2020 EARLY SEASON REPORT

Columbia Shuswap Regional District
Golden, BC (Area 'A') Mosquito Program

Submitted by Morrow BioScience Ltd.
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Executive Summary

Morrow BioScience Ltd. (MBL) is entering into the fourth year of a renewed, 5 year contract providing mosquito control services to Golden/Area 'A' within the Columbia Shuswap Regional District (CSRD). The goal of the pre-season report is to present predictions for what the 2020 mosquito season may look like based on current environmental conditions.

The early April snow pack within the Upper Columbia snow basin contributing to the Columbia River and Kicking Horse River is largely predictive of the peak flooding level of both rivers for the season. In 2020 the average snow pack in this basin across various snow stations is considerably high, exceeding normal values and that of 2018 – the most recent high-water year in the region. As such, MBL is preparing for a comparable high-water year with extensive mosquito development habitat. Site monitoring of snowmelt sites along the mountain benches will occur later in April. Floodwater mosquito development sites will commence prior to the consistent rise of the Columbia River and Kicking Horse River levels at the Donald and Golden gauges, respectively. The BC River Forecast Centre is predicting that the peak may be later (i.e. late May to early June) in 2020 based on anticipated stints of cooler weather in April. MBL staff will again utilize the real-time data collection portal and provide point specific data on client-enabled dashboards. The dashboard data will allow the CSRD program manager to instantaneously see what the site monitoring indicates and when treatments begin to take place.

MBL staff are educated in new WorkSafe procedures introduced to reduce the spread of COVID-19. In addition to certain field procedures, education outreach efforts will also be altered this season. As MBL follows provincial guidelines in an effort to minimize potential exposure, education outreach efforts will shift to a more web-based format. Mail-out information packets may also be considered to reach residents unable to access documents online.

Introduction

This report is provided to the Columbia Shuswap Regional District (CSRD) for use as a projection tool in 2020 and with regards to the magnitude of potential flooding within the City of Golden/Area 'A', as it relates to mosquito larval abundance potential. The report will include information on current snow pack data within basins contributing to the regional Columbia River and Kicking Horse River levels, the projected weather outlook for the spring and summer, a brief summary of monitoring methodology conducted by Morrow BioScience Ltd. (MBL), and a reminder of MBL staff resources for up-to-date information. This report provides an estimate of how the mosquito season may develop based on current weather predictions and snow levels; it is possible that conditions could change in late April and early May. The mid-season report will have more thorough explanations of environmental conditions affecting mosquito larval levels and an update on all deliverables.

Monitoring Methodology

Floodwater mosquito larvae are the primary targets of the Golden/Area 'A' mosquito program within the CSRD. Female floodwater mosquitoes (e.g. *Aedes vexans*, *Ae. sticticus*) deposit their eggs on damp substrate along the Columbia River and Kicking Horse River corridors. When the high water caused by the freshet and/or significant localized precipitation floods these areas, the result is large-scale mosquito egg hatching. If numerous seasons have passed between high-water years, then high river levels may produce a compounded number of mosquito larvae.

The secondary targets of the Golden/Area 'A' mosquito control program are snowmelt mosquito larvae (e.g. *Aedes provocans, Ae. cataphylla*). Snowmelt larvae are laid in depressions that collect precipitation. The eggs lay dormant throughout the winter then begin to hatch when the temperatures increase in the early spring. The majority of snowmelt sites within Area 'A' are located on the mountain benches above the Columbia Wetlands.

MBL field technicians will begin monitoring all known mosquito development sites within the mountain bench sites in the third week of April this season. All floodwater sites will be monitored on a weekly basis prior to rising Columbia River and Kicking River levels in early May (Donald Gauge, Golden gauge, respectively). When both river levels start rising, monitoring efforts may increase to semi-weekly. Because the eggs of certain floodwater *Aedes* species have been documented to complete embryogenesis at lower threshold aquatic temperatures between 6°C and 8°C (Trpis et al. 1973), hatching may commence in the early spring within the Golden/Area 'A' region. Time-to-hatch is considerably longer at lower aquatic temperatures, but early identification of hatching events allows for the highest treatment efficacy rates.

Throughout MBL's tenure as mosquito control contractors for Golden/Area 'A', MBL field technicians have developed an in-depth database of site profiles and consistently added new sites to the monitoring regime. Site monitoring is governed largely by field data, mosquito larval

development rates based on environmental conditions, and changes in river levels. In this way, sites are adaptively monitored and adaptively treated (Image 1). Monitoring and treatment timing adjust to reflect intra-regional habitat variations and accompanying mosquito species variations (i.e. floodwater sites, snow melt sites, etc.). MBL will continue to maintain close and clear communication with the CSRD program manager to ensure all sites are effectively managed and to assess whether program managers have been alerted of possible new mosquito development sites.

Image 1. MBL field technician assesses standard dipping cup for floodwater mosquito larvae (left). Dip contents showing 4th instar floodwater mosquito larvae (right).

Late instar larval mosquitoes in sufficient number (i.e. >4/dip) are treated by applications of a microbial larvicide product (i.e. Aquabac®). This product has the active ingredient *Bacillus thuringiensis israelensis* (Bti) and is carried on a corncob formulation. The mode of action for Bti is relatively simple and with a high degree of species specificity. Receptors within the mid-gut region of the mosquito larvae are specific to the toxin proteins that are produced alongside each bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs. This event leads to considerable damage to the wall of the gut and quickly results in larval death (Boisvert and Boisvert 2000).

As the season progresses and more mosquito development sites become flooded, it is increasingly difficult to treat sites by ground due to inaccessibility and simultaneous larval development at multiple sites. At this point, a helicopter is utilized to conduct aerial campaigns. The aerial campaigns use the same pesticide as ground applications, although typically with a higher application rate to permeate canopy cover. Aerial treatments can take approximately two days per campaign, due mostly to the level of flooding involvement along the Columbia River. All sites are checked within one or two days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted.

MBL field technicians treat mosquito larvae in the 3rd and 4th instar stages. This treatment technique is designed to target the instar stages with the highest feeding rate, leading to higher treatment efficacy. Additionally, by waiting until mosquito larvae are in the 3rd and early 4th instar stages, early instar larvae are available as food sources in their ecosystem.

Data Management

MBL's real-time data collection portal will be utilized again in 2020. This portal enables MBL staff to electronically update site information regarding the number of mosquito larvae and pupae per dip, adult presence, treatment amounts, take photos, and maintain site profile details. All data are related to GPS points and made instantaneously available to the CSRD mosquito program manager in a user-friendly format.

The tool has helped MBL staff increase operational efficiencies. The portal also provides an easily accessible reference platform for discussions between MBL staff and the CSRD program manager via a client-authorized dashboard. The dashboard displays sites and all associated data.

Education Outreach

Providing residents with mosquito-related information is a cornerstone of MBL's mosquito control programs. The goals for education outreach are to raise awareness for ways in which the public can help reduce mosquito abundance (i.e. identify and remove standing water sites) and also to provide residents with assurance that CSRD contractors are committed to mosquito control in their area.

MBL provides information through numerous platforms, including on social media, in person, and in print. The specific information presented by MBL includes:

- general mosquito biology facts,
- tips to reduce development sites around homes/businesses,
- personal protective suggestions, and
- mosquito control activities taking place within contract purviews.

The education outreach campaign in 2020 will not include hosting education booths at large, in-person events due to the current provincial restrictions on gatherings established to minimize the spread of COVID-19. Instead, MBL staff have prepared two FAQ documents addressing each of the topics typically presented at education booths (Appendix I, Appendix II). Included within the 'Floodwater Mosquito Biology and Disease Transmission' FAQ document (Appendix II) are questions regarding the potential of mosquitoes to act as vectors for COVID-19.

Audiences may source information differently this season than in past seasons due to provincial restrictions on large gatherings. Residents may become more reliant upon information that can be accessed in their homes, such as the MBL websites, social media platforms, and mailouts. With that in mind, MBL will be providing links to all FAQs through the **www.morrowbioscience.com** website. Link promotion will be conducted through the MBL social media platforms and, with permission, through the CSRD social media platforms and websites. Additionally, information pamphlets will be prepared for broadcast mailout with tax notifications in the event CSRD managers choose that option. MBL remains committed to providing education outreach within all of our mosquito control programs.

Season Forecast

Snowpack

Floodwater mosquito habitat within Golden/Area 'A' is primarily affected by fluctuations in the regional Columbia River and Kicking Horse River. The snow pack in the basin associated with those rivers can be a good indicator of how much water will come through their systems over the course of the spring and early summer. Specifically, the snow pack in the Upper Columbia basin relate to the Columbia River and Kicking Horse River fluctuations near Golden/Area 'A' (Image 2). River level variations are important to track because they inform the timing and extent of annual floodwater mosquito hatching events and subsequent control efforts.

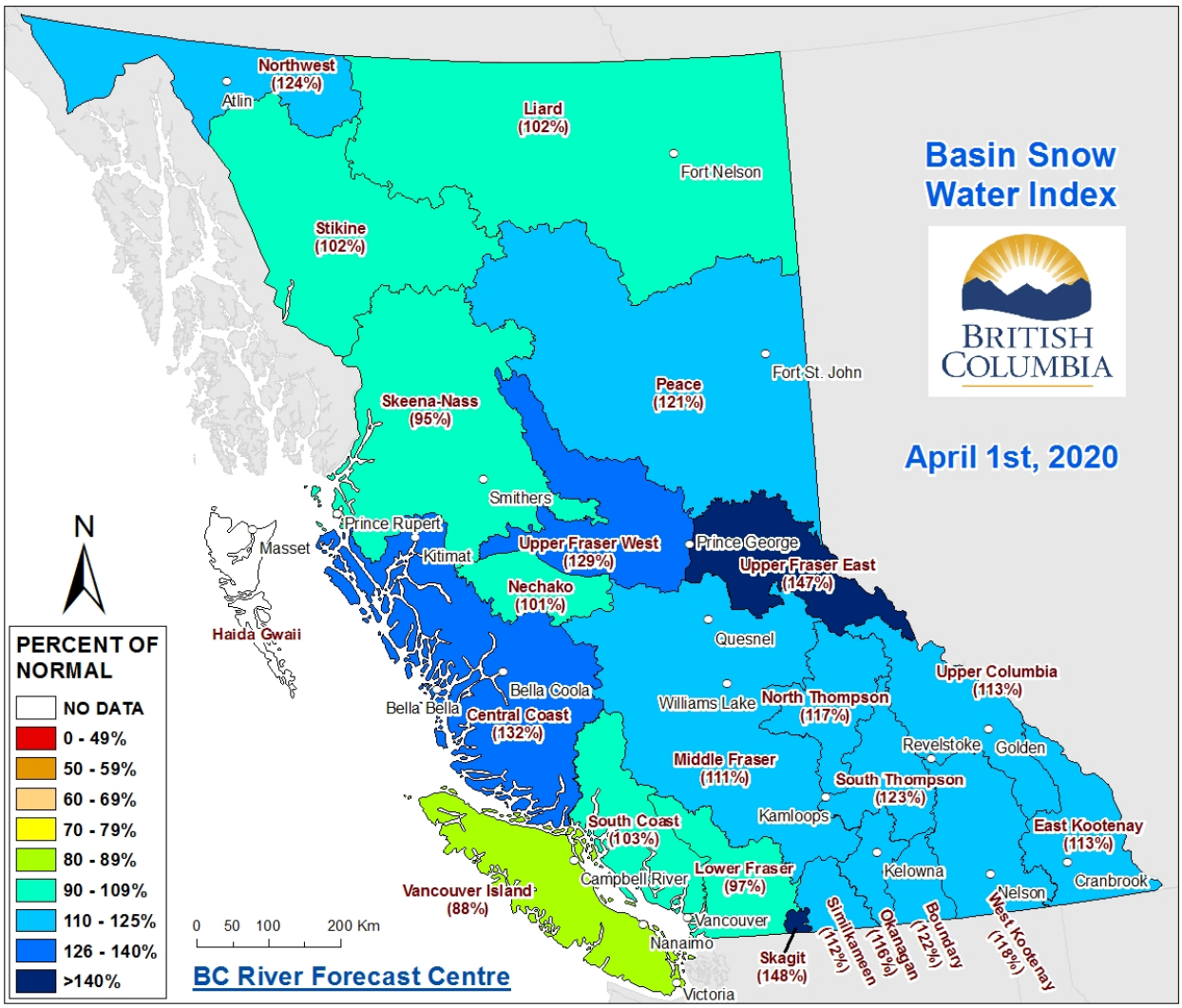

Image 2. River Forecast Centre snow pack melt by basin for 1 April 2020.

The percentages reported in Table 1 reflect the most recent snow pack estimates in the Upper Columbia Basin, as well as those reported from 2018 and 2019, from the same point in time[1]. Leading up to the 2020 mosquito season, the weather in March was generally cold across the province, but with relatively stable weather patterns. Snow packs within the Upper Columbia snow basin, directly affecting the Columbia River and Kicking Horse River levels, were augmented during the first and final week of March. This considerable later-season snow accumulation also occurred in March 2018, which led to the most recent high-water year for associated floodplain communities.

Table 1 provides a point of comparison between snow packs in 2018, 2019, and 2020. Average snow pack percentages for 2020 are more similar to that of 2018 than to that of 2019, portending a considerably high-water year. Although more similar to snow packs of 2018, 2020 snow packs

[1] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2020_april1.pdf

are currently 2 percentage points higher than the percent of normal accumulation in 2018. The Columbia River at Donald peaked at 4.42 m in 2018; the 2020 peak is expected to surpass that peak and may considerably do so if localized precipitation occurs simultaneously.

Table 1. Snow basin indices for the Upper Columbia Basin determined by the 1 April 2018, 1 April 2019, and 1 April 2020 bulletins. (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/river-forecast-centre/snow-survey-water-supply-bulletin).

	Percent of Normal Snowpack		
Basin	**2018**	**2019**	**2020**
Upper Columbia	111	89	113

According to the River Forecast Centre, approximately 95% of the snowpack has typically accumulated by early April[1]. As such, the April 1 survey is considered largely indicative of the flooding forecast for the season. It should also be noted that late season snow accumulation at high elevation stations has occurred in the past (i.e. 2017), but the current weather forecasts do not indicate significant changes to snow packs noted in Table 1.

Weather

El Nino Southern Oscillation conditions are currently neutral in the equatorial Pacific Ocean and predicted to remain neutral into early summer[2]. Thus, El Nino conditions will likely not influence the weather in that timeframe. On average, eastern BC is likely to experience cooler-than-normal ambient temperatures through May or June, with the possibility of cold weather for the second half of April. The cold weather for the remainder of April is expected to delay the freshet. If April proves to be cooler than expected, then followed by consistently hot weather, a sharp rise in the Columbia River and Kicking Horse River would be expected. MBL staff are monitoring snow pack levels, weather forecasts, and regional river levels daily in the event the 2020 mosquito season begins quickly. If current conditions and forecasts hold, the regional Columbia River and Kicking Horse River may peak in late May to early June.

The higher-than-normal snow packs in contributing basins signal high peak Columbia River and Kicking Horse River levels in 2020. In addition, significant precipitation events that occur simultaneously with the freshet can augment localized flooding. Typically, April and May are wet months for Golden/Area 'A'. Spring precipitation could amplify the peaks in both rivers beyond those expected given current snow packs, alone.

[2] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2020_apr1.pdf

Reporting Schedule

In addition to the pre-season report, the technical reporting schedule for 2020 will consist of a mid-season report and a final report. The mid-season report will summarize field activities, relevant weather data, and expectations for the remainder of the season; it will be provided to the CSRD program manager immediately following the peak in the Columbia River (Donald gauge) and the Kicking Horse River (Golden gauge). The final report will summarize and discuss all program deliverables. In the interim, regular activity updates will be supplied to the CSRD program manager. Supplementary reports can be provided, upon request, and instantaneous data is made available via MBL's real-time client-enabled dashboard.

Contacts

MBL recognizes the importance of being available to residents within each of our program areas as well as keeping them informed of relevant mosquito abatement activities and information. In an effort to continue to provide these connection opportunities, MBL regional managers check their email and phone messages on a daily basis. Managers directly reply to email and phone inquiries within 24 hours.

As a reminder, the following people may be contacted directly for any questions from Golden/Area 'A' residents:

Dirk Lewis, Owner and Head Biologist
Phone: (604) 317-1413
Email: dirk@morrowbioscience.com

Jeff Jackson, Golden/Area 'A' Program Manager
Phone: (250) 272-1168
Email: jeff@morrowbioscience.com

Barry McLane, GIS Manager
Phone: (250) 231-6934
Email: barry@morrowbioscience.com

Morgan Sternberg, Research Manager
Phone: (250) 231-4455
Email: morgan@morrowbioscience.com

General Email: info@morrowbioscience.com
MBL Mosquito Hotline: 1-877-986-3363

All emails received to the general email address and calls made to the MBL Mosquito Hotline will also be responded to within 24 hours of receipt. Additionally, residents may find helpful information on our Facebook page (Morrow BioScience Ltd.), our Twitter feed (@MorrowMosquito), as well as blogs and resources on our MBL website (www.morrowbioscience.com).

References

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Frequently Asked Questions

Bacillus thuringiensis var. *israelensis* (Bti) Bacterial Larvicide

Updated: 10 April 2020

MorrowBioScience Ltd

Updated: 10 April 2020

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Category 1: Operations and Treatment Need

Question 1: Why do we use a larvicide product to control mosquitoes?

Most mosquito control programs focus on one complex of mosquitoes, those that develop in floodwaters, primarily during the Spring freshet. These mosquitoes come out in areas where predation is relatively low, and in numbers that overwhelm the ecosystem. Appropriately conducted larval controls can significantly reduce the severity and duration of these infestations.

Mosquito control products primarily target the larval (aquatic) or adult stages of the mosquito lifecycle. Controlling mosquitoes in the larval stage before they emerge as adults better focuses treatment, as larval mosquitoes are located within a more predictable and confined area than adult mosquitoes. Fewer treatments are required if they are timed appropriately, reducing program costs and environmental impact of treatment. Finally, the bacterial larvicides utilized by MBL have considerably fewer non-target and indirect effects associated with inadvertent exposure than adult mosquito control pesticides.

Question 2: How are bacterial larvicides different from other pesticides?

The larval control product utilized by Morrow BioScience Ltd. (MBL) certified pesticide applicators is Aquabac®. The active ingredient is a soil-borne bacterium, Bacillus thuringiensis var. *israelensis (Bti). The efficacy of Bti relies upon the natural bacterium and associated toxin protein to be ingested by the mosquitoes. The toxin protein requires four specific receptors found within the gut of mosquitoes to activate the toxin. With few exceptions within the Dipteran taxa, the four receptors found within mosquitoes are lacking in other taxa. Thus, the Bti is considered non-toxic to, fish, amphibians, reptiles, mammals, and most insects.*

The non-target and/or indirect effects of other mosquito control products, however, are almost all higher. For example, adult mosquito control products with malathion inhibit cholinesterase, which is a neurotransmitter enzyme. As such, non-target or indirect exposure to this active ingredient can be toxic to other aquatic organisms, birds, and mammals. The mode of action for Bti is relatively simple and with a high degree of species specificity. Receptors within the mid-gut region of the mosquito larvae are specific to the toxin proteins that are produced alongside each bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs because of cleavage of the protoxins by mid-gut proteases. This event causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert 2000).

Question 3: What is involved in this type of treatment?

Morrow BioScience Ltd. (MBL) certified technicians conduct site larval monitoring prior to treatment. Bti treatments target the 3rd instar stages to target the primary feeding stages and to leave early instar larvae as food for others within the ecosystem. Treatments are conducted in compliance with the IPM Act. Larvicide will be applied via hand, a backpack sprayer, or helicopter as determined by the qualified MBL technician. Aerial treatment notices will be posted and will remain on site for a minimum of 1 week. The posted public notice will include the following information:

- *The trade name and active ingredient of the larvicide;*
- *The date and time of the larvicide treatment;*
- *The purpose of the treatment;*
- *Precautions to be taken to prevent harm to people entering the treatment area;*
- *The PMP confirmation number and*
- *The contractor's contact information.*

Question 4: Can I do this on my own property?

Residential mosquito control products are available for purchase at local stores. The use of commercial pesticides on private land now requires a Residential Applicator Certificate (RAC). Residents do not require a RAC to use Domestic class pesticides on their property. Residents can apply pesticides listed on Schedule 2 and 5 without a RAC. The RAC is free to obtain on-line, see www.mytrainingbc.ca/homepesiticideuse/ for more information.

It is extremely important that residential treatments ONLY occur in self-contained and man-made bodies of water. This could include constructed ornamental ponds, un-used pools, or other reservoirs located and constructed solely on the related property. Water bodies that are connected to a natural environment should be reported to local authorities who can assess the need for, and appropriateness of, treatments.

Question 5: Where are the Aquabac® treatments applied?

Aquabac® (*Bti) treatments may be applied within the client's purview, with compliance to the product label, provincial legislation, and regional legislation. These treatments primarily take place in floodwaters associated with the freshet.*

Question 6: Do land owners have the right to refuse Aquabac® treatments?

Land owners have the right to refuse access.

Question 7: I do not want/will not allow Aquabac® treatments on my property, are there any alternatives?

The most effective control method for mosquitoes around a residence is to reduce, remove, or refresh standing water where mosquitoes can breed. Specifically:

- *Empty water in old tires, buckets, toys, and flower pots*
- *Refresh water in bird baths, fountains, wading pools and animal dishes at least every 3 days*
- *Clean roof gutters and ensure proper drainage*
- *Fix leaky sprinklers and outside faucets*

Question 8: When Aquabac® is applied by helicopter in high traffic areas, how will residents be warned?

Treatment notices will be posted prior to treatment and will remain on site for a minimum of 1 week. The posted public notice will include the following information:

- *The trade name and active ingredient of the larvicide;*
- *The date and time of the larvicide treatment;*
- *The purpose of the treatment;*
- *Precautions to be taken to prevent harm to people entering the treatment area;*
- *The PMP confirmation number and*
- *The plan holder(s) contact information.*

Question 9: How is Aquabac® applied?

MBL qualified technicians use back pack blowers and helicopters to apply Aquabac®.

Question 10: How long does it take for Aquabac® to have an effect on larval mosquitoes?

- *Larval mosquitoes are affected within hours of Aquabac® exposure.*
- *Within 48 hours, the efficacy rate is between 85-100%.*

Category 2: Personal Non-Target Effects

Question 1: Will Aquabac® (Bti) harm my pets?

- *Because Bti targets certain larval Dipteran species (mosquitoes, biting flies, fungus gnats), it is highly unlikely that pets will be harmed from Bti exposure.*
- *When tested on lab animals, acute oral and dermal LD_{50}s (median lethal dosage where 50% of the test subjects are killed) were all greater than the highest dosages tested. These dosages are far greater than those likely to be experienced in the field.*

Question 2: Could Aquabac® treatments harm humans?

Toxicological studies indicate an extremely low toxicity profile where test animals are concerned (See Question 1, above). To be registered for use in Canada, products must be proven to be non-toxic to test animals at label-specified application rates. Allowable human exposure rates are 10-fold less than the No Observed Adverse Effect Levels (NOAEL) established for test animals, leaving a large buffer for potential inter-species differences between test animals and humans.

Question 3: How far away and for what length of time should people be from Aquabac® treated sites?

Safe distances for the public to maintain are suggested during aerial treatments to avoid being hit by small corn granules impregnated with Bti spores. However, there is no toxicity-based reason to avoid the area. Additionally, there is no restricted-entry interval (REI) for microbial pesticides, such as Bti. As such, the public may be in the treatment area during back-pack application or immediately following aerial application.

Category 3: Environmental Effects

Question 1: How does Aquabac® directly affect non-target aquatic invertebrates, fishes, terrestrial invertebrates, birds, and terrestrial vertebrates?

- *Aquatic organisms: Aquatic organisms (non-target inverts & fishes) are generally not affected by Bti exposure.*
- *Terrestrial invertebrates: Bti is considered non-toxic to the majority of terrestrial invertebrates. However, certain studies have shown impacts on some Lepidoptera (butterfly) when in their larval form and some Nematode eggs (although certain Nematode species' eggs increased following Bti exposure). It is important to consider the low likelihood that Lepidoptera larvae will be exposed to Bti at the rate required to illicit negative impacts.*
- *Birds: No toxic effects with exposure tests.*
- *Terrestrial vertebrates: Toxicity tests on lab animals, acute oral and dermal LD_{50}s (median lethal dosage where 50% of the test subjects are killed) were all greater than the highest dosages tested. These dosages are far greater than those likely to be experienced in the field.*

Question 2: How long does Aquabac® remain active in the water?

The field half-life for Bti in water ranges from approximately 4 hours to 5 months, depending on UV exposure and organic content of the water. The higher the UV exposure, the shorter the half-life. The higher the organic content, the longer the half-life. The great majority of Bti spores will become ineffective within 24 hours of application in a field setting using Aquabac® - the primary product utilized by MBL. Other products may allow for Bti spores to be continuously released in the water column for up to 30 days.

Question 3: What is the soil half-life of Aquabac®?

Bti is a soil-borne bacterium, so is naturally found in soil environments. However, in its active form, it can persist for months in basic soil conditions. Bti's toxin proteins are rapidly broken down in soils with a pH < 5.1.

Question 4: What is the mode of action for Aquabac® (Bti)?

The mode of action for Bti is relatively simple and with a high degree of species specificity. Receptors within the mid-gut region of the mosquito larvae are specific to the toxin proteins that are produced alongside each bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs because of cleavage of the protoxins by mid-gut proteases. This event causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert 2000).

Question 5: If I notice any effects that I think might be connected to an Aquabac® treatment, who should I contact?

Should an individual feel that they, or their pet, have been affected by a treatment, then they should see their doctor. It is extremely unlikely that any malady is related to the treatment, but worth seeing a certified medical practitioner for clarification (and to determine what the cause may be so a treatment can be offered). The affected individual needs to have information about the application from the contract applicator (product name, where the larvicide was applied, when, etc.). If more information is needed, then they should contact the Operations Program Coordinator at MBL for specific information surrounding the potential indirect or non-target effects of the larvicide. If the person wishes to contact someone beyond MBL, they should be directed to contact Health Canada and report a pesticide incident. If a sufficient amount of information has been provided, Health Canada can determine whether or not the effect is due to that product's exposure. The forms can be found at: http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/incident/index-eng.php

Category 4: Registration and Permitting

Question 1: Who registers pesticide products in Canada?

- The Pest Management Regulatory Agency regulates all pesticides and pesticide applications in Canada under the Pest Control Products Act.

Question 2: Where can I go to get more information on the product?

- Health Canada's Public Registry has information on all registered pesticides and the pesticide regulatory system. https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/public-registry.html

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Frequently Asked Questions

Floodwater Mosquito Biology and Disease Transmission

MorrowBioScience Ltd.

Updated: 10 April 2020

MorrowBioScience Ltd

Updated: 10 April 2020

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Category 1: Mosquito Ecology

Question 1: What type of mosquitoes are controlled by Morrow BioScience Ltd (MBL)?

Most mosquito control program operated by MBL focus on one complex of mosquitoes, those that develop in floodwaters, primarily during the Spring freshet (e.g. Aedes vexans, Aedes sticticus). However, certain programs within BC also have snowmelt mosquito species (e.g. Aedes communis). The females of these snowmelt species lay eggs in depressions within the landscape that allow for snowmelt or precipitation to accumulate. Eggs are able to hatch under considerably cooler conditions than those of floodwater or container mosquito species. At this time, MBL does not control mosquito species typically found in containers (e.g. Culex pipiens).

Question 2: Why doesn't MBL control container mosquitoes like those in residential backyards and catch basins?

At this time, MBL doesn't focus on treating containers (i.e. catch basins, bird baths, gutters, old tires, etc.) to control container mosquito species primarily because besides catch basin habitats, most of the container mosquito development sites are located on private property. While sometimes producing enough mosquitoes to create very localized annoyance, they don't create broader nuisance levels. Although MBL doesn't specifically target container mosquitoes, field and outreach staff have developed messaging aimed at informing residents of proactive measures that can reduce container mosquito habitat around their homes. Measures include refreshing stagnant water daily during the height of the season, ensuring gutters are cleaned and not holding water, removing old tires, covering rain barrels with a fine mesh to prevent mosquitoes from accessing, and many more.

Question 3: What conditions need to be present for floodwater mosquitoes to hatch?

Floodwater mosquito eggs are triggered to hatch when submerged by fresh floodwaters, typically occurring as a result of the Spring freshet in BC. As water warms up in the late spring, larvae develop faster.

Question 4: What environmental factors in BC govern floodwater mosquito development?

Tracking environmental factors that affect the flooding capacity within an area are important. Flooding in BC typically occurs in the Spring as a result of the Spring freshet from snow basins contributing to local rivers. Snowpacks vary inter-annually. When snowpacks in contributing basins are low, the freshet usually follows suit and when they are high, the freshet is comparatively high. A high freshet means more mosquito eggs may be activated to hatch,

especially if previous seasons' freshets resulted in low local river levels. Snowpacks in BC are assessed by automated snow weather stations throughout the year and can be found at: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data.

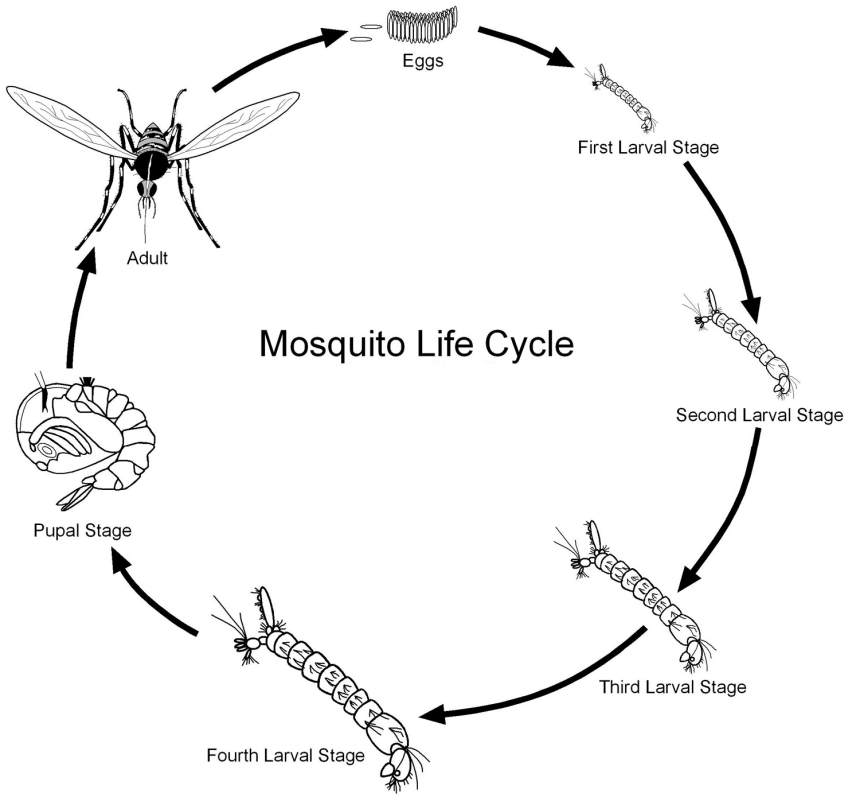
Significant temporally and spatially concentrated precipitation accumulation may also elevate local river levels. Local precipitation can temporarily increase seepage site levels, where considerable mosquito development habitat is located. Thus, tracking local precipitation accumulation can aid MBL field staff with determining how long mosquito development sites may require management. Local weather station data can be found at: https://climate.weather.gc.ca

Question 5: Why are adult mosquitoes most abundant after the peak in local rivers?

Peak river levels represent the time at which the majority of floodwater mosquito eggs have been triggered to hatch for the season. The time from when an egg hatches to emergence and dispersal is typically 2-3 weeks (although this is highly dependent upon water temperatures). So even as local river levels are receding, mosquito development may still be taking place. Adult floodwater mosquitoes are strong enough to disperse from their hatch site quickly and are able to fly multiple kilometers in search of a blood meal. Significantly warm weather increases the rate at which a mosquito develops and may lead to more aggressive activity toward the end of a mosquito's lifespan.

Category 2: Mosquito Development

Question 1: What is the lifecycle of floodwater mosquito species within the program area?



Source: North Shore Mosquito Abatement District (https://www.nsmad.com)

Floodwater mosquito eggs are laid in the damp substrate along floodwater corridors. Flooding along with other appropriate environmental triggers (i.e. sufficiently warm, low dissolved oxygen) allow for the eggs to hatch into larvae. The larvae go through four aquatic instar stages, which are also the primary feeding stages, prior to developing into pupae (i.e. non-feeding stage). Pupae then emerge into adults. The development process can take as little as four days in some species to as long as two weeks. Development times also depend on ambient and aquatic temperature, with warmer water resulting in accelerated mosquito development.

Question 2: At what life stage are mosquitoes targeted for control?

MBL does not conduct adult mosquito control. Adult control requires the use of pesticides with considerable indirect and non-target effects. Instead, MBL targets the larval stage of the mosquito. Mosquito larvae are the feeding stage of the life cycle, which makes the larval instars particularly susceptible to larvicides dependent on ingestion. Specifically, the 3rd and early 4th

larval instars are the target of MBL's floodwater mosquito control program. The feeding rate increases within the 3rd and early 4th instar stages, making the larvicide more effective. Additionally, the 1st and 2nd instar larval stages are left as biomass in the aquatic ecosystem to support the food web. This strategy helps with limiting the frequency of treatments and supporting as robust a food web as possible.

Question 3: How far can mosquitoes fly from their hatch site?

Maximum flight distance from hatch site varies widely dependent upon species. A common floodwater, Aedes vexans, may fly greater than 4 km from their hatch site, on average. The main implication of these data is that uncontrolled mosquitoes may impact people from distances farther than 4 km, in some circumstances. MBL endeavours to reduce mosquito annoyance to residents in all areas within the contract purview.

Category 3: Disease Transmission

Question 1: What diseases can mosquitoes transmit in Canada?

In Canada, mosquitoes have been shown to transmit West Nile virus, Eastern Equine encephalitis virus, and California serogroup viruses. West Nile virus is the most widely distributed vector borne disease in North America. As the climate in Canada becomes warmer, the environment is more hospitable to additional vectors and associated viruses.

Question 2: Is West Nile virus a concern in BC? What are the most recent levels?

West Nile virus (WNv) is only a slight concern in BC given the relatively few number mosquito pools, birds, horses, and humans who have tested positive. From 1 January – 12 October 2019, one positive human WNv case was detected in BC. In that same year no animals, no mosquito pools, and no birds tested positive for the virus. Certain container mosquitoes, such as Culex pipiens and Culex tarsalis, are primary WNv vectors. Thus, in years and situations where container mosquito breeding is more prolific (i.e. warmer weather), more WNv transmissions may occur.

To reduce WNv exposure through mosquitoes, MBL and the BC Centre for Disease Control urges residents to:

- *remove or refresh standing water daily in the warmer months,*
- *ensure that outdoor plants or containers have a drainage hole,*
- *clear rain gutters of debris and make sure they drain,*
- *turn over wading pools when not in use, and*
- *install screens on windows and doors.*

Question 3: Where can I go to find more information about West Nile virus?

Health Canada maintains a thorough surveillance website, delineating cases by type (i.e. human, animal, mosquito), week, and province from mid-April through October. The Health Canada site also provides health-specific information surrounding WNv. It can be found at: https://www.canada.ca/en/public-health/services/diseases/west-nile-virus.html

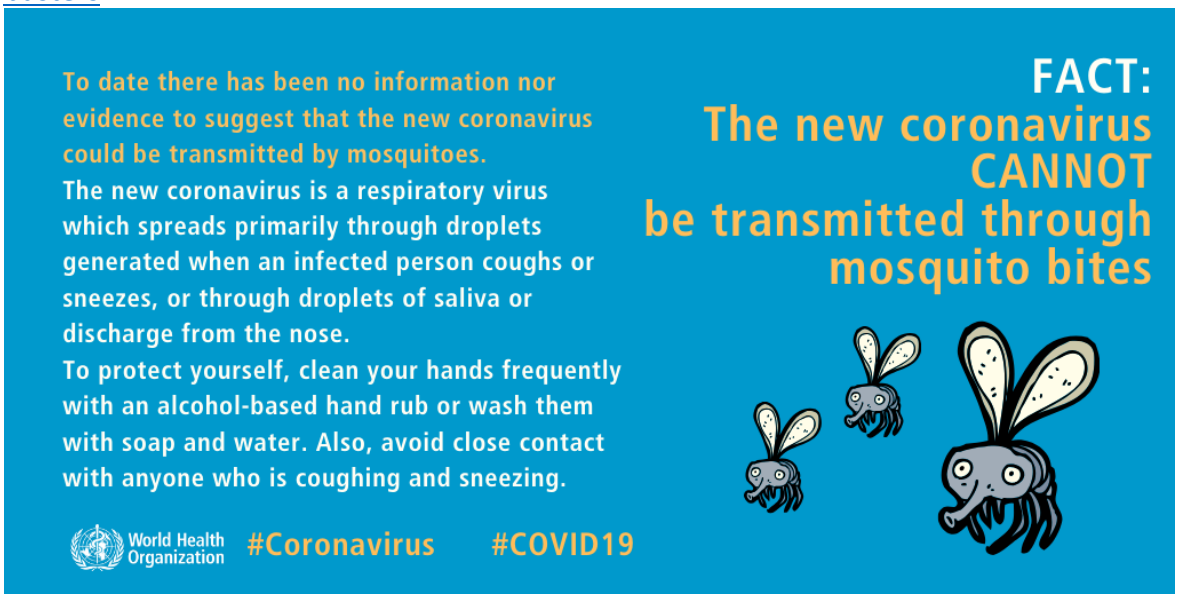
The BC Centre for Disease Control (BCCDC) website also contains health-related information for residents. The BCCDC site has a more detailed map of surveillance activity by region. It can be found at: http://www.bccdc.ca/health-info/diseases-conditions/west-nile-virus-wnv

Question 4: Can mosquitoes act as a vector for COVID-19?

At this time, there is no evidence that mosquitoes are involved in the spread of COVID-19 (SARS-CoV-2). It is thought that the COVID-19 virus may not survive the internal processes of the mosquito. Other supportive evidence for the inability of mosquitoes to act as vectors COVID-19 is that other Coronaviruses have not proven transmissible through mosquitoes.

Question 5: Where can I go to learn more about potential vectorization of COVID-19 in mosquitoes?

The Center for Disease Control addresses the potential for vectorization of COVID-19 in mosquitoes: https://www.cdc.gov/coronavirus/2019-ncov/faq.html
The World Health Organization also addresses this question:
https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters



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