Regional District of Okanagan-Similkameen

Mosquito Control Program

2020

Year End Report

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Prepared by: Cindy Boehm & Shad Collins, RDOS Mosquito Control Program Crew

Zoë Kirk, RDOS Public Works Projects Coordinator

Liisa Bloomfield, RDOS Manager of Engineering

Executive Summary

Nuisance mosquitos have been a problem in the South Okanagan and Similkameen Valley for as long as humans have inhabited them. The primary reason is the quantity and quality of mosquito larval habitats; oxbows to wetlands and annual flood zones.

In 1974, the RDOS initiated a Mosquito Control Program (MCP) to monitor and mitigate local mosquito populations in the more densely populated areas. Over the past four decades the in-house program has been adapting and integrating tools and technology to remain as effective and cost efficient as possible. In the past seven years, the number of sites being treated by the MCP has almost tripled from about 160 sites.

From March to September, the MCP monitors typically around 400 sites throughout the Electoral Areas “A”, “B”, “C”, “D”, “F”, “G”, “H” and “I” as well as the municipalities of Summerland, Osoyoos, Penticton, and Oliver.

The Similkameen Valley experienced significant flooding this year; reminiscent of 2018. The Similkameen River had created pooled areas adjacent to the river from upwelled groundwater. These pools were ideal habitat for mosquito larvae and were spread further when the river overtopped its banks.

In the Okanagan Valley, adjacent to the river, land was continuously flooded into the month of August. Conversely, Willowbrook saw no flooding this year at all with minimal stream flows.

The MCP program continued to refine the Early Detection/Rapid Response method for the 2020 treatment season. The Summerland ball fields in Dale Meadows have proven to be a good indicator for the start of the mosquito season, predicating the need for monitoring and treatment starting in March. The earliest first helicopter flight in the program history occurred on April 17.

On average, the mosquito control program conducts three to four helicopter deployed aerial applications per season or up to six in flood years. In 2020, the combination of high snowpack, prolonged rainfall, and unseasonably cool temperatures, required six strategically organized flights to control mosquito populations.

This season, a total of 5,795.9 kg of VectoBac 200G granular larvicide was applied to 384 sites (an area of 438.5 hectares) of mosquito breeding habitat by helicopter and on the ground broadcasting. All applications were completed under the BC Ministry of Environment Pest Management Plan for the RDOS.

Mosquito population control is most effective when the first hatch biomass potentials are greatly reduced through timely treatment at larval stage. It cannot be stated more strongly, that achieving the reduction in these first hatches, sets the stage for the majority of citizens in the region enjoying the outdoors in the summertime.

Contents

1. Background Information

1.1 Program Purpose and Scope

Since 1974, the RDOS Mosquito Control Program (MCP) has monitored and treated nuisance mosquito populations throughout the south Okanagan and Similkameen Valleys.

The objectives of the RDOS Mosquito Control Program (MCP) are to limit the potential of widespread mosquito annoyance, and reduce the possibility of mosquito-borne diseases for the benefit of residents, visitors, workers, and livestock in the RDOS catchment area.

From March to September, the RDOS Mosquito Control Program (MCP) monitors typically around 400 sites throughout Electoral Areas: A, B, C, D, F, G, H and I as well as Summerland, Osoyoos, Penticton, and Oliver.

The program is driven by property owner requests and has seen a 139% increase in site numbers, from 161 sites in 2013 to 384 in 2020. Figure 1.1 provides the number of treated sites for the past five years.

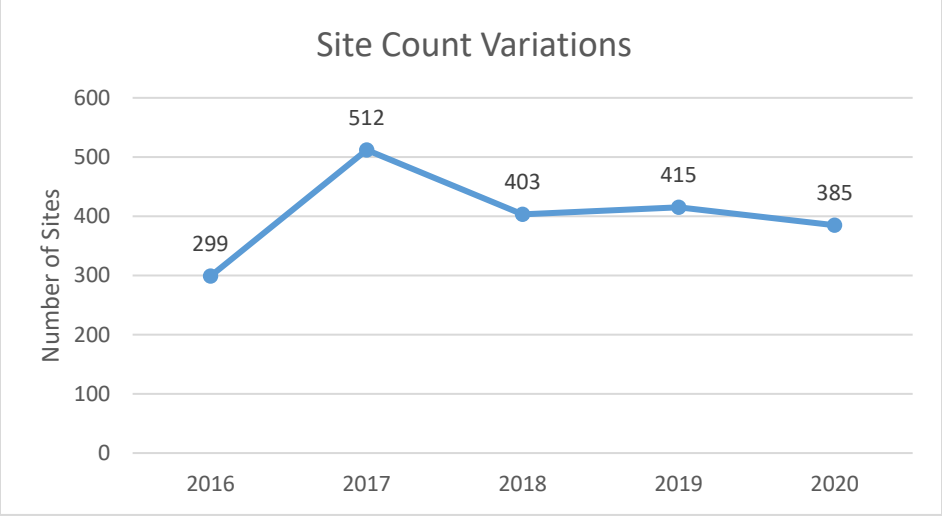


Figure 1.1: Mosquito Control Sites Over Time – Average of 402 sites

The severe flooding of 2017 and 2018 caused sustained high ground water levels in the Okanagan and Similkameen Valleys. This extensive flooding caused site numbers to fluctuate and swell to over 400.

A reprieve in 2019 relieved some of the higher elevation sites, but valley bottoms remained saturated. The prolonged cool spring of 2020, a high snowpack, and record breaking rains in May and June set the stage for another flood year in mid and lower elevations.

1.2 Program Methodology

It is important to state that 'control' does not mean eradication of mosquitos, but reductions of populations of mosquitos in populated areas and on agricultural properties (for worker safety) in the region.

The program methodologies can be put into three main categories: prevention, treatment, and monitoring.

- Prevention focuses on minimizing larval habitats;
- Treatment requires pesticide in order to control mosquito populations;
- Monitoring is constant and requires vigilance from the crews.

Mosquitos being controlled throughout the RDOS can be placed into two categories: nuisance and vector. In the South Okanagan and Similkameen, the vast majority of mosquitos are considered to be nuisance mosquitoes. Nuisance mosquitoes are extremely aggressive towards humans and livestock but are not known to carry life threatening pathogens at this time. Vector mosquitoes, on the other hand, are known to transmit a variety of diseases which can infect humans and animals causing illness, or in more serious situations, death.

The RDOS MCP mainly involves targeting nuisance mosquitos; however, outbreaks have occurred from the vector mosquitos, such as the 2009-2010 West Nile outbreak. These occurrences reiterate the importance of having a robust control program, comprehensive Integrated Pest Management Plan (IPMP) and procedures in place to handle situations as they arise with continued focus on assuring the health and safety of the local residents.

1.3 Early Detection/Rapid Response

New techniques were developed and implemented in 2019 for treating water bodies that froze overnight. After breaking the film of ice that forms overnight and finding high larval levels, crews would sprinkle the BTI granules on top of the ice. As the ice melts in daytime temperatures, it enters the water, resulting in high mortality rates for the larvae. This method allows the crew to treat these areas and efficiently continue to the next site. This not only results in a savings in time and fuel but also provides for timely treatment being applied at critical stages. This early detection/rapid response method is now an integral part of early season operations. The figure to the right illustrates active larvae under a film of ice.

Mosquito population control is most effective when the first hatch biomass potentials are greatly reduced through timely treatment at larval stage.

Figure 1.2: Active larvae in Frozen Water

1.4 Treatment Pesticide

The RDOS uses a granular form of *Bacillus thuringiensis var israelensis*, more commonly referred to as Bti, to control mosquito larvae. Bti is a naturally occurring, non-toxic bacteria (found in the soil) which specifically targets mosquito and black fly larvae. For further information about Bti and how it works refer to the Health Canada-Bti fact sheet:

Link to Health Canada BTI https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/fact-sheets-other-resources/bacillus-thuringiensis-subspecies-israelensis.html

Bti has undergone nearly 40 years of lab/field research and over 30 years of large-scale operational use in a variety of public health programs around the globe.

Bti is very target specific with activity largely restricted to mosquitoes and related flies (in the sub-order Nematocera of the order Diptera). The specific pesticide product used by the RDOS in the MCP is VectoBac 200G, see the figures below. For further information on Vectobac 200G formulation has been provided in Appendix B.

In addition to Bti's non toxicity to beneficial insects, numerous toxicology studies have shown Bti to be non-pathogenic and non-toxic to other forms of wildlife (birds, fish, mammals, etc.) and humans. The World Health Organization has approved the use of Bti for drinking water. This is particularly important in many regions around the globe that depend on potable water or rain water stored in vessels in and around their home. Bti is the primary larvicide used for control in countries where Zika Virus can flourish.

Figure 1.3: VectoBac 200G

Figure 1.4: Pellets of VectoBac 200G

1.5 Treatment Areas of Note

The Similkameen Valley was significantly impacted from inflows into the river system this season. Ground water pressures from the Similkameen River caused pooling in many areas adjacent to the river, providing ideal habitat for very high larva counts through a large portion of the water column. When the Similkameen River overtopped its banks on May 1, the water further expanded the larvae filled flood waters.

Cool weather and flooding persisted well into late July. Okanagan Lake finally dropped below full pool on July 29, but the entire Okanagan River system, north to south, remained a constant contributor to localized flooding into August.

Figure 1.5 (Above) – Wading through Water

- **MCP crew wading through flooded area due to groundwater push-up along the Similkameen River**

Figure 1.6 (Right) – Flood Water Extent:

- **Red shaded area illustrates extent of flood waters away from the Similkameen River and the approximate location where the above photograph was taken**

2. Mosquito Control Program Operation

2.1 Operational Season 2020

The annual weather conditions and resultant snowpack, lake, river and stream levels all play an integral role in the MCP variable start dates. Supervisory staff monitor weather and climate data, connect with Ministry authorities, such as main-stem lake level operations, to forecast potentials for the upcoming season.

In 2020, high snow-pack(s), moderate temperatures, and increased early rainfall was the perfect storm forecast for early flooding. Larval population densities at the start of the season often exceeded 250 per single 250ml dip; the IPMP treatment threshold is 3 per dip. The figure below illustrates the high number of larvae seen in some dips.

Figure 2.1: Larvae dips (2020)

The MCP program continued to utilize and refine the Early Detection/Rapid Response method for treatment. The Summerland ball fields in Dale Meadows have proven to be a good indicator for the start of the mosquito season. With the early detection of emerging larva activity, the MCP started monitoring and treatment in March. The earliest first helicopter flight in the program history occurred on April 17.

As indicated above, the Similkameen Valley was significantly impacted from inflows into the river system this season. Ground water pressures from the Similkameen River caused pooling adjacent to the river, with larvae levels over 1000+/per 250ml dip. Larva distribution through the water column was observed much deeper than usual at depths over 112 cm.

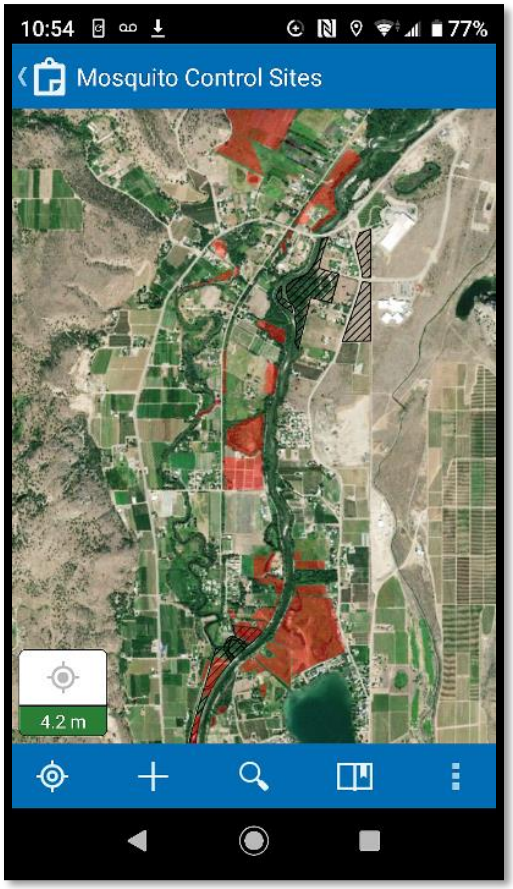
The treatment along the Similkameen River was complicated when the river overtopped its banks on May 1, expanding the already larvae filled flood waters. A second mitigating helicopter flight took place on May 2 in efforts to reduce the spread of viable larvae.

Localized flooding throughout the entire Okanagan River system were occurring until about mid-August due to the persistent cool weather and Okanagan Lake remaining above full pool until July 29th.

A total of six helicopter flights were required this season. This increase from previous years, reflects the return to persistent flood waters in both the South Okanagan and Similkameen.

Figure 2.2: Pre-flight safety check – prior to each flight: shown here with Global TV for their annual segment on the RDOS Mosquito Control Program

Figure 2.3: Treatment Hopper under the Helicopter



Using ArcGIS Collector (mapping and data collection), which RDOS IT/GIS developed specifically for the Mosquito program, continued to provide for full remote access for the crew and the collection/storage of data.

Due to the risks of COVID-19, this application allowed the crew to stay safely out in the field for the season.

Later in the season, in addition to the regular program deliverables, the Lower Similkameen Indian Band and RDOS collaborated to apply treatment to a small area on Band lands. The work was performed under the RDOS Pest Management Plan with the endorsement of the Provincial Ministry. Over the winter, discussions will take place for collaboration potentials for the upcoming 2021 season.

Figure 2.4: Screenshots of ArcGis Collector on a cell phone

In addition, new protocols were implemented and imbedded into the MCP Operational Safety Manual. Additional washing options, safety supplies and creative work-practices were developed to keep the crew safe and operational in the field.

This season, 5,795.9 kg of VectoBac 200G granular larvicide was applied to 384 sites with a total area of 438.5 hectares of mosquito breeding habitat. All applications were completed under the BC Ministry of Environment Pest Management Plan for the RDOS.

2.2 Treatment Distribution for 2020

Flood water mosquitos continued to be a concern into mid-summer as undulating water levels allowed multiple hatches to occur. This issue was most problematic in large, low lying wet lands close to communities, where a change as small as two inches in water table level can translate to entire areas re-submerging.

Larvaciding is done primarily by the ground crew on foot until sites are no longer safely accessible.

The following tables and figures provide a record of the 2020 Mosquito Control Program treatment application records. Figure 2.5 provides the total treated area within each electoral area or municipality. Some of the sites were treated numerous times, which explains some of the large hectare totals as well as the large amounts of pesticide used in these areas as illustrated in Figure 2.6.

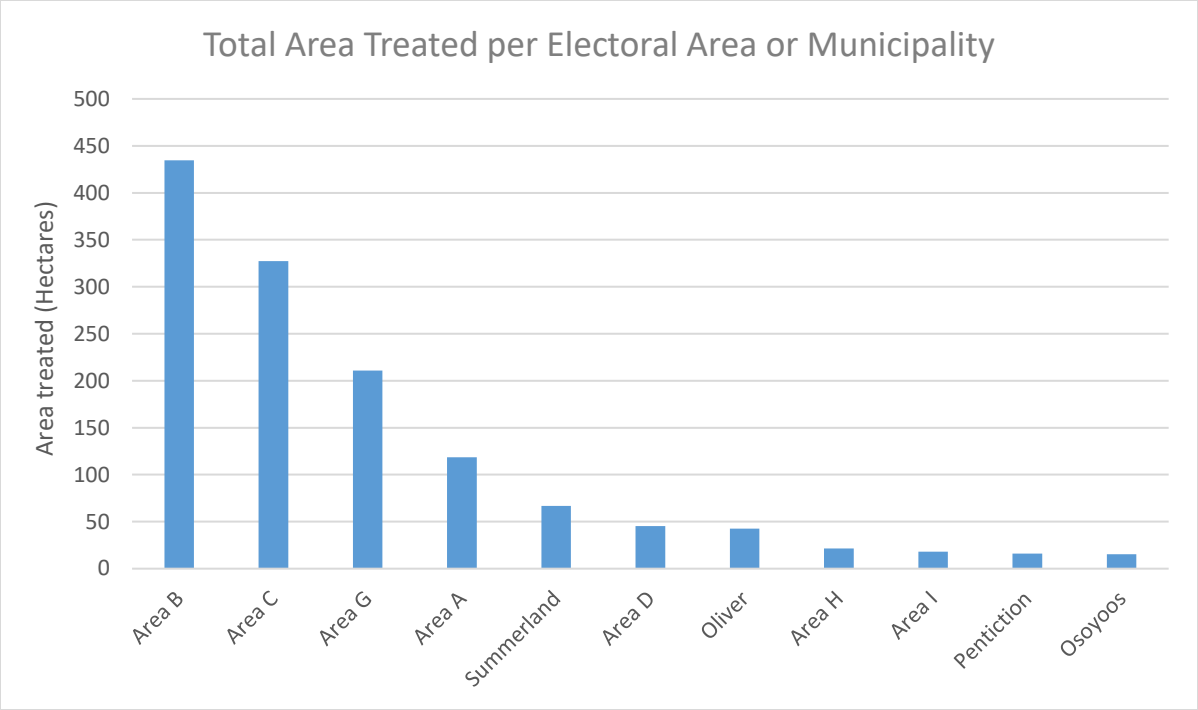


Figure 2.5: 2020 Treated Area per Electoral Area or Municipality – layered multiple treatments

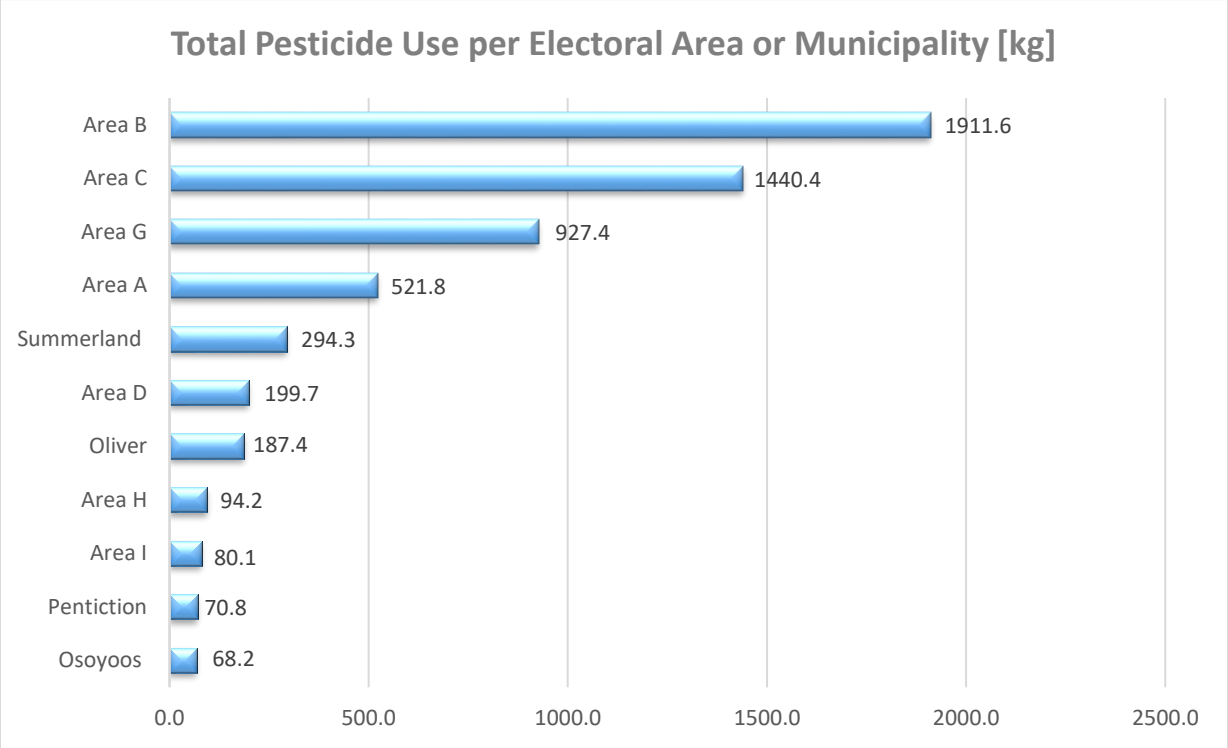


Figure 2.6: 2020 Pesticide Use per Electoral Area or Municipality – Total of 5,795.9 kg

The following table details the hours spent by the crew in each electoral area or municipality carrying out reconnaissance and treatment. The total percentage spent in each area during the 2020 season is also provided for information.

Table 2.1 Time Allocation for each Electoral Area or Municipality – Total of 1,317.4 hours

Percentage of time spent in each Area or Municipality				
Area or Municipality Treated	Helicopter treatment	Back-Pack treatment	Total treatment time	% of Total Time
A	44.8	73.8	118.6	9.0
B	317.3	117.2	434.5	33.0
C	118.9	208.5	327.4	24.9
D	19.5	25.9	45.4	3.4
E	0	0	0	0.0
F	0	0	0	0.0
G	167.7	43.1	210.8	16.0
H	0	21.4	21.4	1.6
I	4.6	13.6	18.2	1.4
Oliver	8.1	34.5	42.6	3.2
Osoyoos	0	15.5	15.5	1.2
Penticton	0	16.1	16.1	1.2
Summerland	0	66.9	66.9	5.1
2020 Totals	680.9	636.5	1317.4	100%

3. Mosquito Populations

Our mandate, first and foremost is to control mosquito larvae in their breeding sites. The high larval levels contained in the vast areas of flooded land made it necessary to begin treatment earlier than in past years. The Mosquito control program has a large area to monitor and treatment of these sites was critical in preventing the release of their adult mosquito population.

In order to understand the most effective way to monitor and treat the breeding sites, it is important to be aware of the seasonal timing and emergence conditions for the different mosquito species.

3.1 Climate Change and Mosquitos

Climate change is effecting mosquito distribution. Over the last 20 years, 6 species of mosquito have been reported as newly established in Canada; in addition, 10 others have expanded their geographic range. Of these, 4 are well established throughout the RDOS: *sticticus*, *cataphylla*, *campesris*, and *tarsalis*.

Four of the past five years the Okanagan and Similkameen have seen unprecedented water levels, adding to already established mosquito habitats, greatly increasing the area of ground where eggs are now deposited. The diverse species collected in our region reflects the variety of localized habitats and the impact that local weather conditions, snowpack, lake and river/creek levels have on their distribution.

The two key factors of climate change that effect endemic mosquito populations in our region are an increase in median temperature, and changes in rainfall patterns. The survival of adult mosquitos is temperature and humidity dependent as forests, long grass, hedges and sheltered areas give good resting places for adult mosquitos and help to extend their life cycle.

Temperature increases over summer reduce the 'instar' (larval) lifecycle stages dramatically requiring more frequent checks and treatment across the region. The increase in precipitation and the variability in timing have given the mosquito(s) more opportunity to flourish and expand its breeding ground.

It is anticipated that both the mosquito lifecycle and virus transmission patterns will continue to be affected by climate change, resulting in an increase in both the range and local abundance of several key mosquito species.

"Climate change is increasingly being recognized for its potential to adversely affect public health. One such consequence of climate change that has been described in the literature is a change in the distribution and habitat of mosquito vectors that are known to transmit disease." National Collaborating Centre for Infectious Disease, 2016

3.2 Mosquito Sampling

In 2019, in response to the changing mosquito species migrations, a new methodology was added to the RDOS Mosquito Control Program to determine the general population distribution for the different mosquito species over the season. The methodology involved larval collection and identification. Due to COVID-19 no samples were submitted for 2020, but are planned for the 2021 season.

The protocols employed were provided by a reputable biologist and lab in Victoria. Samples from larval pools were obtained using consistent methods from multiple sites scattered throughout the RDOS then shipped to Victoria for identification. All sent samples were counted, identified and the larval stage, or instar, was noted. When larva are 3 instar and older, specific identification is relatively simple. However, due to their small size and immaturity, most 1 & 2 instar larval specimens could not be identified to species; in these situations, the larvae were identified to genus.

In the industry, some vector control companies wait for the majority of the larvae at the site to be 3 instar and older for more accurate classification; however, as all sites have larvae at different stages and if treatment is held off to allow more larvae to mature for classification, a large percentage of the larvae will be left untreated and enter the adult airborne stage.

Figure 3.1: Collecting Larvae Samples in 2019

In 2019, mosquito larvae samples were sent to Victoria for identification in April, May and July. Seventeen species of larval mosquitos were collected during the 2019 season: 11 *Aedes*, 3 *Culiseta*, two *Culex*, and one *Anopheles*. All of these mosquitos are able to produce multiple generations during the season if the right conditions persist.

Data collected in 2019, shown in the figure below, illustrates the mosquito species identified.

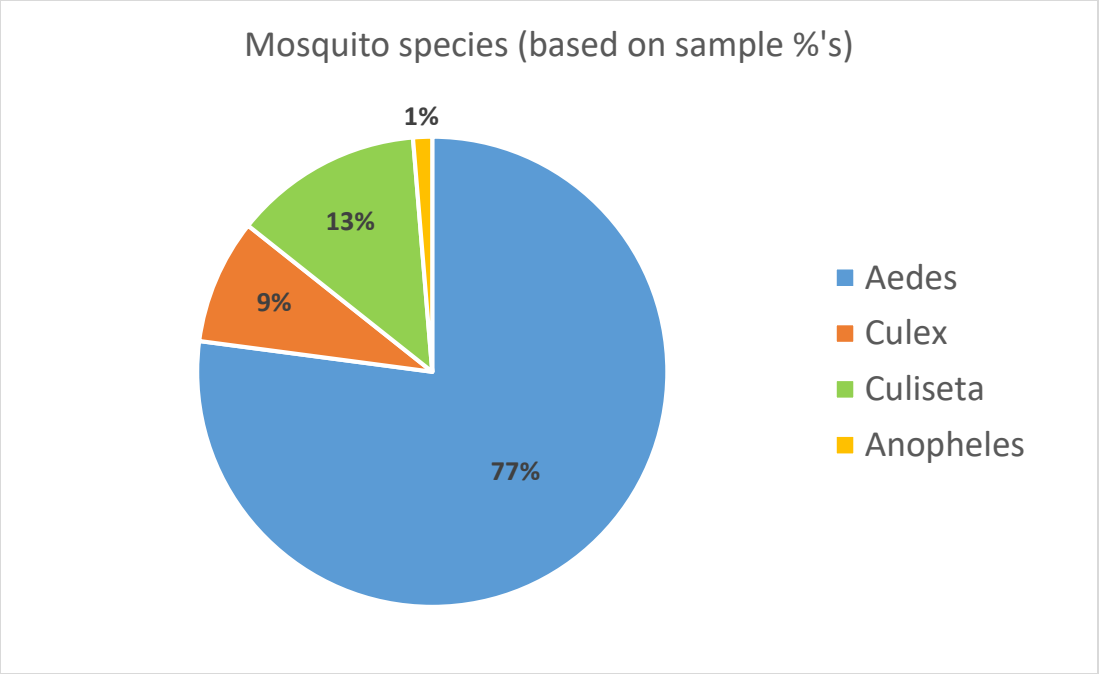


Figure 3.2: Mosquito Species Identified for 2019 Mosquito Season

3.3 Mosquito Species Identification

Aedes mosquitos make up the large majority of the mosquito population in the Okanagan and Similkameen valleys, and is typical for the rest of British Columbia. *Aedes* mosquitos, also known as flood water mosquitos, are noted for its aggressive biting behaviour, its strong flying ability, adaption to very cold water, ability to use a variety of water conditions, and in the case of the species *Aedes cataphylla,* the ability to mature 5 batches of eggs in one season. The *Aedes* species is also carries the canine heartworm.

Figure 3.3 *Aedes vexans*

The *Aedes* species lays its eggs in the mud and wet earth as water retreats. The following year, when the water levels rise with the spring snowmelt, the eggs become saturated and the larvae hatch within a couple of days.

Adult *Aedes* mosquitos hatch around the beginning of March and fly until the end of July. The females are capable of laying multiple batches of eggs (depending on the abundance of blood meals) per season. This process allows females to lay numerous egg batches within a close proximity to each other; resulting in a significant accumulation of eggs within one flood water pool. Again, this adds to the argument that controlling larvae populations before the first hatch of adults is the most effective way to control mosquito levels in the RDOS for the duration of the summer.

Culiseta mosquito species appeared in the 2019 samples by the end of April. It is known as a serious pest to cattle but they also bite people. These mosquitos will fly in weather too cold for other insects and can be seen flying around on a winter day when the sun comes out.

Larva can be found in ice covered pools and they often emerge when snow is still on the ground.

It is the most widespread mosquito in BC and some *Culiseta* species keep pools of water teeming with larva all summer. They are a primary vector for Western Equine Encephalitis.

Figure 3.4
Culiseta inornata

Figure 3.5 *Culex tarsalis*

Culex mosquito species were identified in samples from early May of 2019. Traditionally, these mosquitoes are not present until late May to early June. This species will tolerate any water source, even highly polluted ones. They bite readily, will come into your house, and typically reproduce all summer long. As a primary vector of Western Equine Encephalitis and West Nile Virus, this species needs surveillance and a treatment regime.

Anopheles mosquito species is persistent in their desire to enter houses. They bite freely after dark or in shaded areas. These mosquitos will use any type of water source for reproducing. This species was identified in the May 2019 samples.

Figure 3.6
Anopheles punctipennis

For information, the 2019 results for where the different species were found within the Okanagan-Similkameen region is included in Appendix A in this report.

Data was not collected in 2020 for species identification by a biologist. The distribution of the mosquito species was anticipated to remain fairly consistent each year with about 75% of the mosquitos being from the *Aedes* species. Species identification is planned to be included in the 2021 MCP season.

3.4 Mosquito Biology

In order to become adults, all mosquitoes need non-agitated water in their larval stage. Larvae must proceed through four stages called instars. Each stage requires a molt allowing the larvae to mature and increase in size. The final water stage is called a pupae during which a complete metamorphosis takes place and the winged form emerges. This entire process begins in early spring in snow-meltwater pools and usually takes a few weeks.

With increased temperatures, this process accelerates and can complete in as little as 5-7 days. With normal temperatures, (daytime temperatures reaching 15 degrees) most mosquitoes require 7-14 days.

Adult mosquitoes feed on plant nectar. However, the female mosquito requires a blood meal in order to complete the development of her eggs. Females will take blood as soon as the opportunity presents itself; if no blood is available, she will go looking for it. Although most mosquitoes do not have to fly far to find a blood source (1-2km), some species can fly great distances and up to great heights (30km from their origin and at heights up to 10,000 meters).

With the mountain and valley topography, mosquitos are easily dispersed from the frequent winds thus placing an increased importance on finding and treating new larval sites.

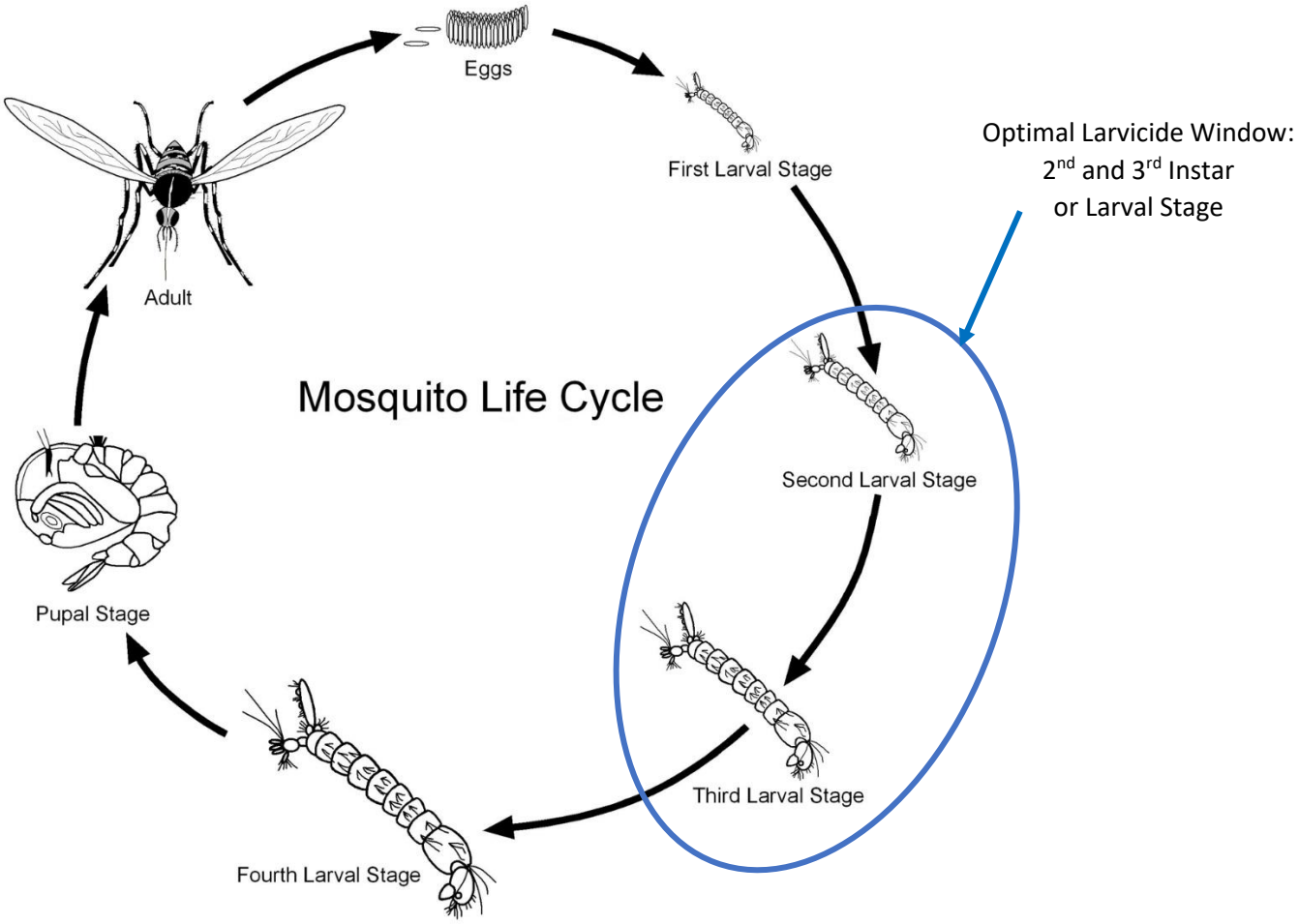


Figure 3.7: Lifecycle of the Mosquito

Floodwater mosquitoes (*Aedes*) lay their eggs in the soil of receding flood water where they overwinter in egg form waiting for the spring floods. These eggs can remain viable for upwards of 20 years and can endure deep cold. When the flood waters come, the eggs hatch synchronously, causing an intense biomass of flying insects that not even the most industrious of predators can hope to control. Large areas of flooded land increases the number of eggs ready to hatch in subsequent flooding events.

Summer Mosquitoes (*Culex*, *Culiseta*, and *Anopheles*) lay their eggs on the water surface. The hotter the temperatures, the quicker the eggs hatch. These mosquitoes continue to lay eggs as long as there is water available and the temperatures remain above freezing. Once temperatures drop below freezing, the remaining hatched females breed and hide away until warmer temperatures return. As soon as temperatures allow, they are ready to take a blood meal first thing in the spring.

3.5 MBD–Mosquito-Borne Diseases

The mosquito as a vector for disease is the undisputed champion. Mosquito-borne diseases are increasing in Canada. According to the Canada Communicable Disease Department the changes in our climate is influencing the extent to which our mosquito vectors spread viruses. Mosquito-borne diseases in our endemic populations have been increasing and new species (and associated pathogens) moving into other territories will only add to the risk of infections.

West Nile virus (WNv) is familiar to us here in western Canada, but other endemic mosquito borne diseases in the area include Western Equine Encephalitis and two California serogroup viruses : Jamestown Canyon virus and the Snowshoe Hare virus. The serogroup viruses can be transmitted by a number of mosquito species, and the virus has been found in all provinces and the North West Territories. These viruses can cause febrile illness and neurological disease in humans. Our canine companions also need to be protected from Canine Heartworm.

Unfortunately, diagnosing many of these infections is difficult because of their non-specific symptoms and the low level of awareness among health care practitioners. Climate change will continue to expand mosquito habitats, their associated diseases and the extension of our mosquito season; our response must be to meet these challenges with continued and expanded surveillance, backed by science and appropriate treatment.

Figure 3.8: Adult mosquito resting on the vehicle dashboard

4. Public Information

4. 1 Preventative Measures

Mosquitos occur in a wide variety of habitats; removal of standing water and control of mosquito breeding sites should be a priority for homeowners. In a 250 ml dip, one larva can translate into an excess of 10,000 mosquitoes emerging from a small backyard pond or swimming pool. Left untreated, or undrained, the resultant adult mosquito population will cause noticeable annoyance for local residents. Tires, lawn depressions, gutters, animal feeders, birdbaths, all assortment of man-made containers, leaking irrigation and rain events can all be harbingers of larvae. Decorative ponds should be aerated with a fountain or aeration device.

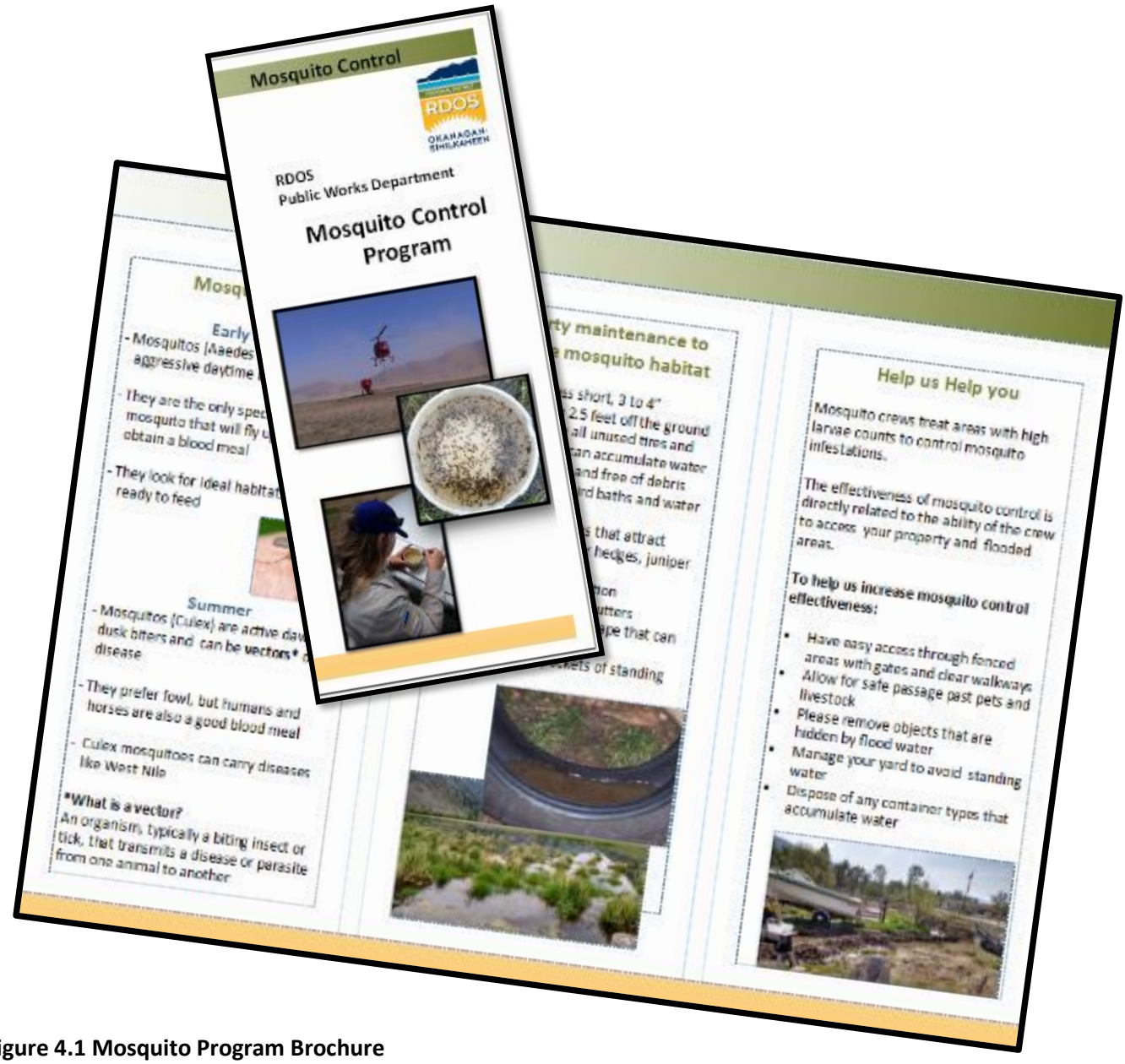


Figure 4.1 Mosquito Program Brochure

4.2 Common Questions and Answers

Q: How does the RDOS control mosquitos?

A: With the use of environmentally friendly pesticide. The RDOS uses a granular product called Vectobac®. Small pieces of crushed corn are saturated with an active ingredient called *Bacillus thuringiensis var israelensis* (Bti). The Bti is 'stuck' to granules using paraffin wax. The product is placed on the water surface where the active ingredient is released. Mosquito larvae are filter feeders and when they ingest the bacteria it creates a toxin in their gut which terminates them.

Q: Can Bti have negative effects on humans and other animals?

A: Bti is a non-toxic naturally occurring bacteria which has been successfully used as a biological pest control agent to combat mosquitoes and black flies since 1982. There has been significant research on the product during its long period of worldwide use. As a listed pesticide, research continues to show its effectiveness on these 2 targeted organisms (mosquito and black fly larva). There have been no registered poisonings of humans due to an intake of Bti.

Q: Do I have to pay for mosquito control?

A: Mosquito control is paid for by the entire Electoral Area or Municipality in which you reside. Therefore, all residents in the area are part of the program even if control is not on their property.

Q: Does the RDOS treat everywhere there is mosquito populations?

A: No. Private property owners must ask for mosquito control to be conducted on their property. Crews only treat where permission has been granted. Also, most conservancies do not allow any form of mosquito control. Additionally, if an Electoral Area or Municipality has chosen not to contribute to the program funding, that area will not be treated.

Q: Can I get sick from a mosquito bite?

A: Mosquitoes are vectors for disease. The biggest killers in tropical countries are Malaria and Yellow Fever. Here in BC, mosquito bites can result in extreme allergic reactions and/or secondary infections. Diseases like Canine Heart-Worm, Western Equine Encephalitis and West Nile Virus are transmitted between birds and mosquitoes to family pets, livestock and humans. Recently, the mosquito-vectored virus that causes Zika has become a major health concern in many areas of the world including the southern USA. The primary vector for Zika, *Ae. aegypti*, does not find our current climate hospitable, but with a changing climate and the possibility of competent secondary mosquito vectors, Canada has employed two specialty labs to study and monitor the situation.

Q: Can I purchase BTI?

A: Yes, Duka Environmental supplies 5kg bags of BTI that can be used **only** in stagnant water on your own property.

5. RDOS Integrated Pest Management Plan and Bylaws

5.1 Integrated Pest Management Plan (IPMP)

The RDOS is required to have an active, approved Integrated Pest Management Plan in place at all times. The plan expires every five years, and reapplication is required. Costs are adjusted in correlation to amount of hectares to be treated as determined from manual data supplied to the Province after the treatment season ends.

Significant consultation is required when a new IPMP is developed, including all Indigenous peoples who have rights or claims on the area to be treated.

Link to IPMP: http://www.rdos.bc.ca/departments/public-works/pest-control/

Figure 5.1 – Integrated Pest Management Plan

5.2 Service Establishment Bylaw and Update

The current bylaw in place for the Mosquito Control Program is located at the following link.

Link to Bylaw 2602-2014:
http://www.rdosmaps.bc.ca/min_bylaws/bylaws/engineering/2014/BL2602.pdf

5.3 Program Cost Comparison

The RDOS has had a long standing in-house MCP. It is prudent to continuously evaluate the cost to benefit ratio of an in-house versus contracted service, in order to insure ratepayers are getting the most value for tax dollars spent. The RDOS uses the Central Okanagan as a nearby, similar geographical area who uses a very reputable contracted service provider as a comparison. The information is publically accessible on their website (as are the RDOS MCP annual budgets and reports.

Regional District of Central Okanagan MCP - Excerpt 2019 Annual Report:

https://www.regionaldistrict.com/media/279320/2019_Mosquito_Report.pdf

A total of some 1,248 kilograms of VectoBac 200G were applied to a total area of 166.37 hectares of active larval mosquito development habitat. Some 190 sites were treated on a total of 816 separate occasions. Although many sites were only treated on 1 or 2 occasions during 2019, numerous sites were treated 3 or 4 times and several sites were treated 15 or more times. A total of 19,806 catch basins were treated during two treatment campaigns: Approx annual costs $200,000.

Note that the RDCO catch basins are close together, easily accessible and very quickly treated

Table: RDOS and RDCO Mosquito Control Program Comparison for 2019

	Hectares treated	~Annual Budget Costs	Larvicide kg totals
RDCO	166.37	$200,000	1,248
RDOS	384.5	$176,000	5,795.9

Rationale for RDOS In-house MCP:

For some provided services, a contracted company is the best option to supply an annual or seasonal service. In this case, the RDOS benefits substantially from continuing to keep the MCP as a seasonal employee in-house program:

- Mosquito crew members are internalized and become a recognized part of the RDOS staff team
- Crew can and do supply area specific information back to the RDOS: topography, logistics etc.
- Local knowledge is important, time saving and a resource tool for other Dept.'s
- Crew have and can be used in Emergency Operations for recognisance, delivery and as active participants in mitigation
- Crew are used to transport goods and materials to outlying RDOS offices or facilities
- Crew members are a first contact for many residents, and therefor provide information and assistance to citizens that contract providers cannot.

APPENDIX A: 2019 Sampled Species, their Characteristics and Location

Species	Charateristics	Location (2019)
Aedes Sticticus	◦**Viscous biters day or night** ◦Several mile flight range ◦**Hatch immediately after eggs are flooded in the spring**	Eastgate, Chopaka
Aedes Cataphylla	◦**Aggressive biter, bites in broad daylight** ◦ Strong flyer predominant species of the dry interior grasslands/pastures, snowmelt pools, forests one ◦**Female can mature 5 batches of eggs in 1 season**	Princeton, Summerland
Aedes Implicatus	◦**Vigorously bites in shaded areas snowmelt pools or rain pool woodland mosquito** ◦Emerges early	Oliver, Princeton, Caweston, Summerland, Osoyoos
Aedes Fitchii	**Strong flyer – is a nuisance up to 1500m snow pool breeder** ◦ Likes open grassland and wooded environment	Chopaka, Osoyoos
Aedes Intrudens	◦**Vicious biter day or night** ◦ A big nuisance as they enter buildings readily through the smallest of openings ◦ **Prefer woodland areas, bogs and snow pools**	Chopaka
Aedes Dorsalis	◦Live and breed in fresh and salt water – major beach pest ◦ **Continuous summer breeder**	Eastgate
Aedes Campestris	◦**Attack even in the extreme heat of the day – attack in swarms bite all day** ◦ Wide flight range ◦ Like alkaline pools and water rich in organic matter	Osoyoos

Species	Charateristics	Location (2019)
Aedes Vexan	◦**Major cause of daytime annoyance** ◦ Wide distribution in Canada ◦ **Strong flyer 20-50 km; 100's of km when they get into the jet streamrequire** ◦ Flooding may immerse eggs several times in any one season each initiating a further hatch	All Areas
Aedes Impiger	◦**Prefer high evelations**	Princeton, Osoyoos, Summerland
Culiseta Inornata	◦Serious biter of cattle ◦ **wide distribution across BC** ◦ Fly when it is too cold for other insects ◦ **Larvae found in ice covered pools** ◦ Main transmitter of WEE	Osoyoos, Oliver
Culiseta Impatiens	◦ **Emerge when snow is still on the ground** ◦ Mainly bite cattle and humans	Osoyoos, Oliver
Culiseta Incidens	◦ **Loves to bite on warm evenings** ◦ Very large in size ◦ **Most common widespread mosquito in BC**	Summerland
Culex Tarsalis	◦ Bite readily and enter houses ◦ **Any water source will do even with high degree of pollution** ◦ Several generations per summer ◦ **Vaccinate horses for WEE and West Nile**	Osoyoos, Oliver,
Culex Territans	◦Breed in permanent pools and swamps ◦ **Do not like polluted water** ◦ Mainly amphibian biter	Oliver, Osoyoos
Anopheles Punctipennis	◦**Bite freely after dark** ◦ Breed any type of water ◦ **Persistent in entering houses**	Caweston, Oliver, Osoyoos

APPENDIX B: Larvacide Credentials and Details

VALENT BIOSCIENCES.
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 USA - 800-323-9597

September 16, 2019

To Whom It May Concern,

Valent BioSciences LLC, located at 870 Technology Way, Libertyville, Illinois, 60048, USA, as the registrant and manufacturer of the end-use product, VectoBac 200G Biological Larvicide, hereby confirms that the inert ingredients in our formulation are approved by EPA for food uses, are all vegetable based and made of renewable agricultural materials.

Jayne Walz
Senior Regulatory Manager
Valent BioSciences LLC

VALENT BIOSCIENCES LLC FORMED MARCH 13, 2017 DELAWARE

VectoBac 200G *Bacillus thuringiensis* var. *israelensis*, Serotype H-14, Strain AM 65-52

A: Product Quality and Proven Effectiveness

1. VectoBac 200G (*Bacillus thuringiensis* var. *israelensis* Serotype H-14, Strain AM65-52) and the consistency of its bacterial fermentation process is ensured through adherence to the highest of pharmaceutical-grade standards, as set out by the international Health Sciences company Abbott Laboratories, the parent company of Valent BioSciences Corporation (VBC). All VBC bio-rational larvicides are manufactured in its new (July 2014), dedicated, "state of the art" production facility in Osage, Iowa. Unlike other larvicide products, VectoBac is not "out sourced" for production or packaging.

2. Valent BioSciences is a quality driven company and is an ISO 9001:2008 Certified Company, a globally recognized certification placing a high value upon a company's sustainable management systems. Required internal and external audits ensure adherence to the rigors of this certification.

3. VectoBac corn cob granules are carefully produced and selected for size, shape and density to ensure application equipment performance, to eliminate dust and to optimize applicator and public safety. These, and other characteristics including the wax coating minimizes the potential for drift and ensures good penetration of vegetation and effective distribution of the active ingredient throughout the larval feeding zone by the presence of both floating and sinking granules.

4. All VectoBac 200G destined for use in Canada is manufactured and specifically packaged with Pesticide Management Regulatory Agency (PMRA) approved labelling for Canada. Vectobac 200G is not relabeled or repackaged for sale into Canada.

5. All VectoBac 200G bags are readily identified with a Production Number (Lot #) and date of manufacture to ensure the "freshest" of product, it's timely use and effective inventory rotation and management.

6. All VectoBac 200G released for sale, meets or exceeds the minimum efficacy standards of 200 ITU/mg), as confirmed through using *Aedes aegypti* bio-assay testing.

7. In addition, all VectoBac 200G product in inventory is routinely tested using bio-assays to ensure minimum product efficacy (+200 ITU/mg) and the status of individual production lots is confirmed for the purchaser through the issuance of Certificates of Analysis (COA).

8. VectoBac 200G is made throughout the year and can be made as required to replenish inventory and guarantee that clients are always able to access necessary product. There has never been a "shortage" of VectoBac 200G product, or its availability.

9. VectoBac 200G strain (AM65-52) has completed the World Health Organization Pesticide Evaluation Scheme (WHOPES) vector control products review and is on the World Health Organization (WHO) pre-qualification list. This is not true for competing products. The WHO process addresses product safety and efficacy, as well as manufacturing standards. The global authority on Insecticide Resistance Management, the Insecticide Resistance Action Committee (IRAC) recommends that only WHOPES-approved larvicides are used to ensure quality.

10. VectoBac 200G strain AM65-52 has also been approved through the European Union (EU) Biocides initiative which entailed a strict review of product efficacy and safety.

11. Vectobac is listed as Organic Material Review Institute (OMRI) certified in the United States (Organic certified by US regulation). The OMRI has recently expanded to become and encompassing North American registry and has a specific section that addresses Canadian standards. Canadian registration is under review by Valent.

12. VectoBac is the only *Bti* larvicide product used by some of the biggest jurisdictions in Western Canada, including Winnipeg, Regina, Calgary, Edmonton, Yukon, Metro Vancouver, Regional District of Okanagan Similkameen, Regional District of Central Okanagan and many BC municipalities. It is the specified product of many large US mosquito abatement programs who have to assess efficacy and quality before including a larvicide in their tenders.

13. VectoBac has never been disqualified or disallowed in any Mosquito Abatement District or municipal contracts because of quality control, microbial contamination or lack of performance issues.

B. Effective Application Rates and Product Volumes

1. A comparison of the Pesticide Management Regulatory Agency (Health Canada) approved manufacturers labels indicate that the effective application rates, registered, proven and accepted by the PMRA as effective for VectoBac are 3-10 kg/ha, and for AquaBac, they are 2.5-20 kg/ha. Both product labels recommend higher application rates for use in deep or polluted waters and when late 3rd and 4th instar larvae predominate. Older instars are not as actively feeding and some 4th instars may have even stopped to prepare for pupation. Increased application rates increases the concentration and availability/opportunity for larvicide consumption.

2. VectoBac applications rates of 4.25 kg/ha, or 42.5% of the maximum 10kg/ha, is a proven effective application rate aerial applications using this product in Yukon and throughout British Columbia. This is substantiated by over 35 seasons of successful operational mosquito control and numerous Letters of Reference confirming program effectiveness at suppressing larval mosquito populations and reducing adult mosquito annoyance.

   As a proportion of the manufacturers-suggested application rate, an equivalent aerial application rate for AquaBac 200G is 8.5 kg/ha, based on the 20 kg/ha maximum label-

recommended application rate. A review of FVRD Nuisance Mosquito Control Program Reports (2013-2017), the largest user of AquaBac 200G, indicates an actual average aerial application rate of 8.77 kg/ha, (actual range 7.0 - 10.0 kg/ha) and in 2018 it was an average 9.88 kg/ha for aerial applications.

C. Environmental compatibility

1. One of the primary tenets of Integrated Pest Management (IPM) is to use the most effective, least toxic and least persistent product, applied at the lowest effective rates. VectoBac 200G achieves all of these criteria with proven effective application rates of 4.25 kg/ha. *Duka Ltd.* prescribed surveillance frequency for site inspection and assessment every 6-8 days ensures the timely identification of developing, and highly susceptible larval populations comprised of predominantly 2nd, and some 3rd instar larvae.

APPENDIX C: References

1. Public Health Agency of Canada, “Government of Canada,” Endemic mosquito-borne diseases due to climate changes - Canada.ca, 04-Apr-2019. [Online]. Available: https://www.canada.ca/en/public-health/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2019-45/issue-4-april-4-2019/article-3-endemic-mosquito-borne-diseases-climate-change.html. [Accessed: 02-Aug-2019].

2. P. Belton, The Mosquitoes of British Columbia. Victoria: British Columbia Provincial Museum, 1983.

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