Pest Management Plan
(DRAFT)

CRAN-PMP-2026/2031
Nuisance Mosquito Control Program
40 – 10th Avenue South,
Cranbrook, BC, V1C 2M8
Phone 250-426-4211 or toll free: 1-800-728-2726

City of Cranbrook Mosquito Control Pest Management Plan

Introduction

This Pest Management Plan (PMP) has been prepared by the City of Cranbrook (City) to describe their Mosquito Control Program (Program) and to obtain authorization through the Ministry of Environment and Climate Change Strategy for required pesticide use.

This program is funded through municipal and electoral area tax requisition and, as such, it is accountable to the residents and businesses of Cranbrook. An area of considerable importance within Cranbrook is tourism, in particular campgrounds and golf courses. During years of high mosquito infestation, the impact to these venues can be considerable.

The main focus of the program is on mosquito abatement for the purposes of nuisance control and improvements in overall community health. This targets interface areas between high mosquito populations and residential and recreational areas. By managing potential mosquito breeding sites to prevent mosquitoes from becoming pests, monitoring their populations, and using a biological pesticide to supress mosquito populations to acceptable levels, this program is in keeping with regulations set forth in the Integrated Pest Management Act (IPM Act).

This Pest Management Plan includes the following:

- Outline of the Cranbrook Mosquito Control objectives, commitments, control strategies, operational standards, and environmental considerations.
- Description of previous Mosquito Control activities within Cranbrook and the changes that have made this program one of the most effective.
- Documentation of environmental and human health protection measures while undertaking Mosquito Control Activities.
- Address how each of the requirements for a PMP under the IPM Act will be fulfilled.

Overview of Plan Area (IPMR 58(1)(A))

The geographic boundaries of the Program are, at this time, limited to public and private lands within the following existing program areas:

- Public and Private lands within a 10km radius of the City of Cranbrook.

Most mosquito development sites are located in snowmelt areas and rainwater catchments in and around the City. The extent of mosquito development activity varies depending on the flood level of the associated snowmelt. The level of the flooding influenced by high rain events. In low water years, development activity is relatively non-existent and in high water years there are potentially high populations of mosquitoes.

Due to the fact that the target mosquito species (Table 2) have a propensity for stagnant water, mosquitoes are essentially able to breed anywhere in years with extreme flooding. Therefore, especially in high water years, the entirety of the area is a potential mosquito development site. The mosquito population is such that for every area of standing water, temporary or permanent, there is at least one corresponding species of mosquito ready to

take advantage of it. This PMP will cover all non-private lands and owner-approved private lands throughout the included area.[1]

Pest Manager (IPMR 58 (1)(B))

The City of Cranbrook manages mosquitoes within their program through the use of certified contractors on a 3-5 year contract.

Plan Contact (IPMR 58 (1)(C))

The primary contact for this PMP is Curtis Mummery, Construction Compliance Technologist, City of Cranbrook, 40 – 10th Ave, Cranbrook, BC. (250.489.0239)

Term of Plan

This PMP is written to cover a 5-year term from April 1, 2026 to March 31, 2031. All mosquito control activities carried out by the City of Cranbrook and its Contractors will be in accordance with this PMP for its duration.

PMP Outline

The content of PMP's prepared in the Province of British Columbia is legislated under the Integrated Pest Management Regulation (Section 58) and the checklist provided in the Regulation is included in Appendix B. This PMP will describe the Cranbrook Mosquito Control Program (Program) including monitoring activities, treatment decisions, treatment options, and treatment evaluations. It will also outline the operational procedures conducted by the City of Cranbrook to ensure safe methods of transporting, storing, handling, and applying the pesticides used in this program. This PMP will address Cranbrook's policies for disposing of empty pesticide containers and unused pesticide, as well as for responding to pesticide spills. There will be a discussion of Cranbrook's strategies for the protection of community watersheds, domestic and agricultural water sources, fish, wildlife, riparian areas, and food intended for human consumption. Finally, this PMP will outline the commitments of the City of Cranbrook with respect to maintaining pesticide records and submitting annual reports and notices.

Notifications

Notification will be given to the Ministry when any of the following conditions of this PMP change:

- the area of proposed control activities changes
- the control methods change
- the pesticides available to, and used by, this Program change
- situations emerge that require control beyond the level permitted by the PMP, including but not limited to:
    - extreme levels of mosquito activity,
    - emergence of vector[2] related disease, or

[1] See Appendix 1 for a Map of the Current Mosquito Control Program
[2] Vector: a biological vehicle facilitating disease transmission (includes biting flies, rats, etc…)

- introduction and identification of significant mosquito species[3]

Notification will be given as soon as the triggering condition arises, and program activities will continue *status quo* until such time as the Ministry has given approval for the change.

Reporting

Reports will include Pesticide Use Summaries of all areas treated for mosquitoes under this PMP. Specifically, these summaries will include:

- contractor and client contact information
- pesticide application permit number
- the pesticide applicator license numbers belong to all applicators
- the dates and times of pesticide applications, the target mosquitoes
- the pesticide trade name and registration number
- the method and rate of application
- the total quantity used of each pesticide, environmental conditions during application (i.e., temperature, precipitation, wind velocity, etc.)
- the mosquito monitoring methods, and treatment triggers

Reporting of all mosquito control activities will be completed by the end of the same calendar year as the activities that took place.

Program Scope – IPM (IPMR 58 (2)(a))

A requirement of all PMP's in British Columbia is an explanation of how the applicant (in this case, the City of Cranbrook) will utilize the elements of Integrated Pest Management (IPM). The six elements of an IPM strategy that will be discussed in detail in the following Sections are:

1. a strategy to prevent organisms from becoming pests (planning)
2. a method to identify pests
3. a monitoring (surveillance) program
4. a description of the injury thresholds used to make treatment decisions
5. treatment options and selection criteria
6. a method for evaluating effectiveness of pesticide use

Mosquitoes are insidious summertime pests that live and breed in and around wet environments. There are no insects, native or introduced, that are capable of keeping the cyclically burgeoning populations of mosquitoes in check. The proximity of human habitation and recreation to these mosquito producing areas requires the deployment of programs designed to reduce the mosquito populations to non-nuisance levels.

In addition to the nuisance issues surrounding mosquitoes, there are also disease-transmission threats. In this day of global travel, we are faced with the additional challenge of disease introduction. Many of these diseases utilize mosquitoes as vectors for transmission (Table 1). Although the majority of these diseases have not been found in

[3] Significant Mosquito Species are defined, for the purposes of this PMP, as mosquitoes capable of transmitting viruses and parasites of human and agricultural health concerns, and that have not previously been identified as resident or target species.

significant densities to be of concern locally, some diseases have been detected. Local mosquito vectors do exist and could potentially be modes of transmission for these diseases should mosquito populations be allowed to increase dramatically.

West Nile virus (WNv) is likely the most widely distributed vector-borne disease in Canada and the US. It was first introduced to New York City in 1999 and wasn't detected in BC until 2002. Very few locally contracted cases of WNv have occurred in BC, and as of the development of this PMP it is not certain whether or not this will change.

Along with concerns regarding potential vector species, there is also the risk of introduced mosquito species. Since 2000, there have been introductions of exotic mosquitoes into California, Oregon, and Florida. Within BC, some species of mosquitoes have been reported that had never been previously recorded

Table 1. Diseases with known local vectors.

Disease	Local Vectors	Habitats
Malaria	*Anopheles* sp.	temporary pools
Western Equine Encephalitis	*Culex tarsalis, Aedes vexans/sticticus*	
Eastern Equine Encephalitis	*Mansonia perturbans*	ponds
St. Louis Encephalitis	*Culex pipiens*	containers, standing water
California Encephalitis	*Aedes* sp.	floodwater
West Nile Virus	*Aedes* sp., *Culex* sp.	temporary pools
Heartworm	*Culex* sp.	

There are approximately 20 species of mosquito within the City of Cranbrook (Table 2). There are approximately 3,100 species of mosquitos world-wide. The most predominant species are the snowmelt and floodwater species. These species are active in the summer throughout the spring melt and successive high-water and rain events.[4] Each major rain event brings a new hatch of mosquitoes, with the higher water levels resulting in a larger flood area resulting in relatively more mosquitoes.

Table 2. Mosquito species found within the CRANBROOK

Species	Habitat	Target
Aedes vexans	floodwater grasses	human
Aedes communis	forest pools / deciduous	mammal
Aedes fitchii	most semi-permanent pools	mammal
Aedes cinereus	semi-permanent mixed cattail / sedge marsh, sphagnum bog	mammal
Aedes atropalpus	rock pools, artificial pools	mammal
Aedes sierrensis	tree holes, artificial containers	mammal
Aedes sticticus	floodwater pools	lg mammals
Culex territans	permanent pools, artificial containers (see *C. tarsalis*)	amphibian

[4] A "high water event" is defined as a water level that exceeds the bankfull depth, e.g. when the water moves into and/or past the first band of riparian vegetation.

Culex tarsalis	permanent / semi-permanent ponds, irrigation, ditches	bird/mammal
Culex pipiens	water containers, even sewage and manure polluted water	bird
Culiseta minnesotae	found in most water, containers, pools, ponds	bird
Culiseta morsitans	found in most water, containers, pools, ponds	bird
Culiseta incidens	diverse – open or shaded pools, permanent streams / ditches	mammal
Culiseta impatiens	semi-permanent pools / bogs, shaded forest pools	mammal
Anopheles punctipennis	wooded areas / pools with floating debris	mammal
Anopheles earlei	wooded areas / pools with floating debris	mammal
Mansonia perturbans	permanently, particularly cat-tail, marshes	bird/mammal

Aedes mosquitoes are the most common nuisance mosquitoes within the City. As opposed to other mosquitoes (i.e., *Culex*, *Culisetta, Anopholes*), *Aedes* lay their eggs on damp substrate in areas with a high flooding potential; they are often called 'floodwater' mosquitoes for this very reason. If the water flooding the eggs is sufficiently warm, contains a low enough dissolved oxygen (DO) content, and is organically rich (which contributes to a decreased DO content), hatching will commence (Gjullin et al. 1950).

Mosquito abundance in the PMP Area is primarily affected by snowmelt, over-irrigation, and significant rain events. Frequent and large amounts of precipitation can affect water levels, though typically to a lesser degree than snowmelt. During periods of heavy rain, control measures are required on a broader basis. A general rule used by this PMP is that mosquitoes will breed in any standing water.

The City of Cranbrook Mosquito Control Program is focused on controlling mosquitoes in the larval stage. Controlling mosquito larvae is less impactful on the environment because biological larvicides can be used and larvae are generally easier to target than adults, thus requiring less pesticide.

There are several environmental issues to keep in mind when operating a Mosquito Control Program concentrating on larval treatments:

- potential reduction in a fish food source
- potential pollution of freshwater systems
- potential exposure to migratory bird populations
- potential contamination of human and agricultural water sources (including surface and ground water)
- potential overspray

These environmental issues will be discussed in further detail when outlining the restrictions that relate to each proposed pesticide. (Appendix I)

Relevant Legislation, Authorities, and Guidelines

There are a number of Acts and Guidelines that govern mosquito control, either directly or indirectly. Most of these govern from the standpoint of the protection of environmental and human health, not so much from the perspective of mosquito control itself. By no means do the following sections contain an exhaustive list of relevant legislation, they do however contain the most important.

Federal Legislation

- ***Pesticide Control Products Act*** summarizes the registration and availability of pesticides. It also prohibits application under unsafe conditions.
- ***Migratory Birds Convention Act*** describes the requirements to protect migratory birds from pesticides.
- ***Fisheries Act*** establishes criteria for the protection of fisheries and fish habitat from pesticides.
- ***Transportation of Dangerous Goods Act*** provides information regarding the storage and transportation of pesticides (and other dangerous goods).
- ***Food and Drugs Act*** describes restriction on pesticide use on livestock forage and where livestock will be consumed by humans.
- ***Waste Management Act*** outlines procedures for the disposal of pesticide wastes.
- ***Plant Protection Act*** prevents the introduction or spread of insects, nematodes, plant diseases or other pests which may be destructive to agricultural or forestry crops. Treatments can be ordered to control serious pest outbreaks.

Provincial Legislations

- ***Integrated Pest Management Act*** prohibits the application of pesticide on Crown land except under a Pest Management Plan. It also lays out permit requirements for the handling, storage, disposal, and sale of pesticides.
- ***Environmental Appeal Board Procedure Regulation*** governs the process for appeals of Pesticide Use Permits and Pest Management Plans.
- ***Environmental Management Act*** outlines the process for appeals of pesticide use.
- ***Wildlife Act*** establishes criteria for the protection of wildlife and wildlife habitat.
- ***BC Transportation of Dangerous Goods Act*** provides information regarding the storage and transportation of pesticides.

Federal Guidelines

Municipal Mosquito Control Guidelines, prepared for the Health Canada Bureau of Infectious Diseases, it outlines a typical Mosquito Control Program, including disease, habitat, and control methods.

Mosquito Habitat Identification and Prioritization (IPMR 58 (2)(B))

Efficiency is extremely important in mosquito control operations. This program is tax based and, as such, must respond to financial restraints as well as the wishes of the taxpayers who fund the program. A balance has to be set that takes into consideration ease of treatment, effectiveness of treatment, and consequences of no treatment. All sites are prioritized based on those criteria as outlined below. Appendix II is an additional guide to aid in larval treatment decisions.

Habitat Identification

One of the primary steps in Mosquito Control is the identification of mosquito habitat. There are four main habitats within the Region and one significant, though much less likely, habitat. Each of these habitats are relatively easy to classify and recognize. Within each habitat, there are differences in predictability and productivity; each will be discussed in the corresponding sections, to follow.

Flood Water and Snowmelt Habitats

Early season snowmelt causes catchment areas to fill and local tributaries to flood, resulting in mosquito habitat. As the water levels in the local rivers rise, undeveloped (and to some extent, developed) areas along the banks become flooded. Higher rises in the water mean more total area becoming flooded.

Of all the habitat types in Cranbrook, this is by far the most productive. Larval densities can reach 1000 per 280ml of water or approximately 80,000,000 (eighty million) per hectare[5]. The mosquito species that breed in these areas are mostly of the *Aedes* species, most of which bite humans. This is also the easiest habitat in which to predict activity, as it is typically mostly active in early Spring.

Seepage Habitats

As river levels rise, so do the ground water levels. Higher ground water can manifest itself as surface water in low-lying areas. Usually associated with agricultural and private land, it is difficult to predict mosquito activity within these sites. Because these sites are ephemeral, it is possible that landowners are not aware of the site until excessive adult mosquitoes are present. This situation can be exacerbated by rainfall. If the ground is already saturated, then the rainwater will sit on the surface creating more development sites.

The productivity of these sites is the second highest, usually producing similar species to flood water habitats, only far fewer of them. The difficulty with these sites is that the water in them is usually warmer. Warmer water leads to faster larval development and hence decreases the window of opportunity to locate and treat these sites. Mosquito annoyance

[5] Wood, Dang, and Ellis, The Insects and Arachnids of Canada: Part 6. The Mosquitoes of Canada, Diptera: Culicidae, Biosystematics Research Institute, Ottawa, Ontario (1979). pp.269-270

due to seepage sites is more noticeable due to the fact that the sites are typically closer to residential areas.

Local Habitats

Local habitats include children's swimming pools, discarded containers, used tires, clogged gutters, and any other item that can hold water. These habitats allow for water to collect and are quick to warm, giving container mosquitoes an optimal environment for reproduction. Many container mosquitoes (i.e., *Culex pipiens, Culex tarsalis*) are potential vectors for disease.

Due to their potential disease-vector production and proximity to people, these habitats are locally important. Unfortunately, they are the hardest to find and control through typical control methods. The easiest way to control them is through education.[6] Through education, residents are encouraged to check their properties and find and empty these containers.

Productivity in these areas is relatively insignificant. However, it does generate a fair number of complaints. For example, a small number of mosquitoes dispersing from a birdbath in someone's backyard will be problematic to that person (and possibly their neighbours) if all the mosquitoes find their way to a blood meal. In a sheltered backyard, most mosquitoes will remain close to their emergence environment and not disperse.

Standing Water Habitats

Standing water habitats include ponds, slow moving ditches and swamps. These areas are easier to map and easier to treat but usually breed far fewer mosquitoes. A primary reason for reduced mosquito abundance in these sites is due to the existence of natural predators that feed on the larvae, naturally keeping them at low numbers. The species that typically inhabit these areas are not as abundant as those found in temporary flood water or seepage habitats. Mosquitoes standing water habitats are often potential disease vectors. Therefore, these areas are best monitored with action taken only when necessary.

Ports of Introduction

Often, items brought in through shipping come packed with water. When these items come from tropical climates, there is the potential for the introduction of exotic mosquito species. This is less likely to happen within regions such as Cranbrook.

Development Site Prioritization

Six criteria determine the relative priority of a mosquito development site:

1) productivity
2) proximity to residential areas
3) proximity to agricultural areas
4) proximity to recreational areas

[6] Education is performed through the use of pamphlets, public relations, and the internet.

5) species of mosquito produced
6) mosquito-borne disease presence

These priorities are flexible to account for changes in disease presence and for extreme fluctuations in mosquito populations.

Productivity

Productivity is the first determination to be made regarding a mosquito development site during normal conditions. Productivity, for the purposes of this PMP, is measured as the number of mosquitoes produced during peak activity. This number is determined as the potential density of larvae[7] multiplied by the approximate size in hectares of the development site. Higher potential for mosquito infestation equates to a higher treatment priority.

Residential Proximity

Of the highly productive sites, priority is given to those sites that are closest to residential areas[8]. For obvious reasons, these sites draw the most public complaint. Furthermore, this interface is the most important in that it is the most likely area for transmission of disease. The prevention of these proximal outbreaks acts to reduce the potential for disease introduction and nuisance reports.

Agricultural Proximity

Mosquitoes can have a profound effect on all areas of agriculture. In years of heavy mosquito infestations, livestock, milk, and chicken egg production, meat production can decrease significantly. Fruit and vegetable production are also affected from the harvesting perspective. Many farmers find it difficult to hire and keep workers in a field that is inundated with adult mosquitoes, resulting in decreased harvest. Therefore, from an economic and productivity standpoint, agricultural proximity is the third highest priority during site assessment.

Recreational Proximity

Another source of local revenue within Cranbrook is tourism. There are golf courses, campgrounds, cycling areas, walking paths, fishing areas, and many other outdoor activities. Every outdoor activity can be affected by the presence of mosquitoes. In years with large mosquito populations there can be a dramatic decline in revenue for all recreational sources. As with the Residential Proximity criteria, the closer recreational activities are to mosquito production sites, the higher the potential for those people to contract a vector-borne illness. For these reasons, it is important to control mosquitoes near recreation and tourist destinations, making this the fourth most important priority.

Species Presence

[7] Density is measured as the number of larvae per dip.
[8] for the purposes of this PMP, close proximity is defined as <3 km with no barriers to dispersal.

The presence of certain species can prompt careful monitoring and possibly even immediate treatment if that species is of concern to the BC Centre for Disease Control. Within Cranbrook, there are approximately 20 species of mosquito, each with different habitat requirements. Additionally, each species has a different potential for disease transmission. Some species are aggressive human biters and some only bite frogs, hence there are differing potentials for nuisance. Differences in the habitat requirements and the speed of development vary greatly which can alter the ease with which control operations can be carried out.

Disease Presence

In the event of disease introduction, the above list of priorities will change. This makes the close monitoring and potential treatment of the involved mosquito species the highest priority. Included in the monitoring process will be a new criterion that outlines the existence and spatial extent of disease in a particular local population of mosquitoes.[9] This will allow Cranbrook to target that particular area.

There are six criteria that can trigger a re-prioritizing of control and monitoring levels. They are (in order of least to most important trigger[10]):

1. Potential disease vector
2. Local disease detection (outside of MCD[11,12])
3. Disease detection in birds (or other sentinels)
4. Disease detection in mosquitoes or resident wildlife (or domestic animals)
5. Disease detection in equine or agricultural stock
6. Arbovirus detection in humans

The best way to control the disease is to keep the mosquito population to a minimum, and in the event of an introduction of a disease, to remove the source population early in the development cycle. These actions will greatly diminish the further spread of a disease.

Monitoring Methods (IPMR 58 (2)(C))

Monitoring disease presence and populations allows for timely application of larvicides. There are two main populations to monitor:

- larval mosquito populations
- adult mosquito populations

Environmental Monitoring (IPMR 58 (2)(C)i)

Snowpack levels, temperature forecasts and precipitation forecasts are all monitored in the Cranbrook program.

[9] Assuming that disease is detected early enough, then it is usually restricted to a local population of mosquitoes (for example, one breeding area).
[10] see Appendix _ for a decision tree concerning use of chemical control.
[11] Mosquito Control District
[12] outside the MCD but within a bordering State or Province or within our own Province but not within the CRANBROOK.

Snowpack levels are viewed on the Ministry of Forest, Lands and Natural Resource Operation website[13]. Monitoring of each of these variables allows pest managers to estimate the size, timing, and number of larval development sites that will appear throughout the season.

Current weather conditions are monitored through Environment Canada weather forecasts as these can affect whether treatments can be carried out on any given day. Ground based treatments of granular larvicides are occasionally deferred during high precipitation events.

When helicopter applications are planned, wind and precipitation monitoring is important because helicopter treatments are halted when wind conditions make it difficult for the pilot to aim granular larvicides at the larval development sites (*i.e.,* the pilot is unable to compensate for drift of the granular product due to wind). Also, helicopter campaigns are often postponed during precipitation events because the granular larvicides can become wet and clog the application equipment. This can result in improper application rates and possible damage to the application equipment.

Monitoring Larval Mosquitoes (IPMR 58 (2)(C) & (F)ii)

The most important monitoring to ensure the success of the Program is larval monitoring. It is imperative to know where the larvae are located, what their density is, what stage of development they are in, and what species are present. The City of Cranbrook has a comprehensive program for monitoring larvae.

Mosquito development sites are monitored on a weekly basis from mid-April through August. During high water years, sites may be monitored more frequently depending on environmental conditions including precipitation and ambient temperature. Field technicians will use a standard dipper to dip throughout each area and record the highest number of larvae detected. Additionally, technicians will describe the larval development stage for the dip recorded. Notes on larval species and adult presence will also be made.

Data Collected Before and During Pesticide Use (IPMR 58 (2)(C)(i)

Data collected will be as follows:

- Time and date,
- Field technician (and associated information),
- Larval density and stage,
- Temperature and wind conditions,
- Pesticide used (and amount),
- General Observations

Treatment (Injury) Threshold (IPMR 58 (2)(D)(I,II))

Treatment of mosquito larvae will take place when three (3) or more larvae per dip are detected. Typically, with floodwater mosquitoes, the larval density is on the order of 50-500. Treatment timing is directed at treating larvae in the 3rd instar.

[13] http://bcrfc.env.gov.bc.ca/data/asp/realtime/index.htm

Monitoring Adult Mosquitoes (IPMR 58 (2)(F)i))

The Cranbrook Mosquito Control Program employs three methods of adult mosquito monitoring:

- public response
- landing biting counts
- adult trapping

These methods combine to give us an idea of mosquito outbreaks, population levels, and species distribution.

Public Response

During years of high water, the higher-than-normal mosquito activity often elicits more complaint phone calls. The home address of all these callers is entered into a database with a mapping function. In this manner we can determine where the areas of highest infestation are, keeping in mind the differing tolerances of people to mosquitoes. In subsequent years, this data can help direct staff to new and potentially unmapped mosquito development sites.

Landing Biting Counts

This method is used as a fast and coarse assessment tool for relative adult annoyance. Landing biting counts entails counting the number of mosquitoes that land on a specified area of the body to take a blood meal during a specified duration. Programs typically use the count of 3 bites per exposed forearm per minute as the threshold. This is an antiquated method of determining mosquito densities. It works well when describing different mosquito levels to the general public.

Adult Trapping

Adult trapping is sometimes used to help determine which mosquito species is causing the localized annoyance. Mosquito identification assists in determining what sort of mosquito development site to look for when reviewing abatement efforts in that particular area. It also helps to determine weak spots in present control activities. If there are high infestations of mosquitoes, then it is likely that a large mosquito development site went untreated. Adult trapping is rarely conducted within the City of Cranbrook.

Control Methods (IPMR 58 (2)(E)(I-IV))

The Program's goal is the protection of the human and environmental health through public education, mosquito development site elimination, and the judicious use of target-specific pesticides. The four components of IPM are:

- public relations
- physical control
- biological control

- chemical control

Public Relations and Outreach

One of the most difficult, and important components of any control program is educating the public on the reasoning behind certain mosquito control actions. It is also challenging to adequately relay the reason for not conducting other control actions (i.e. adulticiding) that may have been performed in the past.

Public education is one of the most important aspects of any mosquito control program. If the public understand basic mosquito biology and are focused on eliminating mosquito habitat around their property, then mosquito presence (and potential disease exposure) can be greatly reduced. The primary methods for to education the public are the media and personal communication. Each of these methods has advantages and disadvantages that will be discussed in subsequent sections.

Some examples of public outreach initiatives conducted by Cranbrook include:

- Maintenance of a 24-hour Toll-Free Mosquito Reporting Line whereby residents can leave a message for the Pest Manager and have the Pest Manager return the call within 24 hours to answer any questions that residents may have concerning mosquito control, mosquito biology, or current mosquito control activities.
- Attendance (as funding allows) with an information booth at public events such as Farmers' Markets, outdoor festivals, etc.
- A website for information related to the mosquito control program[14].

As part of public education initiatives, Cranbrook promotes the following:

- Avoiding working between dusk and dawn, as mosquitoes tend to be more active between these times.
- Wearing protective clothing including long-sleeve shirts, jackets and long pants that mosquitoes cannot bite through.
- Avoiding dark coloured clothing as it can attract mosquitoes.
- Using mosquito netting for babies and toddlers in cribs and strollers.
- Applying Health Canada approved mosquito repellents, such as those containing DEET (N,N-Diethyl-meta-toluamide), Picaridin or Lemon Eucalyptus Oil (30%).
- Reducing mosquito larval development sites and vegetation that provides harborage on and around residences.

Cranbrook does not promote the use of bug zappers, devices that give off sound waves, and Citrosa plants for protection against mosquito bites. These methods have not been proven to be effective.

The Media

[14] https://Cranbrook.com/Environment/Mosquito-Control

Local newspapers, radio stations, and social media (Facebook, and Twitter) are the predominant media used by the Program. In the event mosquitoes are particularly bad, newspapers and social media are immediately notified of the extra monitoring and treatment measures that are taking place. By providing the public with up-to-date information about the mosquito and relevant environmental conditions, people are able to know what to expect. Through experience, when the public is informed about what level of nuisance to expect there are typically fewer complaint calls.

Personal Communication

Personal Communication is perhaps the most important method of public relations; however, it reaches the least number of people. In the field and in the office, Mosquito Control Technicians are regularly approached by residents with a variety of questions and challenges. These questions range from the use of pesticides to the impacts of mosquito control on the surrounding ecosystem. The most challenging and important question to thoroughly answer is why DDT and other environmentally impactful sprays are not used any longer. When citizens understand the direct implications and relatively less efficient aspects to sprays that were previously used, they are typically satisfied.

Physical Control

Physical control is the hardest method to control mosquitos. Information is provided to the public detailing what can be done around the home. Often this is as simple as emptying the birdbath or removing containers. At the request of residents, the Pest Manager can do a “property survey” to assist people in insect-proofing their home and yard.

Biological Control (IPMR 58(2)(E)ii-iii

Biological control can be accomplished through the use of either predatory organisms, pathogenic organisms, or microbial organisms. In the Cranbrook Mosquito Control Program this is primarily accomplished using *Bacillus thuringiensis israelensis (Bti)*, a naturally occurring soil-borne bacterium. This bacterium is relatively target specific and has low non-target direct and indirect effects.

A secondary product considered by Cranbrook is *Bacillus sphaericus* (Vectolex CG). This has a similar mode of action to *Bti*, however it exhibits residual activity due to the biology of the organism (see Appendix II for a justification paper and supporting references).

Biological control methods, if done carefully, are the preferred method of control. They are usually target specific, non-chemical, non-residual, and generally safer for the environment and the applicators. However, this method isn’t always practical and is most often a method for control around homes on smaller ponds.

Rationale For Selection Criteria Of Biological Agents (IPMR 58(2)(E)ii, iv)

Mosquitoes are most efficiently and economically controlled when they are concentrated as larvae in a larval development site. The relatively low risk nature of biological larvicides proposed in this PMP makes them the preferred choice for use in the Program.

Benefits of Using Biological Agents (IPMR 58(2)(E)iii)

The benefits of using these products are that they pose little risk to the applicator and they have little or no acute toxic impact on non-target species when applied at the recommended label rates.

Limitations of Using Biological Agents (IPMR 58(2)(E)iii)

When biological larvicides are being used, frequent larval monitoring is required to ensure that applications are made within the treatment window. Treatments must be completed before the larvae stop feeding in the late 4th instar phase of development. Also, it is most beneficial from an operational and environmental standpoint to wait until the larvae are in their 3rd or early 4th instar. Waiting for later instars allows the greatest amount of time for the highest number of mosquito larvae to hatch and be available to the larvicide. Also, it keeps the larvae in the environment longer and available to predators that benefit from the larvae as a food source. Consequently, an increased frequency of monitoring is required to ensure that applications are made within the treatment-time window.

In the case of *Bti,* (Vectobac and Aquabac), the second limitation is that the products breakdown rapidly in water through exposure to sunlight and aquatic microorganisms (generally 48 to 72 hours). Treatment must be repeated if monitoring confirms the presence of newly hatched mosquito larvae. *Bacillus sphaericus* formulated as VectoLex does not have this limitation as it has a prolonged action of up to 30 or more days.

According to the *IPM Regulation* Section 78(2), a pesticide-free zone is not required around standing water when applying the mosquito larvicides included in this PMP. However, in accordance with Section 78(1) of the *IPM Regulation*, mosquito larvicides are limited in that they may not be applied in permanent, fish-bearing bodies of water or waters that have permanent, direct, surface water connections with fish-bearing bodies of water. An exception to this rule is if a Medical Health Officer declares that an arbovirus[15] is in the area. In that case, fish bearing waters may also be considered for treatment of larvae.

Biopesticide Control

Biopesticides includes microbial pesticides, biochemical pesticides, and plant-incorporated protectants. Two biochemicals are marketed for the means of long-term control of mosquito larvae: methoprene and diflubenzuron. Both chemicals act to inhibit the development of larval mosquitoes. While they have several benefits, the negative effects outweigh the benefits. These biochemicals do not target mosquito larvae specifically and will affect the development of all arthropods in the area.

In many areas of Cranbrook, there are permanent mosquito development sites that provide habitat for some of the most important potential disease vector species. The intention development sites is to take advantage of the residual activity of methoprene[16], as it has the lowest off-target effects while achieving long-term control.

The City of Cranbrook does not employ the use of Biopesticides.

[15] A virus transmitted by arthropod vectors.
[16] One potential product is Altosid – a granular formulation applied by hand.

Chemical Control

Chemical control is use of chemically derived pesticides, as opposed to the naturally derived products described above. Chemical control is predominantly used for the control of adult mosquito populations. In this regard, the dispersion properties of adult mosquitoes make it virtually impossible to provide any measure of real control. Unless an entire area is sprayed with chemicals, the mosquitoes from neighbouring areas simply move into the now vacant habitat.

Adult mosquitoes are treated with broad spectrum pesticides.[17] This is the most controversial portion of any control program. It is also one of the least efficient methods of control. Unfortunately, the problem with eliminating this part of the program is that the perceived control is great due to the visibility of this portion of the control program. It is typically a noisy process done near residential properties. Public relations become important by informing homeowners of the relatively less efficient and more harmful practices of using chemical control on adult mosquitos as opposed to larval control methods.

The City of Cranbrook does not use chemical controls on adult mosquitoes.

Application Methodology (58 2(e)i)

Granular larvicides are the most common formulation and can be applied either by hand, backpack blower, RPAS (Remotely Piloted Aerial System), or helicopter. Hand applications are used for small spot treatments or ground applications when/where the use of a backpack blower is either not practical or unsafe. Application rates are typically 4kg/ha. Backpack blowers are used for larger, accessible sites where either range of area is too great for distributing the product by hand. RPAS applications are an emerging technology and will supplant some of both hand and helicopter treatments. Helicopters are used when a large proportion of sites are active simultaneously and/or on-the-ground conditions are not safe for ground applications (elevated water levels, complicated substrate, etc.).

Liquid larvicides are becoming more common due to their easy of transport, simple application equipment, and relatively lower product cost. This formulation is most commonly applied with a pressurized backpack with a fine nozzle (either battery powered, or hand-pump powered). Application can also occur via RPAS or specialized helicopter equipment; however, it is less common as the product doesn't penetrate the canopy as well as granular formulations.

Environmental Protection Strategies and Procedures (IPMR 58(3)(B)i-iv)

[17] A broad spectrum pesticide is one that kills any organism that belongs to a larger, often local, family of organisms. For example, *Bti* is specific to mosquitoes, even though there are other insects in the treatment area. A broad spectrum pesticide would kill most, if not all, insects within the treatment area, and often it will injure other associated organisms (e.g. birds, reptiles, amphibians, fish, and mammals).

Much of the information included in the following sections are drawn directly from the Integrated Pest Management Regulation and the Handbook for Pesticide Applicators and Dispensers, 5th Ed. (Ministry of Environment, 2005).

Strategies to Protect Community Watersheds and Domestic and Agricultural Water Sources (IPMR 58(3)(B)i)

The City of Cranbrook will follow the guidelines contained in the Forest Practices Code of British Columbia Act to protect community watersheds and will ensure that each of the steps listed below are conducted:

- the location of community watersheds will be determined by selecting the "Community Watersheds" layer on the Provincial interactive mapping site
- an adequate buffer zone will be maintained around no-treatment zones
- no mixing of liquid larvicide will occur within a community watershed
- no pesticides will be stored within a community watershed

In order to protect domestic drinking water and water for agricultural use, the City will strictly adhere to all standards for pesticide-free zones (PFZs) and no treatment zones (NTZs) as specified in the *Integrated Pest Management Act and Regulations*.

Strategies to Protect Fish and Wildlife, Riparian Areas and Wildlife Habitat (IPMR 58(3)(B)ii)

Riparian areas are defined as the areas around bodies of water. These areas usually contain lush vegetation and high biodiversity (birds, insects, reptiles, amphibians, plants and mammals). Riparian areas are important for stream, lake and marsh health as they support vegetation that maintains bank stability and provides cover for water bodies to help maintain cooler water temperatures. With respect to mosquito control, bacterial larvicide is of little concern to riparian areas. Other pesticides are generally considered the most dangerous pesticides in these ecosystems.

Due to the low toxicity of the bacterial larvicide, applications will be conducted within riparian areas. Care will be taken to keep impacts on vegetation and soil at a minimum (e.g. staff conducting the application will attempt to stay on paths and avoid trampling vegetation). Also, as per the *IPM Regulation*, fish habitat will be protected as no application of bacterial larvicide will take place in fish bearing waters or waters with continuous surface water connections with fish bearing waters. Finally, all maintenance and fueling of bacterial larvicide equipment will be done outside of the riparian areas.

Strategies to Prevent Contamination of Food Intended for Human Consumption (IPMR 58(3)(B)iii)

The bacterial larvicide proposed for use in this PMP will not cause contamination of food intended for human consumption. This is due to their physical properties and their use in aquatic areas. However, general guidelines for safety will be followed by applicators (e.g. the applicator will wash their hands before eating and food will be stored separately from pesticides and equipment used for applying bacterial larvicide).

Pre-Treatment Inspection Procedures for Identifying Treatment Area Boundaries (IPMR 58(3)(B)iv)

Prior to the application of bacterial larvicide, the Pest Manager will speak with landowners (or the agency responsible for the land) to ensure that the Pest Manager has permission to treat the site. The Pest Manager will also ensure that they are not treating in a permanent, fish bearing body of water or waters that have permanent, direct, surface-water connections with fish bearing bodies of water. There will be no application of bacterial larvicide on private land without the landowner's permission.

Procedures for Maintaining and Calibrating Pesticide Application Equipment (IPMR 58(3)(B)v)

For granular larvicide, the Pest Manager is responsible for determining if the application rate is within the label specifications. All hand, blower and helicopter applications are done after factoring in weather and wind effects ("eye-balling" the spread pattern of the granules on the water surface). The Pest Manager will then determine the actually weight of the product that to apply.

Liquid sprayers will be filled with pesticide and then tested for flow rate by measuring the volume of liquid pumped through the system during a one-minute interval. The flow rate and application procedure will be determined by reading the label on the product.

Procedures for Monitoring Weather Conditions and Strategies for Modifying Pesticide Application Methods for Different Weather Conditions (IPMR 58(3)(B)vi)

The Pest Manager will monitor weather and environmental conditions prior to and during the application of bacterial larvicide. All weather monitoring during the course of the application will be done on site.

If wind speeds are too high during larviciding activities, granules or liquid spray can be blown off course and miss the treatment areas. It will be up the applicator to determine whether or not they can accommodate for wind speed and still apply the larvicide effectively.

Precipitation rarely interferes with ground application of larvicide, however during heavy rain, aerial applications of granules may be stopped as water can cause the granules to clump in the application equipment and therefore application rates can be affected.

No applications will be made when the temperature is higher than 35^0C as high temperatures can cause degradation of granules stored in trucks and equipment prior to application.

Treatment Evaluations

Post-treatment evaluation can help to improve the Program over time as the Pest Manager learns which pesticides, the application rates, appropriate methods, and timing worked best at each application site. Constant evaluation of the results of treatment will allow the City and the Pest Manager to improve the Program.

The *IPM Regulation* Section 78(4b) specifies that the efficacy of a mosquito larvicide be assessed by conducting pre-treatment and post-treatment larval samples of the development site. Certified pesticide applicators[18] will conduct and record all pre-treatment monitoring. Certified applicators will return to the development site to conduct post-treatment monitoring using the same methods of assessing larvae as described in "Monitoring Larval Mosquitoes". This information will be used to determine if the rate and type of pesticide application chosen for the location was suitable. If the application was not successful, the applicator to plan for alternate methods of control.

At this time, applicators will evaluate any potential environmental effects of the pesticide application. Any concerns will be identified, mapped, and prepared for follow-up with relevant authorities.

Mapping and Reporting (IPMR 58(2)(C)iii)

The Cranbrook Mosquito Control GIS is a dynamic project that is continually being upgraded. We use a combination of ArcGIS, Open source GIS, and high accuracy GPS to collect, update, and compile data into a GIS.

Data is collected according to industry standards. Due to the variability and size of some major mosquito development sites, the Pest Manager is combining GPS data collection with digitized maps (using orthophotos from Google Earth) to incorporate all potential active areas.

Under the *IPM Regulation*, the City is required to maintain records of all pesticide applications and submit an annual Record of Pesticide Use and an annual Notice of Intent to Treat.

Treatment Records

The City will maintain, for three years from the date of treatment, records of all pesticide applications including:

1. treatment location
2. pre-treatment monitoring results (larval counts, instars, etc.)
3. treatment date and time
4. type of pest targeted (mosquito larvae)
5. trade name of pesticide used and its PCP number
6. method of application
7. rate of application
8. total quantity of pesticide used
9. relevant meteorological conditions (i.e. wind, precipitation, temperature)
10. results of post-treatment monitoring and evaluation (larval counts and instars post-treatment)
11. if the applicator decides that the 30 m non-treatment zone around a water supply intake or well used for domestic or agricultural purposes may be reduced, the information on which the decision was based

[18] All applicators will attain their Pesticide Applicator Certificate: Mosquito and Biting Fly OR Mosquito: Ground application of Bacterial Pesticide And Growth Regulators.

Records of Larval Development Sites

The City will maintain updated records of all larval development sites, including:

1. GPS location or description of the location of the site including specialized site-specific notes
2. name, address and phone number of owner or manager of the treatment site
3. information concerning no-treatment areas or areas where permission has not been granted by the landowner

Annual Report of Pesticide Use

The City will submit an Annual Report of Pesticide Use to the Ministry of Environment by January 31 of every year, as summary of the previous calendar year's use including:

1. the name and address of the City of Cranbrook and their confirmation number
2. the trade name, PCP registration number, active ingredient name(s) and amount of pesticide product used in kilograms
3. the total area treated with each product

Annual Notice of Intent to Treat

The City of Cranbrook will provide a Notice of Intent to Treat to the Ministry of Environment 21 days prior to the commencement of the project in each calendar year of the PMP confirmation. The Notice of Intent to Treat will contain the following information:

1. the name and business location of the confirmation holder
2. a description of the proposed treatment locations for the calendar year and a map or diagram that clearly identifies those locations
3. a description of the proposed treatment for each area, including the pesticide to be used and its method of application
4. the total area of the treatment areas in the proposed treatment locations for the calendar year

Operations Risk Assessment and Management

Considerable efforts will be made to avoid pollution events, and to mitigate the potential of such events. A plan is in place to respond to any such event in a timely and safe manner. Please refer to table 3 outlining potential accidents (including pollution events), potential harm to the environment and human health coming out of such accidents, and the preventative and mitigating procedures put in place to alleviate harm to environmental and human health.

The following sections describe the City's plans for safe handling, preparing, mixing, applying and otherwise using pesticides. Much of the information included in the following sections is drawn directly from the *IPM Regulation* and the Handbook for Pesticide Applicators and Dispensers, 5th Ed. (Ministry of Environment, 2005).

Procedures for Safely Transporting Pesticides (IPMR 58(3)(A)i)

The following procedures for safely transporting pesticides will be practiced by all City of Cranbrook staff/contractors working under this PMP. The *IPM Regulation* (Section 65(1)) legislates that pesticides must be kept, handled, stored and transported in the container in which it was originally packaged and with the label originally affixed by the manufacturer, or in a container designed for containing the pesticide and labeled accordingly. Section 33 (2) of the Regulation states that a "person who transports or causes or allows the transport of a pesticide must ensure that the pesticide is secured and transported in a manner that prevents the escape, discharge or unauthorized removal of the pesticide from the transport vehicle and prevents the contamination of food or drink intended for animal or human consumption, household furnishings, toiletries, clothing, bedding or similar items that are transported with the pesticide."

Further, the Handbook for Pesticide Applicators and Dispensers, 5th Ed. (Ministry of Environment, 2005) outlines a number of general precautions to be taken during transport of pesticides, and the City and its contractors will adhere to the following practices:

1. all pesticide containers will be inspected for defects prior to transporting
2. chemical pesticides will not be transported in the passenger compartment of any vehicle, nor will anyone ride in the back of a truck together with these pesticides
3. pesticides will never be transported along with food, feed or consumer goods
4. chemical pesticides will not be transported on wooden truck beds as it is difficult to clean wood in the case of a spill, and future items carried in the truck could become contaminated
5. all pesticide containers will be secured to prevent spillage
6. the driver of any vehicle transporting pesticides will be trained in spill clean-up and will carry, along with the pesticides, necessary equipment to contain and/or neutralize a spill
7. limited amounts of pesticides shall be carried in any one vehicle. The quantity shall be no more than what is necessary for each project, except where transportation occurs between storage facilities
8. pesticides shall be carried in a secure lockable compartment such as a locked storage box or a canopy
9. pesticides shall be transported separately from food and drinking water, safety gear and people

Procedures for Safely Storing Pesticides (IPMR 58(3)(A)ii)

The City of Cranbrook will adhere to the following standards of the Integrated Pest Management Regulation with respect to the safe storing of pesticides:

1. a person who stores a pesticide will store it in a manner that minimizes hazards to human health and the environment (Section 33 (1))
2. all pesticides will be stored in the container in which it was originally packaged and with the label originally affixed by the manufacturer, or in a container designed for containing the pesticide and labeled with the trade name, chemical name, concentration of active ingredient and Pest Control Product number (Section 65 (1))

3. all pesticides will be stored separately from food intended for human or animal consumption (Section 66 (1a))
4. according to Section 66 (1b) all pesticides will be stored in a facility that is:
    a. ventilated so that pesticide vapors are vented to the outside
    b. not used for the storage of food intended for human or animal consumption
    c. locked when unattended
    d. accessible only to persons authorized by the person storing the pesticide
5. according to Section 66 (2), each door providing access to a storage facility will clearly bear the words “WARNING: CHEMICAL STORAGE — AUTHORIZED PERSONS ONLY" written in block letters”
6. the mosquito contractor will inform the City and the local fire department of the pesticide storage location within 60 days after starting to store pesticides

Procedures for Safely Mixing, Loading and Applying Pesticides (IPMR 58(3)(A)iii)

Some pesticides may be mixed with water if this aids the applicator in obtaining a better distribution on the surface of the larval development habitat. The labels specify that the level of dilution is up to the applicator and is based on weather, the size of the larval development habitat and the method of application.

It is prudent to follow the Provincial recommendations for safe mixing, loading and applying pesticides. At the time of mixing, a spill kit will be nearby. Emergency phone numbers and a telephone will be present. The person mixing the pesticide will wear protective clothing as listed on the product labels, which may include gloves, boots, face shield, and hat. Before pesticides are applied, applicators will inspect all application equipment to ensure there are no leaks or needed repairs.

Procedures for the Safe Disposal of Empty Pesticide Containers and Unused Pesticides (IPMR 58(3)(A)iv)

Empty pesticide containers can be considered a danger to the environment (although the products used in this PMP are considered to be very safe). The Pest Manager will dispose of empty containers as described on the manufacturer’s product label. Also, the recommendations described in the Handbook for Pesticide Applicators and Dispensers, 5th Ed. (Ministry of Environment, 2005) will be followed and at a minimum, all pesticide containers will be emptied by draining them for 30 seconds and any container that contained liquid larvicide will then be triple rinsed. To prevent someone from attempting to reuse the containers, they will be punctured or crushed and taken to an approved disposal or recycling facility.

Procedures for Responding to Pesticide Spills (IPMR 58(3)(A)v)

Spill treatment equipment will be available at the pesticide storage site (including mobile storage), mixing and loading sites, and during all pesticide applications. All persons authorized and trained to work with the pesticides will be familiar with the protocol for containing and responding to spills.

The spill equipment will include:

- personal protective equipment

- absorbent material such as sawdust, sand, activated charcoal, dry coarse clay, kitty litter or commercial absorbent (for liquid formulations)
- a long-handled broom and a shovel
- waterproof waste-receiving container with lid and a pen to label the contents

If a spill occurs, the Pest Manager will follow the recommendations as described in the Handbook for Pesticide Applicators and Dispensers, 5th Ed. (Ministry of Environment, 2005):

1. the source of the spill will be contained
2. people and animals will be kept away from the spill site
3. the product label or knowledgeable agencies will be engaged to determine the best course of action for clean-up of the spill
4. if the spill is small enough to be handled without assistance, clean-up will begin immediately
5. personal protective gear will be worn during clean up
6. the spilled material should be stopped from spreading by creating a barrier
7. absorbent material shall be spread over spills of liquid material
8. the absorbent material shall be collected in waterproof containers with the contents clearly labeled with the pesticide name, P.C.P. number and quantity of pesticide
9. spills of granular or pellet formulated larvicide should be swept up and collected with a shovel and placed in a bucket for disposal or future use

Table 3 *Potential accidents, the activity during which they can take place, the potential impact on the environment, and the mitigating procedures in place to prevent such events. Activities are denoted as Transportation (T), Storage (S), and Application (A).*

Accident	Activity	Impact	Prevention and Mitigation
Spill	T/S/A	• Soil contamination • Groundwater contamination • Fish kill • Collateral damage • Threat to human health	• Proper storage facility • Proper transportation equip. • Training all staff in WHMIS • Appropriate containers • Minimize movement
Leak (similar impacts to a spill, often to a lesser degree)	T/S/A	• Soil contamination • Groundwater contamination • Fish kill • Collateral damage • Threat to human health	• Proper storage facility • Proper transportation equip. • Training all staff in WHMIS • Appropriate containers • Minimize movement • Equipment maintenance complete
Overspray	A	• Fish kill • Collateral damage • Damage to sensitive habitat	• Ensure PFZ and Buffers adequately marked and observed • Notifying appropriate residents before application (ie. Beekeepers)

		• Residential/agricultural intake contamination • Threat to human health	• All personal holding Pesticide Applicator Certificate (Mosquito and Biting Fly)
Misapplication	A	• Illegal application (PFZ) • Fish kill • Collateral damage • Damage to sensitive habitat • Threat to human health	• Ensure PFZ and Buffers adequately marked and observed • Notifying appropriate residents before application (ie. Beekeepers) • All personal holding Pesticide Applicator Certificate (Mosquito and Biting Fly)

Appendix I - Authorized Pesticides

The pesticides listed below are approved for use under the terms of this permit. Product use quantities are based on anticipated needs not maximum potential needs. The lowest application rates and quantities possible must be used to achieve permit and IPM Act objectives.

Product Trade Name	Active Ingredient	PCP No.	Active Ingredient Concentration	Application Rate of Product	Application Method Allowed
Vectobac* 200G	Bacillus thuringiensis Serotype H-14*	18158	200 ITU/mg	3-10.0 kg/ha	Aerial/Ground
Aquabac* 200G	Bacillus thuringiensis Serotype H-14*	26863	200 ITU/mg	2.5-20 kg/ha	Aerial/Ground
Aquabac XT	Bacillus thuringiensis Serotype H-14	26860	1200 ITU/mg	300-2,400 ml/ha	Aerial/Ground/ UAV
Vectobac* 1200L	Bacillus thuringiensis Serotype H-14	21062	1200 ITU/mg	0.75 L/ha	Aerial/Ground/ UAV
Vectolex CG	Bacillus Sphaericus	28008	50 BsITU/mg	5.6-16.8 kg/ha	Ground
Altosid	Methoprene	22676	1.5%	5.6-22.4 kg/ha	Ground

Appendix II – Bacillus sphaericus supporting paper

VectoLex® CG (*Bacillus sphaericus*)

VectoLex® CG (PCP#: 28008) is a commonly used mosquito control product and an excellent, comparable alternative to AquaBac® in certain situations. The active ingredient (AI) in VectoLex® CG is the soil borne bacteria, *Bacillus sphaericus*. The mode of action for B. sphaericus is similar to that of *Bacillus thuringiensis* var. *israelensis (B.t.i.)*, the AI in AquaBac® (PCP #: 26863). Specifically, as the bacteria sporulate a protoxin is produced inside the cell (Yousten et al., 1992). This protoxin has two specific endotoxins that, once ingested by the mosquito larvae, correspond to receptors within their midgut region. Disruption of the larval midgut cells occurs as a result of cleavage of the protoxins by midgut proteases. An osmotic imbalance across the midgut epithelial cell membranes occurs due to this cleavage, which causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert, 2000).

In general, the specificity of *B. sphaericus* for mosquitoes and their lack of effect on non-target insects given allowable application rates are well documented (Mathavan & Velpandi, 1984; Mulla et al., 1984; Ali & Nayar, 1986; Aly & Mulla, 1987; Karch et al., 1990; Lacey & Mulla, 1990; and Mulla, 1990). However, a review of literature by Lacey and Mulla (1990) found that the application of VectoLex® CG did affect a few organisms (e.g. *A.bouvieri*, *C. crassicaudatus*, *D. similis*, *S. dichotomus*, and *P. Clarkii*). It should be noted that effects in these species were only detected when application rates were many 100s times greater than the allowable application rates. Mammals lack the receptors that mosquitoes have for *B. sphaericus* and, thus, are not adversely affected by the bacteria. Acute toxicity tests using *B. sphaericus* on various fishes including the Pacific Blue Eye (*Pseudomugil signifier*) and the Crimson-spotted rainbowfish (*Melanotaenia duboulayi*) reveal that *B. sphaericus* is extremely safe (Lacey and Siegel, 2000; Lacey and Merritt, 2003; Brown et al., 2004; Hurst et al., 2007). Furthermore, juvenile coho salmon experienced no adverse affects when they were exposed to maximum application rates of VectoLex® WSP in a standard 96 hour toxicity test (Sternberg et al., 2009).

Both VectoLex® and AquaBac® are considered extremely safe and effective larvicides. These products are comparable in many ways, though VectoLex® CG has one significant advantage over AquaBac®: residual efficacy. *Bacillus sphaericus* has the ability to grow in larval cadavers, unlike that of *B.t.i*. It is then subsequently released into the water as the cadavers disintegrate (Des Rochers and Garcia, 1984). In laboratory experiments this recycling capability has been responsible for an increase of 100 – 1,000 fold in spore numbers (Des Rochers and Garcia, 1984; Charles and Nicholas, 1986). VectoLex® CG is toted as a 30-day product, but >97 percent efficacy has been observed in catch basin trials through at least 42 days post-treatment (Stenberg, 2009). The increased bioavailability of the spores (and thus, their associated protoxin) means that more larvae can be controlled for longer periods of time without the need for reapplication.

Altosid® (S-Methoprene)

Altosid® is another widely used mosquito control treatment. S-methoprene (isopropyl [2E,4E,7S]-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate) is the active ingredient in

Altosid®. Unlike *B. sphaericus,* S-methoprene is considered an insect growth regulator. In general, insect growth regulators act by preventing metamorphosis from the pupal to the adult stage by mimicking juvenile hormone (JH). The JH found in mosquitoes is the transcription factor called Broad (Riddiford, 2008). Broad is usually only expressed between the larval-pupal transition and for a short time after pupal ecdysis. In addition to Broad, the steroid hormone 20-hydroxyecdysone (20E) is activated between the larval-pupal transition period (Wu et al., 2006). Insect growth regulators mimic one of these hormones ultimately inhibiting molting processes due to the fact that the pupae are not able to undergo metamorphosis while the hormone is present.

S-methoprene has proven to be highly effective at controlling target-specific mosquitoes and non-biting midges. Additionally, due to the slow-release characteristics of Altosid®, it can control mosquito larvae for up to 150 days. Its long-term efficacy is due to the slow-release ability of the briquette. Due to the fact that S-methoprene is highly susceptible to photo degradation, it does not persist in the environment in the absence of the briquette.

Though Altosid® is an effective and long-lasting treatment option, non-target effects are not uncommon. Previous studies have revealed short-term affects on certain Diptera, Ephemeroptera, Hemiptera, Coloptera, and some arthropod species (Hershey et al., 1995). S-methoprene is thought to have adverse affects on crustaceans, especially Mysid shrimp, because it mimics one of their juvenile hormones, methyl farnesoate (Olmstead and LeBlanc, 2002). LC50 values for tested amphibians were at most >1000 ppb in acute and chronic studies (USEPA, 2001). The concentrations that could harm non-target organisms are many times the amount commonly recorded in field. In a recent study performed by Sternberg et al. (2009), an Altosid® briquette was applied to a catch basin and water samples were analyzed immediately after treatment through five weeks post-treatment. Ninety-three percent of the samples were below the S-methoprene detection limit (0.14 ppb) and the highest recorded concentration was 13 ppb. In the same study, efficacy rates were >95% though Week 5 post-treatment, in the absence of precipitation (Sternberg, 2009). Thus, Altosid® has an extremely high rate of efficacy at very low concentrations.

A note on resistance issues…

Bacterial insecticides were once thought to be the solution to resistance problems. However, recent studies have documented resistance in the field and laboratory. There are two proteins within the *B. sphaericus* toxin that produce toxic effects: BinA and BinB (Lacey, 2007). Mosquitoes commonly develop resistance to products containing *B. sphaericus* because it is considered to be a binary toxin (Nielsen-LeRoux et al., 1995). The binary toxin only requires a single receptor type within the larval midgut, which makes it more susceptible to resistance development (Nielsen-LeRoux et al., 1995).

The suggested management strategies for dealing with resistance issues are to use a *B.t.i.* product alone or in combination with a *B. sphaericus* product because resistance issues are fewer with *B.t.i.* (Zahiri et al., 2004). It is also known that resistance issues tend to resolve themselves when the larvicide is not found in the environment for a period of time. Both of these facts bode well for CRANBROOK's current treatment needs which would likely include only require one application of VectoLex® CG, as it is effective for at least 30 days.

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Appendix III – Maps of Program Area

Appendix IV – PMP Checklist

IPMR Section	Task	Associated Page
58 1(a)	Description of geographic boundaries with maps etc.	Pg. 1
58 1(b)	Person responsible for managing pests in relation to land described above	Pg. 2
58 1(c)	Principal contact for information	Pg. 2
58 2(a)	Description of the program to prevent organisms from becoming pests	Pg. 3
58 2(b)	Description of pest identification or techniques for pest identification	Pg. 7
58 2(c)i	Description of monitoring methods of environment and target population before and during pesticide use	Pg. 10
58 2(c)ii	Description of monitoring frequency of above before and during pesticide use	Pg. 11
58 2(c)iii	Collected data of 2(c)i before and during pesticide use	Pg. 11
58 2(d)i	Treatment threshold and description of how it was chosen	Pg. 11
58 2(d)ii	how treatment threshold will be applied	Pg. 11
58 2(e)i	Description of all possible treatment methods	Pg. 16
58 2(e)ii	Rational for treatment selection	Pg. 15
58 2(e)iii	Benefits and limitations for each possible method under sec 2(e)i	Pg. 15
58 2(e)iv	Description of how treatment method chosen	Pg. 15
58 2(f)i	Description of monitoring methods of pesticide efficacy and environmental effects	Pg. 12
58 2(f)ii	Description of frequency of monitoring of above	Pg. 11
58 2(f)iii	Description of data collected for 2(f)i	Pg. 11
58 3(a)i	Procedures for safely transporting pesticides	Pg. 21
58 3(a)ii	Procedures for safely storing pesticides	Pg. 21
58 3(a)iii	Procedures for safely mixing, loading, and applying pesticides	Pg. 22
58 3(a)iv	Procedures for the safe disposal of empty pesticide containers and unused pesticides	Pg. 22
58 3(a)v	Procedures for responding to pesticide spills	Pg. 22
58 3(b)i	Strategies to protect water sources and community watersheds	Pg. 17
58 3(b)ii	Strategies to protect fish, wildlife, riparian areas & wildlife habitat	Pg. 17
58 3(b)iii	Strategies to prevent human food contamination	Pg. 17
58 3(b)iv	Pre-treatment procedures for identifying treatment area boundaries	Pg. 18
58 3(b)v	Procedures for calibrating application equipment	Pg. 18
58 3(b)vi	Procedures for monitoring weather conditions	Pg. 18

Appendix V – Engagement records