The agent of choice will be malathion.

Prior to applying adulticides, several factors must be considered in the context of mosquito and VBD biology to assess the level of risk to human health:

- Mosquito species distribution, density, and trends – to see if mosquito populations are those known to transmit VBD and if they are present at a high or low level.
- The level of VBD present in mosquitoes – the presence of VBD in a high proportion of mosquitoes, especially those known to bite humans, is of greatest concern.
- Density and proximity of human populations to mosquitoes.
- The time of year – human cases of VBD typically are greatest in the last two weeks of August and the first two weeks of September. Therefore, indications of high VBD activity prior to this time are of much greater concern than those past it.
- Weather – certain conditions are necessary for adulticides to be applied effectively and some forecasts may predict a rapid decline in mosquito numbers, making adulticiding unnecessary.
- The distribution of human cases in the district and in adjacent jurisdictions in the current year compared to experience.
- Community and stakeholders' attitudes towards the risk posed by the VBD versus the likely benefits and risks of adulticiding.
- The relative effectiveness and safety of the pesticide product, as evaluated by federal authorities, and the regulatory requirements of provincial and federal authorities.

Because of the large number of factors, the decision to larvicide or adulticide will be made on a case-by-case basis. Effort will be made to target this intervention to specific areas of risk and not an entire city or the entire district, and only when deemed necessary.

Planned Activities:

- Adulticiding decisions will be made on a case-by-case basis according to the level of human risk of VBD.
- PHO will retain the services of a licensed applicator with the ability to adulticide.
- The public will be notified of adulticiding locations and schedules in advance, which will allow sufficient time to take any necessary precautions to reduce pesticide exposure.
- Information will be released at least 48 hours in advance through the media, the Health Unit Web site and the Ontario Regional Poison Control Centre in accordance with MOECC requirements.
- Hospitals and the Ontario Regional Poison Control Centre will be notified regarding the adulticiding schedule. Information on the pesticide that will be used will be provided to the public, physicians and other health care providers
- The Health Unit will monitor and assess control activities for any potential environmental and health effects through several measures that may include pre and post-spray environmental sampling and addressing pesticide exposure public complaints received by the health unit.
- Adult mosquito control will be scheduled when mosquitoes are active and when weather conditions are conducive to its success.

Please note that the use of VBD in the above section includes West Nile virus and Eastern Equine Encephalitis virus.

SECTION 4 - LYME DISEASE AND OTHER TICK-BORNE DISEASES

4.0 Introduction

Lyme disease

Lyme disease (LD) is an infection caused by the bacterium *Borrelia (B.) burgdorferi*. This bacterium is spread to humans through the bite of a blacklegged tick, *Ixodes (Ix.) scapularis*. Lyme disease is the most common vector-borne disease in North America.

Ixodes scapularis ticks infected with *B. burgdorferi* have been collected in most regions of Ontario. These ticks are most commonly found along the North Shore of Lake Erie. This includes Long Point, Rondeau Provincial Park and Turkey Point. *Ix. scapularis* ticks have also been found in the St. Lawrence Islands National Park.

Since the Health Unit is not an area of high risk of exposure to *Ix. scapularis*, passive surveillance is conducted.

Anaplasmosis

Anaplasmosis is a disease caused by the bacterium *Anaplasma phagocytophilum*. This bacterium is spread to people by tick bites primarily from the blacklegged tick (*Ix. scapularis*) and the western blacklegged tick (*Ix. pacificus*).

Babesiosis

Babesiosis is caused by microscopic parasites that infect red blood cells and are spread by blacklegged ticks (*Ix. scapularis)* or deer ticks.

Powassan Virus

Powassan virus is spread to people by the bite of an infected tick. Powassan virus belongs to a group of viruses that can cause infection of the brain (encephalitis) or the membranes around the brain and spinal cord (meningitis).

4.1 Surveillance

4.1.1 Human and Passive Tick Surveillance

Objective: To reduce the risk of human exposure to Lyme disease (LD), Anaplasmosis, Babesiosis, and Powassan Virus.

Reportable Disease Requirements in Ontario:

Lyme disease is a Disease of Public Health Significance (DOPHS) under the Health Protection and Promotion Act, Regulation 569 as of July 24, 2023. Lyme disease falls within the Environmental Health Program Standards (Health Hazard Prevention and Management – Disease Prevention/Health Protection) in the Ontario Public Health Standards, 2018.

On July 1, 2023, Ontario's Ministry of Health made the tick-borne diseases Anaplasmosis, Babesiosis, and Powassan Virus reportable as Diseases of Public Health Significance.

The following provides reporting responsibilities by selected agencies:

Physician/Health Care Professional:

- Reports human LD suspect, probable, and confirmed cases, as per any DOPHS, to the local medical officer of health

Local Medical Officer of Health

- Is required to determine whether action is required by a municipality to decrease the risk of LD, Anaplasmosis, Babesiosis, and Powassan Virus to persons either inside or outside the geographical boundaries of the area served by the MOH, based on a local risk assessment.
- This risk assessment may provide the need to actively collect ticks to determine the presence of species of concern.
- Report all information on human LD, Anaplasmosis, Babesiosis, and Powassan Virus probable and confirmed cases to the Ministry of Health and PHO.

Planned Activities:

- Updates to area physicians and other health care providers will be carried out during the season when deemed necessary. This will be done through a mail out to physicians/health care providers.
- Human acquired ticks brought into the Health Unit are to be submitted for identification and possible testing (WI-EH-061).
- Any suspect human cases will be followed up as per Health Unit policies and procedures.
- Surveillance outcomes observed will be interpreted using the Ministry of Health's West Nile Virus Preparedness and Prevention Plan (April 2023); the Ontario Public Health Standards, 2018; and the Infectious Diseases Protocol,2023.
- Any cluster of positive *Ix. scapularis* for LD, Anaplasmosis, and Babesiosis, as indicated by passive surveillance, in our district, may result in possible tick dragging in and around the location.

*****Please refer to Appendix 4 for Case Definitions***

SECTION 5 – DATA COLLECTION AND ANALYSIS - PUBLIC EDUCATION AND COMMUNITY OUTREACH

5.0 Introduction

Mosquito surveillance provides an early warning of potential risk to human health and helps to guide control and public education interventions. Appropriate and timely response to surveillance data is important in preventing human cases associated with Vector Borne Diseases (VBD). If virus activity is detected in the mosquito population, responses may include effective mosquito control and public education. An Environmental Technician and/or Public Health Inspector in the Environmental Health program collects adult mosquitoes weekly throughout the surveillance season. All data collected will help inform the development of future VBD initiatives in the health unit area. All data collection and analysis detailed below will only occur in a season where the health unit is actively collecting adult mosquitos.

5.1 Data Collection

Global Positioning Systems (GPS) equipment will be utilized to collect geographic coordinates for any new adult mosquito surveillance sites, WNV and EEEV positive mosquito pools, WNV positive human cases, and WNV positive equine cases, where and when necessary. The data collected with the GPS equipment will be analyzed using Geographic Information Systems (GIS) software. Geographic Information Systems software will assist in making decisions regarding surveillance and prevention and control activities.

Adult mosquito surveillance data is tracked using a Microsoft Excel comparative data workbook. The Adult Mosquito Surveillance workbook contains mosquito sample information including location type, date of sample, adult mosquito collection numbers, survey type (light trap), and species classification. This spreadsheet is used to perform data analysis for reporting purposes.

The reportable diseases database (iPHIS integrated Public Health Information System) will record the symptoms of WNV disease in humans and will report cases to the Ministry of Health and PHO.

In the event of a positive equine case, OMAFRA notifies the CFIA and the local health unit. This information is kept on OMAFRA's website.

5.2 Data Analysis

Analysis of the VBD surveillance data will provide information regarding the growth and density of infected WNV and EEEV mosquitoes with the resultant transfer of each virus to human populations. Data analysis will also include mapping of mosquito trapping sites. The data will better inform the number, location, and species of mosquito populations allowing for educated interpretation and decisions pertaining to the potential risk of infection to humans. Data collection will help identify the species of mosquito important in WNV and EEEV amplification and transmission in the Health Unit area. The analysis of our northern weather patterns (i.e. Degree days) and the location, growth, and density of mosquitoes, will identify potential high risk areas and times during the season for source reduction and public education. All data collected will be compared to data from previous years to assess trends and possible risks to the human population, as well as assess species of concern for other diseases.

Adult mosquito analysis will include number and percentage of female adult mosquitoes collected by species, locations of adult trapping sites, proportions of amplification and bridge vector mosquitoes at each trap site, trends in amplification and bridge vector mosquitoes over time, and number of amplification and bridge vector mosquitoes collected each week.

Analysis of Lyme disease data will provide information regarding the location and distribution of human acquired tick submissions. Analysis of the data may also include the mapping of tick locations. Data will

better inform the location of tick populations and if any trends exist in the distribution of ticks throughout the Health Unit area. This allows for better decision-making regarding the potential risk of infection to humans.

Equine surveillance analysis will include the identification, location, and results of WNV horse cases in the Health Unit area. Adult mosquito surveillance will be enhanced once a positive human case has been identified in the Health Unit area and data will be analysed to determine if the species of concern (*Culex* species) is present in high numbers.

5.3 Public Education and Community Outreach

Objective: To increase public awareness and knowledge of: the presence of WNV, EEEV, LD, Anaplasmosis, Babesiosis, and Powassan Virus as vector-borne diseases; the surveillance activities and control techniques that are underway; and personal protective measures needed for individuals to consider in order to reduce the risk of exposure to each VBD.

Background:
Based on our key learnings from VBD awareness activities conducted over the last few years, the Health Unit VBD communication plan will take a passive approach. Should any VBD increase in our district, media releases will focus on two main messages, offering a common-sense approach to minimizing the risk associated with any VBD:

- The most important precaution all residents and business owners in the district can take is to ensure that potential mosquito breeding sites are eliminated from their properties. Reducing the mosquito population reduces the risk of WNV and EEEV to human populations.
- Personal protective measures become more important as the season progresses. Avoid mosquito bites and ticks by wearing long-sleeved tops and long pants, socks and shoes. Stay away from areas with high mosquito populations, and avoid being outdoors at dusk and dawn, when mosquito activity is higher. Use an insect repellent containing DEET, and follow Health Canada recommendations for its use, especially on children.
- Also, cover up if you think you might be entering an area where you may be exposed to ticks. Wear closed-toe shoes, long-sleeved shirts, and pants. Pulling your socks over your pant legs prevents ticks crawling up your legs. Light-coloured clothing makes spotting ticks easier.

Communication vehicles to be used include, where required: news releases and alerts; paid newspaper, radio advertising and Facebook advertising; physician newsletters; website updates; fact sheets and posters; newspaper articles; displays; and Facebook and Twitter updates.

Planned Activities:
- The existing vector-borne diseases information on the Health Unit website, www.myhealthunit.ca will have up-to-date information on transmission and personal protection.
- Media relation activities will include media briefings and / or news conferences, if needed. Ongoing news releases to the local and specialty media and interviews with the Medical Officer of Health/designate will occur as required.
- Social Media will be used at the appropriate time throughout the surveillance season.

Main Messaging for Local Source Reduction
Mosquito populations can be diminished significantly by reducing or eliminating their typical aquatic development habitats, a preventive strategy known as source reduction. The major vectors of WNV in Ontario are the species of *Culex* that tend to develop in natural or artificial containers of standing water. Other vectors of WNV, such as certain species of *Aedes* and *Ochlerotatus,* prefer to develop

in temporary floodwaters or semi-permanent pools of water, respectively. *Culiseta melanura*, the main vector for EEEV, develops in large swamps and flooded land depressions.

- Wetlands must not be drained or altered in any way unless there is an exceptional circumstance of significant human health risk from disease-vector mosquitoes. Consultation with, and permission from, the MNR and the appropriate conservation authority will be required.
- Store tires inside a garage, shed or another water-protected situation. Discarded tires left outside collect water after each rainfall and create perfect development sites for female mosquitoes in which to lay their eggs. Tires that have a function, such as anchors for tarps, should have several holes drilled in them to allow drainage.
- Flush or vacuum storm drains and catch basins frequently and ensure that ditches drain properly to remove stagnant water.
- Promote mosquito development source reduction by having fact sheets available should one be requested.
- Every effort and initiative must be considered to eliminate mosquito development sites on public and private property, both residential and commercial land.

SECTION 6.0 - APPENDICES

6.1 APPENDIX 1 - Mosquito Biology

Introduction

A thorough understanding of mosquito biology as it pertains to WNV and EEEV is essential to ensuring that control measures are as effective and cost-efficient as possible with minimal impact on the environment. Understanding mosquito and WNV/EEEV biology allows control efforts to be directed only to those sites breeding mosquitoes important in WNV/EEEV transmission, using the best method for that site and at the right time.

The Mosquito Life Cycle

All mosquitoes have four stages of development that in order are: egg, larva, pupa, and adult. The larval and pupal stages of mosquitoes are in water. The females of some mosquito species deposit eggs on moist surfaces, such as mud or fallen leaves that may be near water but dry. Later, rain or run-off re-flood these surfaces and stimulate the eggs to hatch into larvae. The females of other species deposit their eggs directly on the surface of still water in such places as ditches, roadside catch basins, tire tracks, streams that are drying up, and fields or excavations that hold water for some time. This water is often stagnant and close to homes in discarded tires, ornamental pools, unused wading and swimming pools, tin cans, bird baths, plant saucers, and even gutters and flat roofs. The eggs deposited on such waters soon hatch into larvae. In the hot summer months, larvae grow rapidly, become pupae, and emerge one week later as flying adult mosquitoes. A few important spring species have only one generation per year. However, most species have many generations per year, and their rapid increase in numbers becomes a problem.

When adult mosquitoes emerge from the aquatic stages, they mate, and the female seeks a blood meal to obtain the protein necessary for the development of her eggs. The female of a few species may produce a first batch of eggs without their first blood meal. After a blood meal is digested and the eggs are laid, the female mosquito again seeks a blood meal to produce a second batch of eggs. Depending on her stamina and the weather, she may repeat this process many times without mating again. The male mosquito does not take a blood meal but may feed on plant nectar. He lives for only a short time after mating.

Most mosquito species survive the winter, or over winter, in the egg stage, awaiting the spring thaw, when waters warm and the eggs hatch. Other mosquito species, particularly the *Culex* species important in WNV transmission, spend the winter as adult, mated females, resting in protected, cool locations, such as cellars, sewers, crawl spaces and well pits. With warm spring days, these females seek a blood meal and begin the cycle again. Only a few species can survive over winter as larvae.

Vector-Borne Disease Transmission Cycle

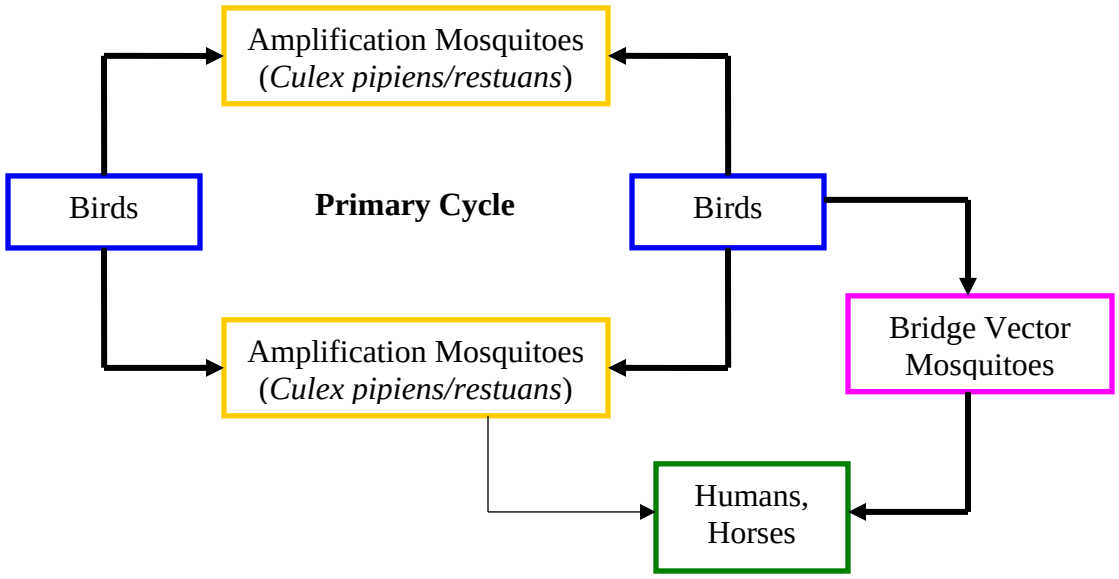
WNV and EEEV survive by circulating between the bird and mosquito population. It is incidentally spread to humans by the bite of an infected mosquito (see Figure 1). A mosquito becomes infected after biting a bird that carries the virus. Wild birds are the principal reservoirs of the virus. Mosquitoes feed on the infected birds, picking up the virus with the blood meal. The virus may circulate in the blood of the mosquito for a few days. After laying their eggs, the infected mosquito may then transmit the virus to other birds, mammals, and humans when they take their next blood meal.

WNV and EEEV are present in the mosquito's salivary glands. During the blood feeding, the virus may be injected into the new host where it may multiply and cause illness. One of the keys to the prevention of WNV and EEEV is the suppression of the vector (i.e. mosquito) populations.

Culex mosquitoes are the most important maintenance vectors of the WNV primarily because of their preference for feeding on birds. *Culex restuans* appears to be important in initiating the WNV transmission among birds in early summer. *Culex pipiens* appears to have a greater role in amplifying the virus later into summer to early fall. When there is a significant amplification in the bird population, sufficient numbers of "bridge vector" mosquitoes – mosquitoes other than *Culex pipiens* and *restuans* that bite both humans and birds become infected in mid to late

summer and then pose an infection threat to humans. Current best practice in WNV control is to aggressively control *Culex pipiens* and *restuans* to disrupt the primary cycle of transmission between bird and mosquitoes. If successful, this keeps the level of WNV in a community at a low enough level so that there is little "spill-over" of WNV into bridge vector mosquitoes and therefore humans. The same philosophy exists for maintaining populations of *Culiseta melanura*, the main vector for EEEV, in check.

Figure 1: The West Nile virus and Eastern Equine Encephalitis virus Transmission Cycle



Mosquito Development Habitat Types

There are two general categories within which mosquito development habitats exist: natural mosquito development habitats and man-made mosquito development habitats. Female mosquitoes lay their eggs either on water or on soils that are periodically flooded. These development areas can be found in habitats that exist naturally, such as within a pond or flood plain, or in habitats that have been created by humans, such as bird baths, water-filled tires, or catch basins.

Mosquitoes can breed in a wide variety of locations, and the discussion below provides a description of the general types of habitats where mosquitoes are known to breed.

Natural Mosquito Development Habitats

Temporary Woodland Pools:

Shallow, temporary pools are common in woodland areas during the spring and wet summers in low lying areas or in small depressions where a variety of mosquito species will breed, most commonly *Aedes canadensis* and *Aedes vexans*. These mosquitoes lay their eggs along the edges of the pool and when rainwater or melting snow fills these pools the larvae hatch.

Freshwater Ponds:

The larvae of *Anopheles* are found primarily in small ponds among the emergent vegetation. Ponds clogged with vegetation can breed large numbers of mosquitoes because of the vast amounts of organic matter available to mosquito larvae for feeding and because fish and other aquatic predators cannot readily feed on the larval mosquitoes.

Streams and Floodplains:
Streams with running water often do not produce large numbers of mosquitoes, if any. However, mosquitoes need to be near water in order to lay their eggs. *Anopheles* and *Culex* mosquitoes are two types of species that can sometimes be found in isolated pockets, adjacent streams or within floodplain areas that undergo only periodic flooding.

Tree Holes and Other Natural Containers:
Tree holes and other natural containers, such as pitcher plants or water trapped in or on plant leaves, can also serve as development habitats for mosquitoes, such as *Aedes triseriatus*. Frequent rainfalls maintain standing water within these types of microhabitats and can breed mosquitoes throughout the summer.

Freshwater Marshes and Swamps:
Mosquitoes such as *Coquillettidia perturbans* and *Culiseta melanura* (main vector for EEEV) breed in freshwater marshes and swamps consisting of emergent vegetation. These types of habitats can occur in both woodland and open field habitats. *Coquillettidia perturbans* larvae attach themselves to the stems and roots of the vegetation to obtain oxygen, and do not need to swim up and down in the water column to feed and to breath. Due to this adaptation, these larvae can avoid exposure to predatory fish.

Man-made Mosquito Development Habitats

Storm water/Wastewater Detention:
A catch basin (a.k.a. storm drain inlet, curb inlet) typically includes a curb inlet where storm water enters the basin to capture sediment, debris and associated pollutants. Similarly, detection/retention basins that perform similar functions for other types of wastewaters, such as waste treatment settlement ponds, provide a similar type of development habitat to that of the storm water catch basin. These detection basins provide development habitat for urban mosquito species, such as *Culex pipiens*. Moisture and organic debris captured within the detention basin can aid in development and provide nutrients for growing larvae.

Roadside Ditches:
Roadside ditches are the suitable habitat for many species of *Culex* mosquitoes. The larvae of *Culex pipiens* and *Culex restuans*, for example, can survive in waters with high organic content. *Culex* mosquitoes will lay their eggs directly on the water's surface; therefore, ditches that hold water for extended periods of time can breed large numbers of mosquitoes.

Artificial Containers:
Artificial containers left out to collect rainwater such as tires, bottles, buckets, and birdbaths can provide an excellent mosquito-development habitat free from any predators. Many tree-hole mosquitoes have learned to adapt to using these man-made mosquito nurseries. The abundance of organic debris, which can also collect in these containers, allows for the proliferation of mosquito development during a season.

Specific Mosquito Information:
There are many species of mosquitoes found in Ontario. Each species of mosquito has a different habitat, behavior and preferred source of blood. *Culex pipiens* and *Culex restuans* (considered the primary vector of WNV), *Aedes vexans vexans, Ochlerotatus canadensis* and *Ochlerotatus triseriatus* are all implicated in the transmission of WNV and *Culiseta melanura* is implicated in the transmission of EEEV. *Culex pipiens* and *Culex restuans* are responsible for maintaining WNV in an area by biting and infecting birds. The other mosquito species mentioned above are "bridge vector" which transmit WNV to humans after biting an infected bird.

Culex pipiens:
Culex pipiens over-winters as adult females and deposit their eggs in rafts on the water's surface in the late spring. Larvae are found in waters with high organic content such as catch basins and roadside ditches and polluted pools of

sewage. *Culex pipiens* breeds throughout the summer, peaking in mid-summer and gradually declining until the first frost. Females feed primarily on birds but also on mammals, which may include humans.

Culex restuans:
Culex restuans are found in a variety of habitats including roadside ditches, polluted pools, and discarded tires and containers. Like all species of *Culex*, they lay their eggs in rafts on the surface of the water. In warm temperatures it takes 7 to 10 days for immature to develop to the adult stage. Females preferably feed on birds but also, to some extent, on mammals, possibly including humans. Adults are morphologically very similar to *Culex pipiens* and it can be difficult to distinguish between them.

The Life Cycle of *Culex pipiens* and *restuans* and Implications for Timing of Larvicides:
Culex mosquitoes survive the winter as adults and leave their over-wintering sites when the average daily temperature reaches 18.3°C (usually late May). They lay their eggs in habitats with high organic content that contain water for an extended period of time. These habitats are typically storm water catch basins, swimming pool covers and small containers such as bird baths and rain barrels.

Culex pipiens and *Culex restuans* normally have three major generations in Southern Ontario. Eggs from the first generation are laid from late May to mid June, the 2nd from mid June to mid July, and the 3rd from mid July to early August. A small 4th generation occurs in August. The 3rd generation of *Culex pipiens* and the 2nd generation *Culex restuans* are usually the largest. Very little information is available regarding the number of generations in North eastern Ontario.

Culiseta melanura:
Culiseta melanura larvae are most numerous in large swamps. Alternate habitats include mature stands of Red Maple that remain flooded well into the summer. This species may be found anywhere that acid water conditions provide optimal larval habitat.

Aedes vexans vexans:
Aedes vexans is a flood water species that lays its eggs in small depressions which are subject to flooding. The females are persistent biters and most active in the early evening. The adults are known to fly great distances and are readily attracted to light.

Ochlerotatus canadensis:
Ochlerotatus canadensis larvae are usually found in cool, temporary pools with scattered shade, especially near coniferous forests and sometimes hardwood swamps and sphagnum bogs. The females bite any time during the day or evening in wooded or shaded areas and in open areas at night. Females feed mostly on mammals and sometimes on birds.

Ochlerotatus triseriatus:
Ochlerotatus triseriatus breeds in a wide variety of natural and artificial containers and can have several generations per year. Suitable development sites for this species include holes in trees, rain barrels, cans, buckets and tires. Females feed in the morning and early evening. This species seems to be indiscriminate in its feeding habits, feeding on mammals, birds, reptiles and amphibians.

Table 1: Mosquito species and vector type

Species	Amplification Vector	Bridge Vector	Development Habitat
Culex pipiens	+	+/-	Catch basins, ground pools, ditches, eutrophic sites
Culex restuans	+	+/-	Temporary pools, edge of swamps, tires, catch basins, road side ditches
Culiseta melanura	+	+/-	Swamps, marshy areas and flooded areas
Aedes vexans		+	Rain pools, tire ruts, storm water basins, ditches, woodland pools, floodplains
Ochlerotatus canadensis		?	Temporary pools with shade, swamps and bogs
Ochlerotatus triseriatus		+	Tires, tree holes and artificial containers

6.2 APPENDIX 2 - Larval Control Methods:

Click here: https://www.publichealthontario.ca/-/media/documents/C/2013/considerations-mosquito-control.pdf **Date of Last Issue:** April, 2023

6.3 APPENDIX 3 - Health Protection and Health Promotion Act – *O. Reg.199/03: Control of West Nile Virus*

Click here: https://www.ontario.ca/laws/regulation/030199/v6 **Date of Last Revision:** December, 2017

6.4 APPENDIX 4 – Case Definitions for Anaplasmosis, Babesiosis, Encephalitis (primary viral), Lyme Disease, Powassan Virus, and West Nile Virus

6.4.1 Click here:
https://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/infdispro.aspx

6.5 APPENDIX 5 - Glossary of Terms

Adulticide	A type of pesticide used to kill adult mosquitoes.
Amplification vector	An arthropod (in this case, a specific species of mosquito) that is involved in the main transmission of West Nile virus between bird species.
***Bacillus thuringiensis israelensis* (BTI)**	A bacterium; type of biological pesticide used to eradicate mosquito larvae in water (mosquito larvae die after ingesting this bacteria).
Bridge vector	An arthropod (in this case, a specific species of mosquito) that serves as a main transmission of virus between the reservoir (birds) and a dead end host (humans).
Catch basins	Grates seen at street corners and in other properties for water run-off.
Culex pipiens	Species of mosquito, the primary known vector for West Nile virus, commonly found in urban areas; breeds in fresh but stagnant water such as backyard containers and storm drains.
Debris	Accumulation of loose materials capable of holding water eg. leaves.
DEET	DEET (chemical name, N, N-diethyl-meta-toluamide) is the active ingredient in many insect repellent products.
Depression	Any natural or man-made condition on property that is capable of holding water but does not include a municipally-owned storm water management facility.
Diapause	A period of suspended development or growth, characterized by inactivity and decreased metabolism.
Encephalitis	Inflammation of the brain, which can be caused by numerous viruses, including West Nile virus.
Enhanced passive surveillance	Not actively participating in surveillance activities however, actively tracking all cases reported.
GIS (Geographic Information Systems)	Computer based systems for the integration and analysis of geographic data.
GPS (Global Positioning Systems)	A navigation system that uses a series of 24 satellites of known position in space to determine a position on the earth's surface.
Icaridin	Is an insect repellent. It has broad efficacy against various insects and is almost colorless and odorless.
Integrated Pest Management	Is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive

	information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment
Larvae	Immature mosquitoes: stage which hatches from the egg, prior to adult stage.
Larvicide	A type of pesticide used to eradicate immature mosquitoes (larvae).
Methoprene	A type of larvicide; chemical that is used to prevent mosquito larvae from emerging and developing into adult mosquitoes.
Mosquito Development Site	Previously known as a "Mosquito breeding Site", a location where mosquitoes lay eggs, usually in stagnant water with organic material and where the larvae hatch and develop to the adult stage. Changed due to the technicality that mosquitoes do not 'breed' in these areas.
Mosquito Pools	A group of mosquitoes collected in one area and combined at the laboratory for testing for the presence of West Nile and related viruses.
Natural Body of Water	A creek, stream, bog, marsh, river, pond or lake created or maintained by the forces of nature, which contains water and include spring fed man-made ponds.
Objects	Container of any kind capable of holding water eg. tires, cars, boats, garden fixtures, bird baths.
Outbreak	An unexpected increase in frequency or distribution of a disease.
Pesticide	Substance used to kill pests such as insects, mice and rats; an insecticide is a form of pesticide.
Overwintering	A period of rest or hibernation by which insects survive the winter.
Source Reduction	The removal or reduction or larval mosquito habitats.
Standing Water	Any water which is not continuously filtered and in movement by mechanical means that is found either on the ground or in any object or debris as defined above but does not include a natural body of water that exists on a permanent basis or is contained within a municipally owned drain or storm water management facility.
Vector	An organism (an insect in most cases) capable of carrying and transmitting a disease-causing agent from one host to another.
Vector Control	Mechanism instituted to control and reduce the vector population.

SECTION 7.0 - REFERENCES:

Best Management Practices for Mosquito Control in New Jersey. Appendix to Brattsten, L.B. 2002. Insecticides recommended for mosquito control in New Jersey in 2002. Retrieved May 9, 2016.
URL: http://entomology.rutgers.edu/

Glare, T.R. and O'Callaghan, M. 1998. Environmental and health impacts of *Bacillus thuringeniensis israelensis.* New Zealand Ministry of Health.
URL: http://www.beyondpesticides.org/mosquito/documents/BacillusThuringiensisIsraelensisNZ.pdf
Retrieved May 9, 2016.

Glare, T.R. and O'Callaghan, M. 1999. Environmental and health impacts of the insect juvenile hormone analogue, S-methoprene. 1999. New Zealand Ministry of Health. Retrieved April 9, 2011.

Ministry of Health. *Infectious Diseases Protocol, 2023*. Toronto, ON: King's Printer for Ontario; 2023. URL: https://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/protocols_guidelines/infectious_disease_protocol.pdf

Ministry of Health. *Ontario Public Health Standards Case Definitions and Disease-Specific Information Disease: Lyme Disease.* Effective: April, 2023. URL: https://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/lyme_disease_chapter.pdf

Ministry of Health. *West Nile virus Preparedness and Prevention Plan*. Toronto, ON: King's Printer for Ontario; 2023. URL: http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/reference/WNV_plan_en.pdf

North Bay Parry Sound District Health Unit (2018). *2017 Vector-Borne Diseases Surveillance Report.* North Bay, ON: North Bay Parry Sound District Health Unit.

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Eastern equine encephalitis: history and enhanced surveillance in Ontario. Toronto, ON: Queen's Printer for Ontario; 2014.

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Guide for public health units: Considerations for adult mosquito control. Toronto, ON: Queen's Printer for Ontario; 2013

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Summary: Tick Species in Ontario. Toronto, ON: King's Printer for Ontario; 2023

Ontario Agency for Health Protection and Promotion Public Health Ontario). Vector-borne diseases 2018 summary report. Toronto, ON: Queen's Printer for Ontario; 2019.

Public Health Agency of Canada – Lyme Disease in Canada
URL: https://www.canada.ca/en/public-health/services/diseases/lyme-disease/surveillance-lyme-disease.html

Westchester County Department of Health. March 2004. Comprehensive Mosquito-borne Disease Surveillance and Control Plan. Comprehensive Mosquito-borne Disease Plan