Regional District of Columbia Shuswap
Golden and Area 'A'
Mosquito Control Program

2022 Year-End Report

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Executive Summary

Morrow BioScience Ltd. (MBL) has now completed the first year of a five-year contract term as mosquito control contractor for Electoral Area A and the Town of Golden within the Columbia Shuswap Regional District. The mosquito control program reduces snowmelt and floodwater mosquito abundance within all areas of the project purview.

In April, immediately preceding the mosquito monitoring season the snowpack in the Upper Columbia Basin contributing to the Columbia River and Kicking Horse River was higher than normal. The snowpack was augmented in April and May, with cooler-than-average temperatures lending to a freshet delay of 2-4 weeks. In late-May, a strong ridge of high-pressure within the Upper Columbia Basin largely initiated the 2022 freshet. Below-normal precipitation did not likely impact Columbia River or Kicking Horse River levels for most of the 2022 season, but may have slightly augmented peak river levels due to high precipitation accumulation on peak river level days, specifically. Warming ambient temperatures within the Upper Columbia Basin in late May caused low and middle-elevation snowmelt. Late June ambient temperature spikes caused residual middle and high-elevation snowmelt to occur, leading to the peak in the Kicking Horse River on 5 July (4.715 m) and the peaks in the regional Columbia River shortly thereafter on 6 July (Donald gauge; 4.714 m) and 7 July (Nicholson gauge; 3.665 m). The 2022 Columbia River peak was lower than the 2021 peak despite record high snowpack in the Upper Columbia Basin. The prolonged melting period led to moderate and steady water input to regional rivers. As such, there was a lack of compounded mosquito eggs triggered to hatch in 2022.

Larval mosquitoes were treated between 13 April and 23 July. The total mosquito habitat treated by ground and air was 1,438 ha (8,542 kg) in 2022. MBL treated 408 ha less in 2022 than in 2021 – a higher water year. No known sites were missed in ground-based or aerial treatment efforts. A total of four aerial treatments were required in 2022. Aerial treatments were conducted on 13, 21, 29 June and 12 July. Aerial treatments book-ended the initial and primary Columbia River peak (Donald gauge). At all known sites, efficacy was assessed as high. A real-time monitoring and treatment data dashboard was provided to the CSRD program manager. The dashboard enabled the manager to view up-to-date treatment information and ensure quality control.

Concern call volume from residents was lower than previous years at 1, with 2 concern emails received from residents. These calls and emails were likely the result of mosquitoes dispersing from peak Columbia River and Kicking Horse River levels in early July. MBL staff responded to the call and emails within 24 hours of receipt. The BCCDC has not reported human cases of West Nile virus or Zika virus yet. West Nile virus data are expected from the province in late-December.

Communications with program residents remains a priority for MBL. With the approval of CSRD staff, MBL staff developed and circulated a press release for local media in June. In response, the Golden Star published a story utilizing the facts from the media release on 24 June. In addition, a total of five TV and radio interviews were given between June 20 and August 18, which were widely broadcast. While not specific to the Area 'A'/Golden

program, the interviews provided advice specific to personal protective measures and mosquito habitat reduction tips. The 2 June Facebook post on MBL’s social media sites regarding Area ‘A’ reconnaissance conducted by MBL staff resulted in a high reach. The reach of social media posts continues to increase annually, meaning that more residents around Area ‘A’/Golden may be aware of and engaged with mosquito abatement efforts.

Adult mosquito trap results and analysis from an associated, but independent, contract will be reported separately. Work with the Provincial Parks to explore treatment of mosquito development habitat located within Burges James Gadsden Provincial Park.

Season Highlights

- The snowpack in the Upper Columbia Basin was 115 % of normal in April, immediately preceding the floodwater mosquito season.
- La Nina weather patterns augmented the snowpack in contributing basins through May.
- The freshet was delayed by 2-4 weeks.
- The peak in the Kicking Horse River occurred on 5 July (4.715 m)
- The peaks in the regional Columbia River occurred on 6 July (Donald gauge; 4.714 m) and 7 July (Nicholson gauge; 3.665 m)
- The 2022 Columbia River peak (Donald gauge) was approximately 0.21 m lower than the 2021 peak.
- Monthly local precipitation accumulation for the season ranged from 4 - 28 mm below average and likely did not significantly augment regional river levels for most of the season.
- High precipitation input on the days the rivers were peaking may have further elevated river levels beyond the freshet-caused levels.
- Lower larval abundance was observed in 2022 due to lower regional river levels.
- Four aerial campaigns were required within the Area ‘A’/Golden mosquito program purview.
- Floodwater mosquito habitat associated with the Columbia River and Kicking Horse River was aerially treated 13, 21, 29 June and 12 July.
- Total area treated by air was 1,395 ha (8,372 kg granular Aquabac®)
- Total area treated by ground was 42 ha (170 kg granular Aquabac®)
- A total of 1 concern call were received to the Mosquito Hotline in 2022.
- A total of 2 concern emails were received by MBL.
- MBL circulated a CSRD-approved media release to local radio and print newspapers in early June, which resulted in print news report about the mosquito control program on 24 July (Golden Star)
- MBL staff gave five interviews to provincial media, including CBC, CTV, and Global News. Information pertaining to personal protection and habitat reduction were relevant to Area ‘A’/Golden residents.
- The BCCDC has yet to provide an update on West Nile virus cases in the province, but a report is expected in late-December.
- Relatively low levels of WNv activity were reported in Washington State and Idaho State following a cooler-than-normal spring and early summer.

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Introduction

Morrow BioScience Ltd. (MBL) is the longest-operating mosquito control firm in British Columbia, having conducted mosquito control in this province for nearly four decades. MBL has been the mosquito control providers for the Electoral Area A – Town of Golden (Area 'A'/Golden) within the Columbia Shuswap Regional District (CSRD) since 2012. In 2022, MBL started a renewed five (5) year contract to provide mosquito control to the residents of Area 'A'/Golden.

The extensive mosquito habitat, program reach, and interannual regional river peak variations make the Area 'A'/Golden mosquito control program complex. However, throughout MBL's contract tenure with this program, MBL staff has acquired thorough knowledge of the area and how Area 'A'/Golden-specific environmental conditions affect mosquito development sites. In addition to having built a program knowledge base, numerous improvements have been made to the program since its inception, including:

- comprehensive site survey along floodplain benches,
- identification of new mosquito development sites,
- the addition of a real-time data collection and review portal,
- increased public engagement through social media, radio and in-person events,
- improved environmental awareness of program impacts through annual carbon offset purchases, and
- increased community involvement through MBL volunteer commitments.

MBL's goal is to continue to provide effective mosquito control to the Area 'A'/Golden residents, while remaining socially and environmentally responsible.

Carbon Offsets

The spatial reach of the CSRD mosquito program is such that driving is an inevitable requirement. The accumulated mileage over the course of 2022 was approximately 10,805 km (ground transportation only).

As an estimation, the driving requirements for this program results in the production of approximately 2.03 tonnes of CO_2 emissions. To compensate for this addition of CO_2 to the environment, MBL has committed to purchasing carbon offsets. In fulfillment of this commitment, carbon offsets are purchased through the Neighbours United – formerly West Kootenay EcoSociety[1]. When the carbon offsets are purchased, a proof of purchase and certificate from the offset provider will be delivered to the CSRD.

[1] https://neighboursunited.org

Methodology

As large areas of the Area ‘A’/Golden purview are within the Columbia River and Kicking Horse River flood plains, the primary targets of the Golden/Area ‘A’ mosquito control program are floodwater mosquito larvae. Female floodwater mosquitoes (e.g., *Aedes vexans*, *Ae. sticticus*) deposit their eggs on damp substrate that experiences flooding. Within Area ‘A’/Golden, floodwater mosquito development sites primarily exist along the flooding corridor of the Columbia River and Kicking Horse River, including associated seepage sites. When water floods these sites, due to the freshet and/or significant localized precipitation, the result is large-scale floodwater mosquito egg hatching. If more than one season has passed between high-water years, then high river levels may trigger a compounded number of mosquito eggs to hatch, resulting in a compounded number of mosquito larvae. While study results vary, Breeland and Pickard (1967) estimate that *Aedes vexans* eggs can remain viable for up to four (4) years while they await environmental hatching cues.

The secondary target of the Area ‘A’/Golden mosquito program is snowmelt mosquitoes. Snowmelt mosquitoes hatch early in the spring (i.e., April – May in 2022) within the area. Snowmelt mosquito habitats consist of smaller depressions in the landscape where snowmelt mosquito eggs were laid the previous summer. The smaller depressions collect water in the fall and freeze. Just as the site begins to thaw, snowmelt mosquito eggs hatch. These species typically hatch early to ensure their development habitat remains wet from hatching to emergence and also to reduce inter-species habitat competition as they develop (Clements 1992). Certain snowmelt mosquito species begin to hatch at a water temperature of approximately 4°C and can complete development to adult emergence at 10°C (Clements 1992). Snowmelt mosquito development sites are mainly located along the mountain benches within Area ‘A’.

MBL field technicians begin monitoring all known mosquito development sites within Area ‘A’/Golden as the snowmelt sites begin to show signs of thawing. Mosquito development sites are adaptively managed, meaning that the regional river levels and environmental conditions largely dictate frequency of visits, as opposed to a prescribed monitoring schedule. At the height of the mosquito season, MBL staff may monitor highly productive sites multiple times a week. Adaptive management techniques allow MBL staff to most accurately time treatments, if necessary. Prescribed monitoring methods increase the risk of missing optimal treatment windows due to accelerated mosquito development rates with rising temperatures (Read and Moon 1996). Hence, as regional river levels and ambient temperatures begin to rise consistently, monitoring efforts increase.

Image 1. Standard dip (350 ml) with 3rd and 4th instar floodwater mosquito larvae.

Larval mosquitoes in sufficient number (i.e., >4/dip; Image 1) are treated by applications of a microbial larvicide product, Aquabac®. This product has the active ingredient *Bacillus thuringiensis* var. *israelensis* (Bti). In 2022, only the granular formulations of Aquabac® was used, which is carried on a corncob mixture. The mode of action is relatively simple and with a high degree of target species specificity. Receptors within the mid-gut region of the mosquito larvae are compatible with 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 causes damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert 2000).

As the season progresses and more mosquito development sites become either flooded or thawed, it is increasingly difficult to treat sites by ground due to access challenges and concurrent site activation. At this point, a helicopter is used to conduct aerial treatments. The aerial treatments use the same pesticide as ground applications, although typically with a higher application rate to permeate canopy cover. High water years may require 2-day aerial treatment campaigns (treatment of the entire Area ‘A’/Golden region). All sites are checked within 1 or 2 days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted.

It is important to time treatments according to the correct stage of larval development (i.e., 3rd and 4th instar). If treatments are applied too early, the larvae will not have advanced to their highest feeding rate yet and if applied too late, the larvae molt into pupae (i.e., non-feeding stage). Both circumstances may result in the development of adult mosquitoes. Additionally, by waiting until mosquito larvae are in the 3rd and early 4th instar stages, early instar larvae are available as food sources within the ecosystem. When flooding commences and ambient temperatures rise, many dips easily exceed this threshold. Larval densities within the range of 200-500 per dip are commonly detected (Image 1).

Environmental Conditions

The three primary environmental conditions that affect floodwater or snowmelt mosquito larval production throughout the mosquito season (i.e., April – August) within Area 'A'/Golden are: 1) local ambient temperature and ambient temperature in the snow basin contributing to either the Columbia River or Kicking Horse River, 2) local precipitation, and 3) the snowpack in the Upper Columbia Basin. Each condition provides insights regarding floodwater or snowmelt mosquito egg hatching onset, development rate, and success. As such, all noted conditions are tracked throughout the season.

Snowpack

Floodwater mosquito abundance within Area 'A'/Golden is largely governed by the regional Columbia River, measured at the Donald (ID: 08NB005) and Nicholson (ID: 08NA002) gauges. The Kicking Horse River (ID: 08NB006) also contributes water to the Columbia River near the Town of Golden, affecting down-stream flows. The water levels of those systems are governed by the snowmelt released from Upper Columbia Basin. When snowpack within the Upper Columbia Basin exceeds 100 percent of normal, higher-than-average Columbia River and Kicking Horse River levels are expected during the mosquito season. Similarly, high ambient temperatures within contributing basins can compress the melt timeline, resulting in high regional river levels even if the snowpack in those basins does not exceed 100 percent.

On 1 April, immediately preceding the 2022 Area 'A'/Golden mosquito monitoring season, the snowpack within the Upper Columbia Basin was 115 percent of normal. The greater-than-normal snowpack was likely a result of the impacts of the La Nina weather pattern that was in place during the spring of 2022. The 2022 snowpack heading into the mosquito season was higher than that of 2021. As is consistent with La Nina weather patterns in British Columbia, unstable weather within the Upper Columbia Basin throughout April and most of May resulted in considerable snowpack augmentation. These circumstances led to a delayed freshet. A short-lived ridge of high pressure in early May caused the initial, but inconsequential, pulse of the freshet. Subsequent weather patterns slowed the freshet and further augmented snowpack until late-May.

The Colpitti Creek snow survey station (ID: 2A30P) is the closest station to the program purview (Figure 1). It serves as a representative site for the regional snowmelt trajectory. Over-all, the Snow Survey data show the highest ever recorded Snow Water Equivalent (SWE) values for this station in 2022. Data have been recorded at this site since 1976. Record SWE was recorded from December 2021 – July 2022 (Figure 1). A brief melting stint occurred toward the end of April[2]. Snow station data also show the first measurable melting trend in late-May, with the lower and middle-elevation SWE dropping significantly.

[2] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data

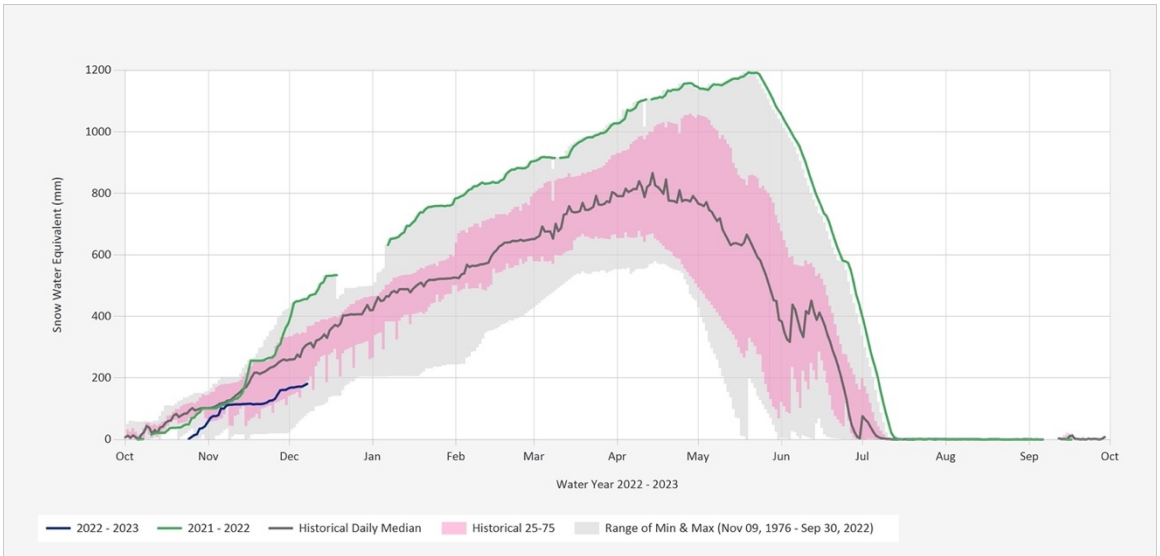

Figure 1. Snow Water Equivalent (SWE; mm) data from the Colpitti Creek snow survey (station ID: 2A30P) within the Upper Columbia Basin (green line).

Warming weather caused the consistent reduction in SWE at the Colpitti Creek snow survey station until mid-July, when the snowpack at this survey station was depleted (Figure 1). Other snow survey stations throughout the Upper Columbia Basin show similar trends[3]. Thus, by mid-July any fluctuations in the regional Columbia River and Kicking Horse River levels were likely not due to regional snowmelt contributions.

In normal years, by 15 June most of the snowpack has melted within the Upper Columbia Basin. However, despite warming ambient temperatures in the Upper Columbia Basin during early June, snowpack was still relatively high through mid-June. The 15 June snow basin index for the Upper Columbia Basin was 212 percent of normal[4]. This relatively high value reflects the abnormality of snow remaining in the basin in mid-June. Warming ambient temperatures within the basin continued through June and July, lending to the depletion of snowpack by mid-July.

Generally, the snowpack remained within the Upper Columbia Basin for approximately 2 weeks longer than normal. The late-season input of water to the Columbia River and Kicking Horse River impacted the length and intensity of the mosquito control season within Area 'A'/Golden. The 2022 Columbia and Kicking Horse River freshets were set apart in two ways: 1) the historically high snowpack within the Upper Columbia Basin and 2) the prolonged snowmelt. Both features led to higher-than-normal and sustained Columbia and Kicking Horse River levels through late-July, when increased mosquito egg hatching cues were more abundant within the program purview.

Local Precipitation

Substantial temporally and spatially concentrated precipitation accumulation may elevate regional Columbia River levels, Kicking Horse levels, and increase seepage site levels.

[3] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=c15768bf73494f5da04b1aac6793bd2e

Tracking local precipitation accumulation can aid MBL field staff in determining how long mosquito development sites may require management. The Golden Airport weather station (ID:1173220) provides both historical precipitation accumulation averages (i.e.,1981 – 2010) and current-year totals, allowing for the comparison between the two. This comparison facilitates some level of prediction regarding larval mosquito hatching and treatment timing requirements. When more than average precipitation is received within peak hatching months, seepage site levels may be higher or sustained for longer. Both scenarios may lead to additional floodwater mosquito egg hatches.

The precipitation received to the Golden Airport weather station (ID: 1173210) from April through August was lower than the monthly station average (1981-2010; Figure 2). Thus, it is likely the precipitation received locally did not measurably impacted Columbia River or Kicking Horse River levels and associated seepage sites for most of 2022. However, a considerable amount of precipitation was received on 4 July, during the time when regional rivers were peaking. It's possible that this specific precipitation event augmented river levels above those that would have been observed due to the freshet alone.

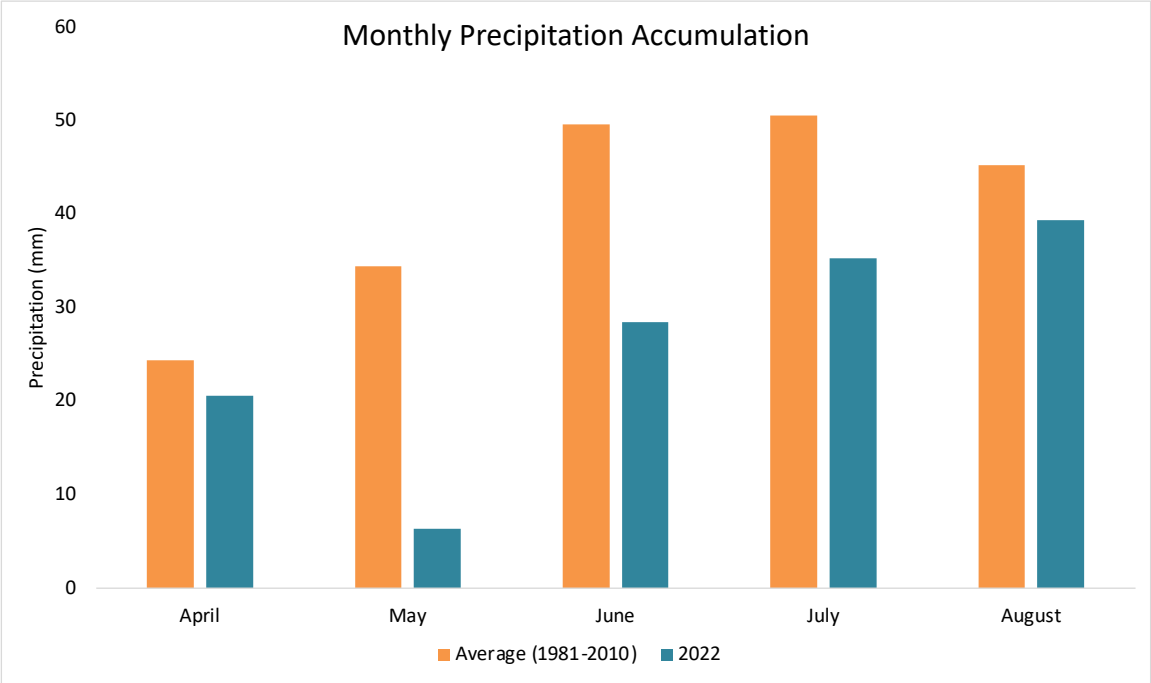

Figure 2. Precipitation values (rainfall and snow accumulation; mm) recorded at the Cranbrook Airport Auto weather station (ID: 1173220) for 01 April – 31 August 2022 (blue) and average station precipitation values (1981-2010; orange).

Precipitation increased in August. Regional precipitation received in August was of little consequence to the Columbia River levels due to the Columbia River size, but may have affected local Kicking Horse River levels as the Kicking Horse River is relatively smaller. It's possible that precipitation received in August created habitat for container mosquito species to reproduce. Thus, adult mosquito presence toward the end of the season was likely due to container mosquitoes dispersing from these sites, not floodwater mosquito species in certain areas.

Ambient Temperature

Local ambient temperature and ambient temperature within the Upper Columbia Basin are important variables to track. Local ambient temperature fluctuations from April through August can affect mosquito egg hatching, larval development rates, adult dispersal, and adult survival within Area 'A'/Golden mosquito development habitat. Within the Upper Columbia Basin, ambient temperature dictates the commencement and often the intensity of the freshet, which directly impacts floodwater mosquito development habitat.

Upper Columbia Basin Temperatures

The 2022 mosquito monitoring season began in April with below-average ambient temperatures within the Upper Columbia Basin. The weather in April was unstable across much of the province [4], with ambient temperatures ranging from 4.5°C - 1.5°C below average. Similarly, ambient temperatures across the province in May were 3°C – 0.5°C below average[5].

Although a short-lived high-pressure system occurred in early May, temperatures remained relatively low and resulted in only a small reduction in snowpack. The first significant spike in ambient temperature occurred in late-May[6]. The spike prompted middle-elevation snowmelt within the Upper Columbia Basin and the consistent rise of the Columbia River and Kicking Horse River levels. Following the brief spike in ambient temperature, the weather within the contributing basin returned to an unstable state for most of June. However, the slow rise in ambient temperatures was sufficient to lead to the slow release of remaining middle and high-elevation snowmelt.

A strong high-pressure ridge was in place over most of the province during the last week of June. This warming stint led to the depletion of high-elevation snowpack within the Upper Columbia Basin, affecting the Columbia River and Kicking Horse River levels. The resulting peak of the freshet culminated in the highest Columbia River and Kicking Horse River levels for 2022 recorded in early July (see 'River Levels' below). Ambient temperatures continued to rise through July and August. However, after the depletion of the Upper Columbia Basin snowpack, ambient temperatures within that basin does not typically impact floodwater mosquito habitat within the Area 'A'/Golden. Ambient temperature data are consistent with 2022 automated snow station data depicting snowmelt points correlating with regional ambient temperature spikes[7].

[4] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_may1.pdf
[5] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_june1.pdf
[6] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_june15.pdf
[7] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data/automated-snow-weather-station-data

Area 'A'/Golden Temperatures

Local ambient temperature is a predictive tool when gauging floodwater egg hatch commencement. If the ground proximate to the Columbia River and Kicking Horse River contains floodwater mosquito eggs and if hatching conditions are present (i.e., low dissolved oxygen, higher ambient temperatures), then floodwater mosquito egg hatching will commence (Mohammad and Chadee 2011). Local ambient temperature data are acquired from the Golden Airport weather station (ID: 1173220).

To illustrate the effect of ambient temperature on floodwater mosquito egg hatching events, Trpis and Horsfall (1969) exposed submerged eggs of a common univoltine floodwater mosquito species, *Aedes sticticus*, to various constant air temperatures and recorded hatching success. Results revealed that eggs began to hatch at 8°C, although larval development was slow and survivorship was low. Eggs held at 21°C provided the optimal temperature, of the five temperatures tested, for hatching and larval development (Figure 3). While *Ae. sticticus* is not the sole floodwater species present in Area 'A'/Golden, it serves as a representative species for our purposes and provides general developmental benchmarks.

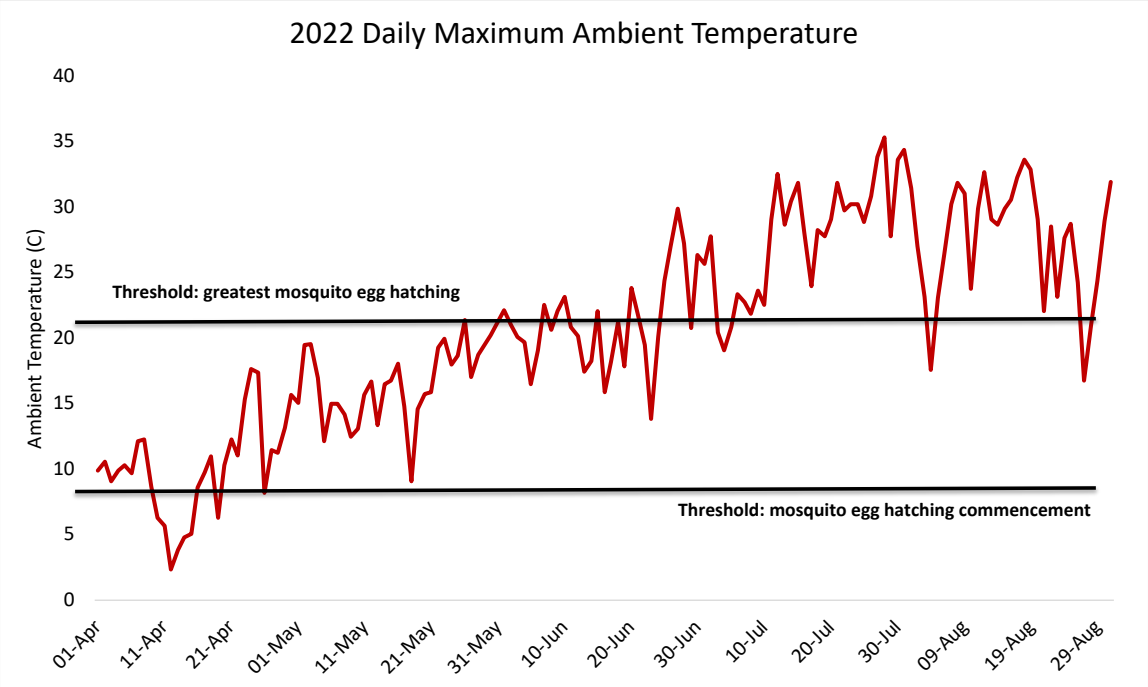

Figure 3. Maximum daily ambient temperatures (C) as recorded at the Golden Airport Station (ID: 1173220) 01 April – 31 August 2022. Lower line illustrates threshold at which *Ae. sticticus* eggs commence hatching; upper line illustrates threshold at which most *Ae. sticticus* eggs hatch.

Snowmelt mosquito eggs hatch earlier than floodwater mosquito eggs. Certain snowmelt mosquito species begin to hatch at a water temperature of approximately 4°C and can complete development to adult emergence at 10°C (Clements 1992). Thus, snowmelt mosquito eggs laid along the Columbia River bench area were triggered to hatch in April as sites began to show initial melting (Figure 3). Of note, Figure 3 shows ambient

temperature, not water temperature. The delay in realized water temperature is likely a few days in relatively small, shallow sites, such as the majority of snowmelt-influenced sites found in along the mountain benches in Area ‘A’/Golden.

Within Area ‘A’/Golden, the 2022 season began with lower-than-average ambient temperatures for April. The 2022 monthly average for April (10 °C) was 3°C lower than the 2012-2021 station average for April (i.e., 13°C). Given that April temperatures frequently dropped below the lower temperature bound for successful floodwater mosquito egg hatching, floodwater mosquito eggs within Area ‘A’/Golden were not likely activated within April if exposed to flooding conditions (Figure 3). If mosquito eggs were exposed to water during this month, the larval development at cooler temperatures would have been slow (Trpis and Horsfall 1969). In contrast, April temperatures were well within the bounds for successful snowmelt mosquito hatching in April. Numerous snowmelt mosquito sites had egg hatching events in April due to these temperatures. Of note, snowmelt mosquito larval development was relatively slow such that most treatments were not required until early May.

Local ambient temperatures in May were relatively warmer and within the temperature range for favorable floodwater larval development conditions for target mosquito species (Figure 3). The average maximum daily temperature for May was 16.6°C, approximately 3°C lower than the historical station average. Despite lower-than-average temperatures, floodwater mosquito egg hatching and larval development rates increased within May, although larval development was still notably slower than normal for that point in the season. Appropriately, larval mosquito treatments increased in mid-May as local ambient temperatures reached the upper bounds of temperatures associated with higher floodwater mosquito hatching success rates.

Ambient temperatures in June were higher than May temperatures and provided sufficient hatching cues for floodwater mosquito eggs exposed to water. Ambient temperatures in early-June were closer to normal, followed by a cooler weather system in mid-June. Although local ambient temperatures cooled in mid-June, other environmental conditions combined with fair temperature cues allowed for large-scale mosquito hatching events. A stint of warm weather occurred in late June and into early July, which contributed additional strong mosquito hatching cues. This stint of warm weather also corresponded with the annual peak of the Columbia River and Kicking Horse River. When river levels peak during periods of higher heat, the result is large-scale mosquito egg hatching events and increased larval development rates. Therefore, because considerable floodwater development sites were at peak levels in late-June and early July, the need to treat mosquito larvae during those times was directly associated with ambient temperature.

As predicted by the Temperature and Precipitation Probabilistic Forecasts for Canada, July and August ambient temperatures were higher than average. Local daily maximum ambient temperatures were 1.7°C and 2.6°C above normal for July and August, respectively. Because the freshet was delayed by 2-4 weeks, there was still considerable floodwater mosquito habitat and activity through July. Warming weather coupled with sufficient habitat farther into the summer meant that floodwater mosquito treatments were required for longer than normal in 2022. High ambient temperatures, such as those noted in later

July and August, increase the lifecycle of adult mosquitoes (Ciota et al. 2014). Thus, any mosquitoes that successfully emerged would have had a reduced lifespan with the heightened ambient temperatures into late August (Figure 3).

While not a target of the Area ‘A’/Golden mosquito control program, container mosquito abundance typically increases in July and August. Container mosquito habitats near residential homes can be created throughout warmer summer months whenever the presence of water is coupled with high ambient temperatures. MBL technicians regularly inform residents that container-bred mosquitoes can be reduced around homes by ensuring conducive environments (i.e., bird baths, kiddy pools, flowerpot holders, etc.) are either free of water or refreshed frequently.

River Levels

Floodwater mosquito development sites within Area ‘A’/Golden are found along the flooding corridors of the regional Columbia River (Donald gauge - 08NB005; Nicholson gauge - 08NA002) and Kicking Horse River (Golden gauge – 08NA006) and within associated seepage sites. As the presence of water is the main hatching cue for floodwater mosquito eggs, springtime and early summer regional river levels provide predictions about the timing and extent of floodwater mosquito egg hatching.

From April through most of May, unseasonably cool temperatures and unsettled weather patterns delayed the annual Columbia River and Kicking Horse River freshets by 2-4 weeks. In early May, a brief stint of seasonal ambient temperatures resulted in a pulse of water that came through the regional river systems from the contributing Upper Columbia snow basin (Figure 4). That pulse was followed by a measurable decline in water levels in the Columbia River and Kicking Horse River until late May. The slow river level increases that began in late May marked the consistent rise of the Columbia River and Kicking Horse River in 2022.

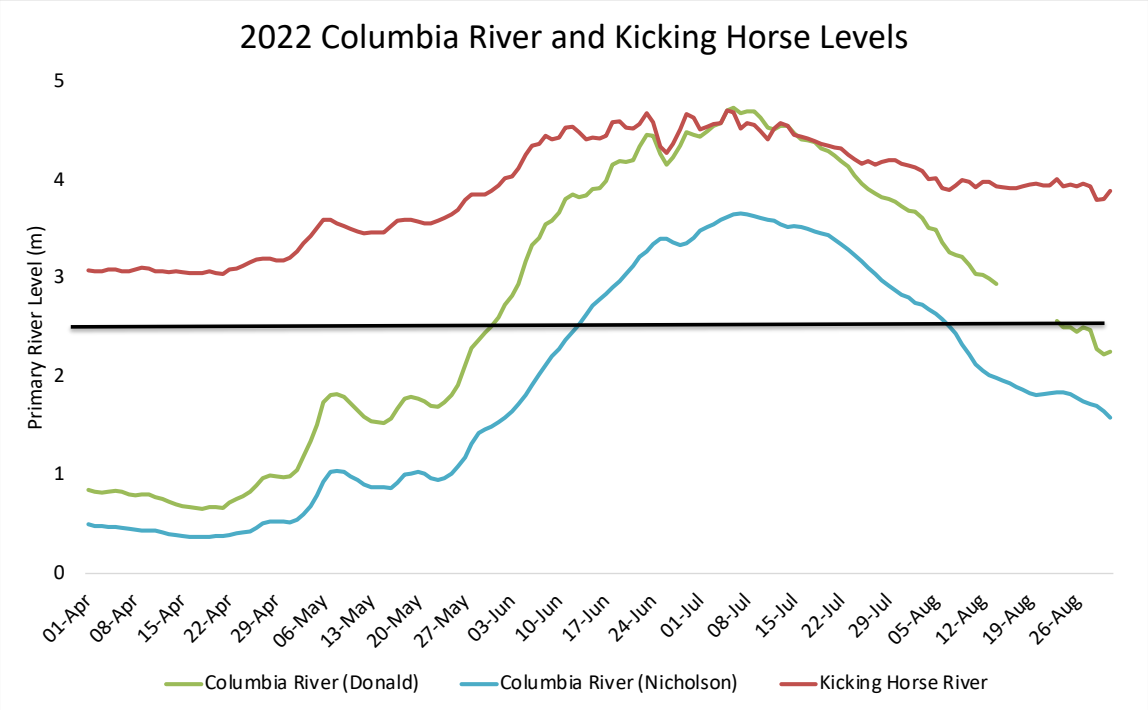

Figure 4. Columbia River (Donald gauge - ID: 08NB005, Nicholson gauge - ID: 08NA002) and the Kicking Horse River (Golden gauge - ID: 08NA006) levels (m) from 1 April – 31 August 2022. Black line indicates the river heights at which most floodwater mosquito eggs are triggered to hatch.

Unsettled weather patterns resulted in cooler-than-average temperatures for May and June, which led to a slower snowmelt and tempered input of snowmelt to regional rivers. Floodwater mosquito eggs laid on substrates at various river levels have optimal environmental cues and adequate time within which to hatch when rivers rise at a slower rate. When river levels rise at high rates, mosquito eggs typically lack sufficient environmental cues due to the pulse of cold, highly oxygenated water moving through the system. Both regional rivers rose at slower rates in 2022. Local floodwater mosquito development sites begin triggering mosquito larvae to hatch when the Columbia River reaches the 2.5 m mark (Figure 4). Thus, beginning in late-May environmental cues were present to trigger mass mosquito hatching events at rising river levels.

A provincial warming trend occurred in late-May and continued through mid-June causing both rivers to experience initial peaks between 23 – 25 June (Figure 4). These initial peaks presented considerable hatching cues for floodwater mosquito eggs, requiring large-scale treatments. Substantial high-elevation snowpack within the Upper Columbia Basin still remained in mid-June. High ambient temperatures in late-June caused the remaining high-elevation snow to melt, contributing towards already elevated regional Columbia River and Kicking Horse River levels. As a result of the late-June warming trend, the peak in the Kicking Horse River was recorded on 5 July (4.715 m). The peaks in the regional Columbia River occurred shortly thereafter on 6 July (Donald gauge; 4.714 m) and 7 July (Nicholson gauge; 3.665 m).

By mid-July 2022, the Upper Columbia Basin was depleted of snow[8]. This depletion corresponded with a marked decline in the Columbia River and Kicking Horse River levels (Figure 4). When the Columbia River levels consistently remain below 2.5 m, associated seepage sites reduce quickly. Thus, in mid-August many of the mosquito development sites were becoming dry.

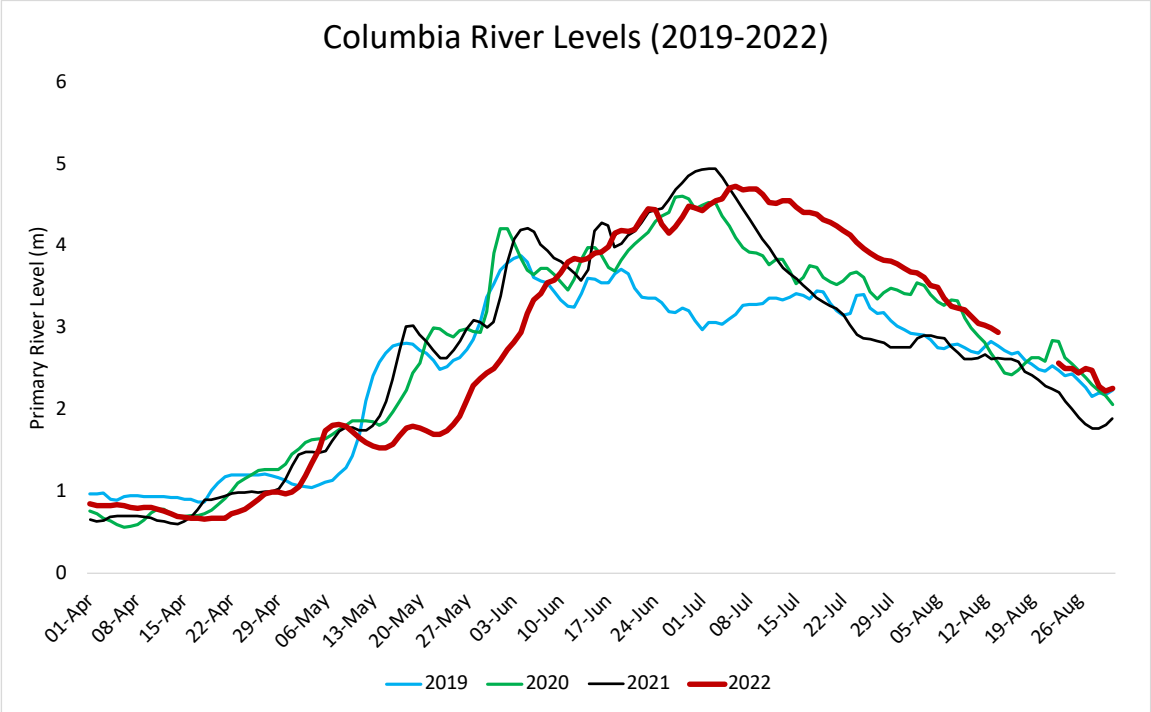

Figure 5. Columbia River (Donald gauge - ID: 08NB005) levels for 2019 – 2022 from 1 April – 31 August.

The Kicking Horse River feeds into the Columbia River at Golden and the Donald gauge is downstream of this confluence. Thus, the Columbia River at Donald gauge provides data for the Kicking Horse River and Columbia River. Comparing data from the Donald gauge through various seasons provides a representative understanding of relative flooding states. The 2022 Columbia River at Donald peak was approximately 0.21 m lower than the 2021 peak (Figure 5). Although regional snowpack was higher in 2022 than in 2021, the prolonged snowmelt of 2022 resulted in a slow supplement to regional rivers. In comparison, the 2021 heat dome resulted in a concentrated snowmelt and contribution to regional rivers.

The current year's peak in the regional Columbia River relative to those of recent seasons is another predictive variable that may help explain a current year's larval abundance. If the current year's peak river levels far exceeded those of the preceding season, mosquito eggs laid between the high-water mark of both years could remain dormant until current-year flood waters trigger their hatching. Because the peak of the Columbia River in 2022

[8] http://bcrfc.env.gov.bc.ca/data/asp/realtime/

was lower than that of the preceding season’s, the peak level noted in 2022 did not trigger a compounded number of floodwater mosquito eggs to hatch. As such, a lower floodwater mosquito larval abundance in comparison to 2021 abundance was noted.

Larval Control

Snowmelt mosquito monitoring begins in the early spring when consistent local snowmelt starts. Snowmelt mosquito development site monitoring began on 13 April. Floodwater mosquito monitoring begins when spring ambient temperatures start to rise steadily in the Upper Columbia Basin, followed by consistently increasing regional Columbia River and Kicking Horse River levels. Consequently, floodwater mosquito development site monitoring began on 10 May. Although most of the floodwater mosquito development sites are not active until the regional Columbia River exceeds 2.5 m, sites were monitored beginning in early-May to evaluate site conditions and catch the leading edge of any potential hatching events that may have occurred with the slowly rising river levels. The relatively warmer ambient temperatures coincided with increased floodwater mosquito development site monitoring and larval mosquito treatments in mid-May.

Appendix I shows a map of average larval densities found throughout the 2022 season. Larval abundance is assessed in the field using a system of ranges (0, 1-4, 5-49, 50+) for early and late instar mosquito larvae. In order to transfer these data to a map (Appendix I), data are summarized and assigned to a hexbin representing an area of 21.65 ha. Only wet sites were included in the analysis. An intensity value representing the relative number and life stage of the mosquito larvae are assigned to each single sample. For each sample, late instar larvae ranges are weighted more heavily than early instar larvae ranges to indicate targeted life stage and treatment urgency. In this way, each sample is assigned an intensity value from 0 to 1. All sample intensity values are then averaged by hexbin. Thus, each hexbin is also assigned an average intensity value from 0-1. The intensity value thresholds within Appendix I denoting ‘low’, ‘moderate’, ‘high’, and ‘very high’ were assigned based on biological significance and operational urgency. Of note, the areas with highest recorded larval abundance amongst known sites are at the confluence of Kicking Horse River and Columbia River at Golden, between the Columbia River and the Trans-Canada Highway throughout Golden proper, near the Columbia River Wetlands RV Park, the Nicholson area, and the Parson area. No new mosquito development sites were identified throughout the Area ‘A’/Golden program purview in 2022.

Hexbins are used to aggregate point data, making general data trends visible at large scales. The primary drawback and disclaimer to hexbin analysis is that generalizations must be made. In general, hexbins denoted as ‘None Detected’ (i.e., white) or ‘Low’ (i.e., light sandy colour) indicate the average sample contained < 5 larval mosquitoes per dip. In most cases, hexbins with a moderate frequency (0.2875 - 0.525 intensity value; light orange colour) or greater indicate those which had an average of > 5 mosquito larvae per dip. Hexbins can contain one or greater sample points, may contain sample points that lie directly on hexbin borders, or contain treatment area associated with a point that is officially housed within a neighbouring hexbin; each of these circumstances may create skewed results.

Relatively lower Columbia River and Kicking Horse River levels coupled with lower-than-average precipitation accumulation resulted in the need for fewer treatments in 2022. A total of approximately 1,438 ha (8,542 kg) were treated within Area ‘A’/Golden in 2022. For comparison, MBL has treated 408 ha less in 2022 than in 2021 – a higher water year. No known sites were missed in ground-based or aerial treatment efforts.

Appendix II is a map depicting where and how frequently treatments took place in 2022. In certain cases, hexbins denoted as ‘Non-Detected’ or ‘Low’ do have treatments associated with them. In these cases, treatments may have been triggered by the larval activity of a representative site. Historically, when representative sites become active the other sites in the area have proven to also be active. Thus, sites with a previous designation of ‘Non-Detected’ or ‘Low’ may require a later treatment due to representative sites’ activity level without the need to sample. However, maps provide a high-level understanding of where treatments were concentrated.

Ground Application Summary

Mosquito development sites within Area ‘A’/Golden are visited on a weekly basis unless conditions required more frequent monitoring (i.e., Columbia River levels > 3m, ambient temperatures > 20°C, large precipitation event). Sites are treated when a standard dip (350ml) collects 5 or more late instar (3rd or 4th instar) larvae per dip. All sites are checked within two days of the initial treatment to ensure high treatment efficacy. If necessary, touch-up treatments are conducted.

The first ground treatment occurred on 13 April (Figure 6). Treatments conducted in the early portion of the season (i.e., 13 April – 13 May 2022) took place at snowmelt sites northeast of Golden and just south of Blaeberry. Treatments conducted on 16 May took place at floodwater-associated sites. Floodwater mosquito development site treatments occurred between 16 May and 26 July (Figure 6).

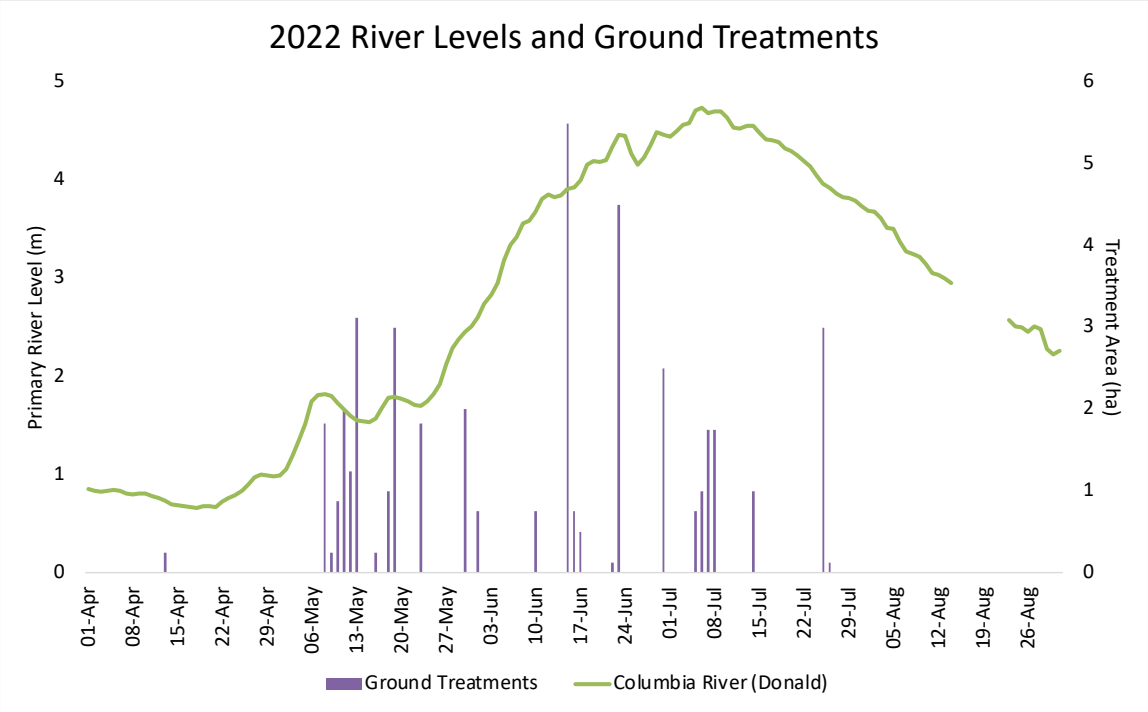

Figure 6. Columbia River levels (m; Donald gauge and Nicholson gauge) with total mosquito development area treated by ground (ha) from 1 April – 31 August 2022. Note ground treatments (ha) are recorded on the alternate y-axis.

Aquabac® (a.i., *Bacillus thuringiensis* var. *israelensis* (BTI)) is the product used for all larval mosquito treatments conducted by MBL. Bti has high target specificity and achieves 95% - 100% efficacy in typical field conditions (Aquabac® Mosquito Biolarvicide - Technical Bulletin). Within Area ‘A’/Golden’s highly organic floodwater mosquito site conditions, MBL staff note an average field efficacy rate of approximately 85%-90%. The granular formulation was used in 2022. The majority of mosquito development sites within Area ‘A’/Golden require 4 kg/ha when treated by ground.

The total area treated by ground in 2022 was approximately 42 ha (170 Kg Aquabac®; 4 kg/ha) (Figures 6, 7). The total area treated by ground in 2022 was 42 ha less than the total area treated by ground in 2021 (Figure 8). This decrease in ground-based treatment area in 2022 is due to the relatively lower Columbia River and Kicking Horse River levels resulting in a lack of compounded mosquito eggs from previous seasons being triggered to hatch. Real-time data associated with each treatment are available through MBL’s client-registered, real-time program portal.

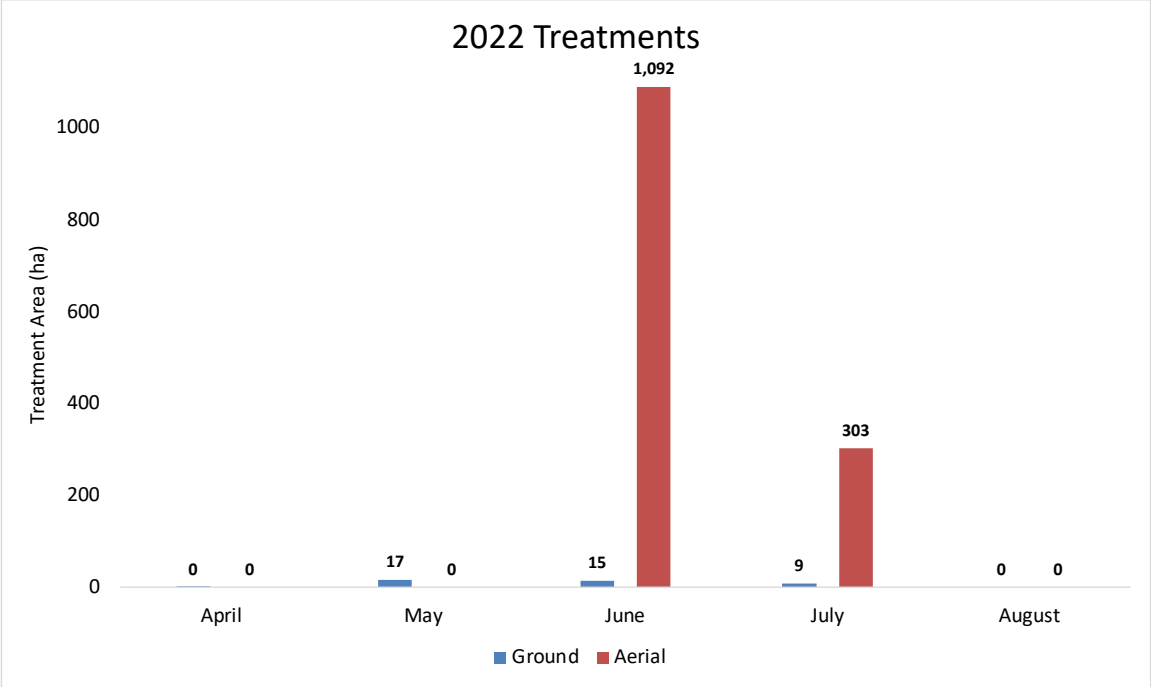

Figure 7. 2022 ground-treated and aerially-treated area (ha) by month from April – August.

Relative to the record-high river levels and condensed freshet year of 2021, floodwater mosquito development habitat was lower in 2022 (Figure 8). The snowpack within influential basins was higher-than-average, but gradually melted starting at the end of May. Those conditions across much of the province led to the slow input of snowmelt to regional river systems through most of June and July. Because river levels were sustained for longer in 2022, treatments were required into late-July.

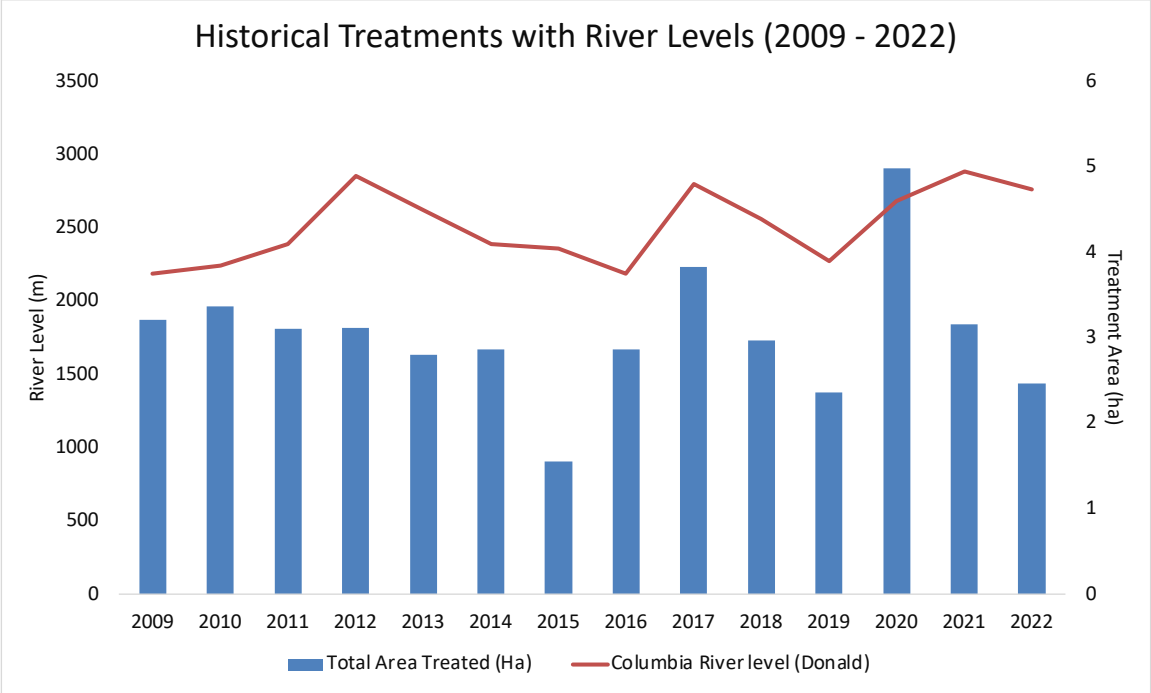

Figure 8. Columbia River levels (m; Donald gauge) with total mosquito development area treated aerially and by ground (ha) for 2009-2022. Note treatments (ha) are recorded on the alternate y-axis.

Aerial Application Summary

Floodwater mosquito development sites are treated by air when multiple large-scale sites become active at once and/or when site-access by ground is unsafe. Four (4) aerial campaigns were required within Area ‘A’/Golden in 2022. Treatments took place on 13, 21, 29 June and 12 July (Figure 9). For comparison, five (5) aerial campaigns were conducted in 2021. The difference in required aerial treatment events signifies the relatively higher abundance of floodwater mosquito larval within the region in 2021 due to higher regional river levels.

Aerial treatments were conducted using granular Aquabac®. To compensate for increased canopy cover, aerial treatments were applied at an average rate of 6 kg/ha. A total of 1,395 ha was treated by air, equating to a total of approximately 8,372 kg of Aquabac® used. Figure 9 shows the aerial treatment events (black) with Columbia River (Donald gauge) levels. Appendix II includes all treatments within each hexbin (i.e., polygons).

Aerial treatment events typically take place immediately after the Columbia River at Donald has peaked because the Bti is able to reach mosquito larvae before they disperse with rising water. As it is difficult to determine exactly when the peak will occur, aerial treatments often bookend a peak. Additionally, when the Columbia River is sustained at high water levels, more floodwater mosquito eggs may have time and abundant environmental cues to hatch. Aerial treatments were conducted around the initial (i.e., 23 June) and primary Columbia River peaks (Figure 9). MBL staff were able to accompany the helicopter pilot again in 2022, which aids in identification and treatment of

inconspicuous mosquito development areas. All treatments successfully controlled targeted floodwater mosquito larvae. Appendix III shows more specific information about site, treatment timing, and extent of treatment.

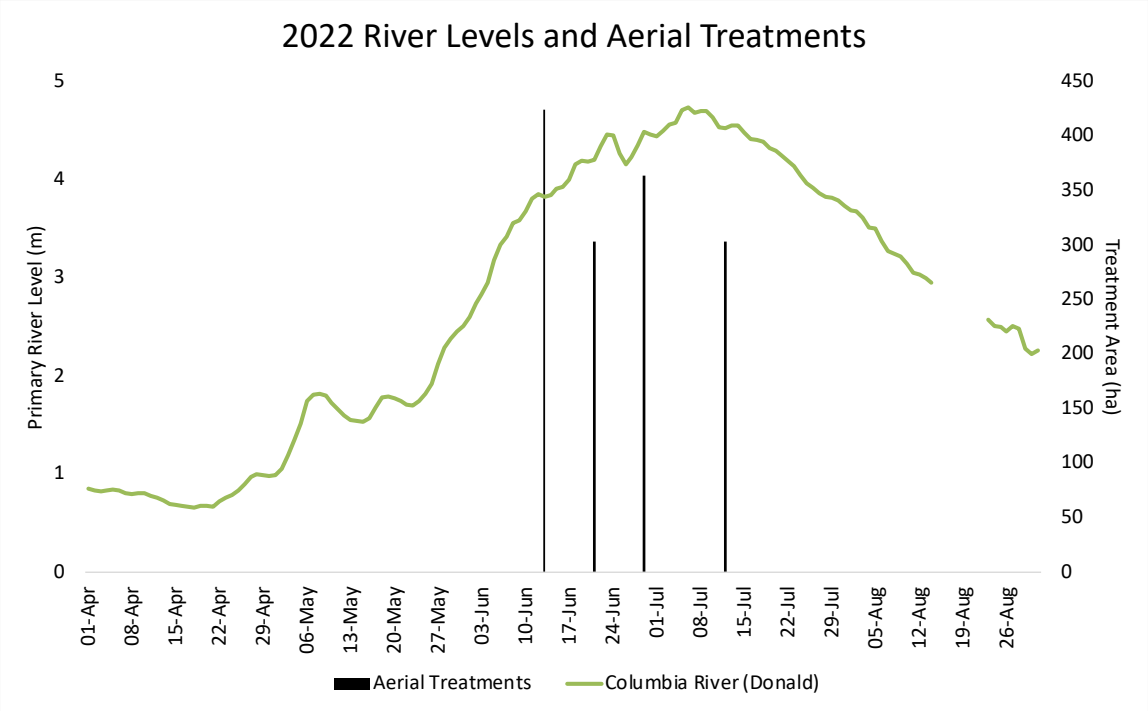

Figure 9. Columbia River levels (m; Donald gauge) with total mosquito development area treated aerially (ha) from 1 April – 31 August 2022. Note aerial treatments (ha) are recorded on the alternate y-axis.

Public Relations

Maintaining positive public relations continues to be a high priority for MBL. Public relations occur on several levels: in-person communication with members of the public, the mosquito hotline, presentations to stake holders, email correspondence, and social media presence. MBL continues to look for new areas to expand this aspect of our program.

Phone Calls and Emails

Area 'A'/Golden residents have multiple venues to communicate with MBL. MBL's Mosquito Hotline (877-986-3363) and email form are outlined prominently on the contact tab of the MBL website (www.morrowbioscience.com). The CSRD has also established a mosquito control website with contact information, FAQ links, and report links[9]. Emails and calls received to the CSRD program manager are documented and forwarded to MBL staff for follow-up.

[9] https://csrd.bc.ca/187/Mosquito-Control

There was a total of two (2) calls received by either the CSRD program manager or directly to the MBL Mosquito Hotline in 2022. A total of two (2) emails were received from Area ‘A’/Golden residents in 2022. All calls and emails are designated as either concern or inquiry-based. One call was designated as ‘concern’ and one call was designated as inquiry-based. Both emails were designated as ‘concern’ notes and forwarded by the Area Director. MBL’s goal is to return all concern calls and emails within 24 hours. While this goal was achieved for most of the season, calls and emails were returned within 72 hours during July 7-12 when call and email volume was at peak levels.

The total number of calls and emails received in 2022 was lower than those received in 2021, likely due to the lower mosquito abundance associated with lower regional water levels. It typically takes 2-3 weeks for mosquitoes to emerge and disperse following hatching events associated with peak river levels. When rivers rise at slow rates in the warmer part of the season, as occurred beginning in late-May this year, mosquitoes may emerge and disperse prior to peak levels. Thus, the potential timeline for mosquito emergence and dispersal in 2022 likely ranged from mid-June through mid-August. Accordingly, hotline calls and emails were concentrated from late-July – early-August. The peak Hotline call and email volume was associated with adult mosquitoes that likely dispersed as a result of the final Columbia River (Donald gauge) peak on 6 July and subsequent high-water levels through early-August.

MBL remains committed to continuing reconnaissance efforts to identify floodwater mosquito development sites, adaptive site management, and expanding in-house knowledge of sites. Expanding public engagement reach may also result in the identification of new sites and reduction of mosquito larvae in the region. Through these efforts, MBL aims to further reduce adult mosquito nuisance within the Area ‘A’/Golden mosquito control purview.

Direct Communications

Direct communication between MBL staff and the public can occur in many situations. The most common direct interfacing with the public occurs when technicians are in the field. While conducting site visits, MBL technicians are often asked questions by residents. These encounters provide an excellent opportunity for public relations. An important outcome of these interactions can be the identification of new sites.

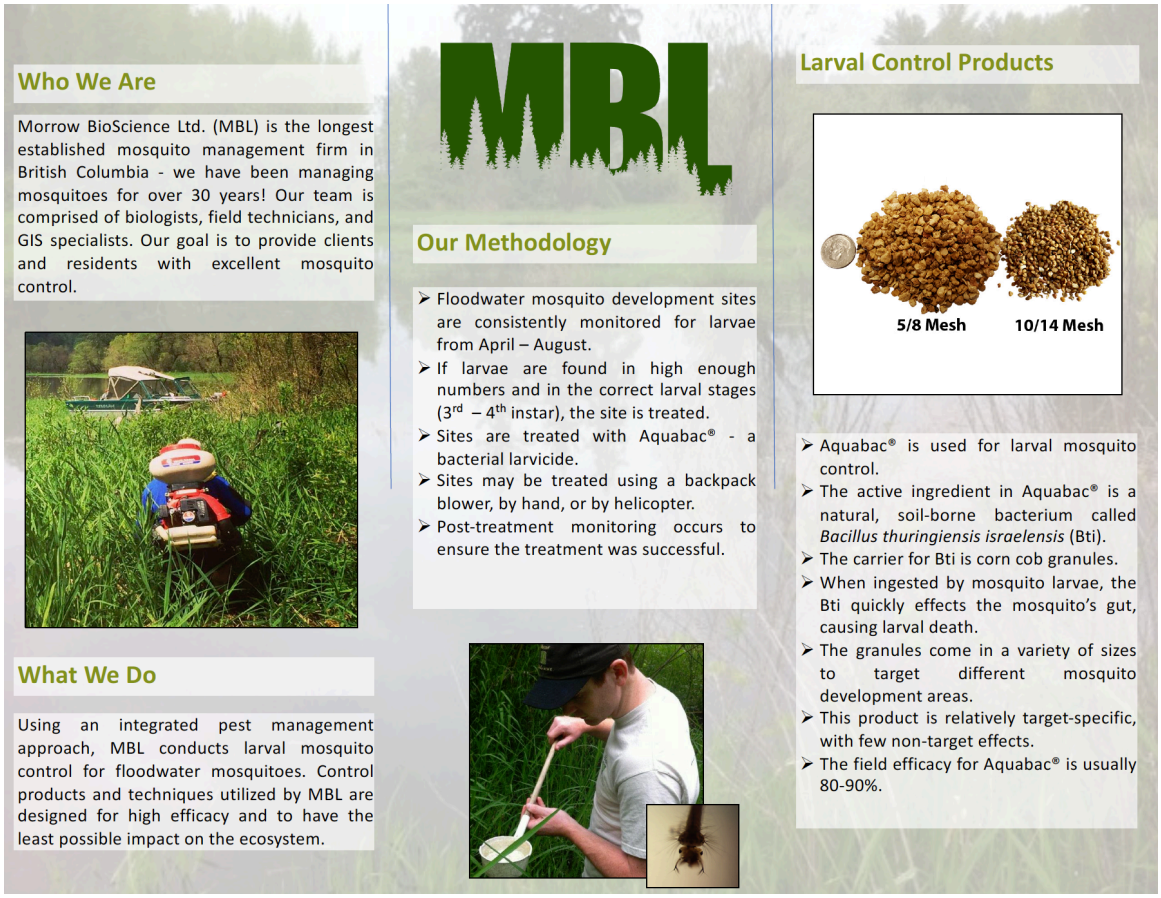

Image 2. MBL education outreach pamphlet.

MBL contact information is disseminated when field technicians have direct communication with the public. Contact information for MBL includes the website address, an email, phone number, and social media sites (Twitter, Facebook, Instagram). Additionally, MBL staff may provide residents with an outreach pamphlet (Image 2). The pamphlet includes information about the larval control product used, mosquito biology, and personal protective tips.

Social Media

MBL maintains a presence on social media with a Facebook account (facebook.com/morrowbioscience), Twitter account (@MoBioScience), and Instagram account (morrowbioscience), which are regularly updated. There are five goals for MBL's social media presence: 1) provide timely and up-to-date information regarding conditions pertinent to mosquito production, 2) relay MBL's current efforts to control mosquitoes, 3) inform the public about MBL's efforts at environmental sustainability, 4) provide the community with opportunities to get involved with related public events, and 5) offer a platform for mosquito-related discussion amongst program residents and the MBL team.

Facebook remains the primary avenue for MBL to disseminate mosquito-related information on social media. Regular updates on mosquito abundance began in early April. The total number of followers on the MBL Facebook page was 387 on 1 December 2022. This number has increased by over 40 since December 2021. Another way to determine

how many people are engaging with MBL’s posts is by considering MBL’s post ‘reach’. In 2022, the maximum reach pertaining to the Area ‘A’/Golden mosquito control program was 1,070 on 2 June and was in response to an update about MBL conducting mosquito habitat reconnaissance within Area ‘A’ (Image 3). All posts related to the Area ‘A’/Golden mosquito program included the hashtag: #CSRDmosquito.

Image 3. Facebook post of Area 'A' mosquito development site reconnaissance (2 June 2022)

MBL Website

The MBL website (**www.morrowbioscience.com**) was launched in 2015 and redesigned in 2021 (Image 4). This site was developed to allow clients and the public to have access to information about MBL’s background, activities, outreach, and company. To further support residents in contract areas, the homepage includes visible tabs for resources and the contact information. The ‘Contact’ tab allows users to directly send a message to MBL. Additionally, there are links to MBL’s Facebook account and Twitter feed, so residents have access to real-time updates on MBL’s activities.

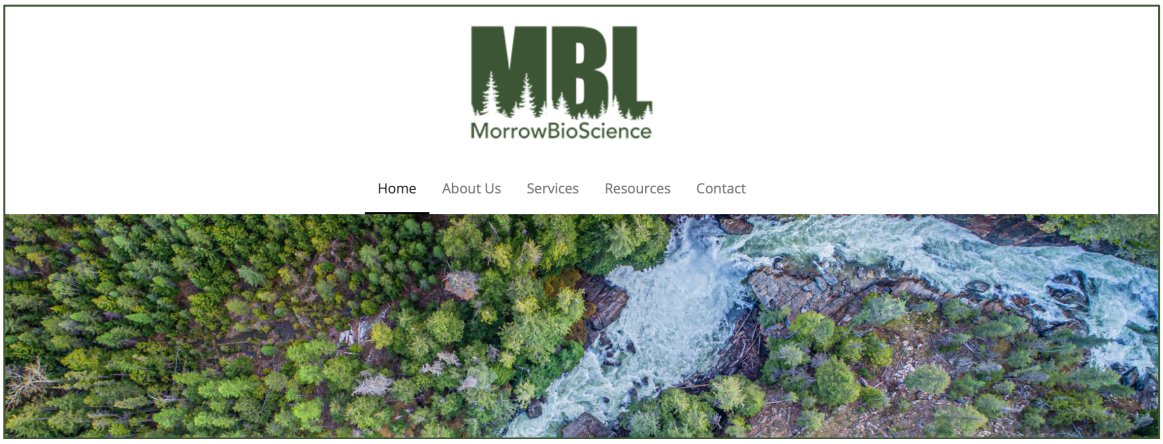

Image 4. Morrow BioScience Ltd. homepage (www.morrowbioscience.com)

The website specifically highlights two sets of FAQs focused on (1) mosquito biology and disease transmission, and (2) the active ingredient used in control efforts (*Bacillus thuringiensis* var. *israelensis*). MBL has added new blogs discussing relevant education outreach topics. Information dedicated specifically to mosquitoes and COVID-19 (published in May 2020) remains available on the website.

Education Outreach

Following CSRD approval, a media release was distributed to a local radio station, Bounce 106.3 FM, and two regional news outlets, The Golden Star newspaper and Castanet. While no interviews were requested from Bounce 106.3 or Castanet, the Golden Star published a story utilizing the facts from the media release on 24 June. Unfortunately, MBL staff illness impacted the ability to host a booth on the planned 20 July Golden Farmers Market.

The MBL Operations Manager and Lead Biologist provided interviews to the following news outlets:

- BC CTV (20 June)
- Global TV (12 July)
- City TV (13 July)
- CBC (14 July)
- CBC – Early Edition (18 August)

While these interviews were requested on behalf of mosquito control programs run by MBL on the coast, the interviews included tips for residents to reduce mosquito habitat around homes and how to increase personal protective measures. These recommendations are applicable to all program residents. If opportunities arise, MBL staff ensure that the CSRD mosquito program manager is consulted prior to agreeing to an interview. Every effort will be made to accommodate interviews which assist in raising awareness about mosquito control efforts and personal protective measures.

West Nile virus Summary

Although floodwater mosquito species in Canada are not the main West Nile virus (WNv) vectors, it is important to remain current in regional mosquito-related diseases. Along with its partners, Health Canada compiles on-going provincially reported surveillance data of WNv cases in humans, animals, and mosquito pools between 1 January and 29 September. As of 8 October, no human case of WNv were reported to Health Canada from British Columbia[10]. Similarly, no horse or bird cases were reported from British Columbia within 2022. Of note, previous reports were not published until December, so it is likely that surveillance did occur in 2022 and will be published shortly. An update will be sent to the CSRD program manager once 2022 provincial WNv surveillance data are received. Also of note, mosquito pool surveillance data are not reported to Health Canada from British Columbia and it is possible that other information was not reported by the BCCDC to Health Canada.

As Washington State and Idaho State share a border with British Columbia, it is important to follow WNv activity in those areas, as well. As of 30 October, no in-state cases of WNv were reported in Washington State[11]. Six mosquito pools tested positive for WNv. No horses/other mammals or birds tested positive in 2022. Of note, cooler ambient temperatures from May – early July contributed to a lower number of degree days during 2022, which likely contributed to lower incidence of WNv activity.

As of 30 October, 16 human WNv cases were identified in Idaho[12]. Additionally, multiple mosquito pools and animals tested positive for WNv. All cases were identified within counties in the southern and southwestern portion of Idaho.

Zika virus Summary

No information regarding Canadian Zika cases has been reported by the Public Health Agency of Canada since 2017 and Heath Canada will no longer be updating case counts[13]. HealthLinkBC reports that no Zika cases have originated in Canada due to presumed lack of vector mosquito species[14]. There have been human Zika cases reported in Canada prior to 2022, although those were determined to have been acquired while traveling.

According to Peach (2018), the primary Zika mosquito vectors (i.e., *Aedes aegypti*, *Ae. albopictus*) are not found in British Columbia. *Ae. albopictus* has been found on east coast, but tested negative for Zika. There is currently a low risk for Zika virus to circulate within British Columbia.

[10] https://www.canada.ca/en/public-health/services/publications/diseases-conditions/west-nile-virus-surveillance/2021/week-37-38-september-13-26.html
[11] http://www.doh.wa.gov/DataandStatisticalReports/DiseasesandChronicConditions/WestNileVirus
[12] https://www.cdc.gov/westnile/statsmaps/preliminarymapsdata2022/index.html
[13] https://www.canada.ca/en/public-health/services/diseases/zika-virus/health-professionals.html#_Surveillance_in_Canada
[14] https://www.healthlinkbc.ca/health-feature/zika-virus

2023 Program Recommendations

- Adult mosquito trap results and analysis from an associated, but independent, contract will be reported separately.

- Work with the Provincial Parks to explore treatment of mosquito development habitat located within Burges James Gadsden Provincial Park.

- Notify the Ministry of Environment of the CSRD intent to treat mosquitoes in 2023 under the CSRD Pest Management Plan. Notification should take place 2 months before the start of the season (the end of February at the latest).

- It is important to attach copies of all the mosquito development site maps with the Notice of Intent to Treat (NIT).

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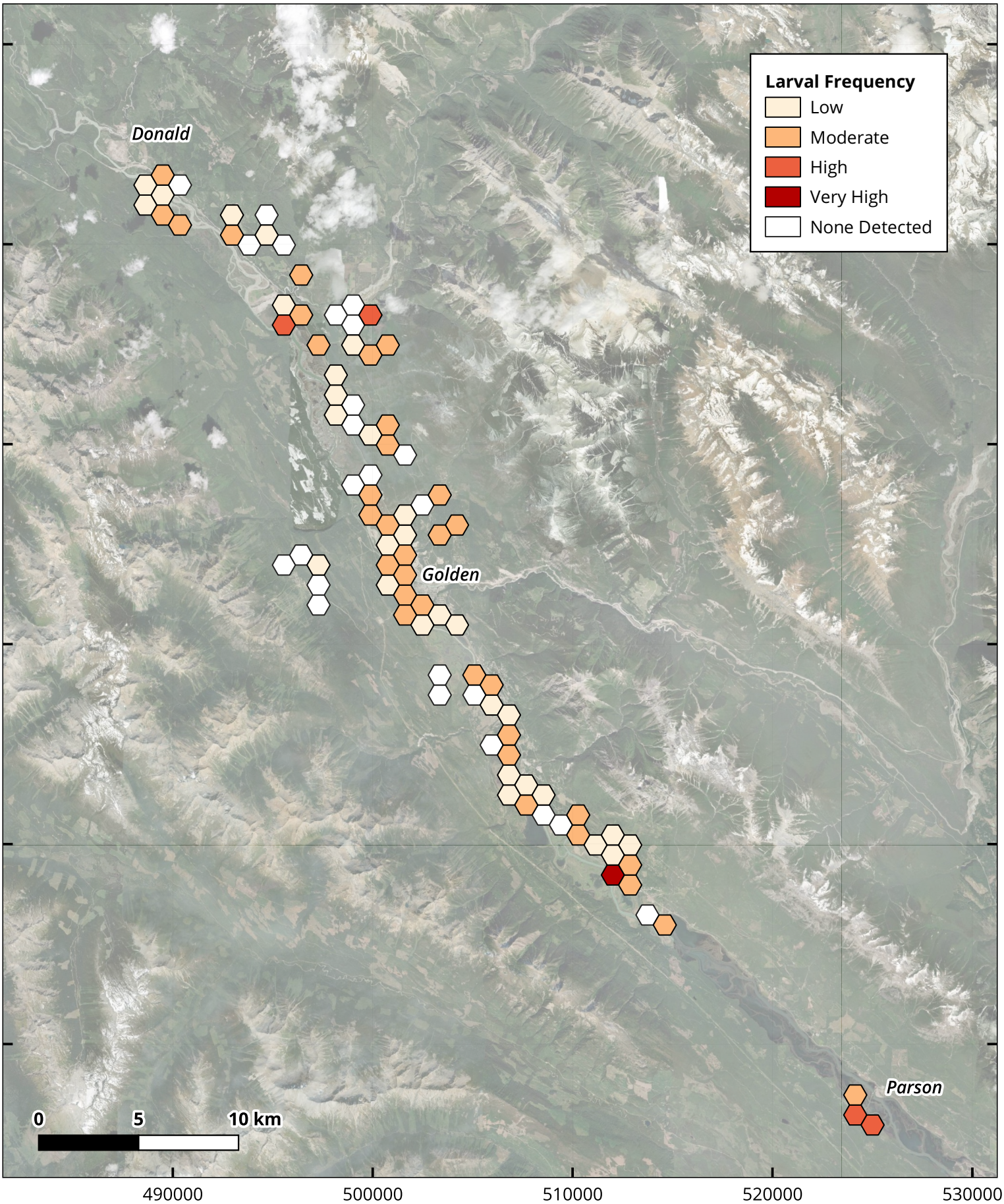
2022 Mosquito Larval Frequencies at Sample Locations

Appendix I-A

Morrow BioScience Ltd
PO Box 1013 Rossland, BC V0G 1Y0
gis@morrowbioscience.com 1(877)986-3363

Scale = 1 : 250,000 CRS = NAD83 UTM Zone 11N

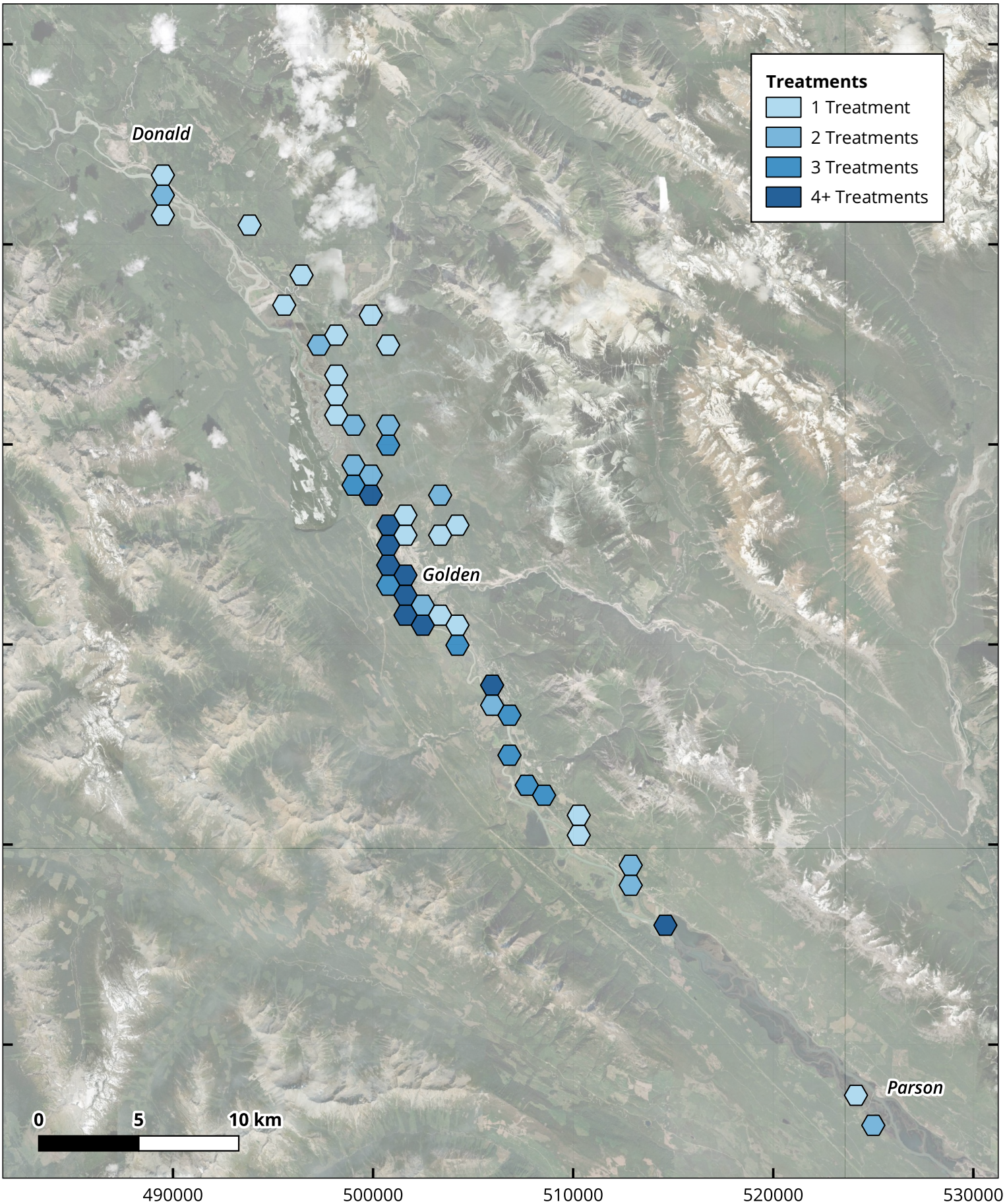


2022 Mosquito Larvicide Treatments

Appendix II

Morrow BioScience Ltd
PO Box 1013 Rossland, BC V0G 1Y0
gis@morrowbioscience.com 1(877)986-3363

Scale = 1 : 250,000 CRS = NAD83 UTM Zone 11N



Appendix III - 2022 Golden, Area 'A' mosquito larvicide treatment data (kg, ha) by site and date for all ground (A) and aerial (B) treatments

III-A: Ground Treatments

Treatment Date	Site Code	Site Name	Amount Treated (Kg)	Area Treated (Ha)
2022-04-13	CSRD-061	Anderson Road Slough	0.5	0.125
2022-04-13	CSRD-061	Anderson Road Slough	0.5	0.125
2022-05-08	CSRD-102	Gun Range Ditches	2	0.5
2022-05-08	CSRD-095	Donald Scale Ditches	3	0.75
2022-05-08	CSRD-024	Highway Grey Water Pond	2.3	0.575
2022-05-09		Palumbo Swamp (corner)	0.5	0.125
2022-05-09	CSRD-131	Unknown wetland - camping ranch	0.5	0.125
2022-05-10	CSRD-077	1087 Upper Donald Road	3.5	0.875
2022-05-11	CSRD-124	Clear Cut Stream	0.5	0.125
2022-05-11	CSRD-105	WABS (owned by Theo residents of 2369 Upper Donald)	7.5	1.875
2022-05-12	CSRD-130	Grey Owl lodge	0.2	0.05
2022-05-12		1181 Golden Donald Upper	0.25	0.0625
2022-05-12	CSRD-043	Buffalo Ranch	4.5	1.125
2022-05-13	CSRD-044	Highway 1 Wetland	4.5	1.125
2022-05-13	CSRD-044	Highway 1 Wetland	8	2
2022-05-16	CSRD-012	Cooper Lake	1	0.25
2022-05-18	CSRD-125	1524 Campbell Road	4	1
2022-05-19	CSRD-034	Al's Slough (#3)	12	3
2022-05-23	CSRD-077	1087 Upper Donald Road	6	1.5
2022-05-23		1680 Moberly School Road	0.5	0.125
2022-05-23	CSRD-149	2397 Forde Station Rd.	0.8	0.2
2022-05-30	CSRD-055	Schiesser Road Swamp (#1)	8	2
2022-06-01	CSRD-096	2601 Highway 1	3	0.75
2022-06-10	CSRD-028	Parson RV Park	3	0.75
2022-06-15	CSRD-084	Watson Farm	8	2
2022-06-15	CSRD-121	Old farm (highway 1)	14	3.5
2022-06-16	CSRD-010	Race Track	3	0.75
2022-06-17	CSRD-107	Kicking Horse Seepage	2	0.5
2022-06-22		1181 Golden Donald Upper	0.5	0.125
2022-06-23	CSRD-028	Parson RV Park	4	1
2022-06-23	CSRD-111	Parson Wetland West #3, 3776 Sanborn Road	14	3.5
2022-06-30	CSRD-076	15th Street Swamp forest	10	2.5
2022-07-05	CSRD-110	Parson Wetlands West #2,3806 Thomas Road	3	0.75
2022-07-06	CSRD-045	Eco Adventure Ranch	4	1
2022-07-07	CSRD-003	Old Mill	7	1.75
2022-07-08	CSRD-005	Golf Course (#1)	4	1
2022-07-08	CSRD-005	Golf Course (#1)	3	0.75
2022-07-14	CSRD-111	Parson Wetland West #3, 3776 Sanborn Road	4	1
2022-07-25	CSRD-045	Eco Adventure Ranch	12	3
2022-07-26		830 Oster Road	0.5	0.125

Appendix III - 2022 Golden, Area 'A' mosquito larvicide treatment data (kg, ha) by site and date for all ground (A) and aerial (B) treatments

III-B: Aerial Treatments

Date	Sites	Amount Treated (Kg)	Area Treated (Ha)
2022-06-13	Columbia Wetlands north, Eagle Pete's wetland, Columbia Wetlands Golden, Nicholson Wetlands, Columbia Wetlands south, Horse Creek north, Horse Creek Wetlands, Nicholson boat launch, Harbart Wetlands, Confluence Park, Eco Adventure Ranch, low-lying forest, LP swamp, Golf Course	2548	424.6669
2022-06-21	Columbia Wetlands Golden, Race Track,LP swamp,Airport Runway,Confluence Park,Airport South End,Old Mill,Columbia Wetlands Golden,Nicholson Wetlands,Eco Adventure Ranch,Columbia Wetlands South (#6),Habart Wetlands,Columbia Wetlands South (#5),Sandhill Lake (east shore),Mitchell Road wetlands,Nicholson Boat Launch,Cow fields ,Parson RV Park	1820	303.3333
2022-06-29	Old farm (highway 1),Highway swamp north ,Low Lying Forest 2,Columbia Wetlands North (#1),Low Lying Forest 1,Golf Course (#1),Golf Course (#2),Cow fields ,Columbia Wetlands North (#3),Airport ditch,Kicking Horse Seepage,Rotary Trails,Columbia Wetlands South (#5),Eco Adventure Ranch,Columbia Wetlands South (#6),Horse Creek Wetlands (south end),Horse Creek North ,Habart Wetlands,Airport Runway,Airport South End,Old Mill,Columbia Wetlands Golden	2184	364
2022-07-12	Cow fields ,Watson Farm,Columbia Wetlands North (#3),Race Track,Golf Course (#1),Golf Course (#2),LP swamp,Old Mill,Airport ditch,Confluence Park,Reflection Lake (South),Reflection Lake (North),15th Street Swamp forest,Nicholson Wetlands,Rotary Trails,Airport Runway,Airport South End,Eco Adventure Ranch,Columbia Wetlands South (#6),Nicholson Boat Launch,Horse Creek North ,Horse Creek Wetlands (south end),Mitchell Road wetlands,Parson RV Park,Columbia Wetlands Golden	1820	303.3333