MorrowBioScience

# Metro Vancouver Regional District 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 2-year contract renewal as mosquito control contractor for Metro Vancouver Regional District (MVRD). The mosquito control program reduces floodwater, saltmarsh, and identified permanent water mosquito abundance within the program-participating municipalities of the City of Coquitlam, City of Maple Ridge, Metro Vancouver Parks, City of Pitt Meadows, Township of Langley, City of Surrey, and City of Richmond. Most control activity takes place along the Lower Fraser River foreshore, River-associated seepage sites, and saltmarsh sites.

In April, immediately preceding the mosquito monitoring season, the snowpack in basins contributing to the Fraser 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 brief ridge of high-pressure within contributing basins largely initiated the 2022 freshet. Significant and consistent precipitation in May and June resulted in amplified Lower Fraser River levels. Continued precipitation combined with upstream snowmelt caused the Lower Fraser River to peak on 4 July at 5.875m. The 2022 Lower Fraser River peak was the highest since 2020. Prolonged and frequent weather systems consistent with La Nina influence led to the Lower Fraser River levels exceeding 5 m for 40 days. High and sustained Lower Fraser River levels resulted in a compounded number of floodwater mosquito eggs that were triggered to hatch at peak levels. Continual local precipitation with sufficiently high ambient temperatures also contributed toward amplified saltmarsh and permanent water mosquito hatching cues. Thus, environmental conditions were optimal for a high rate of mosquito development in 2022.

Larval mosquitoes were treated between 9 May and 31 August. The total floodwater mosquito habitat and saltmarsh/permanent water mosquito habitat treated by ground was 39 ha and 14 ha, respectively. The total floodwater mosquito habitat treated by air was 142 ha. Four aerial treatment events were required in 2022: 8, 15, and 30 June and 9 July. Area treated in 2022 was approximately 60 ha more than what was treated in 2021, likely due to increased mosquito development habitat and optimal environmental hatching cues. At all known sites, efficacy was assessed as high. A real-time monitoring and treatment data dashboard was provided to the managers of all MVRD participating municipalities. The dashboard enabled partner municipality managers to view up-to-date treatment information and ensure quality control.

Concern call volume from residents was high at 156, with six emails received from residents. Most concern calls and emails came from Langley and Maple Ridge. These calls were likely the result of mosquitoes dispersing from Brae/McMillan Island and Kanaka Creek Regional Park. In response, MBL staff spent six additional reconnaissance days (2 staff members) within the Township of Langley, Kanaka Creek Regional Park, and Pitt Meadows. Despite additional efforts, no new sites were identified. A more systematic survey of the Kanaka Creek area, in particular, may reveal new floodwater mosquito sites and is an option for 2023 work. While no known sites were missed, high river levels can create micro-sites within river debris which are difficult to identify and may have gone untreated. Additionally, a 95% efficacy rate still leaves 5% of mosquitoes that may escape

treatment. High, sustained river levels coupled with a compounded number of mosquito eggs from the previous season means that remaining 5% could have been a large portion.

New trap locations and extra trap nights were added to the program in 2022. A total of 83 trap nights were conducted this year. Adult mosquito trap specimen identification indicated that mosquito abundance was low in May and June trapping events. The highest adult mosquito collection events (4 July, 4 August) were a result of adult dispersal from the initial Lower Fraser River peak in mid-June and the primary peak in early-July. A total of 3,042 mosquito specimens were collected in 2022. Approximately 90 percent of the female mosquitoes identified were floodwater mosquitoes. The high and prolonged adult mosquito abundance is a result of high and prolonged Fraser River levels. An adult trap site within the City of Surrey should be moved to evaluate saltmarsh adult mosquito abundance in the future. 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 mid-December.

Communications with program residents remains a priority for MBL. MBL staff were able to host booths at community events within each participating municipality and at a Regional Parks site in 2022. MBL staff showed residents mosquito specimens, discussed program objectives and control methods, and included kid-friendly activities related to mosquito biology. A total of six TV, radio, and print media interviews were given between 20 June and 18 August. Additionally, a press release was developed for social media distribution and resulted in the greatest Facebook reach ever for MBL (i.e., 9,760). The reach of social media posts continues to increase annually, meaning that more residents around the MVRD may be aware of and engaged with mosquito abatement efforts.

## Season Highlights

- The peak Fraser River level at the Mission gauge occurred on 4 July at 5.875m.
- The 2022 peak was approximately 0.4 m higher than the 2021 peak.
- Fraser River levels above 3 m lasted for 70 days, with 40 of those days above 5 m. Sustained high River levels above 5 m for 40 days is an anomaly in the MVRD.
- The snowpack in basins contributing to the Fraser River ranged from 104-140 % of normal in April, immediately preceding the floodwater mosquito season.
- La Nina weather patterns augmented the snowpack in contributing basins through May and for portions of June.
- The freshet was delayed by 2-4 weeks.
- Local precipitation accumulation for May and June was >60 mm above average.
- Peak river levels exceeding those of 2021, the late freshet, and sustained high water levels led to high larval abundance in 2022.
- Four aerial campaigns were required within the MVRD mosquito program purview. Aerial treatments were conducted on 8, 15, and 30 June and 9 July.
- Total ground treatments at floodwater mosquito development sites were applied to 39 ha (155 kg granular Aquabac®).
- Total ground treatments at saltmarsh and permanent water mosquito development sites were applied to 14 ha (54 kg granular Aquabac®).
- Total Aquabac® aerial applications resulted in the treatment of 132 ha (1,420 kg of granular Aquabac®).
- Adult mosquito trap efforts inn 2022 included a total of 83 trap nights, an increase of 14 trap nights from 2021.
- Most adult trap sites were moved to inconspicuous locations in 2022, resulting in fewer vandalism challenges.
- A total of 3,042 adult mosquito specimens were collected from 13 trap site locations.
- Floodwater mosquitoes comprised approximately 90 percent of trap sites contents.
- The peak of adult mosquito abundance was collected at traps set from approximately 3-4 weeks after the initial and official peak of the Lower Fraser River.
- Brae Island Regional Park and Kanaka Creek Regional Park had the highest mosquito trap abundance, suggesting additional reconnaissance efforts may reveal new floodwater mosquito development habitat.
- *Aedes japonicus* was identified from an adult mosquito trap located in Abbotsford, but none were identified in MVRD.
- A total of 156 concern calls were received to the Mosquito Hotline in 2022.
- Of those, 108 came from Langley and 37 came from Maple Ridge. Increased nuisance in those areas was likely due to floodwater mosquitoes dispersing from Brae/McMillan Island and Kanaka Creek Regional Park.
- A total of 6 concern emails were received by MBL staff
- A total of 6 additional days (2 MBL staff/day) were committed to additional reconnaissance within Brae/McMillan Island, Pitt Meadows, and Kanaka Creek Regional Park at the request of residents.

- More time was spent conducting follow-up site visits at the request of residents than in previous seasons within this contract term.
- MBL staff hosted education outreach booths at seven locations within the MVRD mosquito program purview, ranging from 24 April – 5 July.
- Following MVRD approval, MBL staff gave six interviews to local media and developed a media release for distribution on social media sites.
- The BCCDC has yet to provide an update on West Nile virus cases in the province, but a report is expected in mid-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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*Cover Image: MVRD mosquito development site (June 2022)*

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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. The 2022 mosquito season marked MBL's 1st year in a 2-year contract term with the Metro Vancouver Regional District (MVRD).

The MVRD mosquito control program involves a range of floodwater mosquito habitat, saltmarsh mosquito habitat, considerable program reach, and a high population density. These variables make the MVRD mosquito control program complex. Historical experience with this program and other comparable regional programs has created a strong knowledge base from which to build. That understanding has helped improve floodwater and saltmarsh mosquito development site management within the MVRD. In addition to MBL's knowledge base, MBL's commitment to public engagement, program data transparency through the use of MBL's in-house real-time data collection portal and client dashboard, and improved environmental accountability via annual carbon offset purchases further strengthens the MVRD mosquito control program. MBL's goal is to continue to provide effective floodwater mosquito control to Metro Vancouver Regional Parks, City of Coquitlam, City of Maple Ridge, City of Pitt Meadows, Township of Langley, City of Surrey, and City of Richmond while remaining socially and environmentally responsible.

## Carbon Offsets

The spatial reach of the MVRD mosquito program is such that driving is an inevitable requirement. The accumulated mileage over the course of 2022 was approximately 31,000 km (ground transportation only).

As an estimation, the 2022 driving requirements for this program resulted in the production of approximately 9.2 tonnes of $CO_2$ emissions. To offset this addition of $CO_2$ to the environment, MBL has committed to purchasing carbon offsets. To fulfill 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 MVRD.

## Methodology

As large areas of the MVRD are within the Lower Fraser River's flood plain, the primary targets of the MVRD 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 the MVRD, floodwater mosquito development sites primarily exist along the flooding corridor of the Fraser River, including associated

[1] https://neighboursunited.org

seepage sites and the islands within the Fraser River. When water floods these sites, due to the freshet and/or significant localized precipitation, the result is large-scale floodwater mosquito egg hatching. If numerous seasons have 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 necessary hatching cues.

Additional targets of the MVRD mosquito control program are permanent water mosquito species (e.g., *Anopholes punctipennis, Culex pipiens, Culex tarsalis*), found specifically within City of Richmond ditches, and saltmarsh mosquitoes (e.g., *Aedes dorsalis*), found in saltmarsh habitat within the cities of Richmond and Surrey. Female permanent water mosquitoes lay their eggs in rafts on the surface of quiescent water. Most permanent water mosquito species within the MVRD are univoltine. Alternately, many saltmarsh mosquito species may have multiple independent hatches each season. Saltmarsh mosquitoes lay eggs on the damp substrate next to calm brackish or saltwater sites that flood. When water floods the sites due to tidal influences or precipitation, the result is large-scale mosquito egg hatching.

MBL field technicians began monitoring floodwater mosquito development sites within the MVRD prior to the Fraser River levels rising in the spring. Similarly, saltmarsh and permanent water mosquito development sites were monitored beginning in the early spring when maximum daily temperatures were more consistently near 15°C. Mosquito development sites are adaptively managed; regional river levels and local temperatures largely dictate how frequently sites are visited, 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 potential 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 accordingly.

**Image 1. Standard dip (350 ml) with 2nd and 3rd instar floodwater mosquito larvae (7 June 2022).**

Larval mosquitoes in sufficient number (i.e., >4/dip; Image 1) are treated by ground 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. The granular form is carried on a corncob mixture and the liquid form is water-based. 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 eggs are triggered to hatch, it becomes increasingly difficult to treat sites in a timely manner by ground due to access challenges and concurrent site activation. At this point, a helicopter is used to conduct aerial treatments. Aerial campaigns use the same pesticide as ground applications, although typically with a higher application rate to permeate canopy cover.

Treatments are timed to target the 3rd and 4th larval instars. If treatments are applied too early, the larvae will not have reached their highest feeding rate yet and may not ingest the Bti spore. 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 in the ecosystem.

Sites are treated when a standard dip (350ml) collects >4 late instar (3rd or 4th instar) larvae per dip. 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). All sites are checked within one or two days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted.

## Environmental Conditions

Lower Fraser River levels are the main environmental condition that impact floodwater mosquito sites - the great majority of mosquito development area within the MVRD mosquito control program purview. The three primary environmental conditions that affect the Lower Fraser River levels throughout the mosquito season (i.e., April – August) are: 1) the snowpack in basins contributing to the Lower Fraser River, 2) ambient temperature in snow basins contributing to the Lower Fraser River, and 3) local precipitation. Local ambient temperature is also of interest due to the effect that local ambient temperature can have on mosquito egg hatching and larval development rates.

Ambient temperature, precipitation, and tidal fluctuations are the primary environmental predictors for permanent water and saltmarsh mosquito development. Each condition provides insights regarding hatching start, development rate, and success. As such, all noted conditions are tracked throughout the season for all target species.

### Snowpack

The water levels of the Lower Fraser River are largely dictated by the freshet released from the Fraser, Thompson, and Nechako Plateaus between April and July (Image 2; A. Jollymore, personal communication, 15 June 2020). The Fraser River is also influenced by tidal variations and high, spatially concentrated precipitation accumulation, although to a lesser degree. When the snowpack exceeds 100 percent of normal immediately prior to the spring snowmelt and when regional precipitation accumulation is above normal, higher-than-average Lower Fraser River levels are expected during the mosquito season. Similarly, high ambient temperatures within contributing basins can compress the melt timeline, resulting in high Lower Fraser River levels even if the snowpack in those basins does not exceed 100 percent.

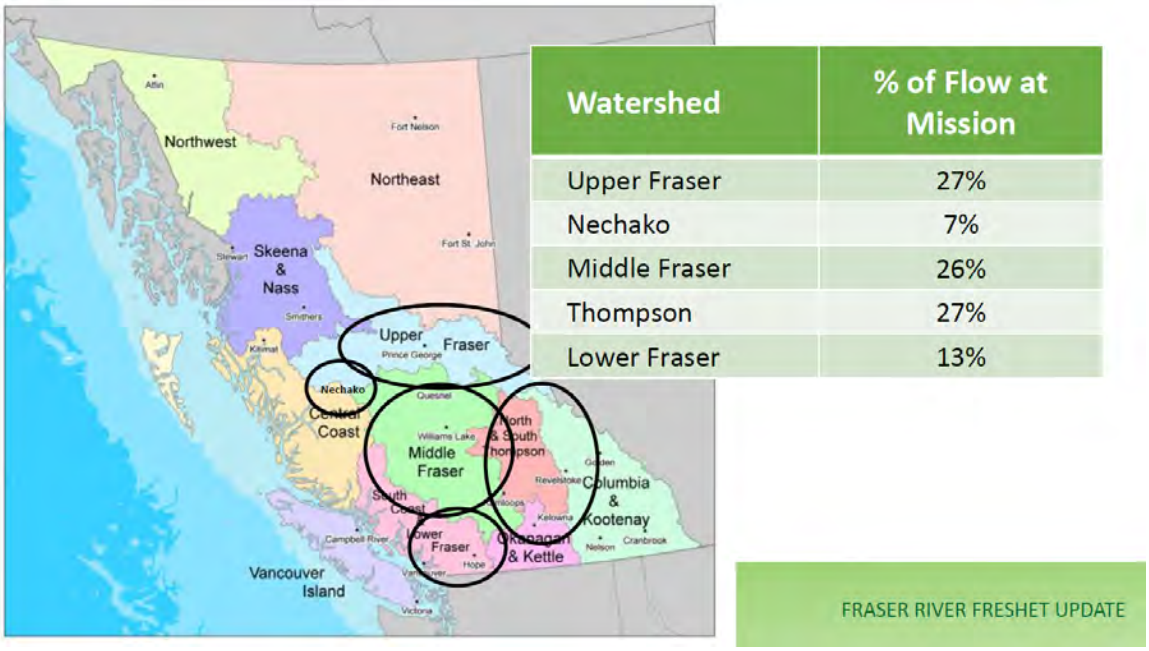


**Image 2. Fraser River sub-basin freshet contribution (A. Jollymore; River Forecast Centre)**

On 1 April, immediately preceding the 2022 MVRD mosquito monitoring season, the snowpack within basins influencing the Lower Fraser River ranged from 107 - 140 percent of normal (Table 1). 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. In all but one case, 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 influential basins throughout April and most of May resulted in considerable snowpack augmentation. Unstable conditions coincided with cooler-than-average ambient temperatures across the province in April and the majority of May, which led to a delayed freshet by 2 – 4 weeks. A short-lived ridge of high pressure in early May led to the initial, but inconsequential, pulse of the freshet. Subsequent weather patterns slowed the freshet and further augmented snowpack until late-May.

**Table 1. Snow basin indices (2021 and 2022, 1 April percent of normal) for basins that directly affect the Lower Fraser River flood plain, determined by the River Forecast Centre.**

| Basin | 2021 April Snowpack | 2022 April Snowpack |
|---|---|---|
| Upper Fraser East | 124 | 125 |
| Upper Fraser West | 117 | 140 |
| Lower Fraser | 117 | 116 |
| Middle Fraser | 90 | 115 |
| North Thompson | 99 | 128 |
| South Thompson | 80 | 107 |
| Nechako | 115 | 104 |

The Revolution Creek snow survey station (ID: 1A17P) reflects weather trends in the Upper Fraser snow basin (Figure 1). The snow basin contributes approximately 30 percent of the Fraser River flow at Hope[2]. The Revolution Creek station serves as a representative site for the regional snowmelt trajectory for high-elevation snowpack. Notably, snowpack increased through April and then reduced slightly in early May. The trend in visible snowpack reduction at the Revolution Creek snow survey station started in late-May, approximately 2 weeks later than normal (Figure 1).

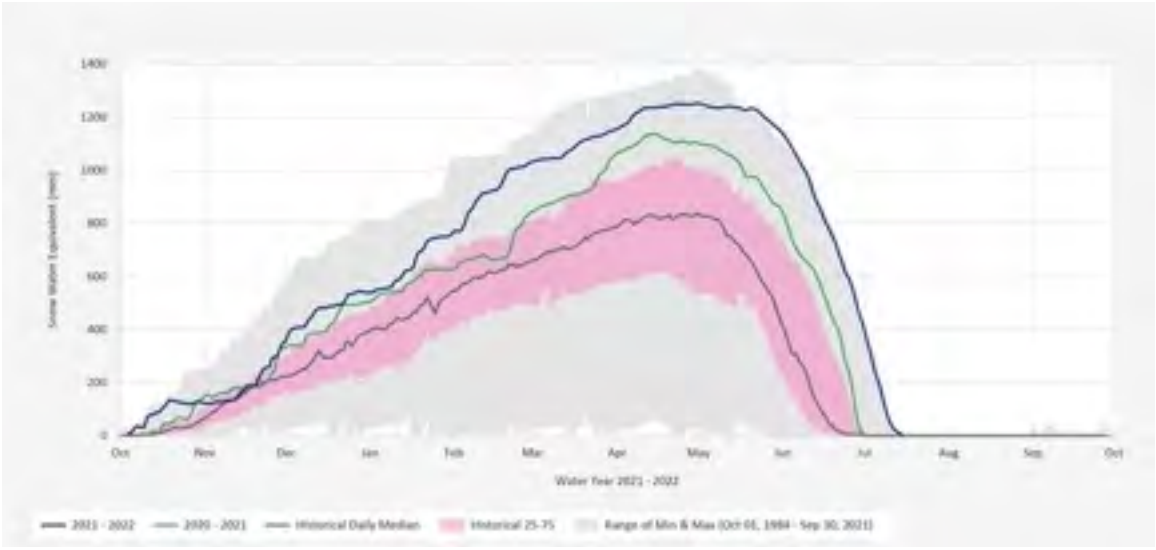


**Figure 1. Snow Water Equivalent (SWE; mm) at the Revolution Creek snow survey station (ID: 1A17P) within the Upper Fraser East basin. The upper blue line indicates SWE data for 2021-2022.**

Warmer weather in the first half of June resulted in the consistent depletion of most high elevation snowpack in the Revolution Creek snow survey station[3]. This trend is consistent with other high elevation snow survey station data throughout the influential basins. Lower elevation snowpack showed signs of considerable melting at points in early May and more significantly in late May.

Historically, by 1 June approximately 60 percent of the snowpack has melted with Fraser River-associated basins. However, despite warming ambient temperatures in those basins during early June, snowpack was still relatively high through mid-June. The 15 June snow basin indices ranged from 159 – 324 percent of normal[4]. This relatively high range reflects the abnormality of snow remaining in those basins in mid-June. Warming ambient temperatures within influential snow basins continued through June and July, lending to the depletion of snowpack by mid-July.

The late-season input of water to the Fraser River impacted the length and intensity of the mosquito control season within the MVRD. The 2022 Fraser River freshet was set apart in two ways: 1) the greater than average snowpack within associated basins and 2) the prolonged snowmelt. Both features led to higher-than-normal and sustained Lower Fraser

[2] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_may1.pdf
[3] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=c15768bf73494f5da04b1aac6793bd2e

River levels through early July, when increased mosquito egg hatching cues were more abundant within MVRD.

**Local Precipitation**

Substantial temporally and spatially concentrated precipitation accumulation may elevate Fraser River levels, increase seepage site levels, expand saltmarsh mosquito development habitat, and increase permanent water mosquito sites. Tracking local precipitation accumulation can aid MBL field staff in determining how long mosquito development sites may require management. The Mission West Abbey weather station (ID: 1105192) 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, then additional floodwater, saltmarsh, and permanent-water mosquito eggs may be triggered to hatch.

Precipitation received to the Mission West Abbey weather station in April was lower-than-average (Figure 2). It is unlikely that local precipitation impacted target mosquitoes in April due to a relatively low input and the lack of additional hatching cues. Local precipitation in May, in particular, and in June was higher-than-average in 2022. The high precipitation values noted in May and June are consistent with the low-pressure systems typical of La Nina weather patterns in southwest BC. Together, the precipitation received in May and June was approximately 60 mm higher than the average sum of the two months. Given that a considerable amount of precipitation was received during the Lower Fraser River freshet, it is likely that precipitation augmented river levels above those that would have been observed due to the freshet alone. High precipitation accumulation amounts were noted throughout the Fraser River watershed, adding to Fraser River levels along the system. Other target mosquito development habitat was also likely amplified due to higher-than-average precipitation.

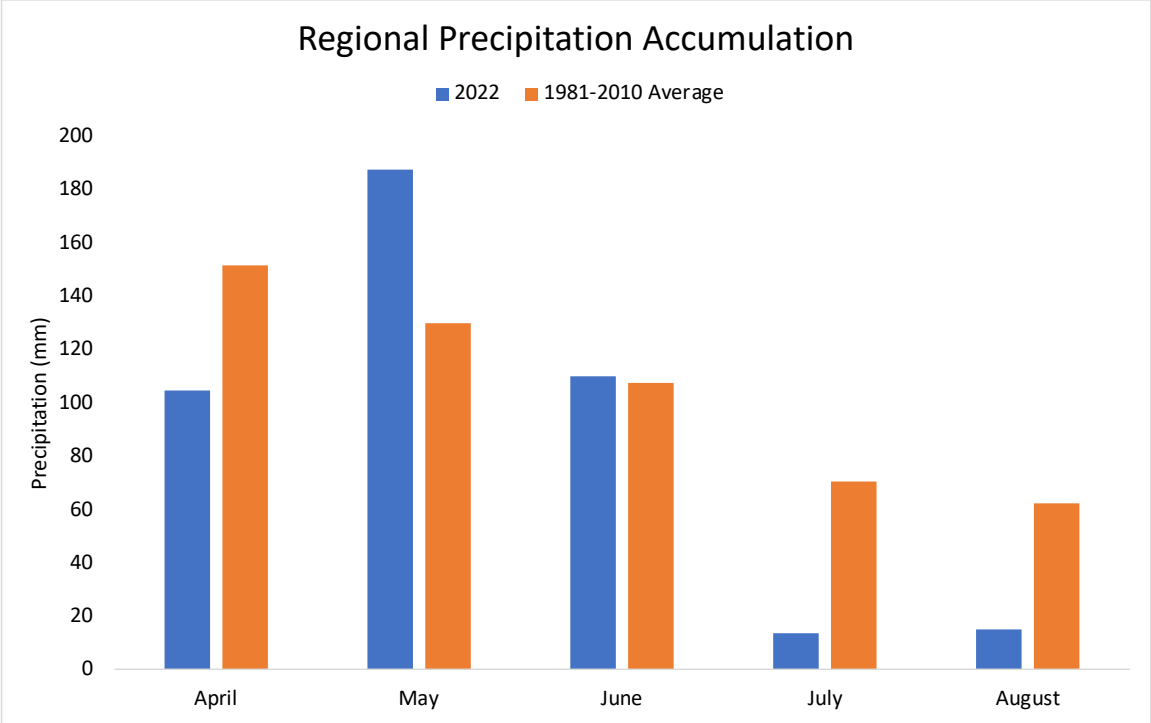


**Figure 2. 2022 precipitation values (rainfall and snow accumulation; mm) recorded at the Mission West Abbey Station (ID: 1105192) for 01 April – 31 August (blue) and average station precipitation values (1981-2010; orange).**

Relatively little precipitation accumulated in July at the Mission West Abbey station. The recorded amount of precipitation in July 2022 was lower than the station's July average by over 55 mm. However, a measurable rain event occurred on 3 July which likely increased the Lower Fraser River levels and other mosquito development sites. Precipitation accumulation tapered dramatically through July and into August. August precipitation was also approximately 50 mm lower than average (Figure 2). Thus, it is unlikely that precipitation received to the Lower Fraser River in the latter half of July through August augmented floodwater, saltmarsh, and permanent water mosquito development sites. Of note, precipitation received in August was of little consequence to the regional Fraser River levels and associated mosquito development sites because the univoltine floodwater mosquito species had already hatched and/or seepage sites had returned to dry states. However, it's possible that precipitation received in August created habitat for container and saltmarsh mosquito hatching. Thus, adult mosquito presence toward the end of the season was likely due to multi-voltine mosquitoes from these sites, not floodwater mosquito species in certain areas.

## Ambient Temperature

Local ambient temperature and ambient temperature within the Fraser River-associated basins is an important variable to track. Local ambient temperature fluctuations from April through August can affect mosquito egg hatching, larval development rates, adult dispersal, and adult survival within MVRD mosquito development habitat. Within contributing snow basins, ambient temperature dictates the commencement and often the intensity of the freshet, which directly impacts floodwater mosquito development habitat.

*Fraser River Watershed temperatures*

The 2022 mosquito monitoring season began in April with below-average ambient temperatures within most basins contributing to the Lower Fraser River. 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 two short-lived, high-pressure systems occurred in early May and toward the end of May, temperatures remained relatively low and resulted in relatively low reduction in snowpack. The first significant spike in ambient temperature occurred in early June[6]. The spike caused low and some middle-elevation snowmelt within the Fraser River watershed and the consistent rise of the Lower Fraser River levels. Following the brief spike in ambient temperature, the weather within contributing basins 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-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 basins affecting the Fraser River. The resulting peak of the freshet culminated in the highest Lower Fraser River levels for 2022 recorded on 4 July (see 'River Levels' below). Ambient temperatures continued to rise through July and August. However, after the depletion of the Fraser River-associated snowpack, ambient temperatures within those basins does not impact mosquito habitat within the MVRD. Ambient temperature data are consistent with 2022 automated snow station data depicting snowmelt points correlating with regional ambient temperature spikes[7].

*MVRD temperatures*

Local ambient temperature is a predictive tool when gauging floodwater egg hatch commencement. If the ground proximate to the Fraser 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 Mission West Abbey weather station (ID: 1105192).

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

[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

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 2). While *Ae. sticticus* is not the sole floodwater species present in the MVRD, it serves as a representative species for our purposes and provides general developmental benchmarks.

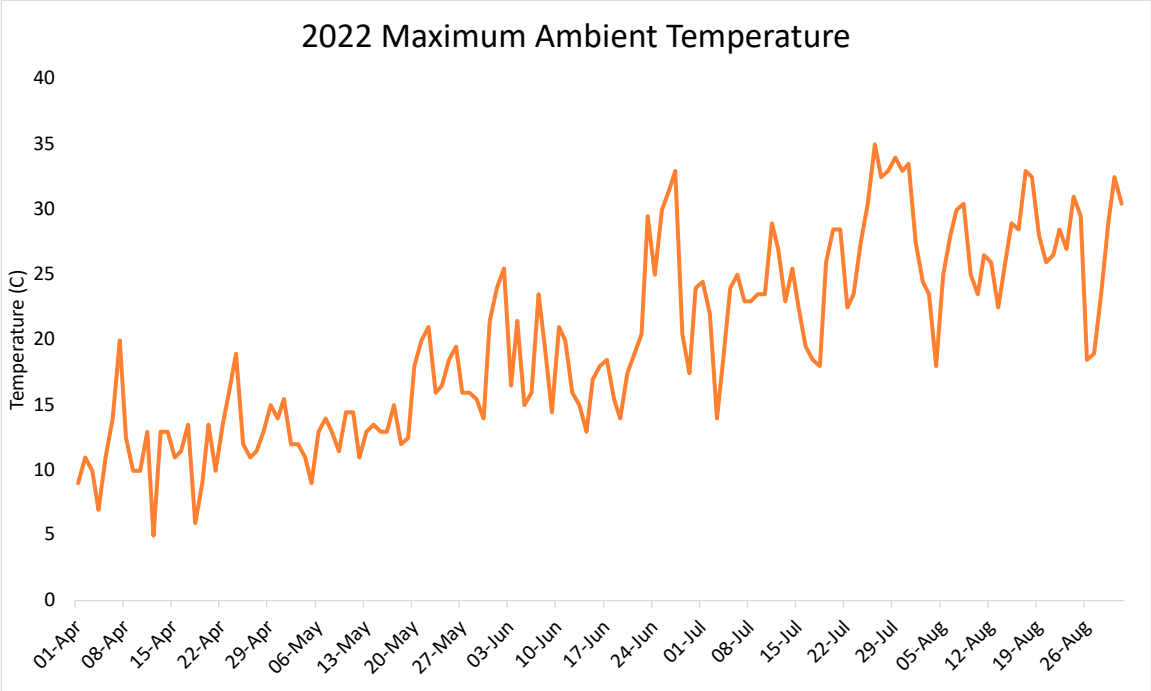


**Figure 3. Maximum daily ambient temperatures (C) as recorded at the Mission West Abbey Station (ID: 1105192) 01 April – 31 August 2022.**

Although floodwater mosquito habitat comprises the largest proportion of mosquito development habitat within the MVRD mosquito control program, saltmarsh and permanent water mosquitoes are also impacted by local ambient temperature. The hatching commencement, success, and rate of development of mosquito species in both saltmarsh and permanent water habitats are dependent on ambient temperature thresholds. To illustrate the effect of ambient temperature on mosquito hatching, Becker et al. (2010) recorded hatching success rates when *Culex pipiens* eggs, a common permanent water mosquito species, were exposed to various temperatures. Results from the study revealed that eggs took one day to hatch at 30ºC and 10 days to hatch at 10ºC. Similarly, Gillespie (1975) determined that ideal water temperatures for C*x. pipiens* to hatch was 20ºC, when considering development time, adult survival, and imago size. Comparably, Parker (1979) showed that *Ae. dorsalis*, a common saltmarsh mosquito species, most successfully hatched at 25ºC.

Within the MVRD the 2022 season began with lower-than-average ambient temperatures for April. The monthly average for April (11.9 °C) was 1.7°C lower than the station average for April (i.e., 13.6°C). Given that April temperatures frequently dropped below the lower temperature bound for successful floodwater mosquito egg hatching, floodwater mosquito eggs within the MVRD were not likely activated within April if exposed to flooding conditions (Figure 3). Additionally, ambient temperatures were well below ideal conditions

for saltmarsh and permanent water mosquitoes to hatch. If mosquito eggs were exposed to water during this month, the larval development at cooler temperatures would have been slow (Trpis and Horsfall 1969).

Local ambient temperatures in May were relatively warmer and within the temperature range for favorable larval development conditions for all target species (Figure 3). The average maximum daily temperature for May was 14.7°C, approximately 2°C lower than the station average. Thus, mosquito 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 approached the upper bounds of temperatures associated with higher floodwater, saltmarsh, and permanent water mosquito hatching success rates (Figure 3).

Ambient temperatures in June were higher than May temperatures and provided sufficient hatching cues for all target 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 to allow for large-scale mosquito hatching events. A stint of warm weather occurred in late June and into early July, which contributed further towards strong mosquito hatching cues. This stint of warm weather also corresponded with the annual peak of the Lower Fraser River levels. 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 3.1°C and 3.8°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. Additionally, saltmarsh and permanent water mosquitoes required increased treatments in July and August due to sufficiently high ambient and water temperatures to provide hatching cues. 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 MVRD 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 the MVRD are found along the flooding corridors of the Fraser River and within associated seepage sites. As the presence of water is the main hatching cue for floodwater mosquito eggs, springtime Fraser River levels provide predictions about the timing and extent of floodwater mosquito egg hatching. The 2022 Lower Fraser River freshet began in early-May as a result of a short-lived high-pressure ridge present within contributing basins from 1-4 May. That input of water marked the slow, consistent rise of the Lower Fraser River (Mission gauge; 08MH024). As a result of La Niña-influenced weather conditions throughout most of British Columbia in the spring, generally cool and unstable weather patterns that followed the early-May high-pressure system led to a delay in the Fraser River freshet by approximately 2-4 weeks.

The horizontal black line in Figure 4 denotes the Lower Fraser River height threshold (i.e., 3 m) at which mosquito development sites within the MVRD have been observed to become active. In 2022, the Fraser River reached that point on 4 June. For comparison, the Lower Fraser River reached 3 m a month earlier in 2021 (Figure 4). This disparity illustrates the considerably late freshet in 2022.

Another high-pressure system was in place over contributing basins in late-May. Following suit, the Lower Fraser River started to consistently and steeply increase shortly thereafter. The subsequent warming events that occurred in early-June, accompanied by considerable precipitation, resulted in an initial peak of the Lower Fraser River (Mission gauge; 08MH024) of 5.655 m on 14 June (Figure 4). Significant precipitation across much of the province coupled with high-elevation snowmelt led the official peak of the Lower Fraser River on 4 July at 5.875m, only 0.22 m higher than the initial peak (Figure 4). Of note, the cooler-than-average weather present from April – June caused the Lower Fraser River to rise at moderate rates during the 2022 freshet.

By mid-July 2022, all the snow basins contributing to the Fraser River were depleted of snow[8]. This depletion corresponds with a marked decline in the Lower Fraser River levels starting in mid-July at the Mission gauge (Figure 4). When the Lower Fraser River levels consistently remain below 3 m, associated seepage sites reduce quickly. Thus, by mid-August many of the mosquito development sites were becoming dry.

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

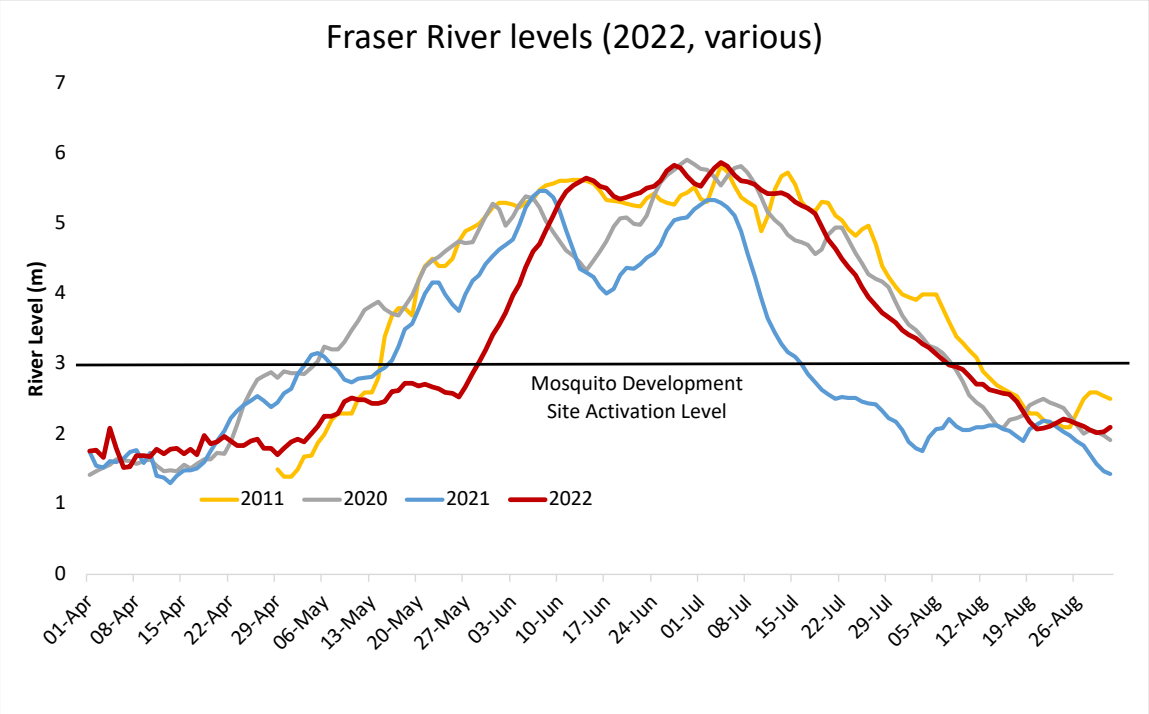


**Figure 4. 2022 - 2020, and 2011 river levels (m) as recorded for the Lower Fraser River (Mission gauge, 08MH024) from 1 April – 31 August. Horizontal black line indicates level at which River-associated mosquito development sites become active.**

The length of time that the Fraser River at Mission remains higher than 5 m helps describe the extent of mosquito larval abundance within a given year. The Fraser River remained above the 5 m threshold for 40 days in 2022. This length of time is considered an anomaly. In average years, such as 2021, Lower Fraser River levels may remain above 5 m for closer to 20 days. The last time Lower Fraser River levels were sustained for this length of time was in 2011, when levels were above 5 m for 55 days. Sustained high river levels allow for micro mosquito development sites to be created amongst debris, new seepage sites to arise, and create surveillance access challenges.

The Fraser River's peak height relative to recent seasons is another predictive variable that may help explain an associated year's larval abundance. If the current year's peak regional river levels far exceed those of preceding season's, mosquito eggs laid between the high-water mark of both years could have remained dormant until current-year flood waters trigger their hatching. Because the 2022 peak of the Fraser River was approximately 0.4 m higher than in 2021, the 2022 peak levels triggered additional dormant floodwater mosquito eggs to hatch (Figure 4). High and sustained water levels largely occurred during warm summer temperatures, which added to hatching cues for floodwater mosquito eggs. Thus, the high, sustained river levels that occurred during warm months lent to the increased abundance of floodwater mosquitoes noted in 2022.

## Larval Control

Monitoring within the MVRD began on 29 April at floodwater mosquito development sites. Permanent water and saltmarsh mosquito development sites were first visited on 4 May. Although most of the floodwater mosquito development sites are not active until the Fraser River (Mission gauge) exceeds 3 m, sites are monitored beginning in late-April to evaluate site conditions and catch the leading edge of any potential hatching events that resulted from the considerable precipitation received in May. Local ambient temperatures higher than approximately 10°C trigger the monitoring season for saltmarsh and permanent water mosquito development sites (Richmond, Surrey). Ambient daily high temperatures were regularly above 10°C starting in mid-May. The relatively warmer ambient temperatures coincided with increased 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 A-F), data are summarized and assigned to a hexbin (i.e., hexagonal polygons) 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 within Brae Island Regional park, Glen Valley (Township of Langley), Kanaka Creek Regional Park, Mud Bay Park, Colony Farm Regional Park, Campbell River in Surrey, Bridgeport (Richmond), Steveston, and Garry Point Park (Appendix I A-G). Again in 2022, further reconnaissance efforts took place within Kanaka Creek Regional Park (1 day, 2 staff), within the Township of Langley (4 days, 2 staff), and within Pitt Meadows (1 day, 2 staff). No new mosquito development sites were identified throughout the MVRD 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.

Higher and sustained Lower Fraser River levels coupled with high ambient temperatures in July and August resulted the need for more treatments and a treatment window extending through most of August. A total of approximately 194 ha (1,629 kg) were treated within the MVRD in 2022. For comparison, MBL has treated more than 70 additional hectares in 2022 than in 2021 – a lower water with a condensed larval mosquito season. No known sites were missed in ground-based or aerial treatment efforts.

Appendix II is a collection of maps by municipality 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 (Appendix II A-G). 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 – Floodwater Sites**

Floodwater mosquito development sites within the MVRD are visited on a weekly basis unless conditions required more frequent monitoring (i.e., Fraser River levels > 5m, ambient temperatures > 20°C, large precipitation event). Sites are treated when a standard dip (350ml) collects 5 or more late instar (3$^{rd}$ or 4$^{th}$ instar) larvae per dip. All sites are checked within 2 days of the initial treatment to ensure high treatment efficacy. If necessary, touch-up treatments are conducted.

The first floodwater mosquito development site was treated by ground on 11 May (Figure 5). Most ground treatments > 1 ha took place between 7 June and 11 July, as dictated by higher Lower Fraser River levels. However, due to the prolonged high-water state in 2022, smaller scale treatments continued until 18 August (Figures 5, 6). All known sites were wet this season.

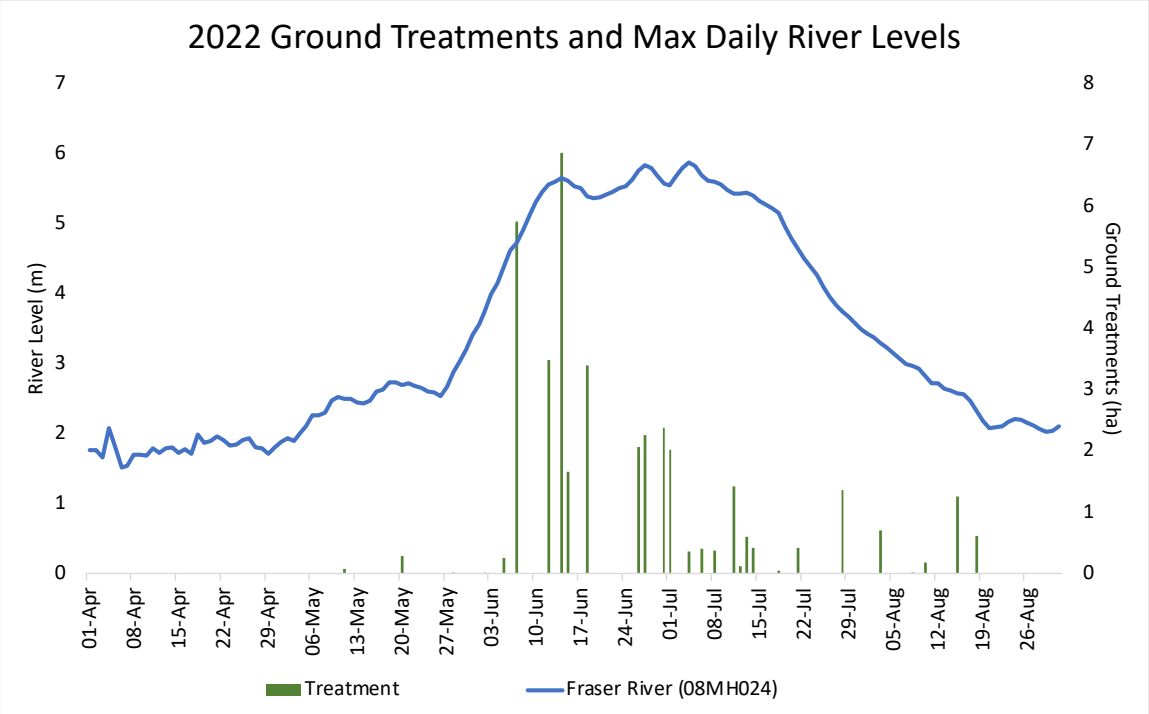


**Figure 5. Fraser River levels (m; Mission gauge) with total floodwater mosquito development area treated by ground (ha) from 1 April – 30 August 2022. Note that ground treatments (ha) are recorded on the alternate y-axis.**

Aquabac® (a.i., *Bacillus thuringiensis* var. *israelensis* (Bti)) is the product used for all larval mosquito treatments conducted by MBL. Bti has a high target specificity and achieves 95% - 100% efficacy in typical field conditions (Aquabac® Mosquito Biolarvicide - Technical Bulletin). Within the MVRD's highly organic water conditions, MBL staff note an average field efficacy rate of approximately 85%-90%. The granular formulation was used in 2022. Certain sites in the MVRD require an application rate of 6 kg/ha, although the majority require 4 kg/ha.

The total area treated by ground at floodwater mosquito development sites in 2022 was approximately 39 ha (155 Kg Aquabac®; 4 kg/ha) (Figure 5). The total area treated by ground in 2022 was more than 7 ha greater than the total area treated by ground in 2021. This increase in treatment area is due to high and sustained Lower Fraser River levels, triggering a compounded number of floodwater mosquito egg to hatch. Real-time data associated with each treatment are available through MBL's client-registered, real-time program portal.

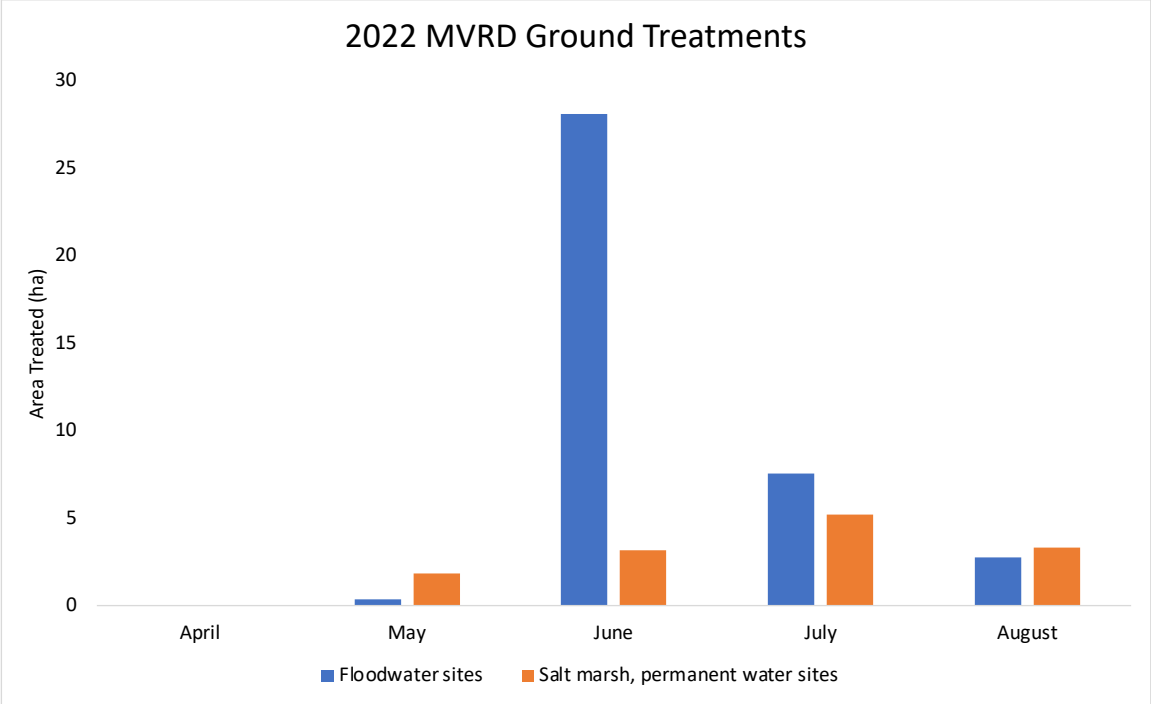


**Figure 6. 2022 ground-treated area (ha) by site (floodwater vs. saltmarsh, permanent water) from April – August.**

Relative to the lower-water and generally condensed freshet year of 2021, floodwater mosquito development habitat was significantly increased in 2022. The snowpack within influential basins was higher-than-average, augmented through much of May and portions of June, and gradually melted. Those conditions across much of the province led to high, sustained Lower Fraser River levels through most of June and July. A compounded number of floodwater mosquito eggs hatched in 2022 and environmental triggers (i.e., water, high ambient temperatures) were in place for continued hatching events through mid-August. Additionally, the considerably high precipitation from May – early July further sustained seepage site levels, creating ideal floodwater mosquito development hatching cues. Thus, more ground treatments were required later into the mosquito season than in most years; the final ground treatment took place on 18 August (Figures 5, 6).

## Ground Application Summary – Permanent Water & Saltmarsh Sites

Permanent water and saltmarsh mosquito development sites within the MVRD are visited on a weekly basis unless conditions required more frequent monitoring (i.e., ambient temperatures > 20°C, frequent precipitation events). As with floodwater development sites, permanent water and saltmarsh sites are treated when a standard dip (350ml) collects 5 or more late instar (3$^{rd}$ or 4$^{th}$ instar) larvae per dip. All sites are checked within 2 days of the initial treatment to ensure high treatment efficacy.

MBL field staff first treated sites on 9 May (Figure 7). Minimal treatments were required until 19 May when ambient temperatures approached 20°C, a more favourable ambient temperature for saltmarsh and permanent water mosquito hatching success. After that date, ground treatments occurred frequently through 31 August. All known sites were wet this season. No sites were missed and no new sites were identified.

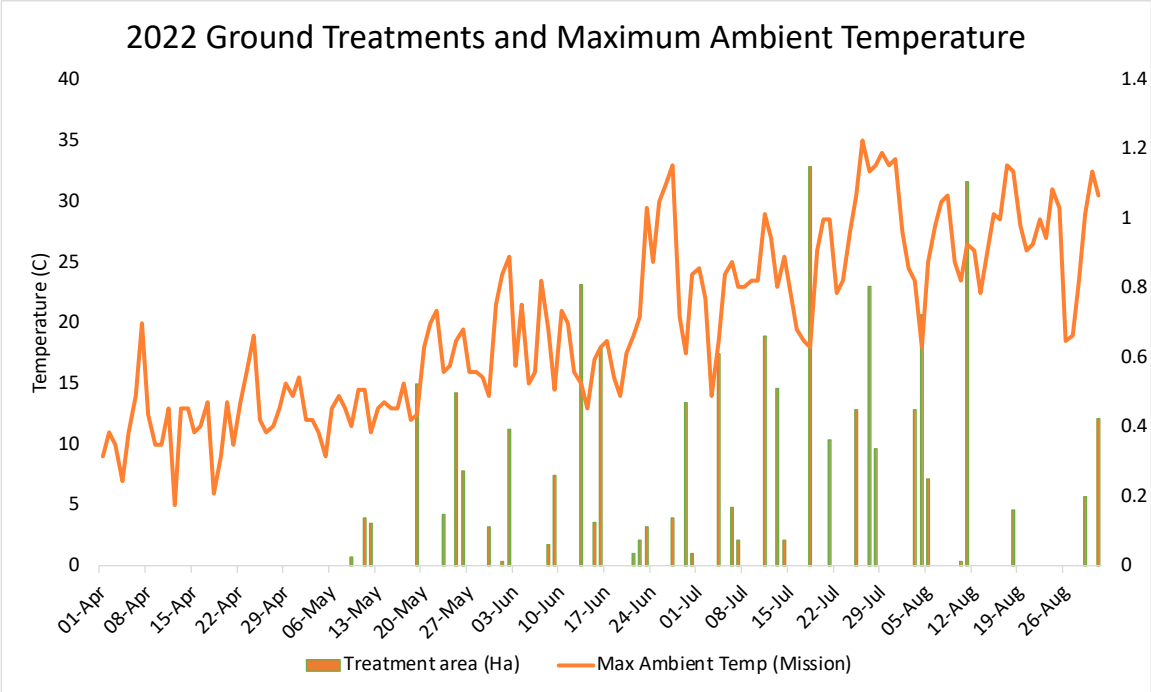


**Figure 7. Maximum daily ambient temperatures (C) as recorded at the Mission West Abbey Station (ID: 1105192) with ground-treated area (ha) at saltmarsh and permanent water sites (1 April – 31 August 2022).**

Most saltmarsh mosquito species are multivoltine and require continuous treatments while ambient temperatures are high because warmer temperatures and tidal influx provide hatching cues. Permanent water mosquitoes are typically univoltine, requiring one treatment a season when ambient temperatures initially spike. Figure 6 depicts the monthly treatment amounts, showing the July spike (permanent water mosquito sites) and measurable treatments through August (saltmarsh mosquito sites). The total area treated by ground at saltmarsh and permanent water mosquito development sites in 2022 was approximately 14 ha, which equates to about 54 kg of granular Bti (4 kg/ha; Figure 7). Real-time data associated with each treatment are available through MBL's client-registered, real-time program portal.

## 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 the MVRD in 2022. Treatments took place on 8, 15, and 30 June and 9 July (Figure 8). For comparison, only one aerial campaign was required in 2021. The difference in required aerial treatment events signifies the relatively higher

abundance of floodwater mosquito larval within the region in 2022. The high mosquito larval abundance was due to a compounded mosquito eggs abundance triggered to hatch with high, sustained Lower Fraser River levels.

Aerial treatments were conducted using granular Aquabac®. To compensate for increased canopy cover, aerial treatments were applied at an average rate of 10 kg/ha. A total of 142 ha was treated by air, equating to a total of approximately 1,420 kg of Aquabac® used (Figure 8). The total area treated in 2022 was approximately twice that treated in 2021.

Aerial treatment events typically take place immediately after the Fraser River 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 hit, aerial treatments often bookend a peak. Additionally, when the Fraser River is sustained at high water levels, more floodwater mosquito eggs may have time and abundant conditions to hatch. Aerial treatments were clustered around the initial and primary Lower Fraser River peaks (Figure 7). MBL staff were able to accompany the helicopter pilot again in 2022, which aids in identification and treatment of inconspicuous mosquito development areas. To increase understanding of the program reach during high-water, a MVRD Regional Parks staff member was also able to ride in the helicopter during one aerial treatment over Brae Island. All treatments successfully controlled targeted floodwater mosquito larvae. Shapefiles of aerial treatments are maintained by MBL and will be supplied to the MVRD. Appendix III shows more specific information about site, treatment timing, and extent of treatment. All ground and aerial treatment data were assigned to treatment hexbins in 2022.

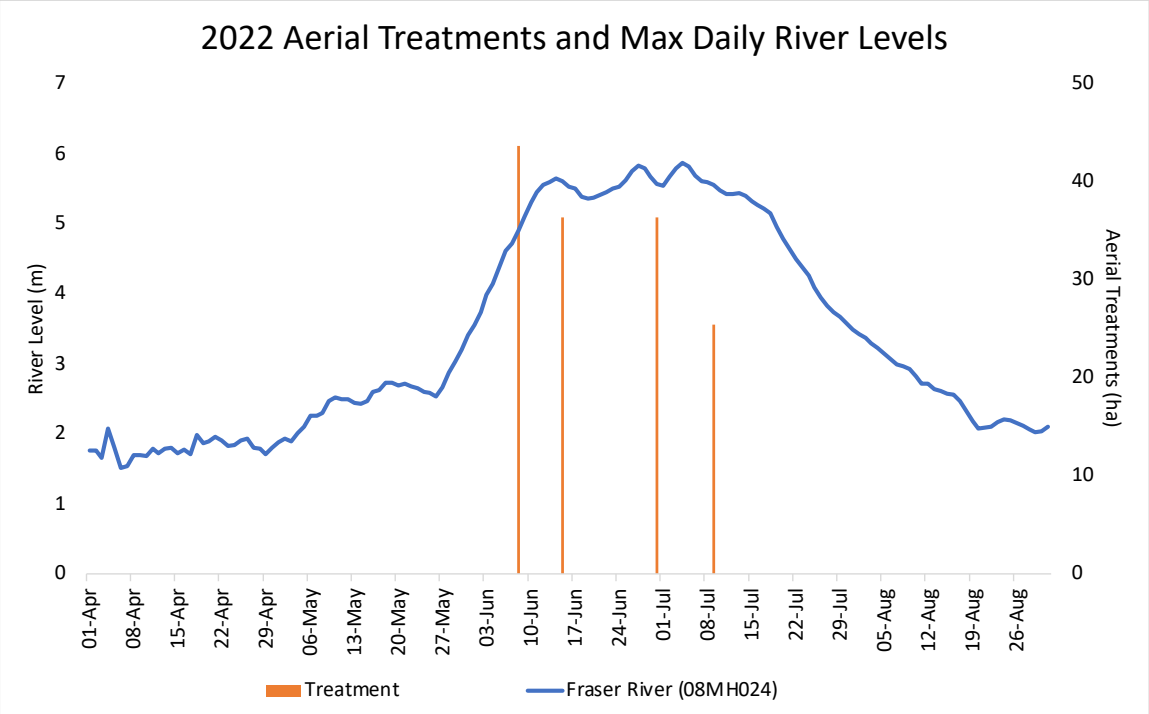


**Figure 8. Aerial application events (orange lines; ha) with Fraser River levels (blue line; m) from 1 April through 31 August 2022. Note that treatment values (ha) are on the alternate y-axis.**

## Adult Mosquito Trapping

The primary objective of the adult mosquito trapping program is to assess adult mosquito abundance, which operates as a quality assurance/quality control (QA/QC) measure for larval mosquito control activities conducted by MBL technicians. The trap data allow MBL to compare intra and inter-annual nuisance levels. Additionally, species composition data elucidates species present in the region, their primary habitat, and contributes to the general knowledge bank of mosquito science in the region.

Trap locations have changed since the beginning of MBL's contract tenure with the MVRD. While trap locations were initially located as close as possible to historical trap sites, many were moved in subsequent years to target areas of higher noted larval mosquito abundance and/or increased residential concern notifications. In 2022, numerous trap locations were repositioned again to reduce the incidence of vandalism noted in 2021. A total of 13 trap locations were selected in 2022. New site selection was facilitated and approved by each municipality. Over all, trap locations remain spatially representative of mosquito development habitat within each of the program partner municipalities. With the exception of Richmond and Pitt Meadows, two trap locations were established in each of the municipalities (Appendix IV). An additional trap location was added within the City of Pitt Meadows to target potential new floodwater mosquito development habitat. One trap location was selected in the City of Richmond to target saltmarsh mosquito habitat. An additional trap location focused on permanent water mosquito habitat should be selected for 2023.

Vandalism has been greatly reduced in 2022. However, one incident of tampering occurred at Brae Island Regional Park. Otherwise, all adult mosquito traps have been functioning properly and were recovered at the end of the monitoring season.

All adult mosquitoes were collected using battery operated Center for Disease Control (CDC) traps with dry ice as bait. A black light (night-operating only) and dry ice (i.e., $CO_2$) act to attract adult mosquitoes. A continuously working fan ensures that attracted mosquitoes are pulled into an attached basket. Basket contents were collected the following morning. As per MBL collection and shipping protocol, adult mosquito specimens were collected from traps, stored in a freezer, then sent to the MBL head offices for counts and later identification. A real-time data collection application was developed to track trap set-up, take-down, and content shipments. Additionally, one consistent MBL staff member was responsible for all mosquito trap efforts, improving field efficiency and reducing operator error.

Traps were monitored approximately every 1 - 2 weeks between 30 May and 31 August. A total of 83 trap nights were conducted. A total of 3,042 adult mosquito specimens collected (Table 2). An additional 14 trap nights were added in 2022. Approximately 1,500 more mosquito specimens were collected in 2022 in comparison to 2021. Higher, longer-sustained, and the late-season Lower Fraser River peak are likely responsible for the increased adult mosquito trap abundance.

Figure 9 shows the total adult mosquito trap abundance in relation to Fraser River levels (Mission gauge) by day. Typically, adult mosquitoes begin to disperse at least 2-3 weeks after the spring peak in the regional Fraser River levels. Depending on weather conditions (i.e., wind direction, wind velocity, ambient temperature, precipitation) the dispersal may be accelerated or decelerated.

Trap numbers were low in May and June trapping events because adult mosquitoes had not emerged from the delayed Fraser River freshet (Table 2, Figure 9). The initial Fraser River peak occurred on 15 June and the adult mosquito trapping event on 4 July yielded a high number (i.e., 870) of mosquito specimens for the first time in the 2022 season. The 4 July species composition was primarily comprised of the common floodwater mosquito species, *Aedes sticitcus* and *Aedes vexans* (Figure 10). Thus, it is likely that the majority of specimens from the 4 July trap collection event had dispersed from floodwater sites on or near the initial Fraser River Peak. The recorded peak of adult mosquito activity was on 4 August and likely in response to the main peak of the Lower Fraser River in early July (Figure 9). The species representing the highest percentages of specimens on 4 August were *Aedes sticitcus* and *Aedes vexans* (i.e., 43% and 49%, respectively) (Figure 10), suggesting that these floodwater mosquito species had dispersed from seepage sites that emerged from peak Fraser River levels. Adult mosquito trap content totals decreased following the 4 August trap night, reflecting the declining Fraser River levels.

**Table 2. 2022 adult mosquito count by trap location and date. Cells with 'N/A' means that trap contents were unidentifiable.**

| | Brae Island Regional Park | Garry Point Park | Cliff Park | Colony Farm Regional Park | Construction Rd. | Derby Reach Regional Park | Harris Landing Park | Kanaka Creek Regional Park | Mundy Park | Pitt River Walking Path | Pitt River Athletic Field | Town Centre Park | Tynehead Regional Park |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30-May | | | | 0 | | | 0 | | 0 | 0 | 0 | 0 | |
| 06-Jun | | | 0 | | 0 | | | 1 | | | | | 0 |
| 07-Jun | 1 | | | | | 2 | | | | | | | |
| 13-Jun | | 0 | | 0 | | | 0 | | 0 | 1 | 0 | 0 | |
| 20-Jun | | | 0 | | 1 | 4 | | 2 | | | | | 0 |
| 27-Jun | | | | 0 | | | 19 | | 2 | 3 | 8 | 1 | |
| 01-Jul | | | | | 0 | | | | | | | | |
| 04-Jul | 507 | | 7 | | | 58 | | 298 | | | | | 6 |
| 06-Jul | | 5 | | | | | | | | | | | |
| 08-Jul | | | | | | | 0 | | | | | | |
| 11-Jul | | | | 95 | | | 11 | | 3 | 300 | 36 | 2 | |
| 18-Jul | N/A | | 17 | | N/A | N/A | | N/A | | | | | N/A |
| 25-Jul | | | | 17 | | | 89 | | 10 | 15 | 95 | 5 | |
| 27-Jul | | | | | | | | | | 0 | | | |
| 04-Aug | 460 | | 1 | | 1 | 160 | | 660 | | | | | 14 |
| 07-Aug | | | | | | | | | | 8 | | | |
| 09-Aug | | | | 8 | | | 6 | | 4 | | 5 | 7 | |
| 19-Aug | 2 | | 6 | | 3 | 0 | | 1 | | | | | 0 |
| 26-Aug | | | | | | | | | 7 | | | | |
| 29-Aug | | 1 | | | | | | | | | | | |
| 31-Aug | 1 | | 3 | | 3 | 20 | | 14 | | | | | 26 |

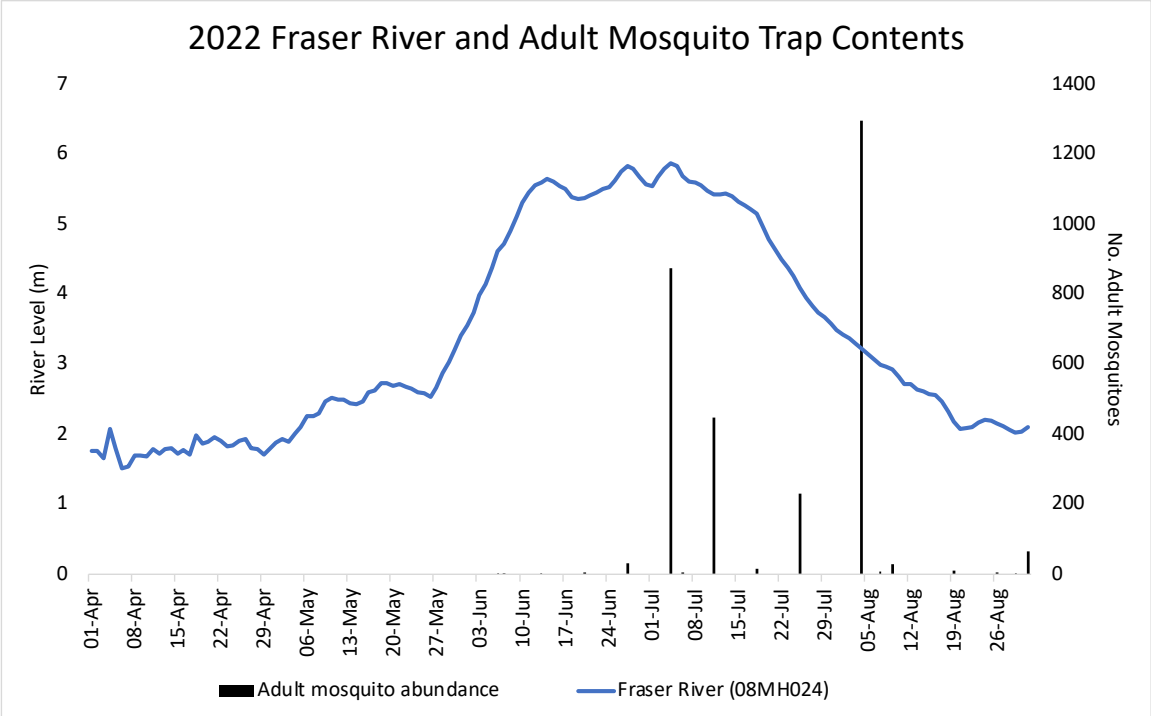


**Figure 9. 2022 MVRD adult mosquito trap abundance by day (black; alternate y-axis) with Fraser River level (m; Mission gauge).**

Adult mosquito traps with the greatest number of specimens were from Kanaka Creek and Brae/McMillan Island (Table 2). The adult trap numbers within these locations are consistent with high mosquito larval densities noted from those same locations. Hotline call origin data (see 'Public Relations' below) also confirm high adult mosquito abundance in those areas, particularly from the Township of Langley, which is most impacted by Brae/McMillan Island adult mosquito emergence. Site reconnaissance efforts will continue within these areas.

The adult mosquitoes collected from traps were generally well-preserved in 2022. Approximately 6% of specimens were damaged in 2022, as compared to approximately 14% in 2020, and nearly half in 2019. All damaged specimens were from the 18 July trapping event and were unidentifiable due to mould development. Specimens that get wet during collection will be preserved with a desiccant (e.g., silica beads) in the future. Because the 18 July trap night was near the peak of expected floodwater mosquito dispersal, it is likely that the reported total number of specimens collected in 2022 would have been much higher with the inclusion of the 18 July trap data.

Specimen identification was conducted and verified by trained professionals using a 60X microscope. The primary resources for species identification were Wood et al (1979) and Darsie and Ward (2005). All female specimens were identified from samples with <50 female mosquitoes. Approximately 30% of female specimens were selected for identification from trap contents with high mosquito counts. The species confirmed in the

2022 MVRD adult mosquito traps were *Aedes vexans, Ae. sticticus, Ae. cinereus, Ae. canadensis, Culex tarsalis, Cx. pipiens, Cx. territans, Coquillettidia perturbans, Culiseta incidens, Cul. inornate, Cul. morsitans* and *Anopheles punctipennis*. Certain indistinguishable specimens were either unknown or identified as either the *Aedes* or *Culex* genus (Figure 10).

During the period in which most adult mosquitoes were caught (i.e., 4 July – 4 August), floodwater mosquito species were found in high abundance. Container mosquito species were present in traps in relatively high percentage in early-June and later-August, but were of relatively low trap numbers in 2022. These analyses indicate that trap locations primarily targets floodwater mosquito habitat. No saltmarsh habitat mosquito species were identified in 2022 despite the Garry Point Park location that is near potential saltmarsh mosquito habitat. A 2023 program recommendation is to move one Surrey adult mosquito trap to a saltmarsh-influenced area to obtain a better idea of saltmarsh mosquito treatment QA/QC. The abundance and frequency of floodwater mosquitoes throughout the season is indicative of the late, prolonged, and relatively high peak in comparison to the peak in 2021.

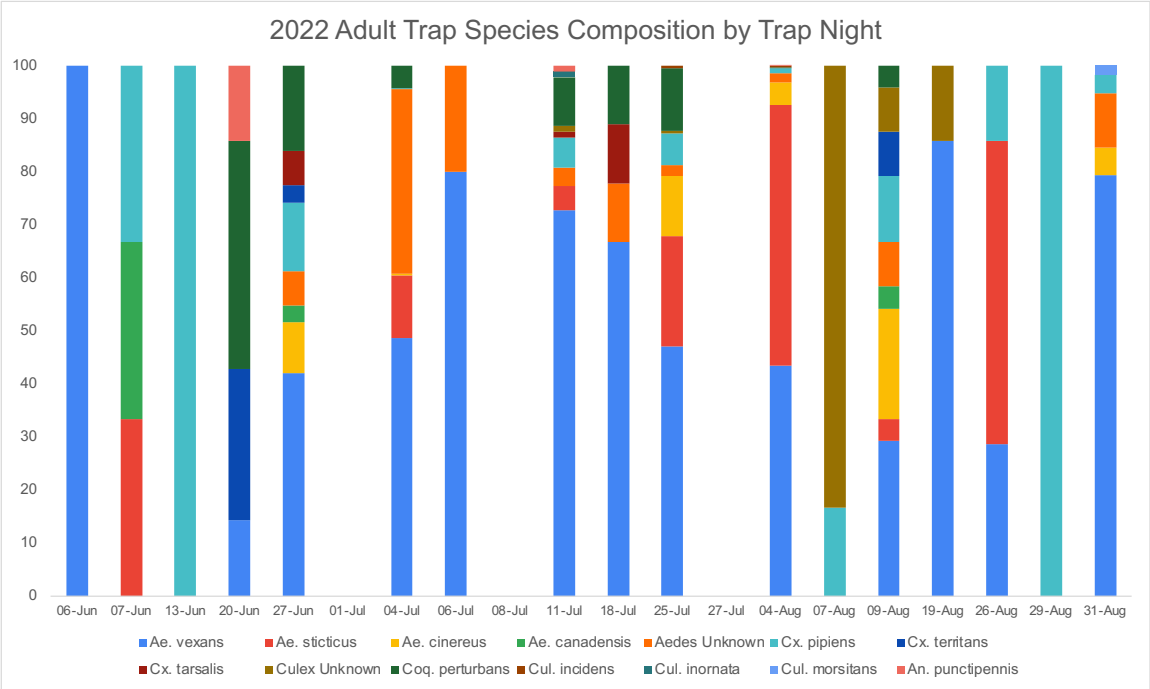


**Figure 10. 2022 adult trap species composition by trap night from traps within the MVRD.**

*Aedes japonicus* was not detected in any MVRD adult mosquito traps in 2022, but was found in an adult mosquito trap in Abbotsford on 27 July. *Ae. japonicus* rarely occurs in the province and is distinguished for its success as a vector for West Nile virus, St. Louis encephalitis, dengue, chikungunya, and Japanese encephalitis. The species was first reported in British Columbia in 2015 (Jackson et al. 2015). The specimen was confirmed by a secondary source and reported to Director of the Entomological Society of BC at the University of British Columbia (the 'Director'). Thus, it is likely that *Ae. japonicus* is also inhabiting areas of the MVRD, but at low levels of occurrence.

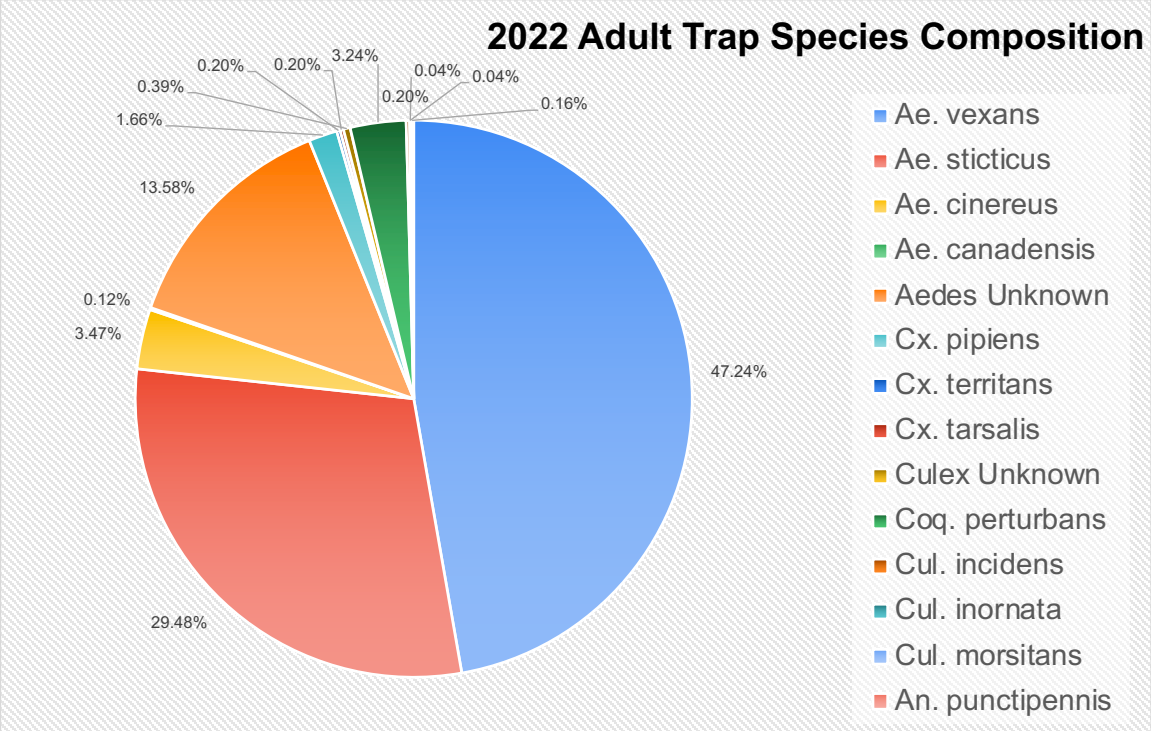


**Figure 11. 2022 over-all mosquito species composition from adult mosquito trap established throughout the MVRD.**

Overall, floodwater *Aedes* species comprised the majority of the species in 2022 traps (i.e., ~90%; Figure 11). As the dominant floodwater species in the MVRD, *Aedes* species were found throughout the mosquito season. *Coquillettidia perturbans* comprised the next highest percentage of species (i.e., ~ 3%). The primary habitat for *Cq. perturbans* is emergent vegetation, and more specifically *Typha* species (Batzer and Sjogren 2012). The high Fraser River levels of 2022 may have created additional habitat for *Cq. perturbans.* The high presence of *Cq. perturbans* was also noted in similar abundance and from similar areas within the MVRD by Jackson and Patterson (2018) during the high-water year of 2018. It is possible that higher-water years may yield greater habitat and hatching cues for *Cq. perturbans*. Known areas with high *Cq. perturbans* presence or suitable habitat should be prioritized in high-water years (i.e., Township of Langley, Maple Ridge).

## 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(s), presentations to staff and politicians, email correspondence, and social media presence. MBL continues to look for new areas to expand this aspect of our program.

**Phone Calls and Emails**

MVRD residents have multiple venues to communicate with MBL. MVRD set up an in-house mosquito control hotline number (604-432-6228), which is forwarded directly to the MBL Mosquito Hotline. The MVRD Mosquito Hotline number is specified on the education outreach postcard (Image 2). MBL's Mosquito Hotline (877-986-3363) and email form, are outlined prominently on the contact tab of the MBL website (www.morrowbioscience.com).


**Image 2. Updated education outreach postcard (2022)**

There was a total of 181 calls received to either the MVRD Mosquito Hotline or directly to the MBL Mosquito Hotline in 2022. Six (6) emails were received from MVRD residents in 2022. All calls and emails are designated as either concern or inquiry-based. A total of 156 calls were designated as 'concern' and 25 were designated as inquiry-based (Appendix V). MBL's goal is to return all concern calls within 24 hours. While this goal was achieved for most of the season, calls were returned within 72 hours during 7-12 July when call volume was at peak levels.

The total number of calls and emails received in 2022 was the highest recorded since 2020 (Figure 12). The high number of concern calls and emails is due to the compounded number of mosquito eggs that hatched in 2022 from high and sustained Lower Fraser River levels in the warmer part of the season. Additionally, a Walnut Grove (Langley) Facebook page circulated the Mosquito Hotline number in July, suggesting that all residents call. Over 30 calls came from Walnut Grove within this time. Numerous follow-up site visits were conducted in the Walnut Grove area as a result. No new sites were identified from those additional surveys; it is likely that most nuisance mosquitoes affecting Walnut Grove were blown in from Brae/McMillan Island. While follow-up site visits are normal, multi-day reconnaissance efforts as a result of concern calls are seldom necessary or conducted. In the event this trend occurs in the future, MBL will issue an update to community Facebook pages with the surveys and results that have already been completed, provided partner municipality permission. This will hopefully help residents understand that the collective voice has been heard by MBL with appropriate follow-up action taken and will avoid overwhelming the Hotline system.

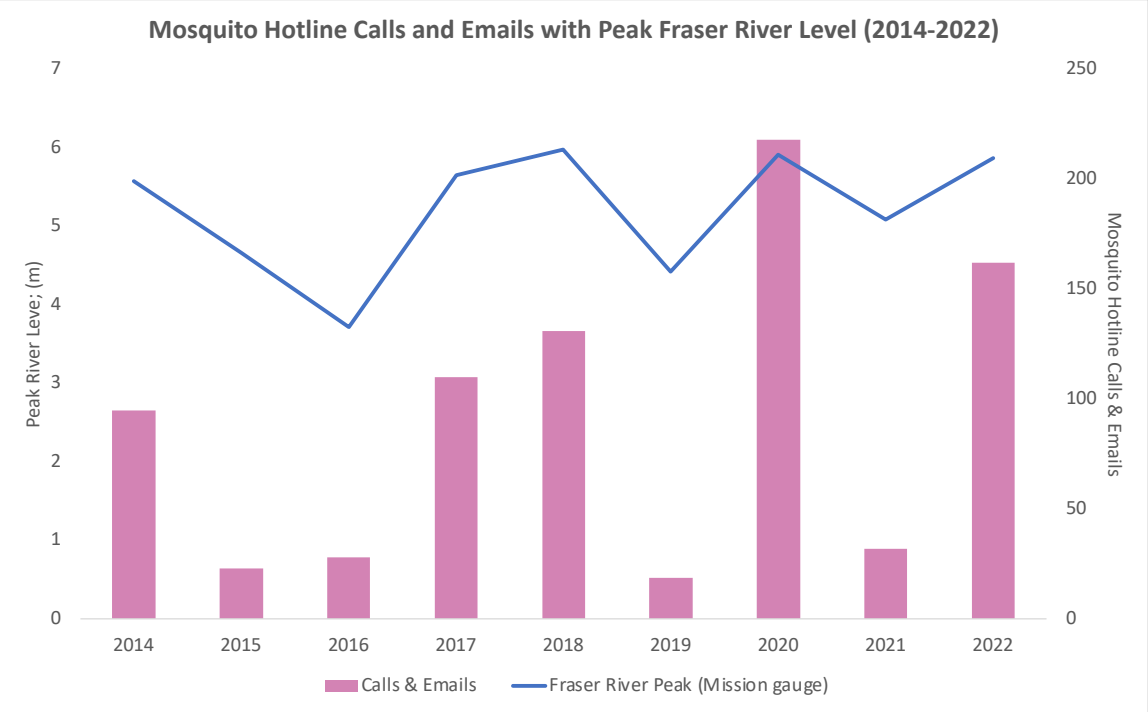


**Figure 12. Peak Fraser River levels (m; Mission gauge) with total Mosquito Hotline calls and emails (2014-2022).**

Concern calls were received from all partner municipalities, except the City of Coquitlam in 2022. The highest percentage of concern calls and emails (i.e., 68%; 110 calls) were received from or pertaining to the Township of Langley (Appendix V; Appendix VI). The Township of Langley has extensive and dynamic floodwater mosquito habitat. As such, a considerable amount of control effort – including three of the four aerial campaigns – was focused on mosquito habitat within the Township of Langley. If product efficacy reaches its highest reported rate of 95%, the residual 5% in a year with high larval mosquito abundance can still amount to significant nuisance. Concerns coming from Township of Langley residents were generalized regarding the high abundance of adult mosquitoes; MBL staff followed-up with numerous reconnaissance visits and located no new sites on residential properties.

Calls from Maple Ridge (i.e., 38; 23%) were regarding larval mosquito abundance in Kanaka Creek (Appendix VI). Despite an additional day of reconnaissance with two MBL staff members within Kanaka Creek Regional Park, no new habitat was identified. However, the Park has wide-ranging mosquito development habitat potential over a sizeable area. In order to systematically survey the area, MBL's recommendation is to send the company's head biologist to survey and map the extent of the Park's mosquito development area, using Lower Fraser River levels as a variable to assess appropriate survey timing.

Concern calls and emails from residents within all other municipalities ranged from six in Surrey, four in Richmond, and four in Pitt Meadows (Appendix V, Appendix VI). Most of these calls and emails were generalized adult mosquito abundance concerns and not associated with a specific site. Two calls from Richmond residents specified potential

mosquito development around a school. MBL staff conducted a site evaluation and determined that there was no target mosquito habitat located immediately near the school. Container mosquito habitat was suspected.

In the early portion of the season, 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 late-July. Accordingly, hotline calls were concentrated between mid-June and mid-July (Figure 13). The peak Hotline call volume was associated with adult mosquitoes that likely dispersed as a result of the initial Lower Fraser River peak on 14 June and the final peak on 4 July (Figure 13). Calls received after early-August were likely associated with highly localized container mosquito abundance.

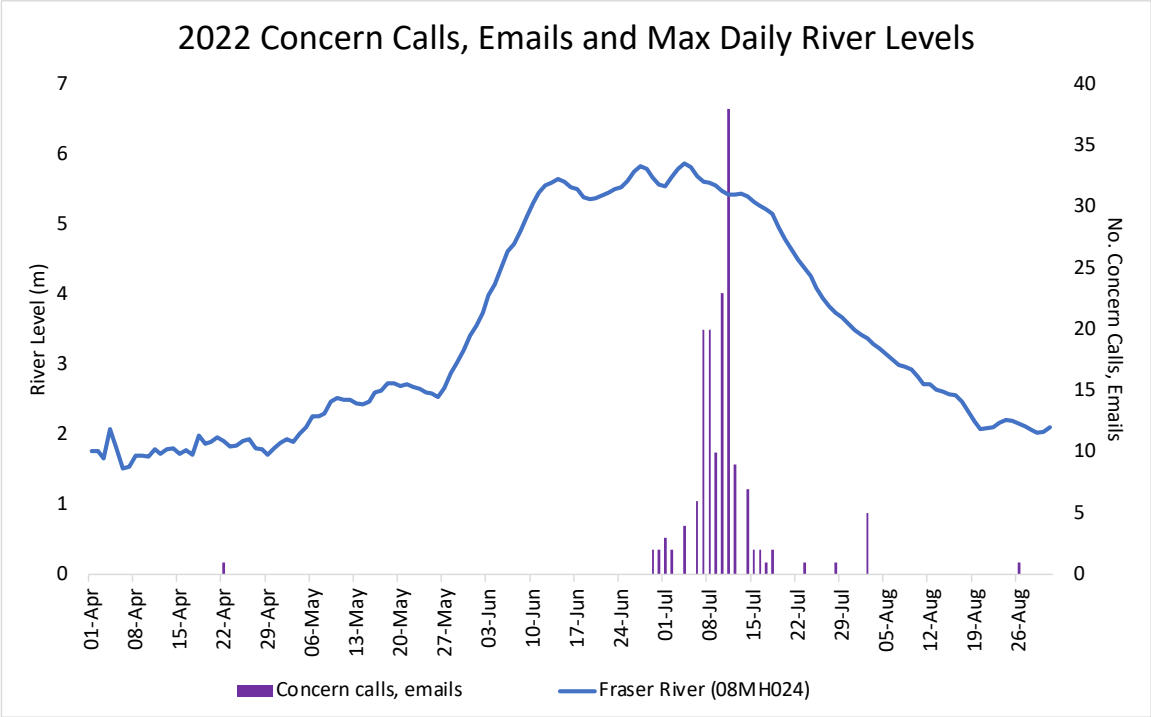


**Figure 13. 2022 Lower Fraser River levels (Mission gauge) with concern calls and emails received to the MVRD and/or MBL Mosquito Hotlines.**

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 MVRD 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 3. 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). Additionally, MBL staff may provide residents with an outreach pamphlet (Image 3). The pamphlet includes information about the larval control product used, mosquito biology, and personal protective tips. MBL staff also disseminated MVRD mosquito control postcards (Image 2).

## 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 384 on 6 November. This number has increased by over 40 since November 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 MVRD mosquito control program was 9,760 on 15 July and was in response to a media release addressing why the current adult mosquito abundance was high, MBL's efforts to control larval mosquitoes, and expectations for the remaining portion of the summer. The reach associated with MBL's media release is significantly higher than any post MBL has made. The high reach reflected the high and sustained Lower Fraser River level and linked floodwater mosquito abundance. The high reach may also reflect an increased circulation of MBL contact information potentially through updated postcards and presence at in-person events. All posts related to the MVRD mosquito program included the hashtag: #mvrdmosquitoes.

**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.

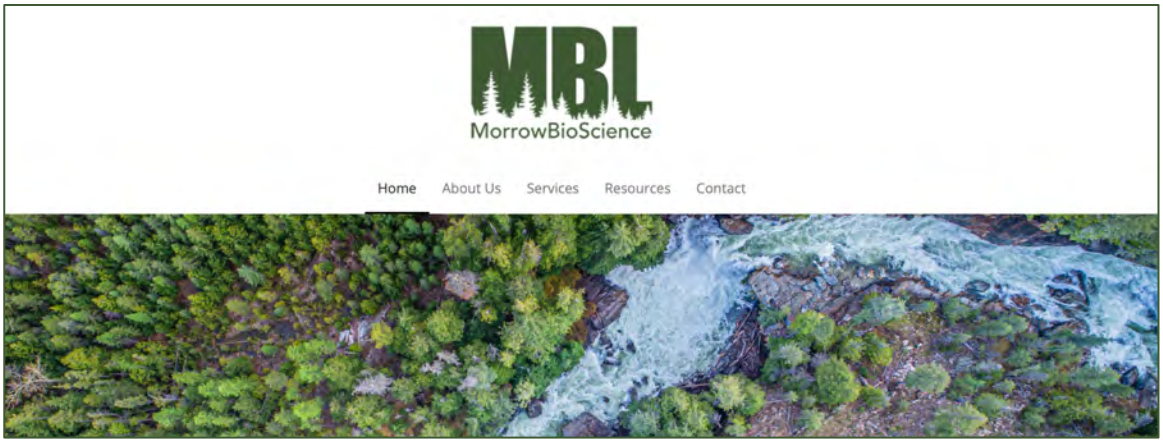


**Image 4. Morrow BioScience Ltd. homepage (www.morrowbioscience.com)**

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**

With the provincial allowance of larger, in-person gatherings in 2022, MBL was able to attend outreach events within each partner municipality. MBL staff shared program-

specific information, facts about mosquito biology, and had mosquito-related education activities aimed at younger demographics. Many residents were interested in the personal protective tips provided by MBL staff. Specific outreach events included:

- Goodbye Chums (Metro Vancouver Regional Parks, Kanaka Creek Regional Park, 24 April)
- Party for the Planet (Surrey, 30 April)
- Fort Langley May Day Parade (Langley, 23 May)
- Pitt Meadows Day (Pitt Meadows, 4 June)
- Teddy Bear Picnic (Coquitlam, 12 June)
- Maple Ridge Haney Farmers Market (Maple Ridge, 18 June)
- Kwantlen Farmers Market (Richmond, 5 July)

As a result of the high and sustained Lower Fraser River levels, one media release was developed in 2022. With the help and approval of MVRD staff, media releases were posted on MBL social media sites on 15 July. In addition to the media releases, 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)
- Maple Ridge News (13 July)
- CBC (14 July)
- CBC – Early Edition (18 August)

All interview requests are approved by the MVRD program manager. Every effort is 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[9]. Similarly, no horse or bird cases were reported from British Columbia within 2022. Of note, previous BCCDC reports were not published until mid-December, so it is likely that surveillance did occur in 2022 and will be published shortly. An update will be sent to partner municipalities 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.

[9] https://www.canada.ca/en/public-health/services/publications/diseases-conditions/west-nile-virus-surveillance/2021/week-37-38-september-13-26.html

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[10]. 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[11]. 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[12]. HealthLinkBC reports that no Zika cases have originated in Canada due to presumed lack of vector mosquito species[13]. 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] http://www.doh.wa.gov/DataandStatisticalReports/DiseasesandChronicConditions/WestNileVirus
[11] https://www.cdc.gov/westnile/statsmaps/preliminarymapsdata2022/index.html
[12] https://www.canada.ca/en/public-health/services/diseases/zika-virus/health-professionals.html#_Surveillance_in_Canada
[13] https://www.healthlinkbc.ca/health-feature/zika-virus

## 2023 Program Recommendations

- Systematic surveillance of the Kanaka Creek area conducted by MBL's Lead Biologist.
- Adult mosquito trap contents should be preserved with a desiccant to avoid mould development.
- The adult trap location on Brae/McMillan Island should be re-located to a protected area in order to prevent tampering.
- An additional adult trap location should be selected and approved within the City of Richmond, targeting permanent water (i.e., ditch) environments.
- An adult trap in Surrey should be relocated to target saltmarsh mosquitoes
- If necessary, produce targeted social media posts directed at community group pages noting acknowledgement of any issues, site visit results, and follow-up plans.
- Notify the Ministry of Environment of the MVRD intent to treat mosquitoes in 2023 under the MVRD 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). NOTE: all sites have been re-mapped. These new data should be used to reprint maps for the purposes described above.

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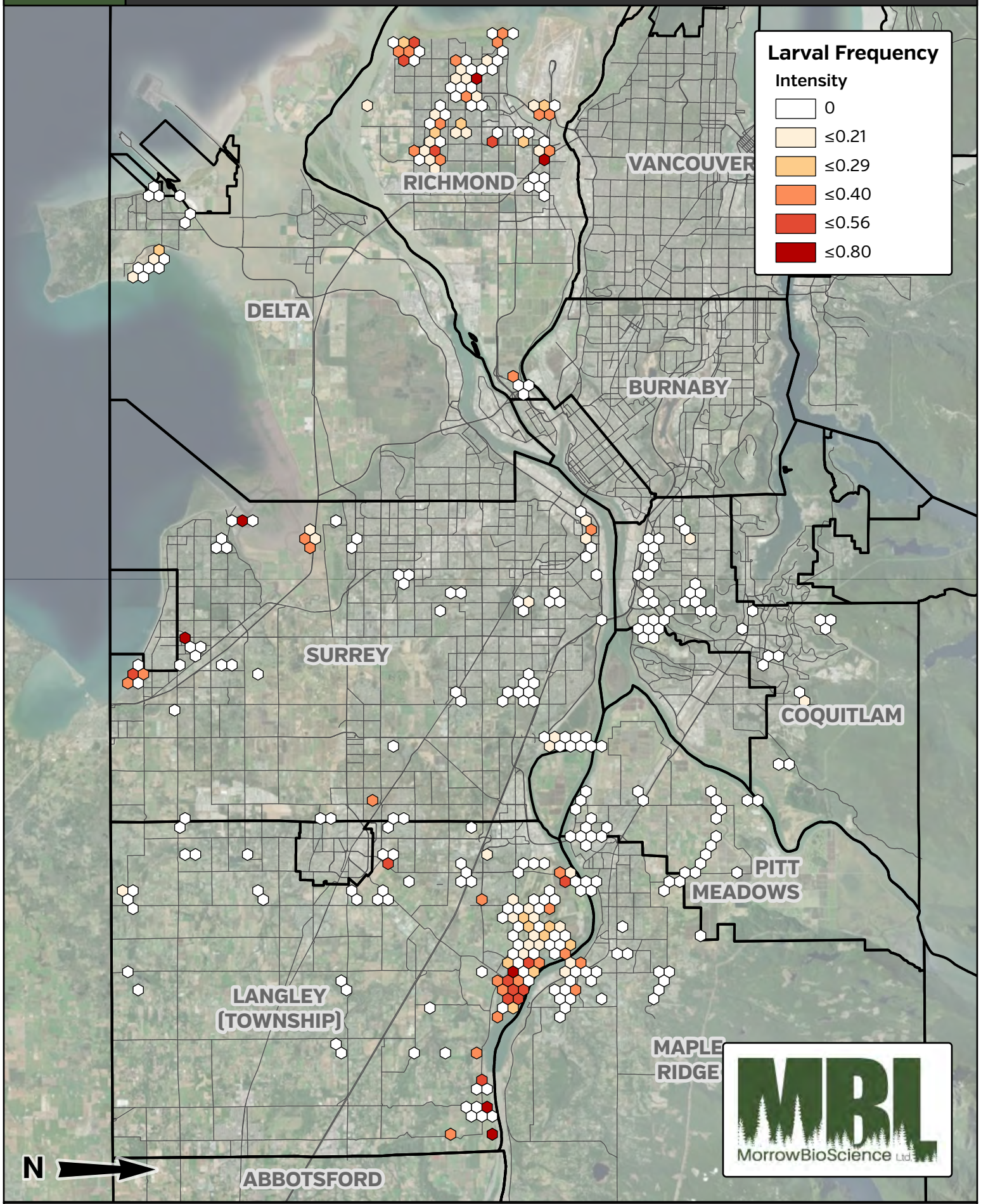
Appendix I-A

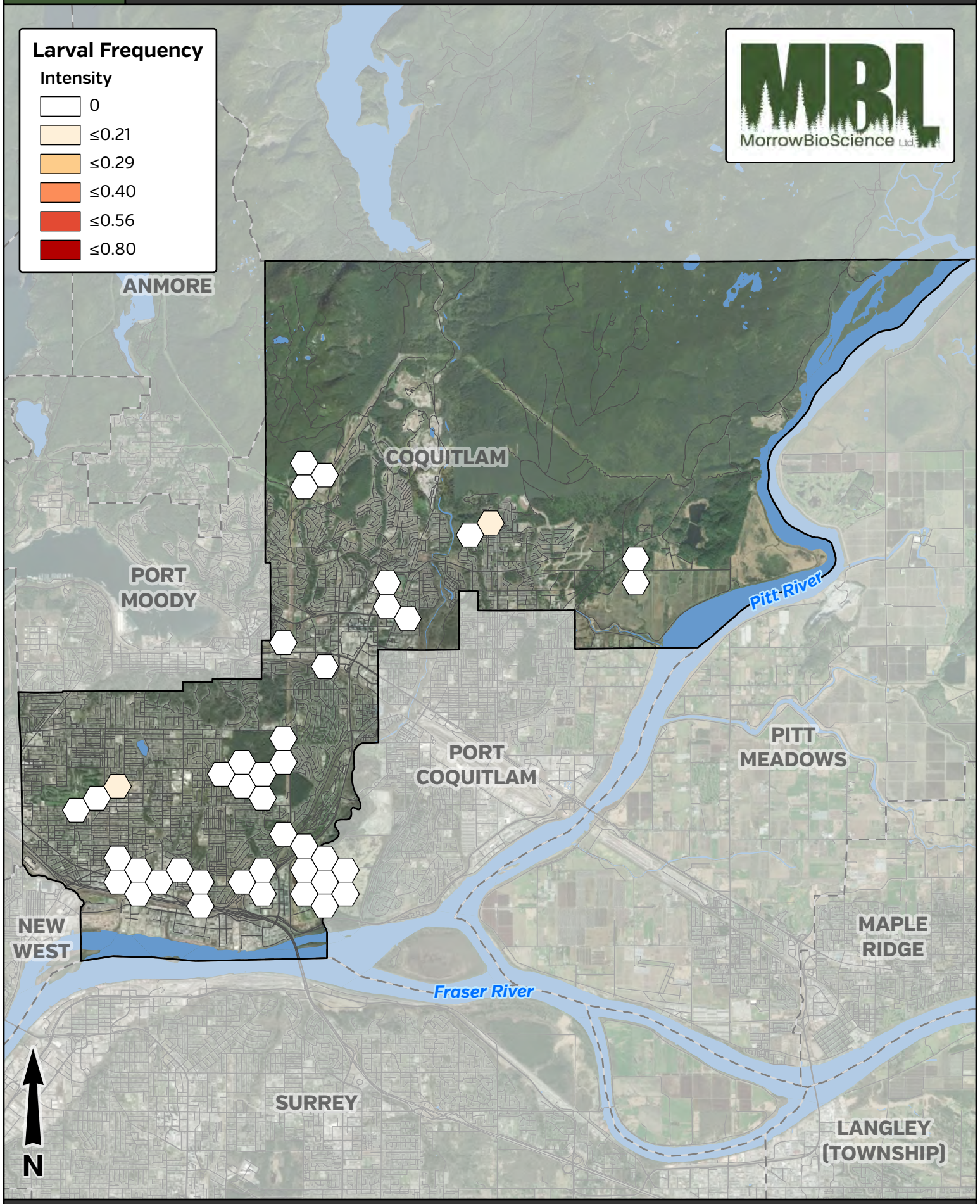
# 2022 MVRD Mosquito Larval Frequency




Scale = 1:230,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-20

Appendix I-B

# 2022 Larval Frequency - Coquitlam

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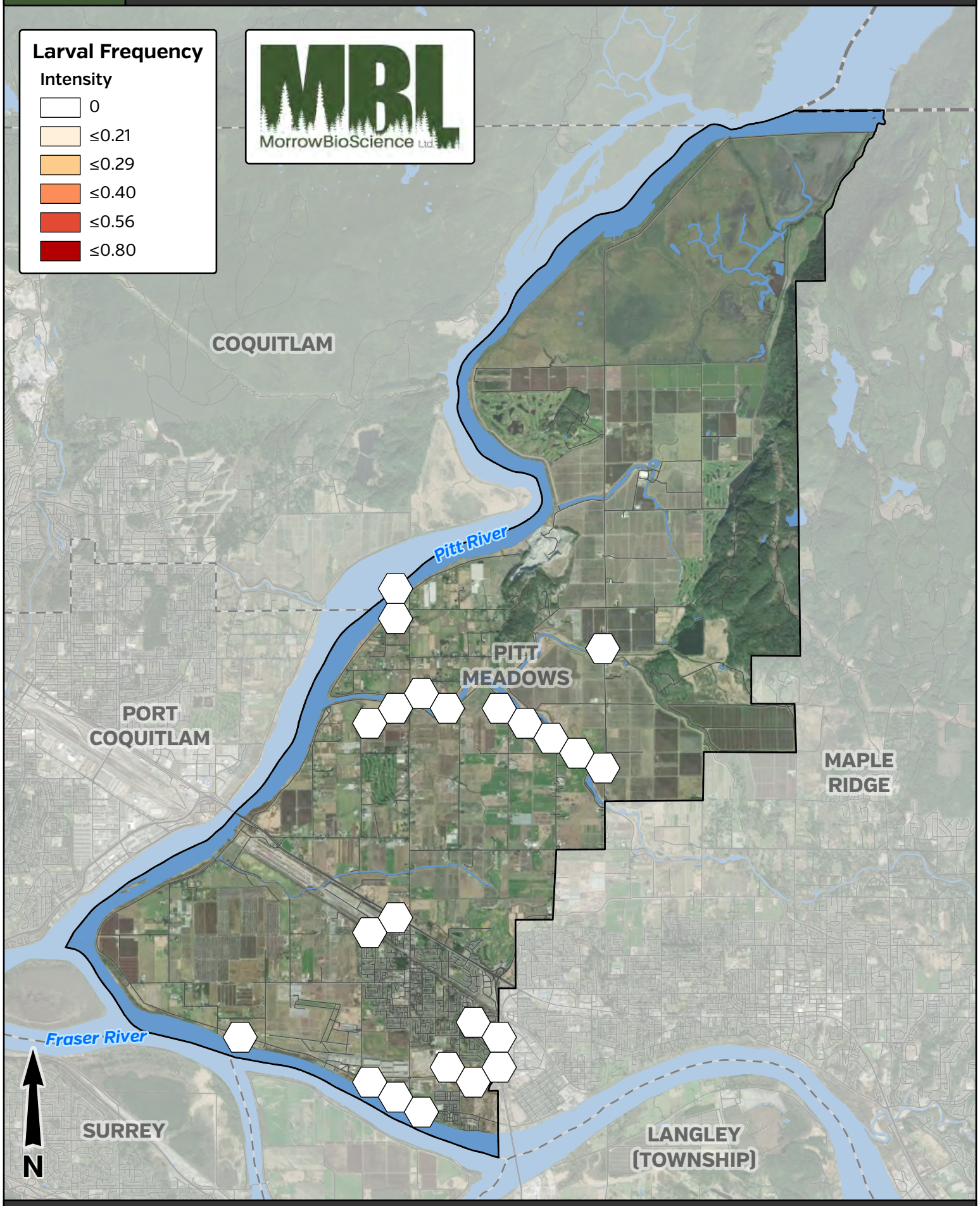
Appendix I-C

# 2022 Larval Frequency - Pitt Meadows

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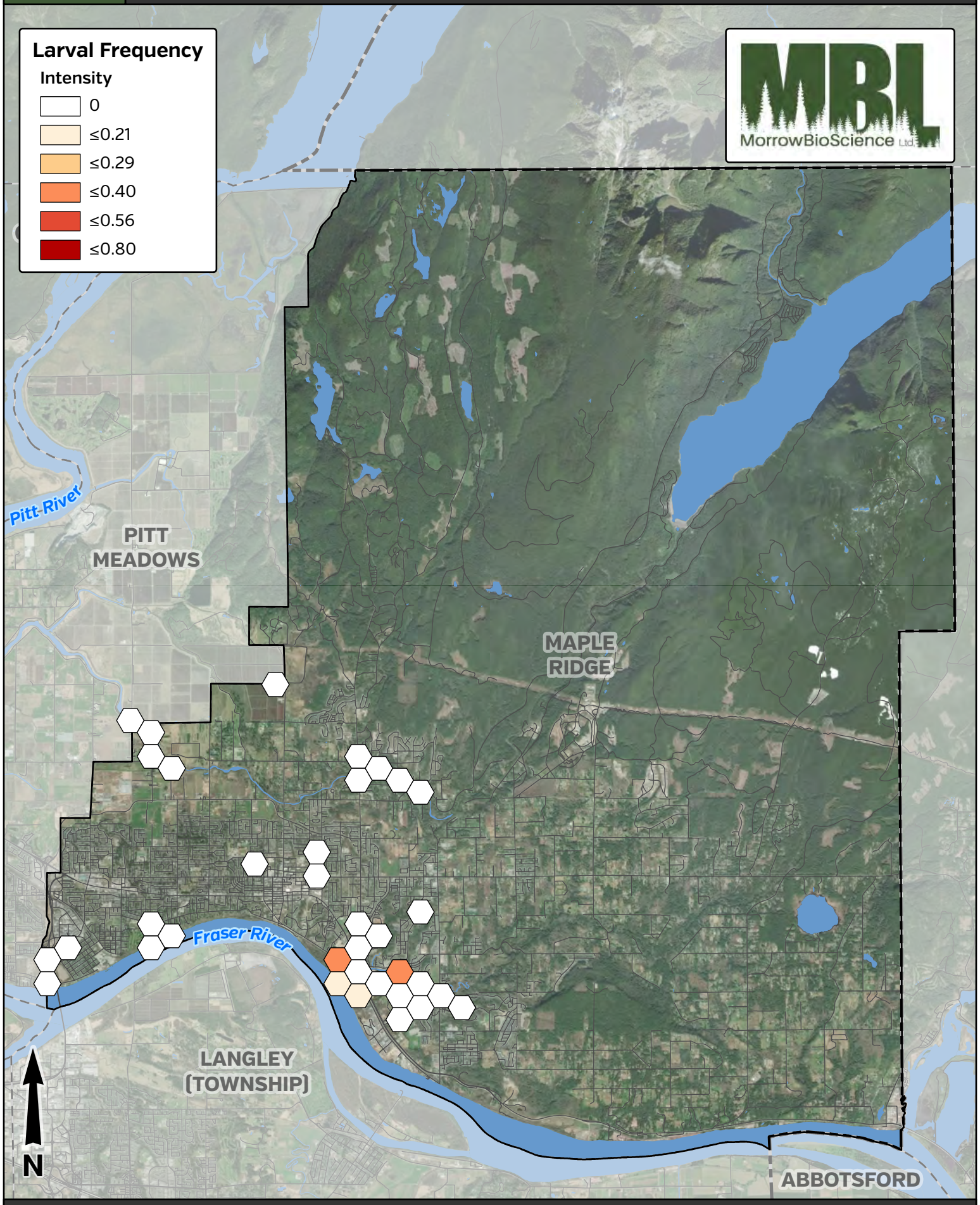
Appendix I-D

# 2022 Larval Frequency - Maple Ridge

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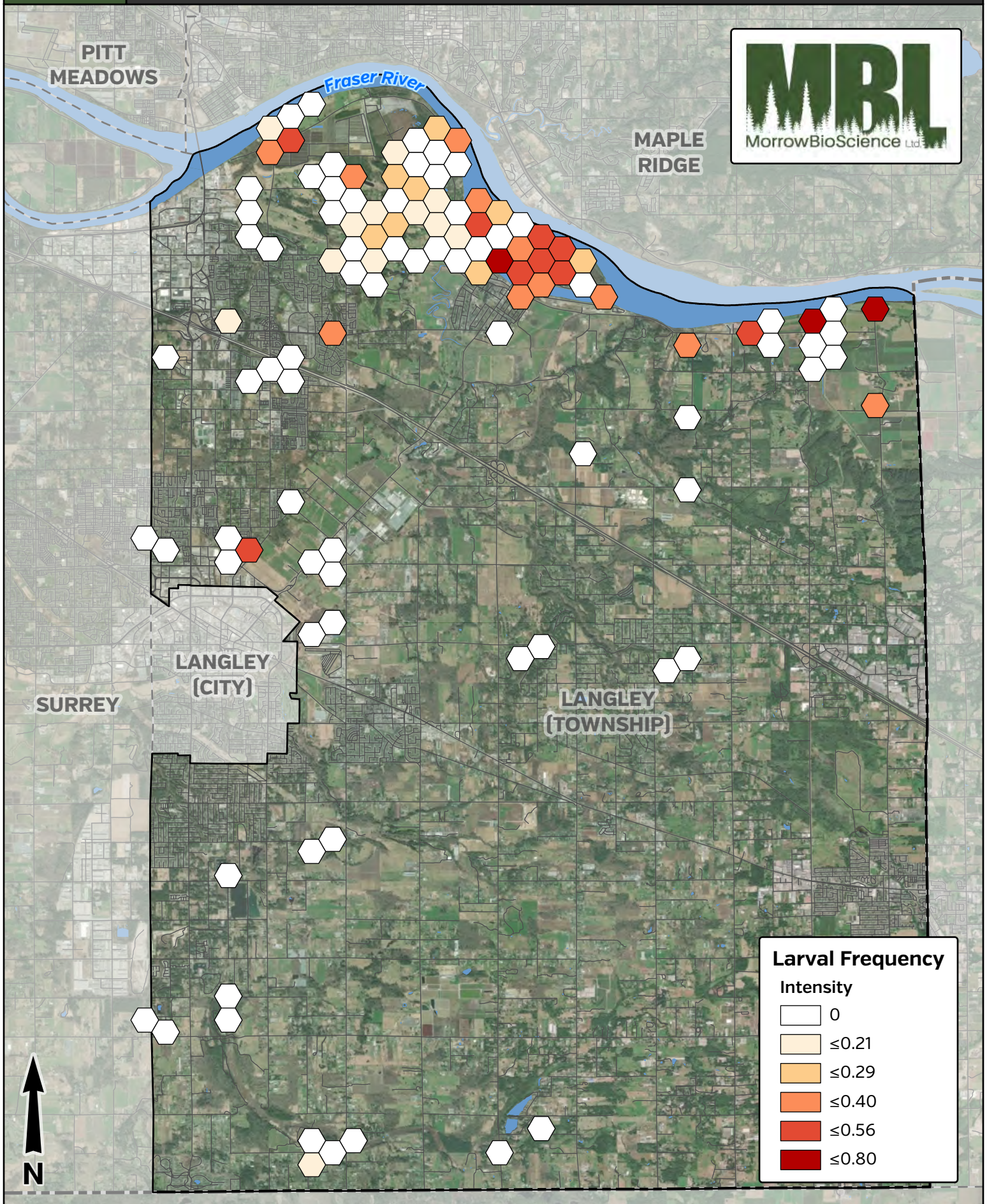
Appendix I-E

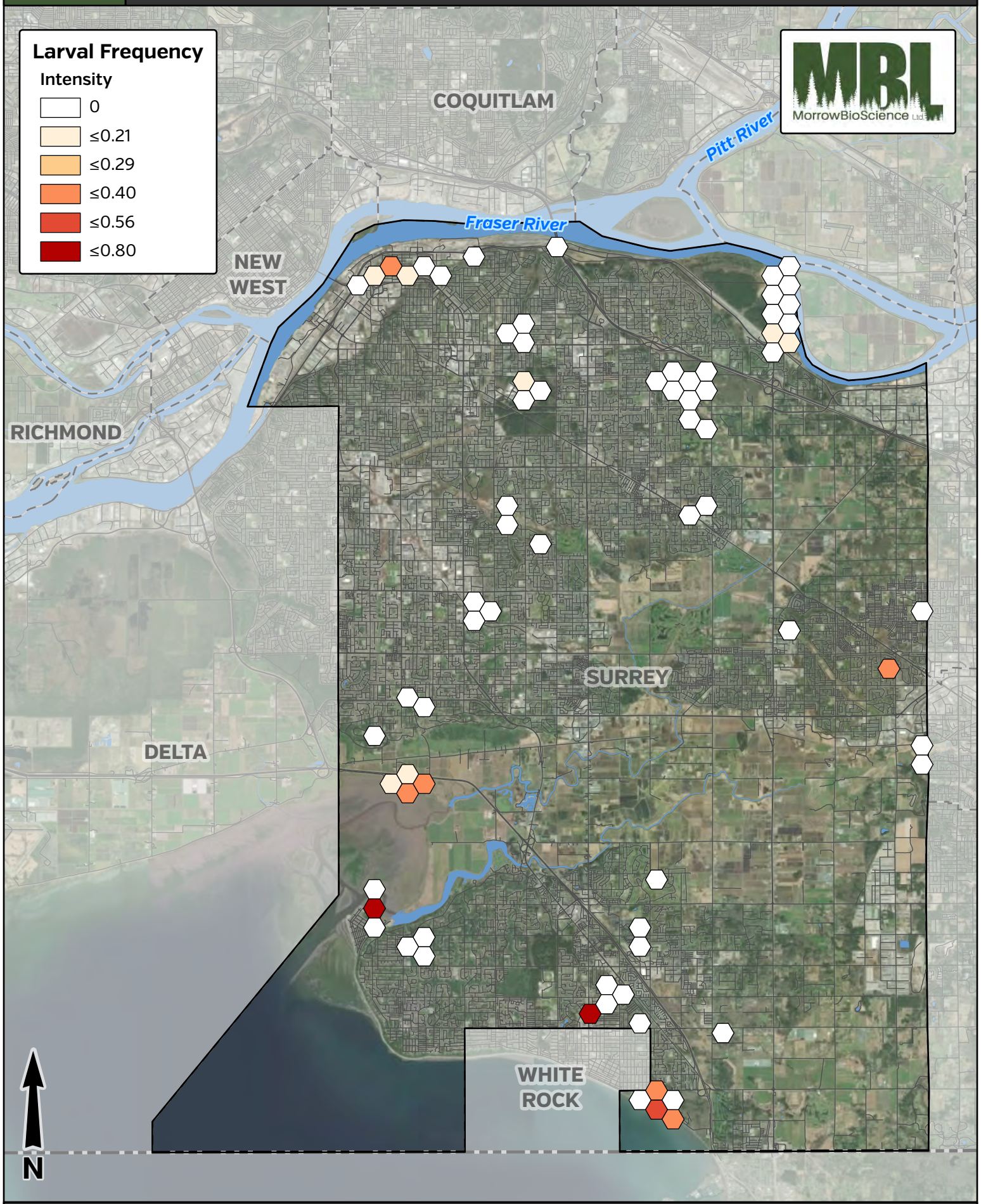
# 2022 Larval Frequency - Langley




Scale = 1:100,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-20

Appendix I-F

# 2022 Larval Frequency - Surrey

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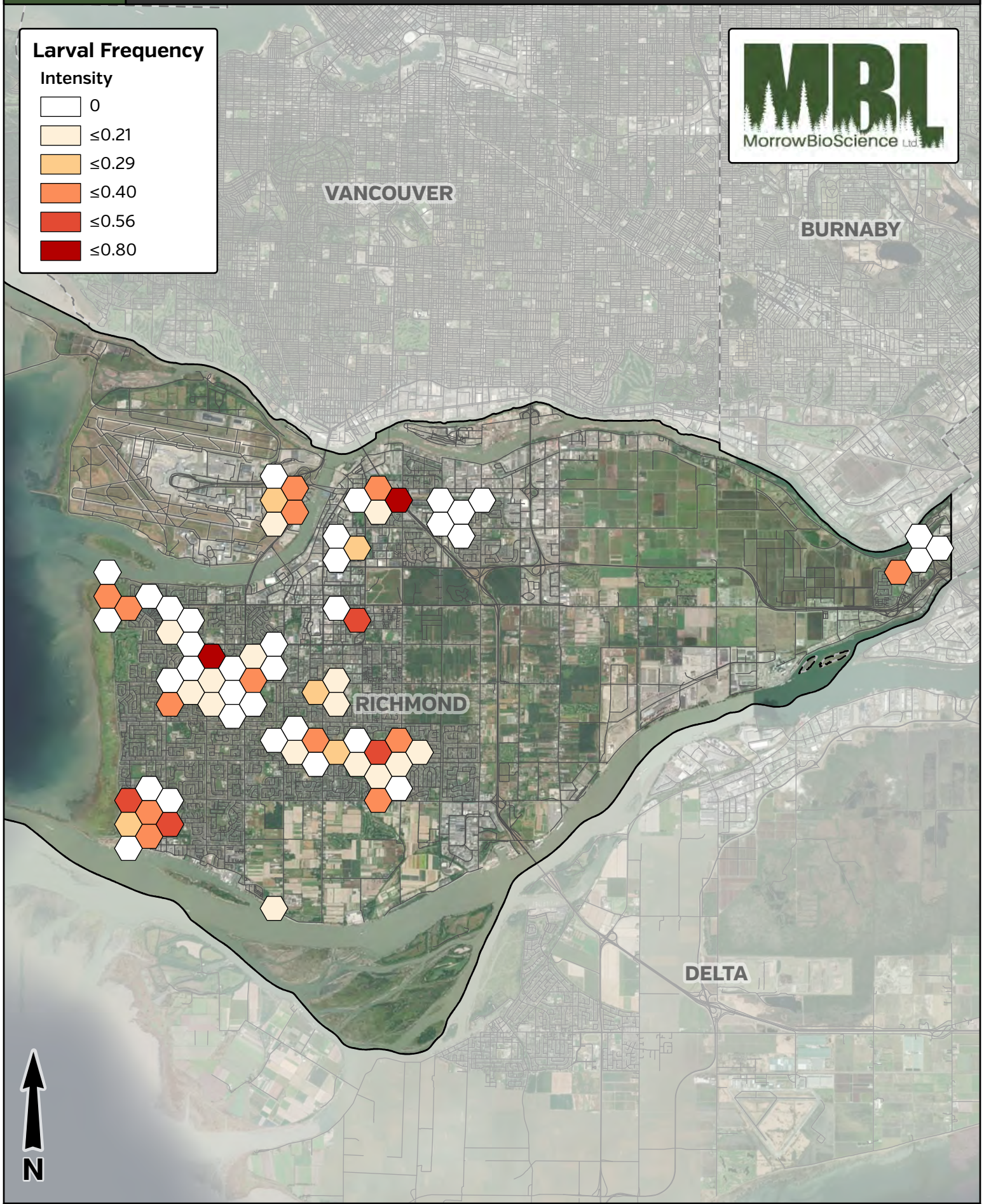
Appendix I-G

# 2022 Larval Frequency - Richmond

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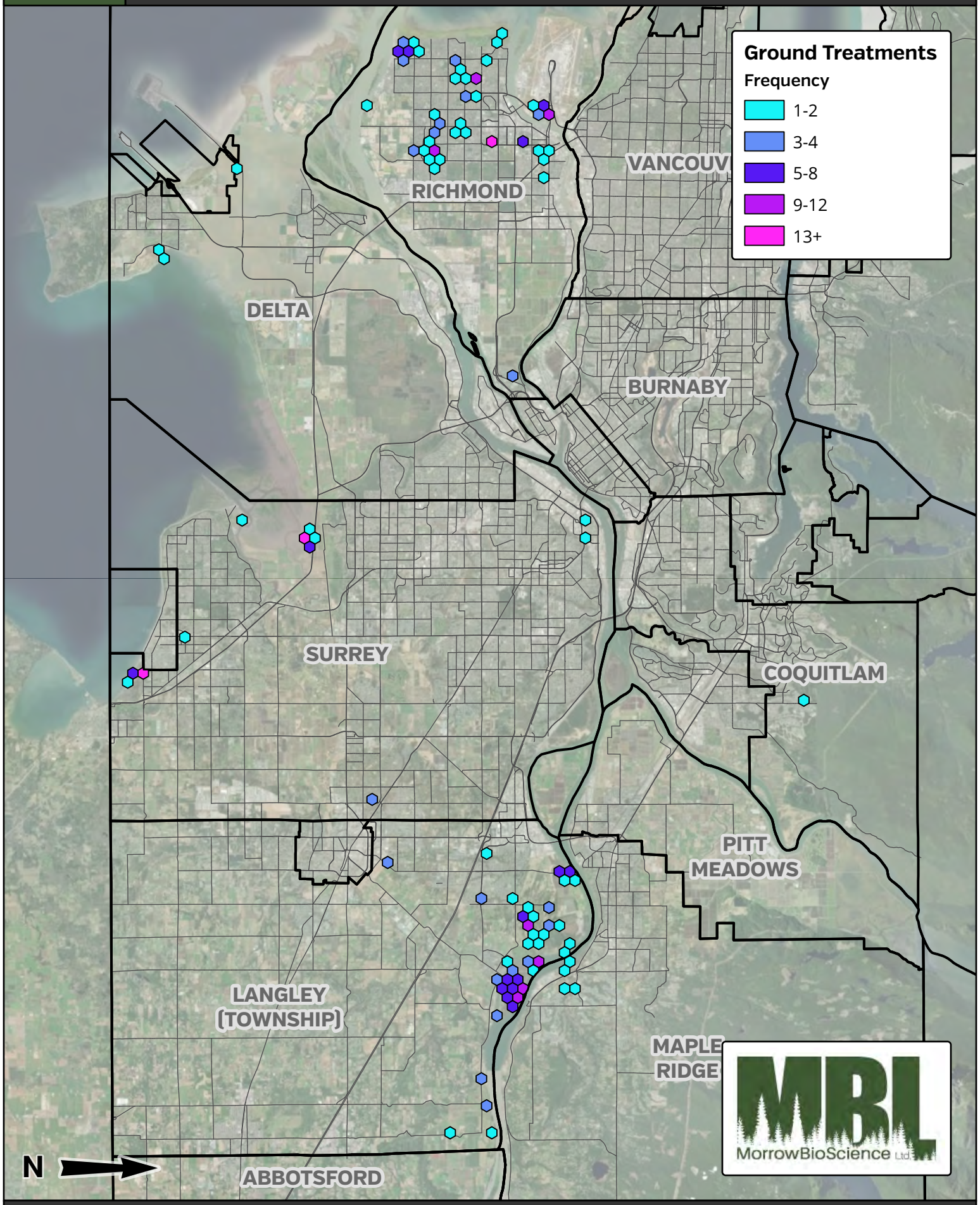
Appendix II-A

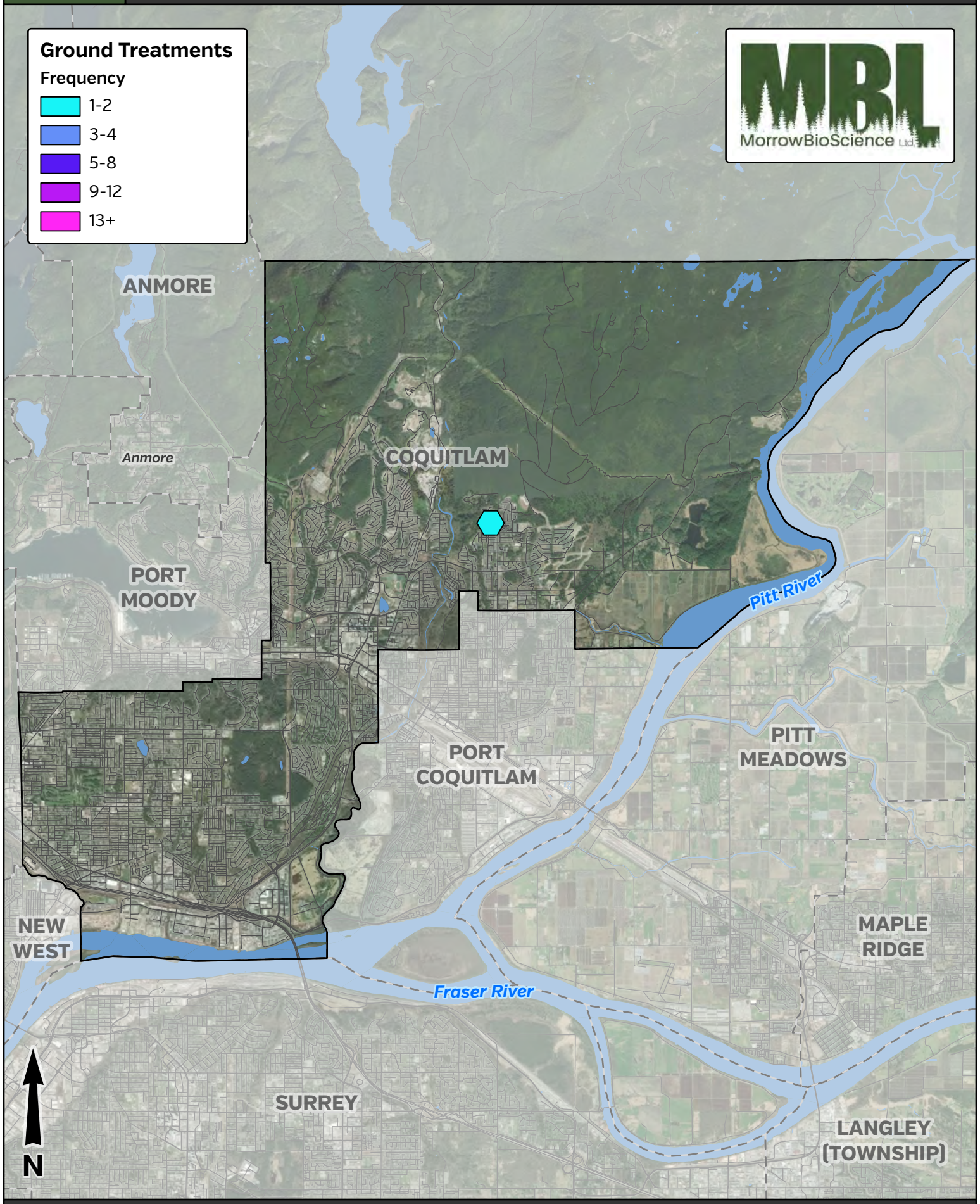
# 2022 MVRD Larvicide Treatment Frequency




Scale = 1:230,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-24

Appendix II-B

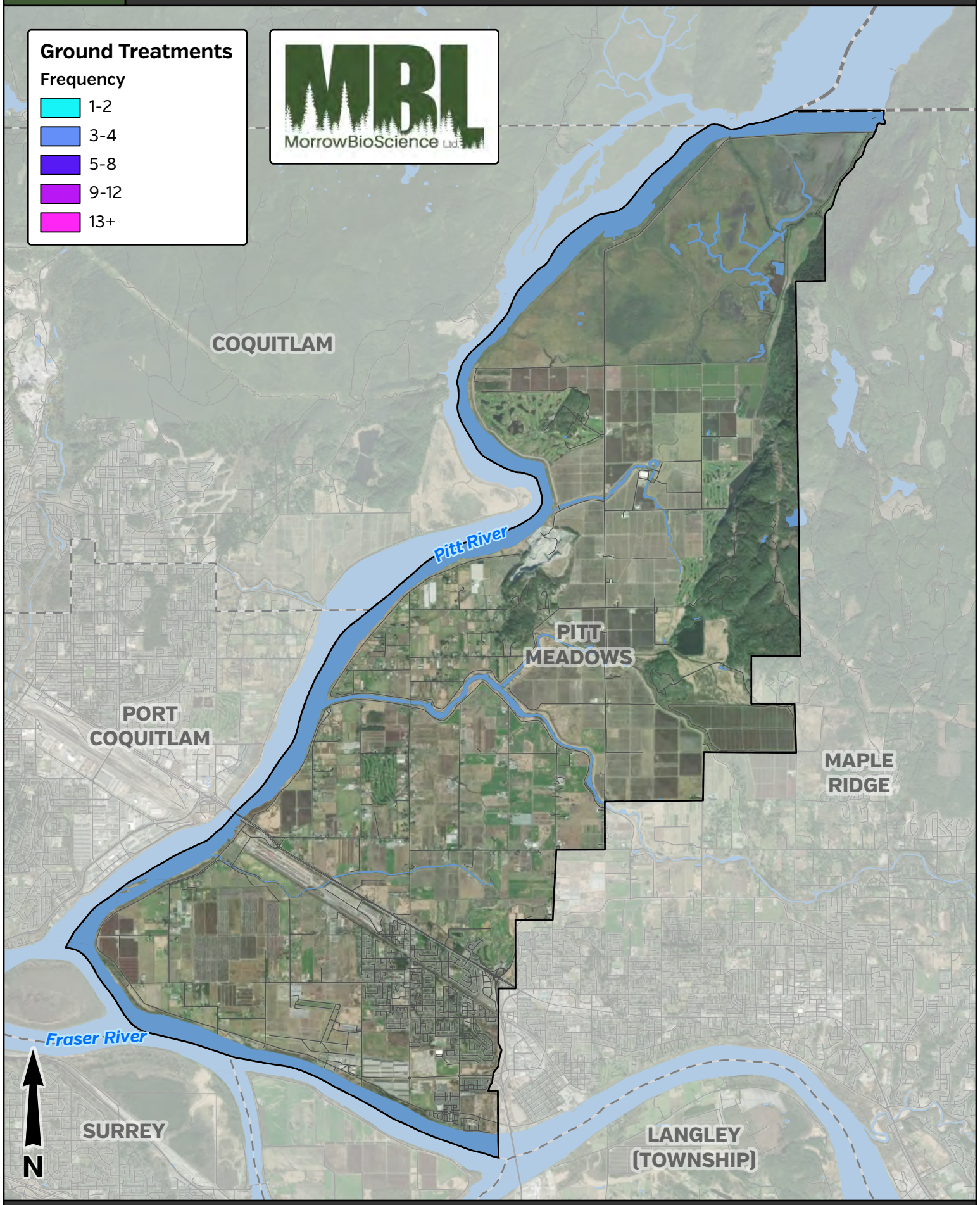
# 2022 Larvicide Treatments - Coquitlam




Scale = 1:100,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-20

Appendix II-C

# 2022 Larvicide Treatments - Pitt Meadows

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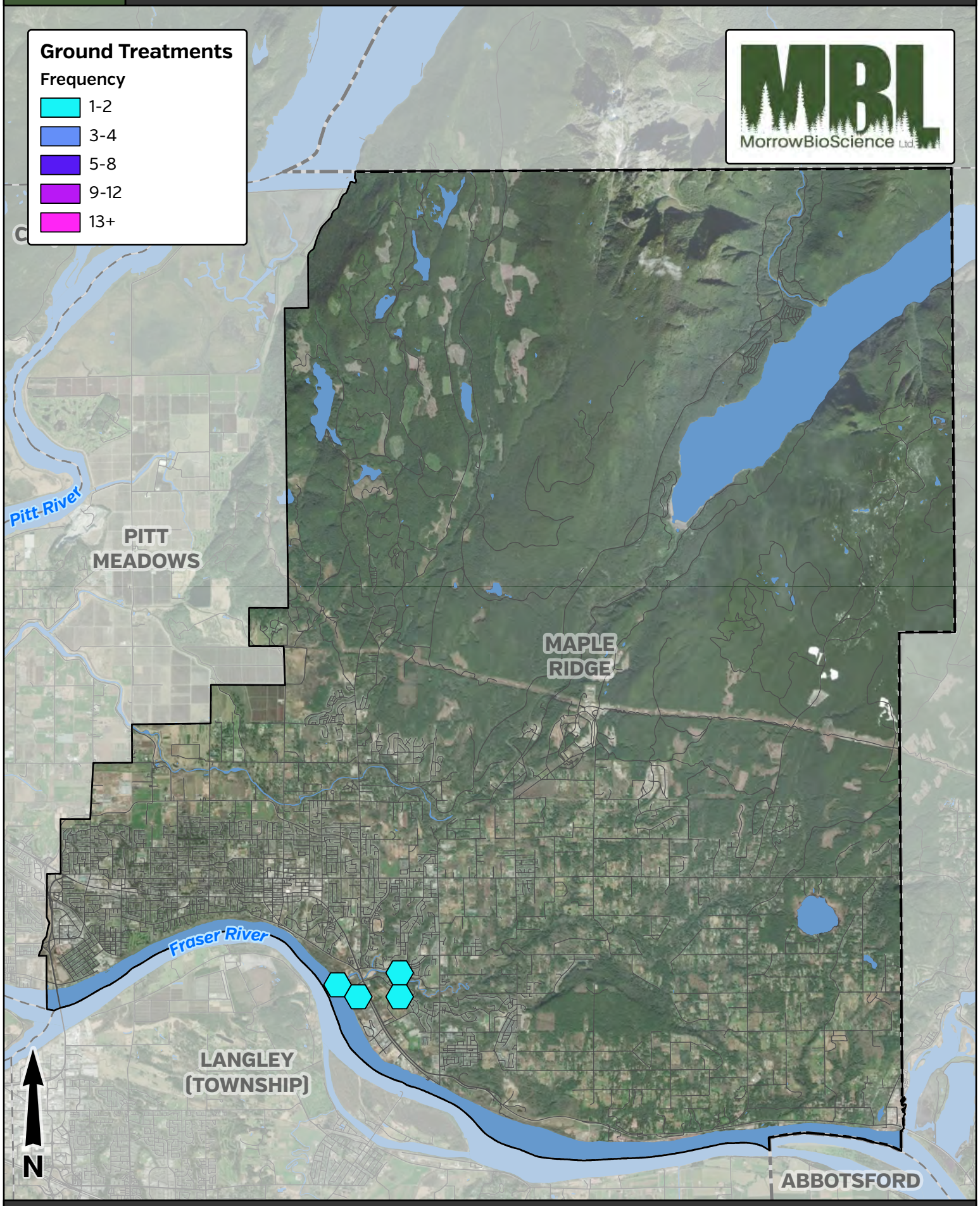
Appendix II-D

# 2022 Larvicide Treatments - Maple Ridge

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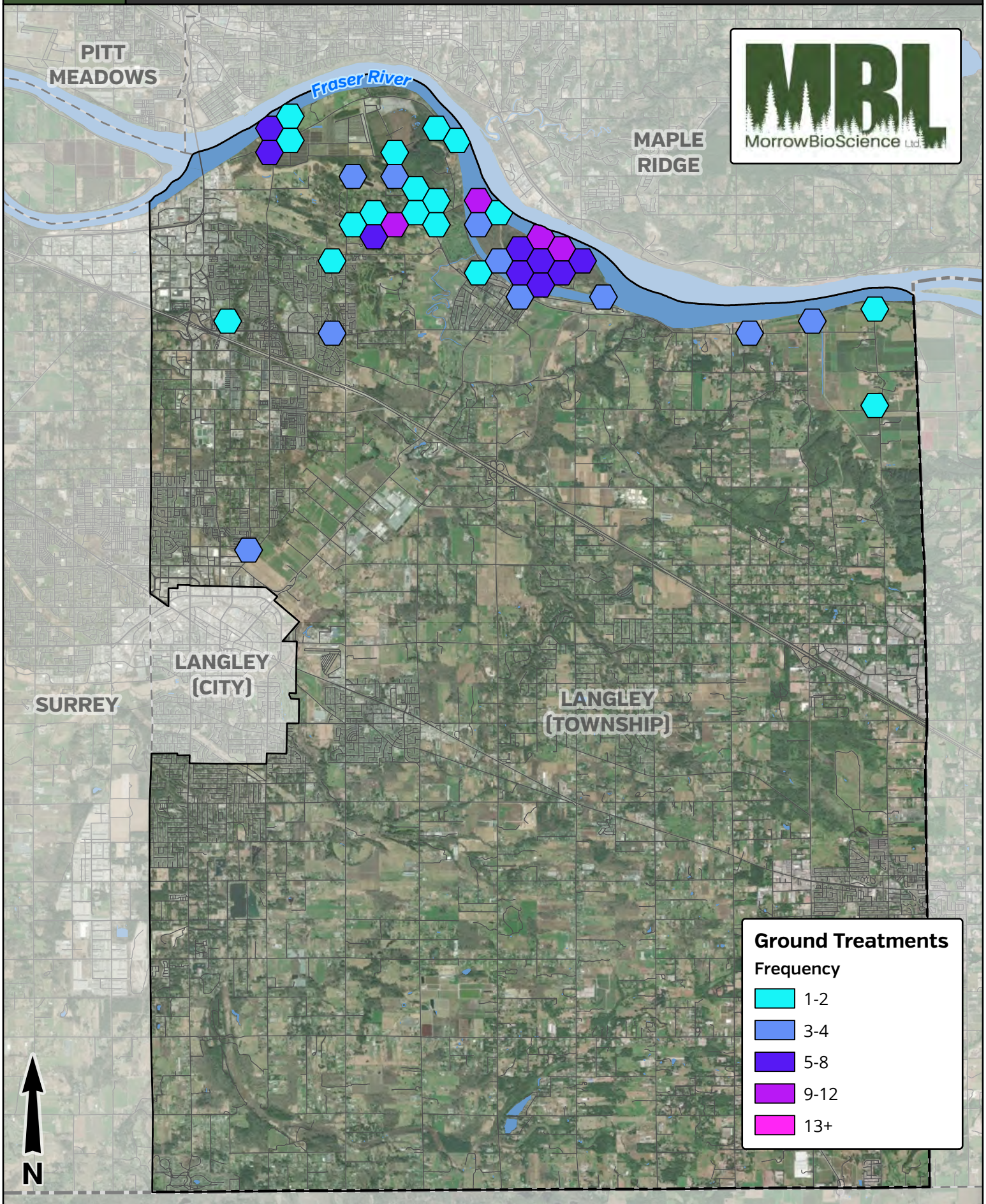
Appendix II-E

# 2022 Larvicide Treatments - Langley

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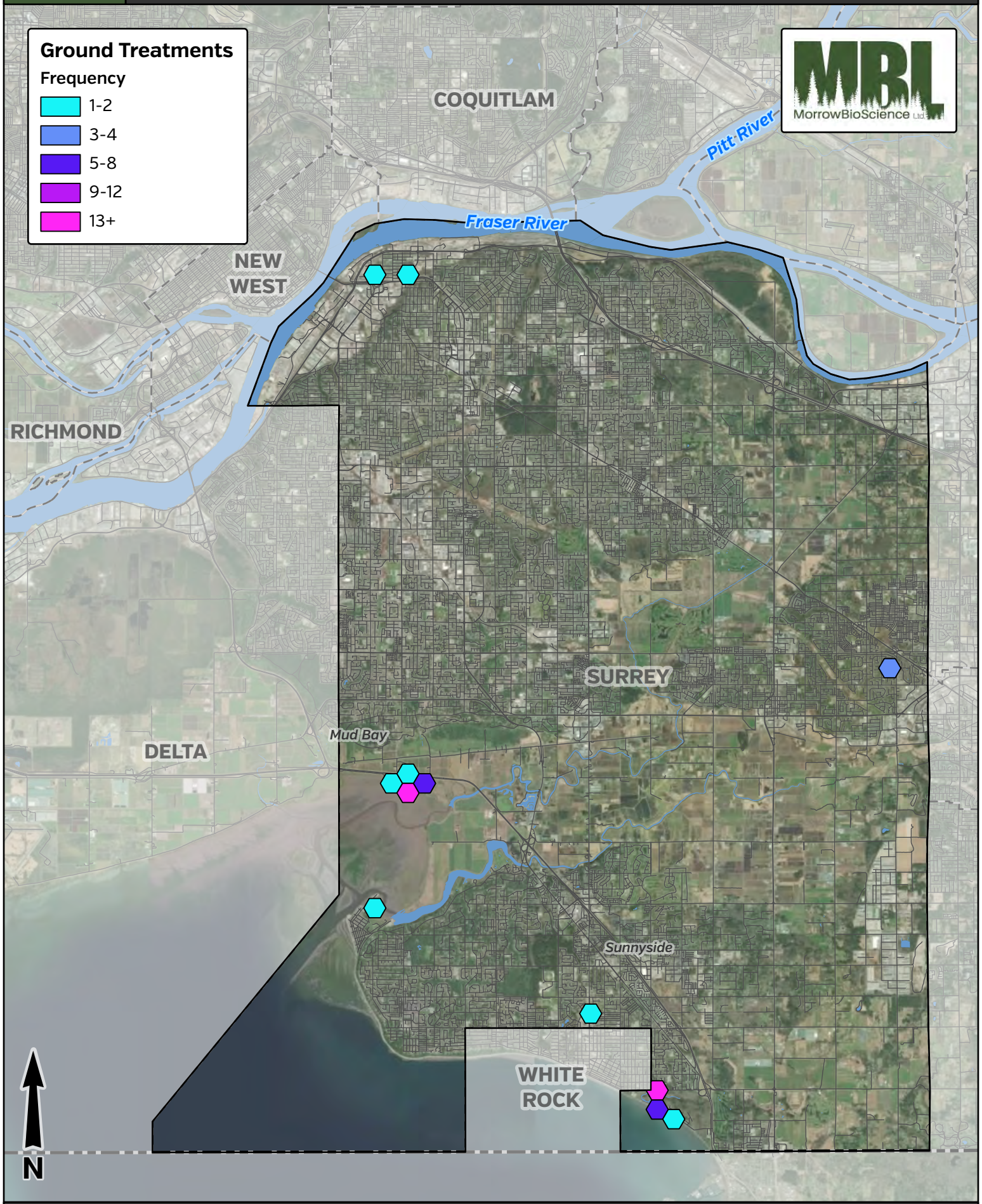
Appendix II-F

# 2022 Larvicide Treatments - Surrey

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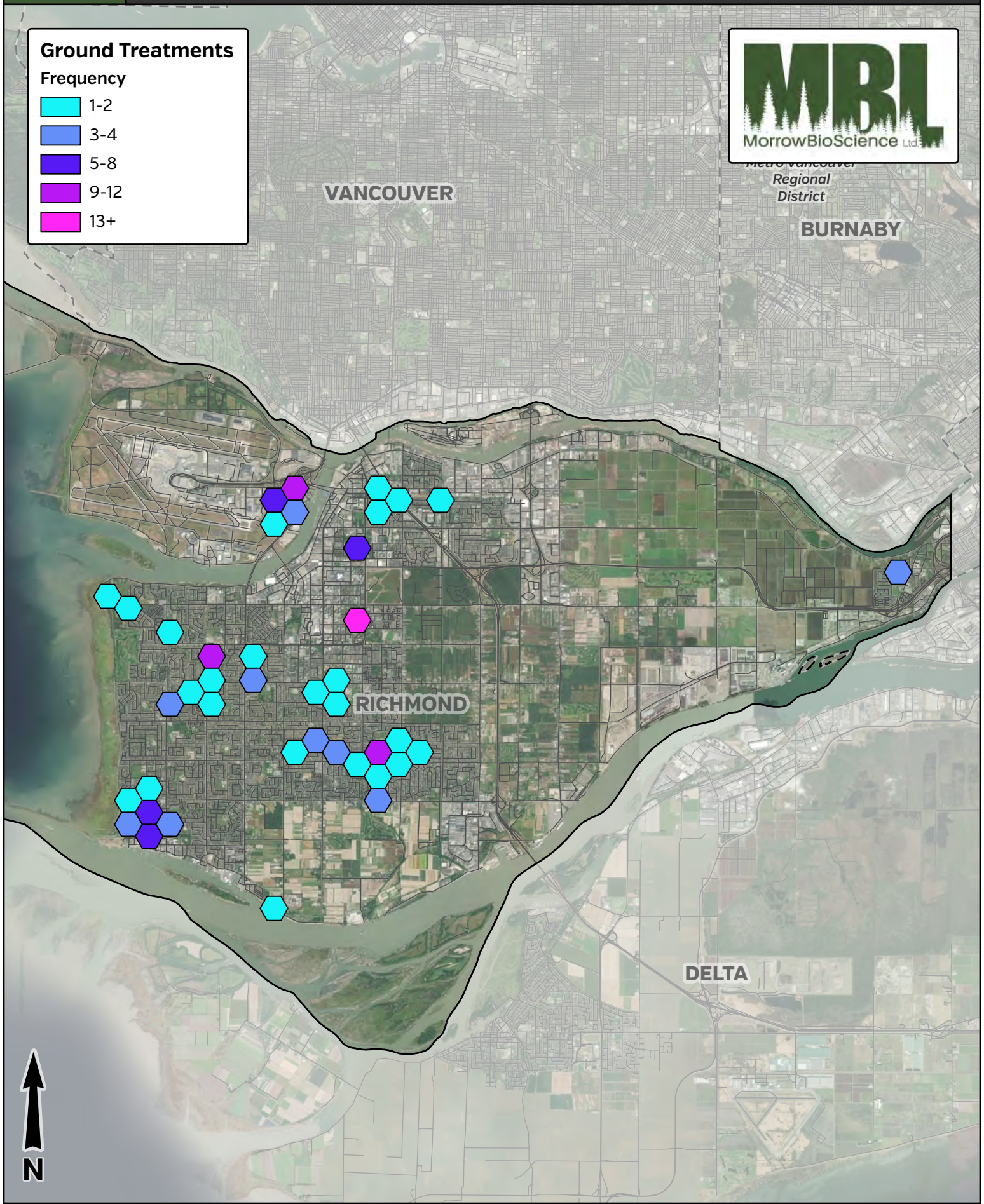
Appendix II-G

# 2022 Larvicide Treatments - Richmond




Scale = 1:100,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-20

**Appendix III -** 2022 MVRD 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 | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-08-31 | | C19 | 0.8 | 0.2 |
| 2022-08-31 | | C19 | 0.6 | 0.15 |
| 2022-08-31 | | C19 | 0.3 | 0.075 |
| 2022-08-29 | RICH-B6 | B6 | 0.5 | 0.125 |
| 2022-08-29 | RICH-B6 | B6 | 0.3 | 0.075 |
| 2022-08-18 | | Chatham | 0.1 | 0.025 |
| 2022-08-18 | | Broadway St & Second Ave | 0.4 | 0.1 |
| 2022-08-18 | | Broadway St & Second Ave | 0.15 | 0.0375 |
| 2022-08-11 | RICH-B4 | B4 | 0.4 | 0.1 |
| 2022-08-11 | RICH-B4 | B4 | 0.25 | 0.0625 |
| 2022-08-11 | RICH-B4 | B4 | 0.2 | 0.05 |
| 2022-08-11 | SR-622 | Mud Bay Park 3 | 0.05 | 0.0125 |
| 2022-08-11 | SR-622 | Mud Bay Park 3 | 0.1 | 0.025 |
| 2022-08-11 | SR-630 | Mud Bay Park 2 | 0.8 | 0.2 |
| 2022-06-13 | SR-630 | Mud Bay Park 2 | 0.02 | 0.005 |
| 2022-08-11 | SR-630 | Mud Bay Park 2 | 0.05 | 0.0125 |
| 2022-08-11 | SR-046 | Mud Bay Park | 0.1 | 0.025 |
| 2022-08-11 | SR-046 | Mud Bay Park | 0.8 | 0.2 |
| 2022-08-11 | SR-046 | Mud Bay Park | 0.1 | 0.025 |
| 2022-08-11 | SR-011 | Bakerview Park | 0.5 | 0.125 |
| 2022-08-11 | | Parking lot | 0.1 | 0.025 |
| 2022-08-11 | | Parking lot | 0.3 | 0.075 |
| 2022-08-11 | | Parking lot | 0.1 | 0.025 |
| 2022-08-11 | | Parking lot | 0.075 | 0.0187 |
| 2022-08-11 | SR-014 | Northeast wetland | 0.3 | 0.075 |
| 2022-08-11 | SR-014 | Northeast wetland | 0.2 | 0.05 |
| 2022-08-10 | SR-012 | SR-Request site 3 | 0.05 | 0.0125 |
| 2022-08-05 | | C11 | 1 | 0.25 |
| 2022-08-04 | | C2 | 0.5 | 0.125 |
| 2022-08-04 | | C2 | 0.6 | 0.15 |
| 2022-08-04 | | C2 | 0.5 | 0.125 |
| 2022-08-04 | RICH-B2 | B2 | 0.8 | 0.2 |
| 2022-08-04 | RICH-B2 | B2 | 0.5 | 0.125 |
| 2022-08-03 | RICH-B6 | B6 | 0.6 | 0.15 |
| 2022-08-03 | RICH-B6 | B6 | 0.5 | 0.125 |
| 2022-08-03 | RICH-B6 | B6 | 0.6 | 0.15 |
| 2022-08-03 | RICH-B6 | B6 | 0.1 | 0.025 |
| 2022-07-28 | RICH-B6 | B6 | 0.35 | 0.0875 |
| 2022-07-28 | | C12 | 0.2 | 0.05 |
| 2022-07-28 | | C12 | 0.4 | 0.1 |
| 2022-07-28 | | B7 | 0.4 | 0.1 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-07-27 | | C10 | 0.15 | 0.0375 |
| 2022-07-27 | SR-630 | Mud Bay Park 2 | 0.6 | 0.15 |
| 2022-07-27 | SR-630 | Mud Bay Park 2 | 0.5 | 0.125 |
| 2022-07-27 | SR-630 | Mud Bay Park 2 | 0.3 | 0.075 |
| 2022-07-27 | SR-046 | Mud Bay Park | 0.25 | 0.0625 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.1 | 0.025 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.025 | 0.0063 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.3 | 0.075 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.3 | 0.075 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.3 | 0.075 |
| 2022-07-27 | SR-014 | Northeast wetland | 0.15 | 0.0375 |
| 2022-07-27 | | Large pool | 0.05 | 0.0125 |
| 2022-07-27 | | Walking bridge side | 0.2 | 0.05 |
| 2022-07-25 | | C6 | 0.1 | 0.025 |
| 2022-07-25 | | C6 | 0.25 | 0.0625 |
| 2022-07-25 | RICH-B5 | B5 | 0.6 | 0.15 |
| 2022-07-25 | RICH-B5 | B5 | 0.4 | 0.1 |
| 2022-07-25 | RICH-B5 | B5 | 0.4 | 0.1 |
| 2022-07-25 | SR-012 | SR-Request site 3 | 0.05 | 0.0125 |
| 2022-07-21 | | C1 | 0.4 | 0.1 |
| 2022-07-21 | | C1 | 0.5 | 0.125 |
| 2022-07-21 | | C1 | 0.3 | 0.075 |
| 2022-07-21 | | C1 | 0.25 | 0.0625 |
| 2022-07-18 | | Chatham | 0.5 | 0.125 |
| 2022-07-18 | | Chatham | 0.2 | 0.05 |
| 2022-07-18 | | Garry street/second ave | 0.4 | 0.1 |
| 2022-07-18 | | Garry street/second ave | 0.45 | 0.1125 |
| 2022-07-18 | RICH-A1 | Richmond A1 | 0.35 | 0.0875 |
| 2022-07-18 | RICH-A1 | Richmond A1 | 0.1 | 0.025 |
| 2022-07-18 | RICH-A1 | Richmond A1 | 0.2 | 0.05 |
| 2022-07-18 | | Hunt St ditches | 0.25 | 0.0625 |
| 2022-07-18 | | Hunt St ditches | 0.1 | 0.025 |
| 2022-07-18 | SR-204 | Industrial ditches. | 0.2 | 0.05 |
| 2022-07-18 | SR-606 | 128 St Ditches | 0.35 | 0.0875 |
| 2022-07-18 | SR-104 | 124 St/112A Ave Ditches | 1.5 | 0.375 |
| 2022-05-26 | RICH-B6 | B6 | 0.3 | 0.075 |
| 2022-07-14 | RICH-B2 | B2 | 0.3 | 0.075 |
| 2022-07-13 | RICH-B4 | B4 | 0.4 | 0.1 |
| 2022-07-13 | | C8 | 0.4 | 0.1 |
| 2022-07-13 | | C8 | 0.5 | 0.125 |
| 2022-07-13 | | C8 | 0.4 | 0.1 |
| 2022-07-13 | | C8 | 0.35 | 0.0875 |
| 2022-07-11 | | C11 | 0.4 | 0.1 |
| 2022-07-11 | | C11 | 0.1 | 0.025 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-07-11 | | C7 | 0.2 | 0.05 |
| 2022-07-11 | SR-630 | Mud Bay Park 2 | 0.4 | 0.1 |
| 2022-07-11 | SR-624 | Blackie Spit Park | 0.1 | 0.025 |
| 2022-07-11 | SR-014 | Northeast wetland | 1.05 | 0.2625 |
| 2022-07-11 | SR-014 | Northeast wetland | 0.15 | 0.0375 |
| 2022-07-11 | | Large pool | 0.1 | 0.025 |
| 2022-07-11 | | Walking bridge side | 0.025 | 0.0063 |
| 2022-07-11 | | Walking bridge side | 0.025 | 0.0063 |
| 2022-07-11 | | Walking bridge side | 0.1 | 0.025 |
| 2022-07-07 | RICH-B2 | B1 | 0.3 | 0.075 |
| 2022-07-06 | SR-012 | SR-Request site 3 | 0.025 | 0.0063 |
| 2022-07-06 | | B7 | 0.25 | 0.0625 |
| 2022-07-06 | | B7 | 0.2 | 0.05 |
| 2022-07-06 | | B7 | 0.2 | 0.05 |
| 2022-07-04 | RICH-B5 | B5 | 0.15 | 0.0375 |
| 2022-07-04 | RICH-B5 | B5 | 0.1 | 0.025 |
| 2022-07-04 | RICH-B5 | B5 | 0.15 | 0.0375 |
| 2022-07-04 | RICH-B5 | B5 | 0.2 | 0.05 |
| 2022-07-04 | RICH-B5 | B5 | 0.25 | 0.0625 |
| 2022-07-04 | RICH-B5 | B5 | 0.2 | 0.05 |
| 2022-07-04 | RICH-B5 | B5 | 0.2 | 0.05 |
| 2022-07-04 | RICH-B5 | B5 | 0.2 | 0.05 |
| 2022-07-04 | RICH-B5 | B5 | 0.2 | 0.05 |
| 2022-07-04 | | C6 | 0.3 | 0.075 |
| 2022-07-04 | | C6 | 0.5 | 0.125 |
| 2022-06-30 | | C1 | 0.05 | 0.0125 |
| 2022-06-30 | | B3 | 0.1 | 0.025 |
| 2022-06-29 | SR-630 | Mud Bay Park 2 | 0.2 | 0.05 |
| 2022-06-29 | SR-630 | Mud Bay Park 2 | 0.2 | 0.05 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.2 | 0.05 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.035 | 0.0088 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.025 | 0.0063 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.2 | 0.05 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.075 | 0.0187 |
| 2022-06-29 | SR-014 | Northeast wetland | 0.1 | 0.025 |
| 2022-06-29 | RICH-B2 | B2 | 0.1 | 0.025 |
| 2022-06-29 | RICH-B6 | B6 | 0.6 | 0.15 |
| 2022-06-29 | RICH-B6 | B6 | 0.15 | 0.0375 |
| 2022-06-27 | | Chatham | 0.4 | 0.1 |
| 2022-06-27 | | Hunt St ditches | 0.15 | 0.0375 |
| 2022-06-23 | | C7 | 0.1 | 0.025 |
| 2022-06-23 | | C8 | 0.1 | 0.025 |
| 2022-06-23 | RICH-B6 | B6 | 0.25 | 0.0625 |
| 2022-06-22 | | C11 | 0.05 | 0.0125 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-06-22 | | C11 | 0.25 | 0.0625 |
| 2022-06-21 | | C2 | 0.15 | 0.0375 |
| 2022-06-16 | | C10 | 0.05 | 0.0125 |
| 2022-06-16 | | C10 | 0.1 | 0.025 |
| 2022-06-16 | | B3 | 0.15 | 0.0375 |
| 2022-06-16 | | B3 | 0.2 | 0.05 |
| 2022-06-16 | | B3 | 0.15 | 0.0375 |
| 2022-06-16 | | B3 | 0.4 | 0.1 |
| 2022-06-16 | | B3 | 0.3 | 0.075 |
| 2022-06-16 | | B3 | 0.25 | 0.0625 |
| 2022-06-16 | | B3 | 0.15 | 0.0375 |
| 2022-06-16 | | B3 | 0.1 | 0.025 |
| 2022-06-16 | | B3 | 0.05 | 0.0125 |
| 2022-06-16 | | B3 | 0.1 | 0.025 |
| 2022-06-16 | | B3 | 0.06 | 0.015 |
| 2022-06-16 | | B3 | 0.05 | 0.0125 |
| 2022-06-16 | | B3 | 0.05 | 0.0125 |
| 2022-06-16 | | B3 | 0.05 | 0.0125 |
| 2022-06-16 | | B3 | 0.05 | 0.0125 |
| 2022-06-16 | | B3 | 0.1 | 0.025 |
| 2022-06-16 | | B3 | 0.15 | 0.0375 |
| 2022-06-15 | RICH-B5 | B5 | 0.1 | 0.025 |
| 2022-06-15 | RICH-B5 | B5 | 0.1 | 0.025 |
| 2022-06-15 | | C6 | 0.15 | 0.0375 |
| 2022-06-15 | | C6 | 0.15 | 0.0375 |
| 2022-06-13 | SR-622 | Mud Bay Park 3 | 0.025 | 0.0063 |
| 2022-06-13 | SR-630 | Mud Bay Park 2 | 0.2 | 0.05 |
| 2022-06-13 | SR-046 | Mud Bay Park | 0.3 | 0.075 |
| 2022-06-13 | SR-046 | Mud Bay Park | 0.15 | 0.0375 |
| 2022-06-13 | | Parking lot | 0.05 | 0.0125 |
| 2022-06-13 | | Walking bridge side | 0.05 | 0.0125 |
| 2022-06-13 | SR-014 | Northeast wetland | 0.025 | 0.0063 |
| 2022-06-13 | SR-014 | Northeast wetland | 1.2 | 0.3 |
| 2022-06-13 | SR-014 | Northeast wetland | 0.3 | 0.075 |
| 2022-06-13 | | Walking bridge side | 0.025 | 0.0063 |
| 2022-06-13 | | Walking bridge side | 0.35 | 0.0875 |
| 2022-06-13 | | Second Ave & Richmond St | 0.3 | 0.075 |
| 2022-06-13 | | Hunt St ditches | 0.25 | 0.0625 |
| 2022-06-09 | | C1 | 0.4 | 0.1 |
| 2022-06-09 | | C1 | 0.4 | 0.1 |
| 2022-06-09 | | C1 | 0.25 | 0.0625 |
| 2022-06-08 | | C4 | 0.25 | 0.0625 |
| 2022-06-02 | SR-630 | Mud Bay Park 2 | 0.3 | 0.075 |
| 2022-06-02 | SR-630 | Mud Bay Park 2 | 0.075 | 0.0187 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-06-02 | SR-014 | Northeast wetland | 0.9 | 0.225 |
| 2022-06-02 | SR-014 | Northeast wetland | 0.1 | 0.025 |
| 2022-06-02 | | Walking bridge side | 0.05 | 0.0125 |
| 2022-06-02 | | Broadway St & Second Ave | 0.15 | 0.0375 |
| 2022-06-01 | RICH-A2 | A2 | 0.05 | 0.0125 |
| 2022-05-30 | | C6 | 0.25 | 0.0625 |
| 2022-05-30 | | B3 | 0.2 | 0.05 |
| 2022-05-26 | | C7 | 0.3 | 0.075 |
| 2022-05-26 | | C7 | 0.25 | 0.0625 |
| 2022-05-26 | RICH-B6 | B6 | 0.25 | 0.0625 |
| 2022-05-25 | | C1 | 0.5 | 0.125 |
| 2022-05-25 | | B3 | 0.3 | 0.075 |
| 2022-05-25 | | B3 | 0.3 | 0.075 |
| 2022-05-25 | | B3 | 0.25 | 0.0625 |
| 2022-05-25 | | B3 | 0.4 | 0.1 |
| 2022-05-25 | | C14 | 0.25 | 0.0625 |
| 2022-05-19 | SR-046 | Mud Bay Park | 0.4 | 0.1 |
| 2022-05-11 | RICH-B4 | B4 | 0.25 | 0.0625 |
| 2022-05-23 | RICH-A1 | Richmond A1 | 0.4 | 0.1 |
| 2022-05-23 | | Second Ave & Richmond St | 0.2 | 0.05 |
| 2022-05-19 | SR-014 | Northeast wetland | 0.6 | 0.15 |
| 2022-05-19 | SR-014 | Northeast wetland | 0.1 | 0.025 |
| 2022-05-19 | | Chatham | 0.6 | 0.15 |
| 2022-05-19 | | C1 | 0.4 | 0.1 |
| 2022-05-12 | | Garry street/second ave | 0.25 | 0.0625 |
| 2022-05-12 | | Ditches along beach rd | 0.05 | 0.0125 |
| 2022-05-12 | SR-014 | Northeast wetland | 0.04 | 0.01 |
| 2022-05-12 | | Walking bridge side | 0.15 | 0.0375 |
| 2022-05-11 | | C2 | 0.3 | 0.075 |
| 2022-05-09 | SR-630 | Mud Bay Park 2 | 0.1 | 0.025 |
| 2022-08-18 | | Retention pond | 1.25 | 0.3125 |
| 2022-08-18 | TOL-373 | Forest hills park pond | 0.4 | 0.1 |
| 2022-08-18 | TOL-1021 | Jenny Lewis | 0.8 | 0.2 |
| 2022-08-15 | | On property: access to pond | 0.3 | 0.075 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-08-15 | | On property: access to pond | 0.2 | 0.05 |
| 2022-08-15 | | On property: access to pond | 0.3 | 0.075 |
| 2022-08-15 | | Ian's | 0.3 | 0.075 |
| 2022-08-15 | | Ian's | 0.2 | 0.05 |
| 2022-08-15 | | Tree farm drainage area | 0.3 | 0.075 |
| 2022-08-15 | | Tree farm drainage area | 0.1 | 0.025 |
| 2022-08-15 | | 22207 102 ave | 0.4 | 0.1 |
| 2022-08-15 | TOL-212 | Ditch | 0.9 | 0.225 |
| 2022-08-15 | | Pond 2 | 0.25 | 0.0625 |
| 2022-08-15 | | Pond 2 | 0.2 | 0.05 |
| 2022-08-15 | | Pond 1 | 0.2 | 0.05 |
| 2022-08-15 | | Kindry's Property (& neighbors) | 0.2 | 0.05 |
| 2022-08-15 | | Kindry's Property (& neighbors) | 1.2 | 0.3 |
| 2022-08-10 | TOL-550 | Langley Gardens Pond | 0.2 | 0.05 |
| 2022-08-10 | TOL-550 | Langley Gardens Pond | 0.025 | 0.0063 |
| 2022-08-10 | | 10050 McKinnon Crescent | 0.5 | 0.125 |
| 2022-08-08 | | Drive way | 0.03 | 0.0075 |
| 2022-08-03 | | Retention pond | 1.4 | 0.35 |
| 2022-08-03 | TOL-373 | Forest hills park pond | 0.4 | 0.1 |
| 2022-08-03 | TOL-1021 | Jenny Lewis | 0.6 | 0.15 |
| 2022-08-03 | TOL-023 | Derby Reach Parking lot | 0.4 | 0.1 |
| 2022-07-28 | | Ian's | 0.4 | 0.1 |
| 2022-07-28 | | Ian's | 0.4 | 0.1 |
| 2022-07-28 | | Tree farm drainage area | 0.4 | 0.1 |
| 2022-07-28 | | Tree farm drainage area | 0.2 | 0.05 |
| 2022-07-28 | | Tree farm drainage area | 0.4 | 0.1 |
| 2022-07-28 | TOL-011 | Cory's property | 0.2 | 0.05 |
| 2022-07-28 | | Kindry's Property (& neighbors) | 2.1 | 0.525 |
| 2022-07-28 | | 9977 Allard Crescent | 0.2 | 0.05 |
| 2022-07-28 | | Fran Moffet - 10170 McKinnon C | 1.15 | 0.2875 |
| 2022-07-21 | TOL-611 | Canada Trail Ditch | 0.3 | 0.075 |
| 2022-07-21 | TOL-611 | Canada Trail Ditch | 0.8 | 0.2 |
| 2022-07-21 | TOL-611 | Canada Trail Ditch | 0.25 | 0.0625 |
| 2022-07-21 | TOL-611 | Canada Trail Ditch | 0.35 | 0.0875 |
| 2022-07-18 | TOL-1077 | River/Mavis corner swamp | 0.2 | 0.05 |
| 2022-06-26 | | Flooding | 0.3 | 0.075 |
| 2022-07-14 | | Retention pond | 1.25 | 0.3125 |
| 2022-07-14 | TOL-373 | Forest hills park pond | 0.2 | 0.05 |
| 2022-07-14 | | 10050 McKinnon Crescent | 0.25 | 0.0625 |
| 2022-07-13 | | Ian's | 0.4 | 0.1 |
| 2022-07-13 | | Tree farm drainage area | 0.5 | 0.125 |
| 2022-07-13 | | Tree farm drainage area | 0.2 | 0.05 |
| 2022-07-13 | | Kindry's Property (& neighbors) | 1.25 | 0.3125 |
| 2022-07-13 | | Mary Martini's ponds | 0.075 | 0.0187 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-07-12 | TOL-601 | Across historic center | 0.5 | 0.125 |
| 2022-07-11 | | Further seepage | 5 | 1.25 |
| 2022-07-11 | | Carmen's House | 0.7 | 0.175 |
| 2022-07-08 | | Flooding | 0.5 | 0.125 |
| 2022-07-08 | | Flooding | 1 | 0.25 |
| 2022-07-06 | TOL-004 | Brae Island Park / Fort Camping | 0.9 | 0.225 |
| 2022-07-06 | | Bridge | 0.7 | 0.175 |
| 2022-07-04 | | Retention pond | 1.2 | 0.3 |
| 2022-07-04 | TOL-707 | Stream between houses | 0.25 | 0.0625 |
| 2022-07-01 | TOL-1012 | Old dirt road | 1 | 0.25 |
| 2022-07-01 | | Drainage area | 0.6 | 0.15 |
| 2022-07-01 | | Further seepage | 4 | 1 |
| 2022-07-01 | | Bridge | 2.5 | 0.625 |
| 2022-06-30 | TOL-604 | Canada Trails Farm Field | 0.15 | 0.0375 |
| 2022-06-30 | TOL-604 | Canada Trails Farm Field | 0.15 | 0.0375 |
| 2022-06-30 | TOL-611 | Canada Trail Ditch | 0.2 | 0.05 |
| 2022-06-30 | TOL-611 | Canada Trail Ditch | 0.1 | 0.025 |
| 2022-06-30 | TOL-611 | Canada Trail Ditch | 0.1 | 0.025 |
| 2022-06-30 | TOL-001 | Marine park trail | 0.6 | 0.15 |
| 2022-06-30 | | Water channel 88 | 0.6 | 0.15 |
| 2022-06-30 | TOL-656 | TOL-656 | 0.6 | 0.15 |
| 2022-06-30 | | Ditch 264 | 7 | 1.75 |
| 2022-06-27 | TOL-106 | Derby Reach Wetlands | 1.55 | 0.3875 |
| 2022-06-27 | TOL-016 | Creek behind construction site | 1 | 0.25 |
| 2022-06-27 | TOL-1012 | Old dirt road | 0.5 | 0.125 |
| 2022-06-27 | | KFN bridge | 5 | 1.25 |
| 2022-06-27 | | Drive way | 1 | 0.25 |
| 2022-06-26 | | KFN bridge | 0.2 | 0.05 |
| 2022-06-26 | | KFN bridge | 0.5 | 0.125 |
| 2022-06-26 | | KFN bridge | 0.5 | 0.125 |
| 2022-06-26 | | Drive way | 0.25 | 0.0625 |
| 2022-06-26 | | Drive way | 1.2 | 0.3 |
| 2022-06-26 | | Drive way | 0.4 | 0.1 |
| 2022-06-26 | BRAE-1 | Kwantlen FN ditch | 0.6 | 0.15 |
| 2022-06-14 | BRAE-1 | Kwantlen FN ditch | 6 | 1.5 |
| 2022-06-26 | | Water channel 88 | 0.3 | 0.075 |
| 2022-06-26 | | Ditch 264 | 4 | 1 |
| 2022-06-14 | TOL-004A | Seepage FN Site | 12 | 3 |
| 2022-06-14 | TOL-004A | Seepage FN Site | 6 | 1.5 |

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

| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-06-18 | | Kwantlen First Nation | 0.5 | 0.125 |
| 2022-06-18 | | Kwantlen First Nation | 0.3 | 0.075 |
| 2022-06-18 | | Kwantlen First Nation | 0.15 | 0.0375 |
| 2022-06-18 | | Kwantlen First Nation | 0.1 | 0.025 |
| 2022-06-18 | | Kwantlen First Nation | 0.2 | 0.05 |
| 2022-06-18 | | Drive way | 3 | 0.75 |
| 2022-06-18 | | Drainage area | 0.8 | 0.2 |
| 2022-06-18 | TOL-1012 | Old dirt road | 0.4 | 0.1 |
| 2022-06-18 | TOL-1012 | Old dirt road | 0.7 | 0.175 |
| 2022-06-18 | | Endsleigh Point | 0.8 | 0.2 |
| 2022-06-18 | | Endsleigh Point | 1.2 | 0.3 |
| 2022-06-18 | | Flooding | 0.1 | 0.025 |
| 2022-06-18 | | Flooding | 0.1 | 0.025 |
| 2022-06-18 | | Flooding | 0.7 | 0.175 |
| 2022-06-18 | | Flooding | 0.7 | 0.175 |
| 2022-06-18 | TOL-004A | Seepage FN Site | 2 | 0.5 |
| 2022-06-18 | | Further seepage | 1.5 | 0.375 |
| 2022-06-18 | TOL-004 | Brae Island Park / Fort Camping | 0.05 | 0.0125 |
| 2022-06-18 | | Flooded areas | 0.1 | 0.025 |
| 2022-06-18 | | Flooded areas | 0.05 | 0.0125 |
| 2022-06-18 | | Flooded areas | 0.15 | 0.0375 |
| 2022-06-15 | | Kanaka creek pond | 2 | 0.5 |
| 2022-06-15 | | Kanaka Creek Floodwater | 3 | 0.75 |
| 2022-06-15 | | Kanaka Pipeline Path | 1 | 0.25 |
| 2022-06-14 | COQ-041 | Marguerite Park | 2.5 | 0.625 |
| 2022-06-07 | | Rainbow bridge | 2.5 | 0.625 |
| 2022-06-07 | | Rainbow bridge | 4.5 | 1.125 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.075 | 0.0187 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.075 | 0.0187 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.05 | 0.0125 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.075 | 0.0187 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.1 | 0.025 |
| 2022-06-15 | TOL-611 | Canada Trail Ditch | 0.15 | 0.0375 |
| 2022-06-15 | TOL-017 | Derby Reach Field | 0.15 | 0.0375 |
| 2022-06-14 | TOL-1009 | TOL-1009 | 1 | 0.25 |
| 2022-06-12 | | Flooded areas | 0.75 | 0.1875 |
| 2022-06-12 | | Flooded areas | 0.75 | 0.1875 |
| 2022-06-12 | | Bridge | 0.3 | 0.075 |
| 2022-06-12 | TOL-240 | Stream bed | 1 | 0.25 |
| 2022-06-12 | | Flooded grass | 1.5 | 0.375 |
| 2022-06-12 | | Flooded grass | 0.5 | 0.125 |
| 2022-06-12 | | Flooded areas | 0.01 | 0.0025 |
| 2022-06-12 | | Flooded areas | 0.01 | 0.0025 |
| 2022-06-12 | | Bridge | 0.2 | 0.05 |

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

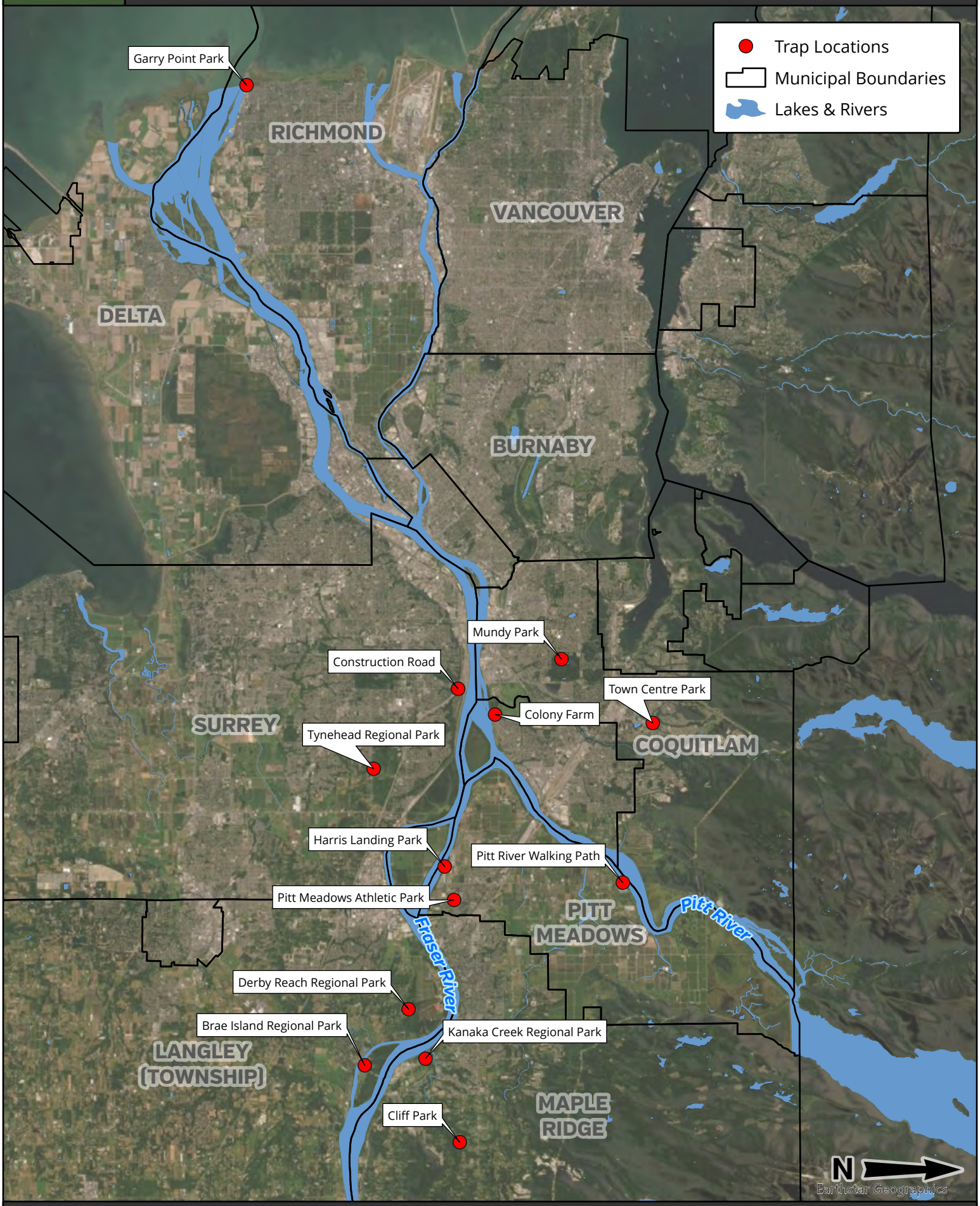
| Treatment Date | Site Code | Site Name | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|---|
| 2022-06-07 | | Rainbow bridge | 8 | 2 |
| 2022-06-12 | TOL-004A | Seepage FN Site | 7 | 1.75 |
| 2022-06-12 | | Drive way | 0.4 | 0.1 |
| 2022-06-12 | | Kwantlen First Nation | 0.3 | 0.075 |
| 2022-06-12 | | Drainage area | 1 | 0.25 |
| 2022-06-12 | TOL-004A | Seepage FN Site | 0.25 | 0.0625 |
| 2022-06-07 | TOL-004 | Brae Island Park / Fort Camping | 8 | 2 |
| 2022-06-05 | | Water Channel | 1 | 0.25 |
| 2022-06-02 | | Pasture | 0.005 | 0.0013 |
| 2022-05-28 | | Farm field | 0.05 | 0.0125 |
| 2022-05-20 | | Water Channel | 0.005 | 0.0013 |
| 2022-05-20 | | KFN bridge | 0.01 | 0.0025 |
| 2022-05-20 | | Kwantlen First Nation | 0.01 | 0.0025 |
| 2022-05-20 | | Further seepage | 0.01 | 0.0025 |
| 2022-05-20 | TOL-1009 | TOL-1009 | 0.1 | 0.025 |
| 2022-05-20 | TOL-1051 | Ditch | 1 | 0.25 |

## III-B: Aerial Treatments

| Treatment Date | Sites | Treatment Amount (Kg) | Area Treated (Ha) |
|---|---|---|---|
| 2022-06-08 | Kwantlen First Nation,Brae Island Park / Fort Camping,Crescent Island, Creek behind construction site | 436.8 | 43.68 |
| 2022-06-15 | Kwantlen First Nation,Creek behind construction site,Crescent Island | 364 | 36.4 |
| 2022-06-30 | Kwantlen First Nation, Crescent Island | 364 | 36.4 |
| 2022-07-09 | Kwantlen First Nation, Crescent Island, Brae Island | 254.8 | 25.48 |

Appendix IV

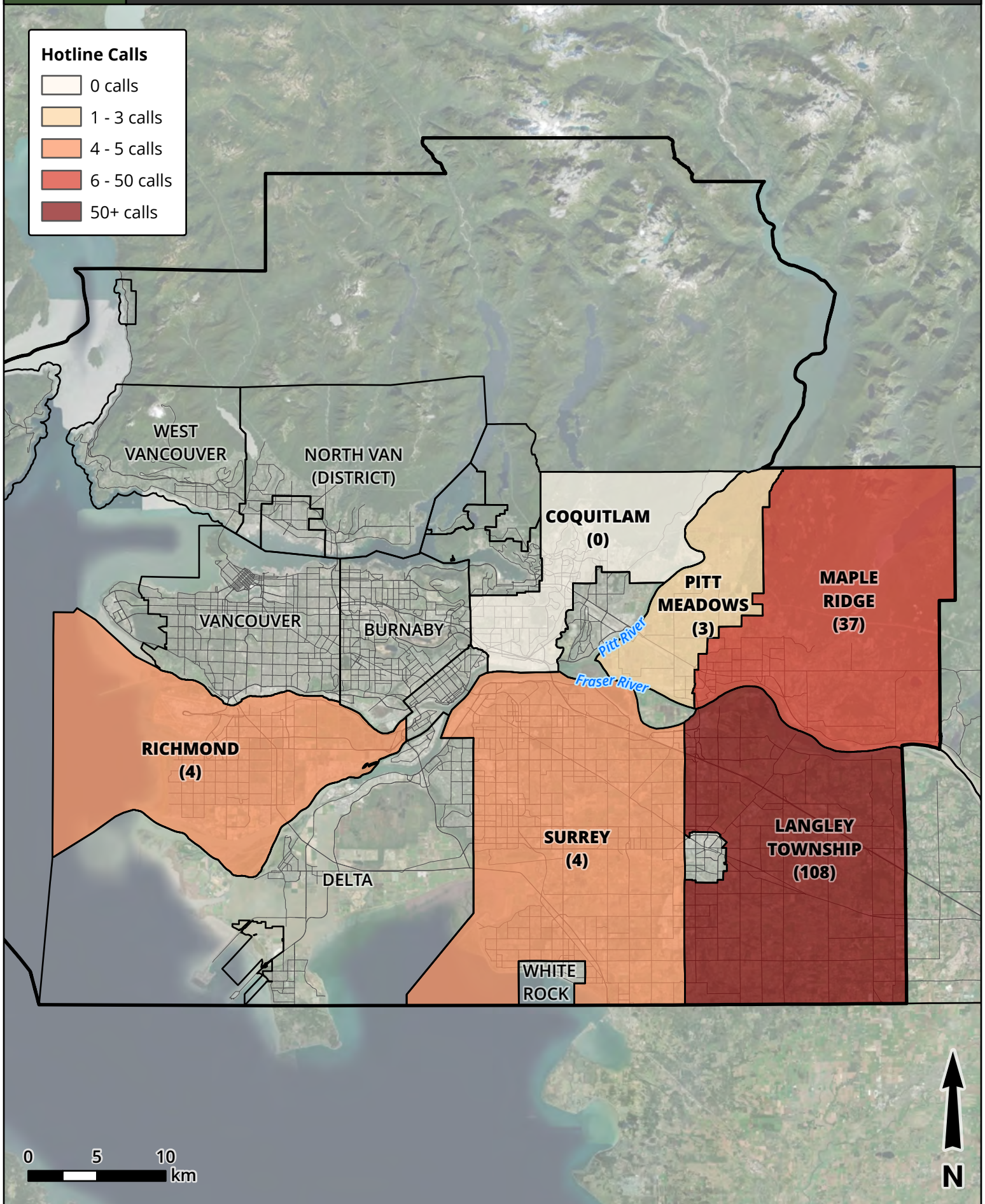
# 2022 MVRD Mosquito Trap Locations




Scale = 1:220,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-03

Appendix V

# 2022 Mosquito Hotline Concern Calls




Scale = 1:350,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2022-11-20

# Appendix VI – 2022 MVRD Mosquito Hotline call and email summary

| Date | Municipality | Resident Comments | Action Taken |
|---|---|---|---|
| 2022-06-30 | MVRD - Langley | Lots of mosquitoes by the river | Return call |
| 2022-06-30 | MVRD - Langley | Mosquitoes are bad in Glen Valley area. What has been done? | Return call |
| 2022-07-01 | MVRD - Langley | Noticed mosquitoes are getting worse. What can be done. | Return call |
| 2022-07-01 | MVRD - Langley | Mosquitoes are bad in the area. | Return call, site visit |
| 2022-07-02 | MVRD - Langley | Excessive mosquitoes in area | Return call, site visit |
| 2022-07-04 | MVRD - Langley | Member of canoe/kayak club and mosquitoes are bad at both Salmon River and Nathan Creek | Return call, site visit |
| 2022-07-04 | MVRD - Langley | Mosquitoes are horrible | Return call, site visit |
| 2022-07-04 | MVRD - Langley | Mosquito problem in the area. What has been done | Return call |
| 2022-07-06 | MVRD - Langley | Wondering if we have treated the area | Return call |
| 2022-07-06 | MVRD - Langley | Worst she has seen in the last 40 years. What is being done. | No number given. |
| 2022-07-06 | MVRD - Langley | Mosquitoes are awful. What can be done | Return call |
| 2022-07-06 | MVRD - Langley | Wondering what has been happening this year and if someone can stop by | Return call, site visit |
| 2022-07-06 | MVRD - Langley | It is really bad in Fort Langley. What can be done. | Return call |
| 2022-07-06 | MVRD - Langley | Concerned about mosquitoes they are probably coming from Fraser River. No need to call him back. | No call back requested |
| 2022-07-07 | MVRD - Langley | What has been done in the area to date. When will it get better | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad in the area. What is being done. | Return call |
| 2022-07-07 | MVRD - Langley | What control measure have been taken | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | No number given. |
| 2022-07-07 | MVRD - Langley | It's really bad. What is going on | Return call |
| 2022-07-07 | MVRD - Langley | I've never seen it this bad before. What's going on | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are awful. What's going on | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad in the area | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are really bad. What is being done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad in the area | Return call, site visit |
| 2022-07-07 | MVRD - Langley | Massive amounts of mosquitoes | Return call, site visit |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What's going on | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. | Return call |
| 2022-07-07 | MVRD - Langley | Mosquitoes are bad. What can be done. Will the upcoming aerial treatment help | Return call |
| 2022-07-08 | MVRD - Langley | Mosquitoes are bad in the area | No number provided |
| 2022-07-08 | MVRD - Langley | Mosquitoes are not very good. | Number did not work. |
| 2022-07-08 | MVRD - Langley | Mosquitoes are bad. What's going on | Return call |
| 2022-07-08 | MVRD - Langley | Mosquitoes are horrific. Livestock is getting eaten alive | Tried calling several times. Did not answer. |
| 2022-07-08 | MVRD - Langley | Lots of mosquitoes in area. | Return call, site visit |
| 2022-07-08 | MVRD - Langley | Mosquitoes are awful. What's being done. | Return call |
| 2022-07-08 | MVRD - Langley | Mosquitoes are horrendous | Return call, site visit |
| 2022-07-08 | MVRD - Langley | Mosquitoes are really bad | Return call |
| 2022-07-08 | MVRD - Langley | Lots of mosquitoes in the area | Called several times. Number not working. |
| 2022-07-08 | MVRD - Langley | Mosquitoes are awful. Can you spray | Return call |
| 2022-07-08 | MVRD - Langley | Lots of mosquitoes in the area | Return call |
| 2022-07-08 | MVRD - Langley | Mosquitoes are the worst in years | Return call |
| 2022-07-08 | MVRD - Pitt Meadows | Mosquitoes are awful. What can be done | Return email |
| 2022-07-08 | MVRD - Langley | What's been going on | Return call |
| 2022-07-09 | MVRD - Langley | Mosquitoes are bad. Help | Return call, site visit |
| 2022-07-09 | MVRD - Langley | What's going on with mosquitoes | Return call |

# Appendix VI – 2022 MVRD Mosquito Hotline call and email summary

| Date | Municipality | Resident Comments | Action Taken |
|---|---|---|---|
| 2022-07-09 | MVRD - Langley | You don't know what you are doing. | Return call |
| 2022-07-09 | MVRD - Langley | Mosquitoes are really bad. What can be done. | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are out of control | Return call |
| 2022-07-10 | MVRD - Maple Ridge | Mosquitoes are awful. What's going on | Return email |
| 2022-07-10 | MVRD - Langley | Pond producing mosquitoes. They are bad | Return call |
| 2022-07-10 | MVRD - Langley | Concerning amount of mosquitoes | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are awful. Can you spray | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are bad in the area | Return call |
| 2022-07-10 | MVRD - Langley | Big mosquito issue. Creek is producing mosquitoes | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are awful | Return email |
| 2022-07-10 | MVRD - Langley | Mosquitoes are bad. What has been going on | Return call |
| 2022-07-10 | MVRD - Langley | Concerning infestation of mosquitoes. | Return call |
| 2022-07-10 | MVRD - Langley | This year is exceptionally bad | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are bad | Return call |
| 2022-07-10 | MVRD - Langley | Abundance of mosquitoes | Return call |
| 2022-07-10 | MVRD - Langley | Making you aware mosquitoes are bad. Thought I'd let you know worst in 15 years | Return call |
| 2022-07-10 | MVRD - Langley | What am have you been doing? It's unbearable | Return call |
| 2022-07-10 | MVRD - Langley | Mosquitoes are very bad around the park. It's a hot spot | Return call |
| 2022-07-11 | MVRD - Langley | Mosquitoes are bad. Can treatment by done all over Langley. No need to call back | Return call |
| 2022-07-11 | MVRD - Langley | It's awful. Think they're coming from ditch. | Return call |
| 2022-07-11 | MVRD - Langley | Wondering what is going on | Return call |
| 2022-07-11 | MVRD - Langley | What had been done | Return call |
| 2022-07-11 | MVRD - Langley | Mosquitoes are bad | Return call |
| 2022-07-11 | MVRD - Langley | Absolutely ridiculous here. It is not being dealt with. You are accountable | Return call |
| 2022-07-11 | MVRD - Langley | Mosquitoes are intolerable | Return call |
| 2022-07-11 | MVRD - Langley | Whatever we have been doing isn't working | Return call |
| 2022-07-11 | MVRD - Langley | Need something done | Return call |
| 2022-07-11 | MVRD - Langley | Extremely bad | Return call |
| 2022-07-11 | MVRD - Langley | We are being attacked. What is the solution | Return call |
| 2022-07-11 | MVRD - Langley | No spraying please. Concerned about adult spraying | Return call |
| 2022-07-11 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Langley | Mosquito invasion | Return call |
| 2022-07-11 | MVRD - Langley | Mosquitoes are awful | Their phone wasn't working |
| 2022-07-11 | MVRD - Langley | Insane mosquitoes | Return call |
| 2022-07-11 | MVRD - Langley | Mosquitoes are a major nuisance | Return call |
| 2022-07-11 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Langley | Problem with mosquitoes around home | Return call |
| 2022-07-11 | MVRD - Langley | Bad Mosquito problem around residence | Return call |
| 2022-07-11 | MVRD - Langley | Summer school is run from this location mosquitoes have been tough on the kids | Return call |
| 2022-07-11 | MVRD - Surrey | Mosquitoes are a major nuisance | Return email |
| 2022-07-11 | MVRD - Langley | Terrible Mosquito problem | Return call |
| 2022-07-11 | MVRD - Langley | Residential complaint worst in 11 years | Return call |
| 2022-07-12 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-12 | MVRD - Langley | There is a pond | Return call |
| 2022-07-12 | MVRD - Langley | Terrible Mosquito issue | Return call |
| 2022-07-12 | MVRD - Langley | The students are being hassled by the mosquitoes | Return call |

# Appendix VI – 2022 MVRD Mosquito Hotline call and email summary

| Date | Municipality | Resident Comments | Action Taken |
|---|---|---|---|
| 2022-07-12 | MVRD - Langley | The mosquitoes are bad here | Return call |
| 2022-07-12 | MVRD - Langley | North otter by the salmon river | Return call |
| 2022-07-12 | MVRD - Langley | Three doors west there is an old swimming pool | Return call |
| 2022-07-14 | MVRD - Langley | Awful mosquitoes. What's going on | Return call |
| 2022-07-14 | MVRD - Langley | Mosquitoes are bad and are coming from green belt behind him | Return call |
| 2022-07-14 | MVRD - Langley | Mosquitoes are awful. He's going to sue us and the government. There is no reason why we can't do adult control and he doesn't care about environmental impacts. | Return call |
| 2022-07-14 | MVRD - Langley | Mosquitoes are awful | Return call |
| 2022-07-14 | MVRD - Surrey | Mosquitoes are a major nuisance | Return email |
| 2022-07-14 | MVRD - Langley | Mosquitoes are awful. What's been going on | Return call |
| 2022-07-15 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-16 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-17 | MVRD - Langley | Lots of mosquitoes | Return call |
| 2022-07-18 | MVRD - Langley | Concerned about the mosquito issue | Return call |
| 2022-07-18 | MVRD - Langley | From Fort Langley Association wanting to get information | Return call |
| 2022-07-28 | MVRD - Langley | Ditches are full of mosquitoes | Return call |
| 2022-08-02 | MVRD - Langley | It is not because of the high river that we have mosquitoes. It is because we don't have any dragon flies. Chem trails are causing death and it's proven. You don't know what you're talking about. The Township needs to spend money planting wild flowers. | Return call |
| 2022-08-02 | MVRD - Langley | Want area surveyed. Mosquitoes aren't good | Return call |
| 2022-08-26 | MVRD - Langley | Her neighbour is producing mosquitoes. What can be done | Return call |
| 2022-06-29 | MVRD - Maple Ridge | Noticed an influx of mosquitoes at Jordan Park | Return call |
| 2022-07-01 | MVRD - Maple Ridge | Mosquitoes are really bad at Jordan Park. Something needs to be done | Return calll, site visit |
| 2022-07-02 | MVRD - Maple Ridge | Mosquitoes are bad at Jordan Park | Return call, site visit |
| 2022-07-07 | MVRD - Maple Ridge | Mosquitoes are bad right now. What can be done. | Return call |
| 2022-07-07 | MVRD - Maple Ridge | Mosquitoes are bad in the area | Return call |
| 2022-07-08 | MVRD - Maple Ridge | Mosquitoes are awful. What is going on. | Return call |
| 2022-07-08 | MVRD - Maple Ridge | Mosquitoes are everywhere. Can't go outside. | Return call |
| 2022-07-08 | MVRD - Maple Ridge | Lots of mosquitoes. | Return call |
| 2022-07-08 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-09 | MVRD - Maple Ridge | Can't go outside | Return call |
| 2022-07-09 | MVRD - Maple Ridge | Can I spray something to get rid of mosquitoes. | Called several times. No answer and no voicemail. |
| 2022-07-09 | MVRD - Maple Ridge | Mosquitoes are awful. What's been going on. | Return call |
| 2022-07-09 | MVRD - Maple Ridge | What's been done this year. Mosquitoes are bad | Return call |
| 2022-07-10 | MVRD - Maple Ridge | Mosquitoes are bad | Return call |
| 2022-07-10 | MVRD - Maple Ridge | Large amount of mosquitoes | Return calll, site visit |
| 2022-07-10 | MVRD - Maple Ridge | Worst mosquitoes she has ever seen in her life. What is going on. | Return calll, site visit |
| 2022-07-10 | MVRD - Maple Ridge | This area of Maple Ridge is really bad | Return calll, site visit |
| 2022-07-10 | MVRD - Maple Ridge | Can anything be done | Return calll, site visit |
| 2022-07-10 | MVRD - Maple Ridge | What's going on | Return calll, site visit |
| 2022-07-10 | MVRD - Maple Ridge | Mosquitoes are insane | Return calll, site visit |
| 2022-07-11 | MVRD - Maple Ridge | Mosquitoes are awful | Return call |
| 2022-07-11 | MVRD - Maple Ridge | What has been done? | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Hate been going on | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Is somebody doing something about it | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Outrageous mosquitoes. Need something done | Return call |
| 2022-07-11 | MVRD - Maple Ridge | What is the solution | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Can't go outside | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-11 | MVRD - Maple Ridge | Had a party the mosquitoes were a new sense. Handed out flyswatters. Inquiring about control for are | Return call |
| 2022-07-12 | MVRD - Maple Ridge | People say the mosquitoes are terrible here difficult to use park | Return call |
| 2022-07-16 | MVRD - Maple Ridge | Lots of mosquitoes | Return call |
| 2022-07-23 | MVRD - Maple Ridge | What's been going on. Are you still treating | Return call |
| 2022-08-02 | MVRD - Maple Ridge | So many mosquitoes. It's a disaster. Can't go outside | Return call |
| 2022-07-08 | MVRD - Pitt Meadows | Down by the Fraser River it is awful | Return call |
| 2022-07-09 | MVRD - Pitt Meadows | Mosquitoes are bad. | Return call |
| 2022-07-14 | MVRD - Pitt Meadows | Mosquitoes are bad | Return call |
| 2022-04-22 | MVRD - Richmond | Lots of mosquitoes | Return call |
| 2022-06-29 | MVRD - Richmond | Pond at bank of city owned property | Return call, site visit |
| 2022-07-04 | MVRD - Richmond | Kids are getting lots of mosquito bites. What can be done | Return call, site visit |
| 2022-08-02 | MVRD - Richmond | Mosquitoes are bad around the school | Return call |
| 2022-07-08 | MVRD - Surrey | Mosquitoes are terrible. What's going on | Return call |
| 2022-07-09 | MVRD - Surrey | What have we done to date? | Return call |
| 2022-07-12 | MVRD - Surrey | We are getting eaten alive, it's crazy | Return call |
| 2022-08-02 | MVRD - Surrey | Mosquitoes are not good. Need some help | Return calll, site visit |
| 2022-08-15 | MVRD - Langley | Mosquitoes are a major nuisance | Return email |