MorrowBioScience

Metro Vancouver Regional District
Mosquito Control Program

2023 Year-End Report

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Executive Summary

Morrow BioScience Ltd. (MBL) has now completed the final 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 most basins contributing to the Fraser River were lower than normal. The snowpack was slightly augmented during April but rapidly melted during May, with warmer-than-average temperatures delivering freshet earlier by two (2) weeks to the Lower Fraser River. From late April until mid-June, a long-lasting high-pressure system within contributing basins exhausted the 2023 snowpack by mid-June. Significant precipitation events during May resulted in slightly amplified Lower Fraser River levels. Precipitation combined with freshet resulted in the Lower Fraser River peaking on 21 May at 5.53m. The 2023 Lower Fraser River peak was relatively high considering low snowpack in contributing basins as of 1 April, however, high water was short-lived compared to the Lower Fraser peak of 2022. Unseasonably warm and dry weather through May led to the Lower Fraser River levels exceeding 5 meters for just 10 days. Peak Lower Fraser River levels were lower than those of 2022 and did not trigger a compounded number of floodwater mosquito eggs to hatch. Environmental conditions were not optimal for a high rate of mosquito development in 2023.

Larval mosquitoes were treated between 19 May and 13 September. The total floodwater mosquito habitat and saltmarsh/permanent water mosquito habitat treated by ground was 63 hectares. The total floodwater mosquito habitat treated by air was 94 ha, with two aerial treatment events occurring, on 17 and 23 May, 2023. Area treated in 2023 was approximately 48 ha less than the much longer high-water season of 2022. 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.

Residential concern was low in 2023, with two concern calls and one concern email received from local residents. The two concern calls were from Langley and the email was in regard to the Pacific Spirit Park area. The calls were likely the result of mosquitoes dispersing from Brae/McMillan Island and Kanaka Creek Regional Park.

MBL staff responded to both calls and emails within a timely manner. 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.

A total of 25 trap nights were conducted this year. Adult mosquito trap specimen identification indicated that mosquito abundance was relatively low in May and June trapping events. The highest adult mosquito collection events occurred on 7 July and 1 August at Derby Reach Regional Park, the most abundant species identified was *Aedes Vexan,* a local floodwater mosquito that is influenced by the Lower Fraser River peak levels from early-May to early-June in 2023. A total of 909 mosquito specimens were collected in 2023. Approximately 97 percent of the female mosquitoes identified were floodwater mosquitoes. The relatively low adult mosquito abundance is a result of high but only shortly sustained Fraser River levels. As of 6 September, the BCCDC has reported one human case of West Nile virus in British Columbia and no cases of Zika virus.

Communications with program residents remains a priority for MBL. MBL staff were able to host booths at five community events throughout the Metro Vancouver program area in 2023. MBL staff showed residents mosquito specimens, discussed program objectives and control methods, and included kid-friendly activities related to mosquito biology. On 29 May, MBL participated in a CBC interview which was subsequently posted on MBL's website on 2 June. The reach of social media posts continues to rise 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 21 May at 5.53 m.
- The 2023 peak was approximately 0.34 m lower than the 2022 peak.
- Fraser River levels above 3 m lasted for 30 days, with 10 of those days above 5 m.
- The snowpack in basins contributing to the Fraser River ranged from 82-111% of normal in April, immediately preceding the floodwater mosquito season.
- ENSO-neutral weather patterns slightly augmented the snowpack in contributing basins through April and May.
- The freshet was early by 1-2 weeks.
- Local precipitation accumulation for April, May, June, July and August were all below average.
- Peak river levels were below those of 2022, the early freshet, and shortly sustained high water levels led to low larval abundance in 2023.
- Two aerial campaigns were required within the MVRD mosquito program purview. Aerial treatments were conducted on 17 and 23 May.
- Total ground treatments at floodwater mosquito development sites were applied to 63 ha (254 kg granular Aquabac®).
- Total Aquabac® aerial applications resulted in the treatment of 94 ha (946 kg of granular Aquabac®).
- Adult mosquito trap efforts in 2023 included a total of 25 trap nights, a decrease from 58 trap nights during 2022.
- Most adult trap sites were set up in inconspicuous locations in 2023, resulting in fewer vandalism challenges.
- A total of 909 adult mosquito specimens were collected from 14 trap site locations.
- Floodwater mosquitoes comprised approximately 97 percent of trap sites contents.

- The peak of adult mosquito abundance was collected at traps set from approximately 6 weeks after the official peak of the Lower Fraser River.
- Derby Reach Park, Brae Island Regional Park, and Kanaka Creek Regional Park had the highest mosquito trap abundance, suggesting continued reconnaissance efforts may reveal new floodwater mosquito development habitat.
- A total of three concern calls were received to the Mosquito Hotline in 2023. Of those, two came from Langley with adult nuisances likely due to floodwater mosquitoes dispersing from Brae/McMillan Island and Kanaka Creek Regional Park.
- One concern email was received and addressed by MBL staff.
- MBL staff hosted five education outreach booths within the MVRD mosquito program purview between 29 April–11 June.
- Following MVRD approval, MBL staff gave one interview to CBC.
- On 6 September, the BCCDC issued an alert identifying one human West Nile virus case located on Vancouver Island; however, the source exposure was suspected to be due to out-of-province travel.
- As of 20 November, BCCDC updated the alert by reporting zero West Nile virus cases originating from British Columbia.
- Relatively high levels of WNv activity were reported in Washington State and Idaho State following a warmer-than-normal spring and early summer.

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Introduction

Morrow BioScience Ltd. (MBL) is the longest-operating mosquito control firm in British Columbia, having conducted mosquito control in this province for nearly four decades. The 2023 mosquito season marked MBL's final 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. As an organization, MBL travelled just under 100,000 km. The accumulated mileage for the Metro Vancouver program over the course of 2023 was approximately 28,000 km (ground transportation only). As an estimate, the driving requirements for this program resulted in the production of approximately 7.1 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 program manager.

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 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

[1] https://neighboursunited.org

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.

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

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.

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 2023, 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 salt-marsh 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 2023). 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.

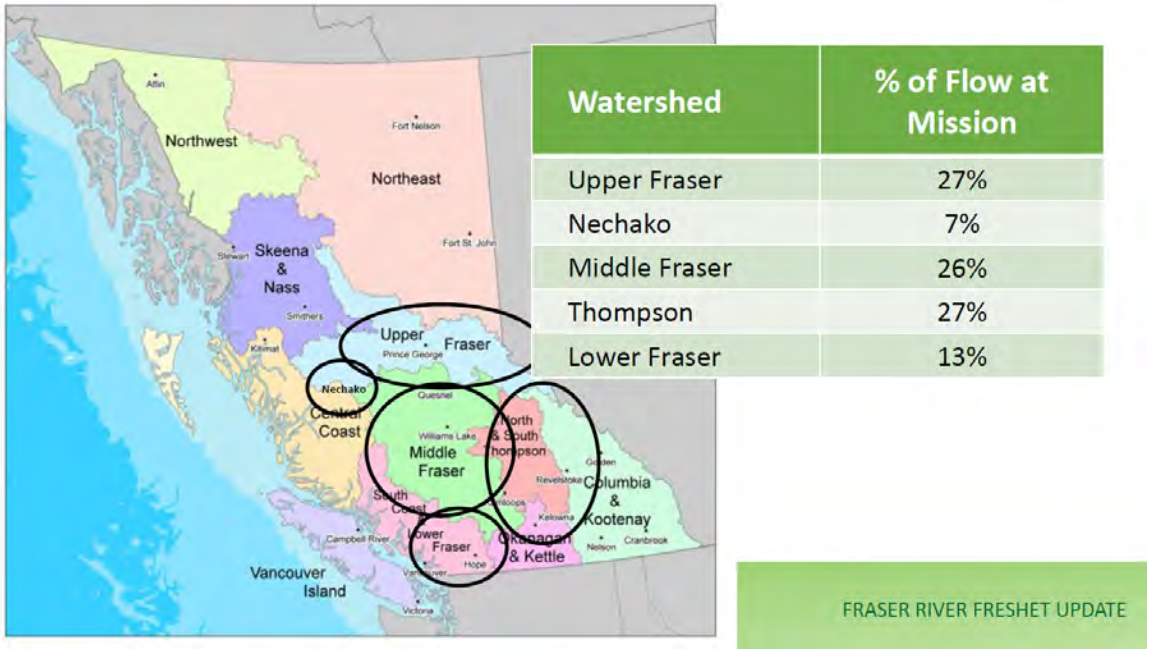

Image 2. Fraser River sub-basin freshet contribution (A. Jollymore; River Forecast Centre)

On 1 April, immediately preceding the 2023 MVRD mosquito monitoring season, the snowpack within basins influencing the Lower Fraser River ranged between 82-111 percent of normal (Table 1). The lower-than-normal snowpack may have been the result of the ENSO-neutral (El Nino – Southern Oscillation) weather pattern that was in place during the spring of 2023. On 1 April contributing snowpack stations in the contributing basins were lower than that of 2022. Unseasonably warm weather within influential basins through May resulted in the early exhaustion of contributing snowpack. Freshet arrived approximately 1-2 weeks earlier than normal but was shortly sustained as the Lower Fraser River was in recede by early June. Subsequent warm, relatively dry weather patterns influenced the continued drop of regional Fraser River levels through August.

Table 1. Snow basin indices (2022 and 2023, 1 April percent of normal) for basins that directly affect the Lower Fraser River flood plain, determined by the River Forecast Centre.

Basin	2022 April Snowpack	2023 April Snowpack
Upper Fraser East	125	87
Upper Fraser West	140	111
Lower Fraser	116	83
Middle Fraser	115	89
North Thompson	128	82
South Thompson	107	97
Nechako	104	95

The Revolution Creek snow survey station (ID: 1A17P) records 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. Snowpack slightly increased through April and then rapidly depleted through May. The trend in visible snowpack reduction at the Revolution Creek snow survey station started in late-April, approximately 1 week earlier than normal (**Figure 1**).

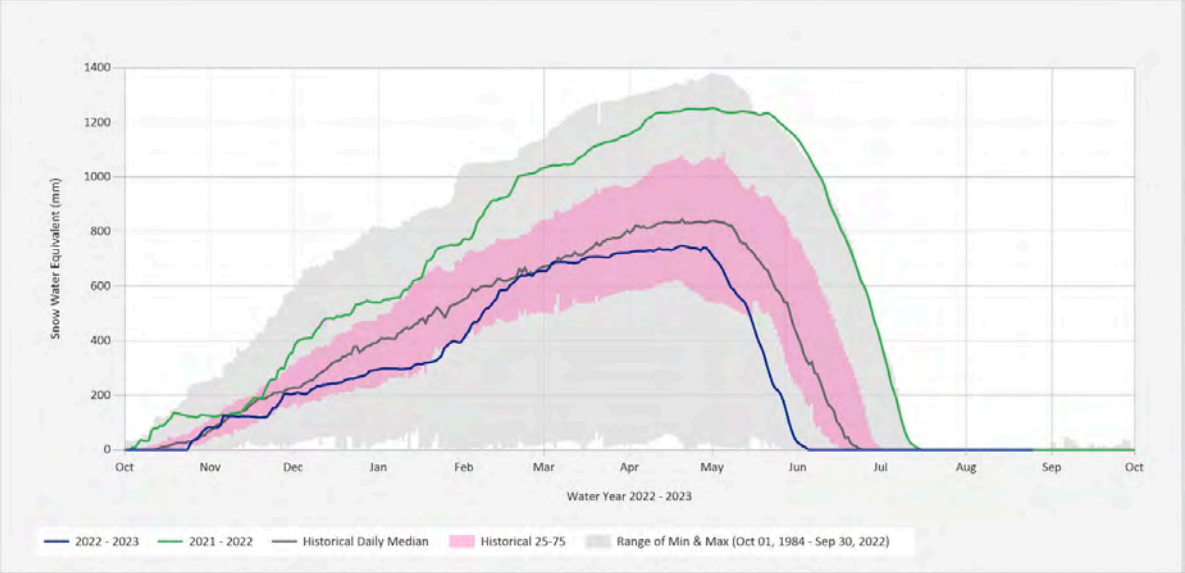

Figure 1. Snow Water Equivalent (SWE; mm) at the Revolution Creek snow survey station (ID: 1A17P) within the Upper Fraser East basin. The blue line indicates SWE data for 2022-2023. (The green line indicates SWE data for 2021-2022.)

Warm weather through May resulted in the rapid depletion of high elevation snowpack at the Revolution Creek snow survey station[3]. This trend is consistent with other high elevation snow survey station data through the influential basins. High elevation snowpack was depleted approximately three weeks earlier than 2022.

Historically, by 1 June, approximately 60 percent of the snowpack melted within Fraser River associated basins. However, with warm ambient temperatures during May, the 1 June Snow Survey and Water Supply Bulletin showed 11 - 44 percent of normal snowpack at contributing snow basin stations. The 15 June snow basin indices were almost all zero percent of normal, with the exception of 29% of normal snowpack within the Nechako basin. This relatively low range reflects the abnormality of ambient temperatures from Late April until mid-June.

The 2023 Fraser River freshet was set apart in three ways: 1) lower than average snowpack within associated basins, 2) the relatively high regional Fraser River peak, and 3) shortly sustained peak levels. These features led to a lower-than-normal adult mosquito abundance

[2] 2023.pdf (gov.bc.ca) (Annual snow survey bulletins).
[3] Link to snow survey sites.

through August, with environmental cues present for mosquito egg hatching for a significantly shorter-than-average period of time.

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, 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 slightly 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, June, July, and August were all lower-than-average in 2023, however, precipitation events on May 21-22 may have influenced peak Lower Fraser River levels. The otherwise low precipitation values noted June through August did not influence river levels beyond those critical for mosquito larvae development. Together, the precipitation received in June and July was approximately 180 mm lower than the average sum of the two months. Given the lack of precipitation received during June and July and the already low Lower Fraser River levels, it is unlikely precipitation received during this time influenced floodwater mosquito development at river associated sites. Low precipitation accumulation amounts were noted throughout the Fraser River watershed despite rainfall events, adding to the continued recede of Fraser River levels along the system. Container mosquito, permanent-water, and saltmarsh development habitat may have been amplified during precipitation events during May and June.

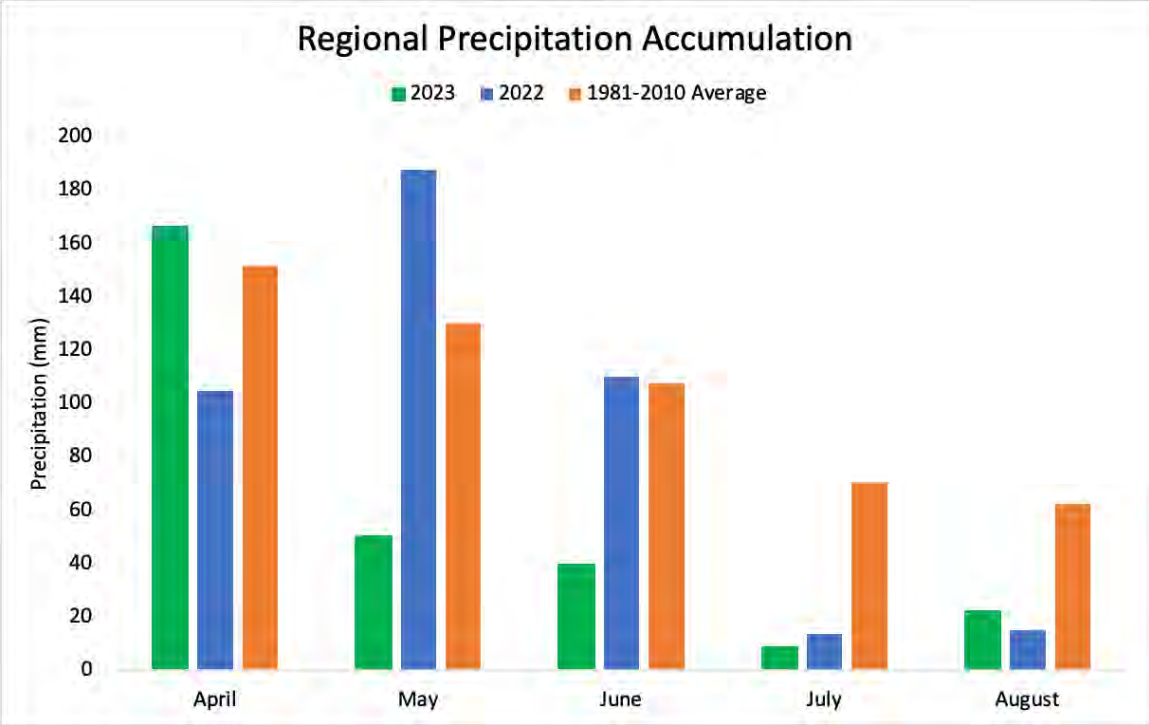

Figure 2. 2023 precipitation values (rainfall and snow accumulation; mm) recorded at the Mission West Abbey Station (ID: 1105192) for 01 April – 31 August, 2023 (green), 01 April – 31 August, 2022 (blue) and average station precipitation values (1981-2010; orange).

Very little precipitation accumulated in July at the Mission West Abbey station. The recorded precipitation during July was lower than the station's July average by approximately 51 mm, with all 8.6 mm of precipitation falling over two days, having little influence on the Lower Fraser River levels and associated mosquito development sites. Precipitation accumulation tapered dramatically through July and August. August precipitation was approximately 57 mm lower than average (**Figure 2**). It is unlikely that precipitation received to the Lower Fraser River in August augmented Lower 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 multivoltine 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 2023 mosquito monitoring season began in April with slightly below-average ambient temperatures within most basins contributing to the Lower Fraser River. The weather in April was slightly below the seasonal average across much of the province [4], with ambient temperatures ranging from 0.4 to -1.6°C below average. Ambient temperatures greatly increased during May across the province being +1.1 to +5.1°C above average[5].

The long-lived high-pressure systems present from late-April to mid-June, resulted in the rapid depletion of snowpack. Following unusually warm springtime ambient temperatures, approximately one week of cool ambient temperatures and precipitation were recorded during the third week of June. During late June, warm, dry weather returned to MVRD and lasted through August, while the Lower Fraser River continued to recede.

The above-average seasonal ambient temperatures through July and August helped to reduce mosquito habitat within the MVRD. Ambient temperature data are consistent with 2023 automated snow station data depicting snowmelt points correlating with regional ambient temperature spikes[6].

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 development was slow, and survivorship was low. Eggs held at 21°C provided the optimal temperature, of the five temperatures tested, for hatching and larval development (**Figure 3**). While *Ae. sticticus* is not the sole floodwater species present in the MVRD, it serves as a representative species for our purposes and provides general developmental benchmarks.

[4] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2023_may1.pdf
[5] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2023_june1.pdf
[6] 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

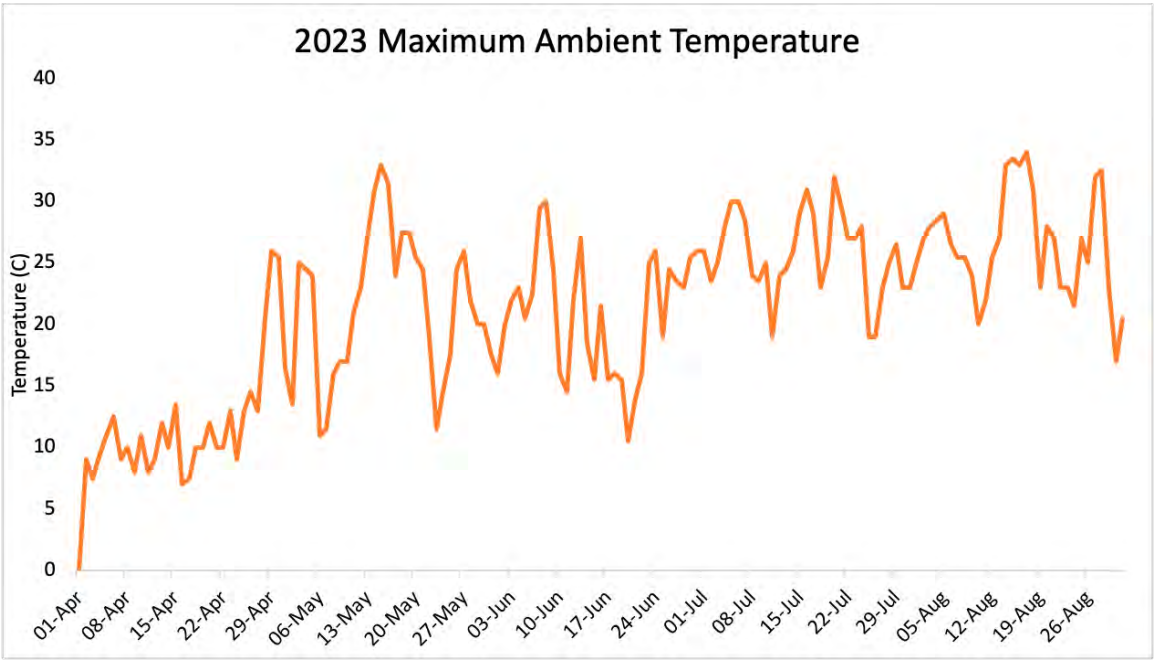

Figure 3. Maximum daily ambient temperatures (C) as recorded at the Mission West Abbey Station (ID: 1105192) 01 April – 31 August 2023.

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.

The MVRD 2023 season began with lower-than-average ambient temperatures for April. The monthly average for April 2023 (11.9 °C) was 1.7°C lower than the station average for April (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 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 favourable larval development conditions for all target species (**Figure 3**). The

average maximum daily temperature for May (21.4°C), was approximately 4.4°C warmer than the station average. Mosquito hatching and larval development rates greatly increased within May with the rapid arrival of freshet to the Lower Fraser River and associated mosquito development sites. Appropriately, mosquito larval treatments increased in late-May as local ambient temperatures were consistently within upper bounds of temperatures associated with higher floodwater, saltmarsh, and permanent water mosquito hatching success rates.

Average daily maximum ambient temperatures for June were 3.1°C higher than average and provided sufficient hatching cues for all target mosquito eggs exposed to water. Ambient temperatures were unseasonably warm until the middle of June when temperatures cooled and significant rainfall fell on 19 June, before warm weather returned on 25 June and lasted through July. Although local ambient temperatures were very warm during July, the Lower Fraser River was below critical levels for associated mosquito development sites and the summer heat likely helped to reduce the lifespan of adult mosquitos locally.

When river levels peak during periods of higher heat, the result is large-scale mosquito egg hatching events and increased larval development rates. Considerable floodwater mosquito development sites were active in May and June and the need to treat mosquito larvae during this time was directly associated with both warm ambient temperature and peak Lower Fraser River levels.

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 2.7°C and 3.4°C above normal for July and August, respectively. Continued warm weather, coupled with insufficient habitat farther into the summer meant that floodwater mosquito treatments were most prevalent during May and June in 2023. Additionally, saltmarsh and permanent water mosquitoes required minimal treatments in July and August due to reduced development habitat, active for a shorter period of time than 2022. High ambient temperatures, such as those noted in July and August, likely decrease 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 through 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 2023 Lower Fraser River freshet began in late-April due to a long-lived high-pressure ridge present within contributing basins until mid-June. The arrival of freshet at the end of April marked the beginning of the rapid rise of the Lower Fraser River (Mission gauge; 08MH024). As a result of unseasonably warm weather conditions throughout most of British Columbia during May, the Fraser River peaked approximately six weeks earlier than in 2022.

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 2023, the Lower Fraser River reached that point on 5 May, nearly a month earlier than in 2022 (**Figure 4**). This disparity illustrates the early freshet in 2023 and considerably late freshet in 2022.

The unseasonably warm weather through May accompanied by a significant rainfall event precipitation on 21-22 May, resulted in the peak of the Lower Fraser River (Mission gauge; 08MH024) at 5.53 m (**Figure 4**). Unusually warm weather across much of the province depleted the majority of high-elevation snowpack in contributing snow basins through May, resulting in a relatively high, but short-lived Lower Fraser River peak.

By mid-June 2023, all snow basins, with the exception of Nechako (29%), were zero percent of normal snowpack[7]. The exhaustion of high elevation snow in nearly all snow basins corresponds with a marked decline in the Lower Fraser River levels starting at the end of May Mission gauge (**Figure 4**). When the Lower Fraser River levels consistently remain below three meters, associated seepage sites reduce quickly and by mid-June in 2023 many of the mosquito development sites were becoming dry.

The length of time that the Fraser River at Mission remains higher than 5 meters helps describe the extent of mosquito larval abundance within a given year. The Lower Fraser River remained above the 5-meter threshold for 40 days in 2022, but just 10 days in 2023. This length of time is considered an anomaly and resulted in fewer adult mosquitos than 2022. In average years, such as 2021, Lower Fraser River levels may remain above 5 meters for closer to 20 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. The 2023 peak of the Fraser River was approximately 0.34 meters lower than in 2022, thus, the 2023 peak levels did not trigger additional dormant floodwater mosquito eggs to hatch (**Figure 4**). High but briefly sustained water levels occurred during warm summer temperatures, providing hatching cues to floodwater mosquito eggs. The

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

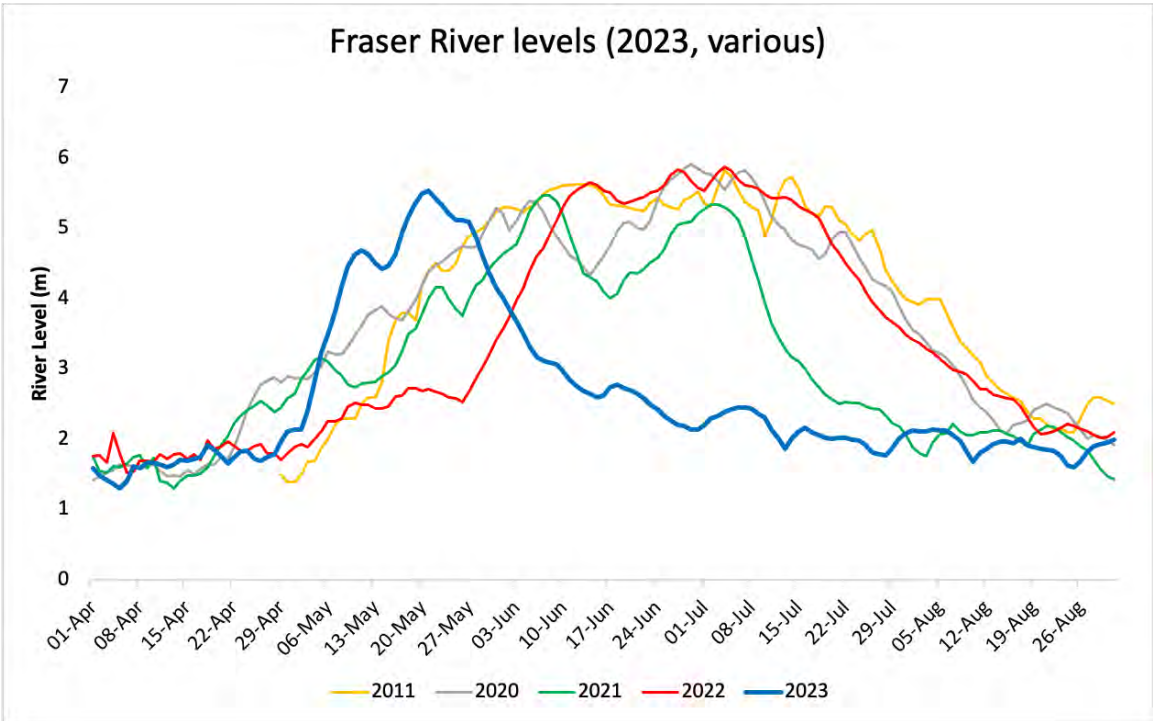

Figure 4. 2023 - 2022, and 2021 river levels (m) as recorded for the Lower Fraser River (Mission gauge, 08MH024) from 1 April – 31 August. Three (3) meters is the level at which River-associated mosquito development sites tend to become active.

relatively high, but briefly sustained river levels were sufficient for floodwater mosquito larval development in 2023.

Larval Control

Monitoring within the MVRD began on 1 May at floodwater mosquito development sites. Permanent water and saltmarsh mosquito development sites were visited on 12 May. Although most of the floodwater mosquito development sites are not active until the Fraser River (Mission gauge) exceeds 3 meters, sites are monitored prior to peak levels to evaluate site conditions and catch the leading edge of any potential hatching events that may have 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 late-April. The relatively warmer ambient temperatures that continued through May coincided with increased monitoring and larval mosquito treatments in mid-May.

Appendix I shows a map of average larval densities found throughout the 2023 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, Langley, and Kanaka Creek Regional Park (**Appendix I A-G**). No new mosquito development sites were identified throughout the MVRD program purview in 2023.

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.

High but briefly sustained Lower Fraser River levels, coupled with high ambient temperatures in May and June, resulted in less floodwater treatments but the need for small treatments through August. A total of approximately 157 ha (1200 kg) were treated within the MVRD in 2023. 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 2023. 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 site's 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 (3rd or 4th 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 9 May (**Figure 5**). Most ground treatments > 1 ha took place between 12 May and 22 May, as dictated by

higher Lower Fraser River levels. However, due to the short-lived high-water in 2023, but occasional precipitation events, smaller scale treatments continued until 13 September (**Figures 5, 6**). All known sites were wet this season.

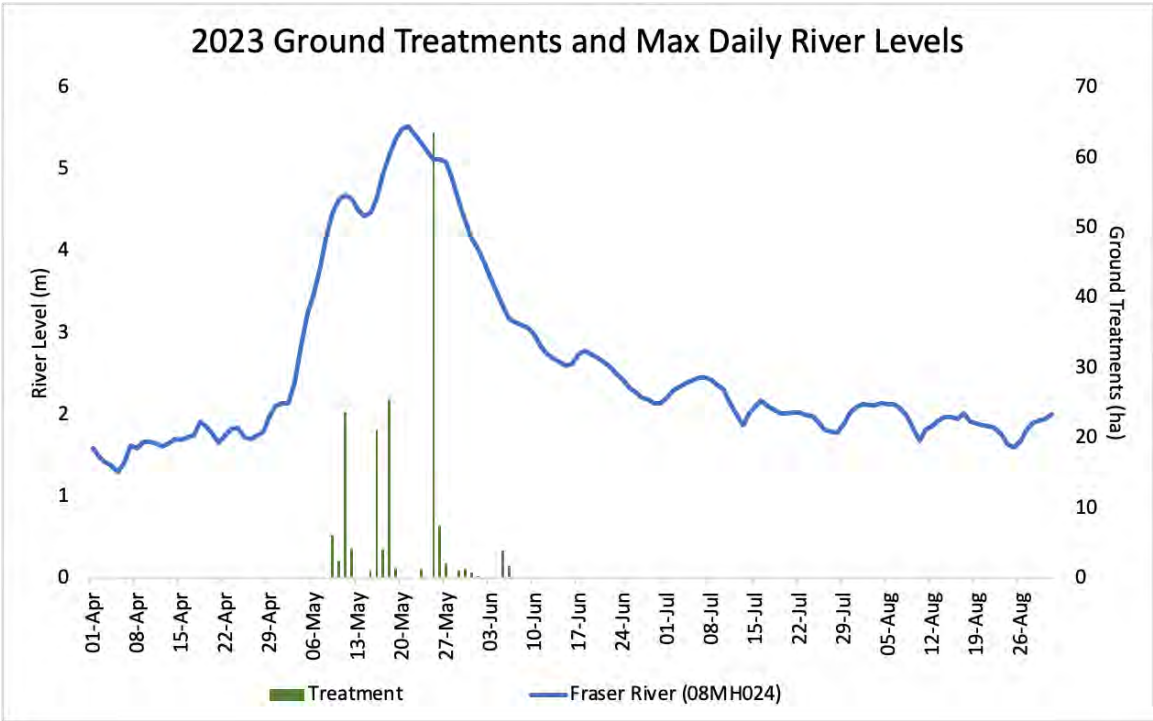

Figure 5. Fraser River levels (m; Mission gauge) with total floodwater mosquito development area treated by ground (ha) from 1 April – 30 August 2023. Note that ground treatments (ha) are recorded on the alternate y-axis.

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 2023. 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 mosquito development sites in 2023 was approximately 63 ha (254 Kg Aquabac®; 4 kg/ha) **(Figure 5)**. Real-time data associated with each treatment are available through MBL's client-registered, real-time program portal.

Table 2. 2023 ground-treated area (ha) by site (floodwater vs. saltmarsh, permanent water) from April – August.

Program	Floodwater Site		Non Floodwater Site		
	Kg	Ha	Kg	Ha	% floodwater
MVRD	0	0	4.5	1.13	0%
MVRD - Coquitlam	5.9	1.48	1.3	0.33	82%
MVRD - Langley	125.31	31.33	16	4	89%
MVRD - Maple Ridge	25.6	6.4	16.2	4.05	61%
MVRD - Pitt Meadows	3.2	0.8	0	0	100%
MVRD - Richmond	1.35	0.34	41.05	10.26	3%
MVRD - Surrey	13.63	3.41	0	0	100%
Grand Total	174.99	43.75	79.05	19.76	

Relative to the high-water and long freshet year of 2022, floodwater mosquito development habitat was present for a shorter period of time in 2023. The snowpack within influential basins was lower-than-average, only slightly augmented through April and melted rapidly during May. Those conditions across much of the province led to high, but briefly sustained Lower Fraser River levels through most of May and June. Significant rainfall on 21 May may have slightly elevated the Lower Fraser River peak beyond the freshet alone. The briefly sustained Lower Fraser River peak was long enough to provide floodwater mosquito development hatching cues. However, environmental cues were not present long enough to provide multiple floodwater mosquito hatching events, resulting in less adult floodwater mosquitos compared to 2022.

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 (3rd or 4th 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**). Treatments were required until 13 September with ambient temperatures above 20°C, a more favourable ambient temperature for saltmarsh and permanent water mosquito hatching success. All known sites were wet this season. No sites were missed, and no new sites were identified.

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. The total area treated by ground at saltmarsh and permanent water mosquito development sites in 2023 was approximately 20 ha, which equates to about 80 kg of granular Bti (4 kg/ha; **Table 1**). 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. Two aerial campaigns were required within the MVRD in 2023. Treatments took place on 17 and 23 May (**Figure 6**). For comparison, four aerial campaigns were required in 2022. The reduced aerial treatment events signify the relatively lower abundance of floodwater mosquito larval within the region in 2023. The lower mosquito larval abundance was due to briefly sustained Fraser River levels above three (3) meters and appropriately timed treatments.

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 94 hectares were treated by air, equating to a total of approximately 946 kg of Aquabac® used (**Figure 6**). The total area treated in 2023 was approximately 48 hectares less than was treated in 2022.

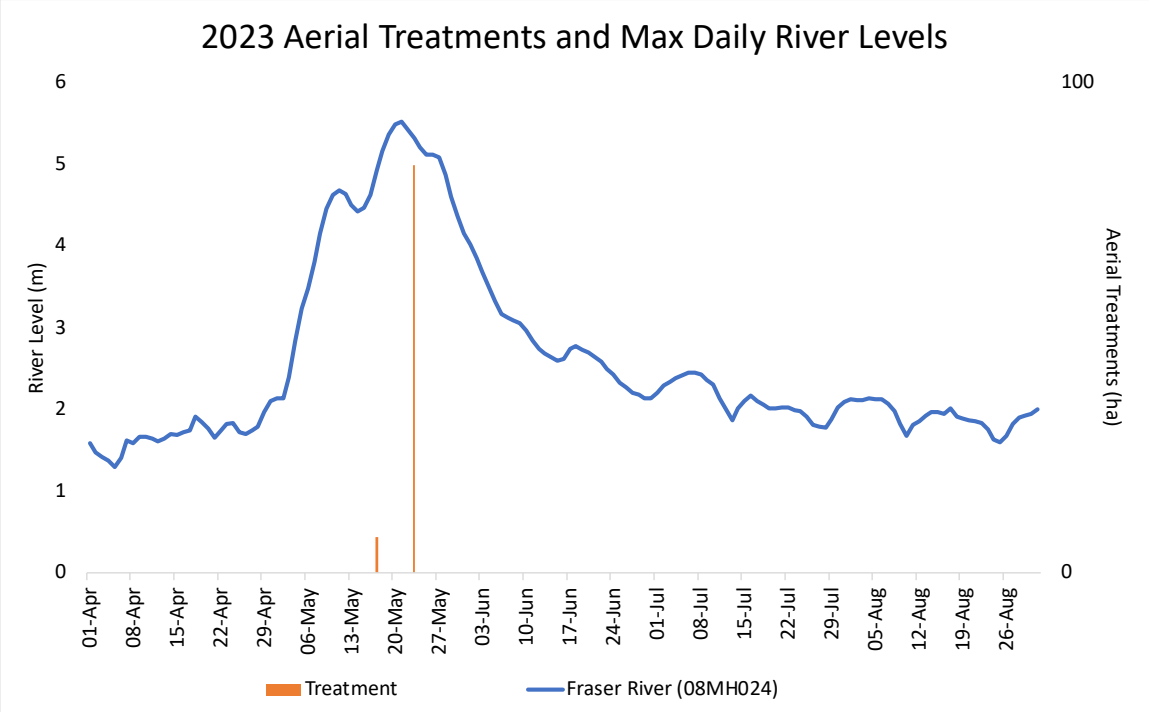

Figure 6. Aerial application events (orange lines; ha) with Fraser River levels (blue line; m) from 1 April through 31 August 2023. Note that treatment values (ha) are on the alternate y-axis.

Aerial treatment events typically take place immediately after the Fraser River has peaked when 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 primary Lower Fraser River peak (**Figure 6**). MBL staff were able to accompany the helicopter pilot again in 2023, which aids in identification and treatment of inconspicuous mosquito development areas. 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 2023.

Adult Mosquito Trapping

The primary objective of the adult mosquito trapping program is to assess adult mosquito abundance 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 did not change significantly this year. Overall, trap locations remain spatially representative of mosquito development habitat within each of the program partner municipalities. One trap location was selected in the City of Richmond to target saltmarsh mosquito habitat for 2023.

Vandalism has been greatly reduced in 2023. However, one trap was stolen in Coquitlam this year. Otherwise, all adult mosquito traps have been functioning properly and were recovered at the end of the monitoring season.

Table 3. Trapping schedule for 2023 season.

	Trap site	Municipality
Week 1	Brae/MacMillan Island	MVRP/TOL
	Derby Reach Park	MVRP
	Tynehead Regional Park	MVRP
	Construction Road	SUR
	Garry Point Park	RICH
Week 2	Mundy Park	COQ
	Colony Farm	MVRP
	Town Centre	COQ
	Pitt River Reg Greenway– Harris Landing	MVRP
	Pitt River Dyke Trail	MVRP
	Pitt Meadows Athletic Park	PM
	Kanaka Creek Regional Park	MR
	Cliff Park	MR

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 MBL staff member was responsible for all mosquito trap efforts, improving field efficiency and reducing operator errors.

Traps were monitored approximately every 1-2 weeks between May and August (**Table 3**). A total of 25 trap nights were conducted. A total of 940 adult female mosquito specimens were collected (**Table 4**). Approximately 2,000 more mosquito specimens were collected in 2022 than 2023. A relatively high but shortly sustained Lower Fraser River peak was likely responsible for the decreased in adult mosquito trap abundance.

Table 4. Absolute mosquito numbers caught per trap per night in each municipality.

Date	COQ	MR	MVRP	PM	RICH	SUR	TOL	Grand Total
09-May						6		6
15-May								
17-May		1						1
22-May								
29-May				1				1
31-May								
05-Jun			77				43	120
12-Jun	7		26	1				34
14-Jun		10	42					52
19-Jun			48			2		50
25-Jun			79					79
26-Jun			1	0				1
03-Jul			3			0	1	4
05-Jul		3						3
17-Jul			260				1	261
20-Jul	1		0	1				2
23-Jul							88	88
24-Jul		6	14					20
01-Aug			162					162
03-Aug	0		10	1				11
08-Aug		1	3					4
14-Aug			21					21
16-Aug	9		1					10
21-Aug		1	0					1
23-Aug	1							1
28-Aug					8			8
Sum	**18**	**22**	**747**	**4**	**8**	**8**	**133**	**940**

Figure 7 shows the total adult floodwater 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 increased rapidly in early June as floodwater mosquitoes dispersed post-freshet (**Table 4**, **Figures 7, 8**). The initial Fraser River peak occurred on 21 May and the adult mosquito trapping event on 5 June yielded a moderate number of flood water mosquito specimens (75) (*Aedes vexans*) for the first time in the 2023 season. The sample containing the largest number of adult specimens occurred on 17 July with a species composition primarily comprised of female floodwater mosquito *Aedes vexans* (258) and permanent water species *Coquillettidia perturbans* (2). Thus, it is likely that most specimens from the 17 July trap collection event had dispersed from floodwater sites after the Fraser River Peak, and likely was composed of mosquitoes hatched between late May through June. The species representing the highest percentages of specimens was *Aedes vexans* (65%), suggesting that the floodwater mosquito species had dispersed from seepage sites created during peak Fraser River levels. Adult mosquito trap content totals decreased following the 4 August trap night, reflecting the recede of Lower Fraser River levels.

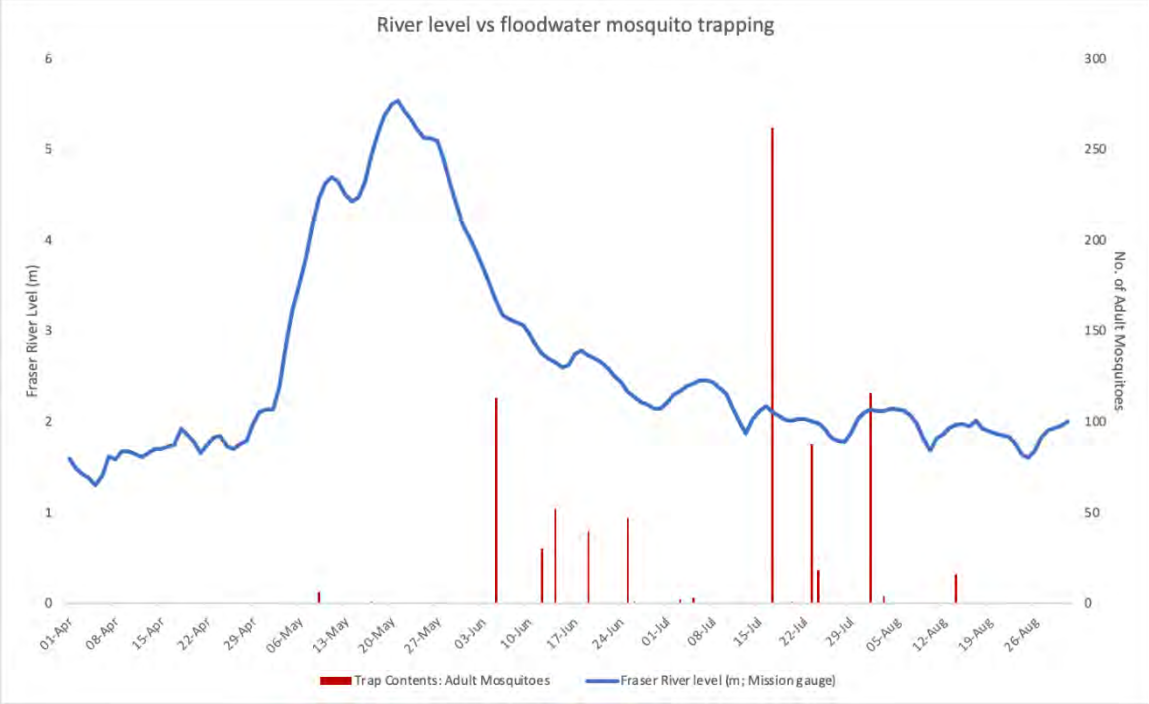

Figure 7. 2023 MVRD adult mosquito trap abundance by day (red; alternate y-axis) with Fraser River level (m; Mission gauge).

Adult mosquito traps with the greatest number of specimens were from Kanaka Creek and Brae/McMillan Island (**Table 4**). 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 2023. Approximately 6% of specimens were damaged in 2022, as compared to approximately 14% in 2020, and nearly half in 2019. Some specimens were damaged beyond identification, but the vast majority were in good shape, a marked improvement from 2022, likely due to the inclusion of desiccant (e.g., silica beads) with individual samples.

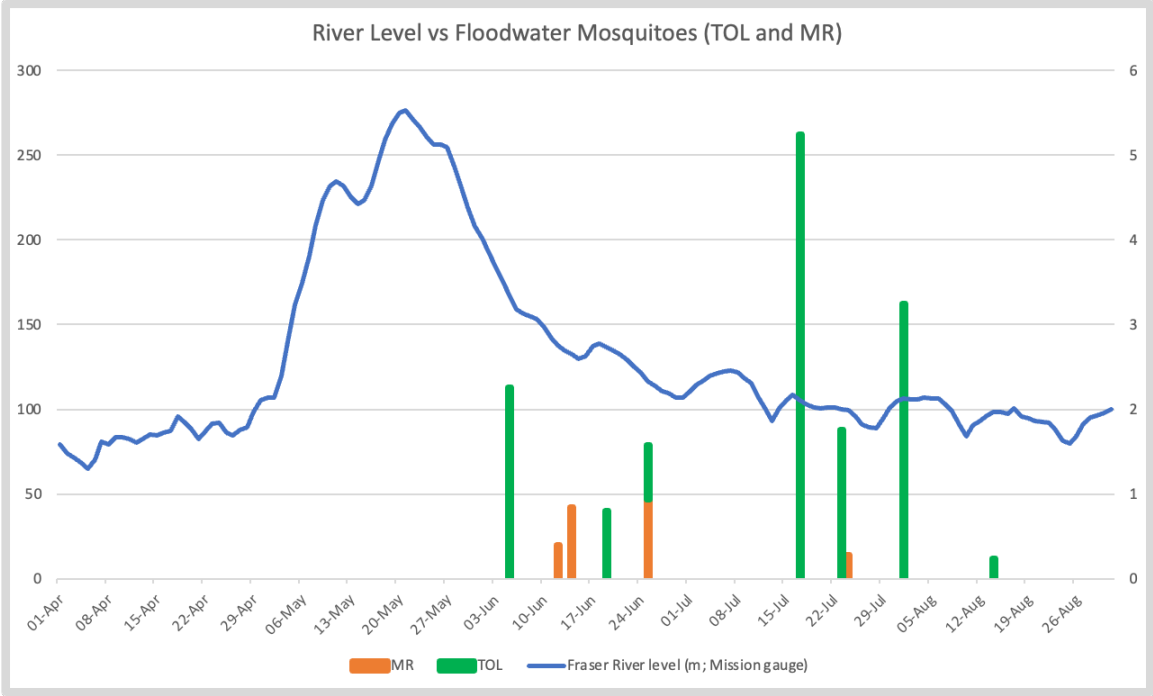

Figure 8. Floodwater mosquito trap counts by night for Township of Langley (green) and Maple Ridge (orange) relative to river levels. Note that TOL and MR traps contain 88% of all trapped mosquitoes. This data includes MV Regional Park data from the two noted municipalities.

During the period in which most adult mosquitoes were caught (i.e., 4 June – 4 August), floodwater mosquito species were found in high abundance, particularly in two waves, the first as expected after the 21 May peak, and the second in mid-late July. Container species appeared in much smaller numbers towards the end of the summer. These analyses indicate that trap locations primarily targets floodwater mosquito habitat. No saltmarsh habitat mosquito species were identified in 2023. The abundance and frequency of floodwater mosquitoes throughout the season is indicative of the relatively high peak of the Lower Fraser River in 2023.

Specimen identification was conducted and verified by trained professionals using a 60X microscope. The primary resources for species identification were Wood et al (1979), 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 main species confirmed in the 2023 MVRD adult mosquito traps were *Aedes vexans, Aedes sticticus, Culex pipiens, and Coquillettidia perturbans*. Certain indistinguishable specimens were either unknown or identified as either the *Aedes* or *Culex* genus (**Figure 9**).

Aedes japonicus was not detected in any MVRD adult mosquito traps in 2023 but was found in an adult mosquito trap in Abbotsford on 27 July, 2022. *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

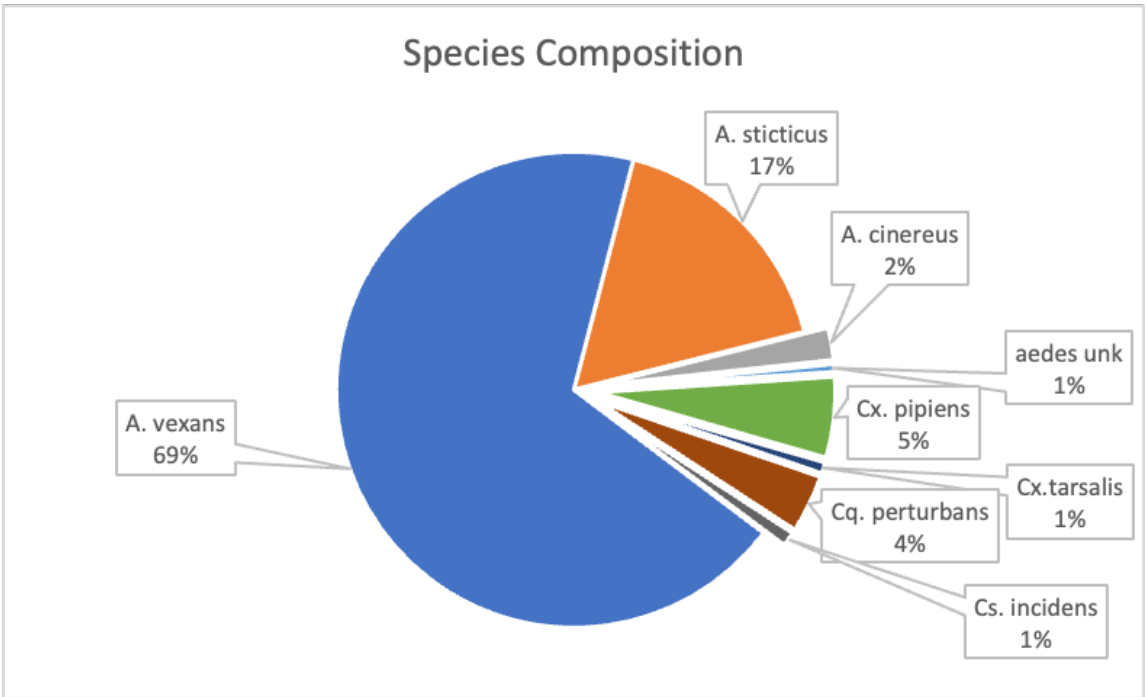

Figure 9. 2023 over-all mosquito species composition from adult mosquito trap established throughout the MVRD. Note that *An. punctipennis* and *A. canadensis* are not represented due to their small counts.

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.

Overall, floodwater *Aedes* species comprised most of the species in 2023 traps (i.e., ~90%; **Figure 9**). 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 (1%). The primary habitat for *Cq. perturbans* is emergent vegetation, and more specifically *Typha* species (Batzer and Sjogren 2012). The high Fraser River levels of 2023 may have created additional habitat for *Cq. perturbans.* The presence of *Cq. perturbans* was also noted in higher 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 local elected officials, 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).

There were two calls received to either the MVRD Mosquito Hotline or directly to the MBL Mosquito Hotline in 2023.

One concern email was received from MVRD residents in 2023. All calls and emails are designated as either concern or inquiry based.

All calls and emails were designated as 'concern' and as inquiry-based (**Appendix V**). MBL's goal is to return all concern calls within 24 hours.

The total number of two calls and emails received in 2023 was the lowest on record and a stark difference from the high concern call volume of 2022 (**Figure 10**). The low number of concern calls and emails is due to the low adult mosquito abundance, a result of shortly sustained Lower Fraser River levels above three (3) meters during warm ambient temperatures.

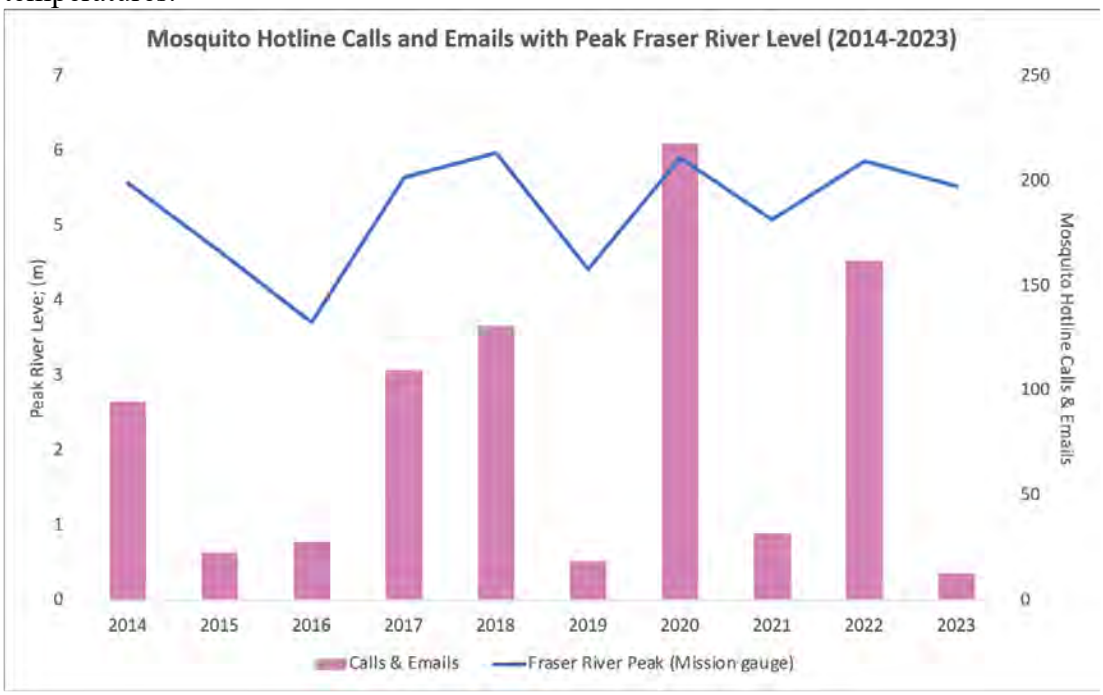

Figure 10. Peak Fraser River levels (m; Mission gauge) with total Mosquito Hotline calls and emails (2014-2023).

Concern calls were received 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 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 reconnaissance visits and located no new sites on residential properties. One (1) concern email was received from the Pacific Spirit Park area, the email was returned, with follow up reconnaissance, leading to a small treatment on 30 August. The calls and emails were generalized adult mosquito abundance concerns and not associated with a specific site.

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 rapid rates in the warmer part of the season as occurred beginning in late-April this year, floodwater mosquitoes eggs may hatch during a shorter period of peak river levels. Thus, the potential timeline for mosquito emergence and dispersal in 2023 likely ranged from late-May through early-June. Hotline calls were concentrated after the dispersal of adult mosquitoes around 5-6 July. The peak Hotline call volume was associated with adult mosquitoes that likely dispersed from high water between late-May and early-June. The email received in August was likely associated with container and, or permanent water mosquito species.

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.

Image 3. MBL Outreach Pamphlet.

These encounters provide an excellent opportunity for public relations. An important outcome of these interactions can be the identification of new sites.

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 (Facebook, Instagram). 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 4**).

Image 4. Updated education outreach postcard (2022).

Social Media

MBL maintains a presence on social media with a Facebook account (facebook.com/morrowbioscience) and Instagram account (morrowbioscience), which are regularly updated. We no longer maintain an X (formerly Twitter) presence. 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 and Instagram remain the primary avenues for MBL to disseminate mosquito-related information on social media. Periodic updates on mosquito activities began in early April. The total number of followers on the MBL Facebook page was 387 as of 26 November. Another way to determine how many people are engaging with MBL's posts is

by considering MBL's post 'reach'. In 2023, the total reach pertaining to the MVRD mosquito control program (posts with #mvrdmosquitoes) was 329 (Facebook) and 229 (Instagram). The relatively low reach of posts this year likely reflected the lower-than-average abundance of adult mosquitoes. 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. 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 contact information. The 'Contact 'tab allows users to directly send a message to MBL. Additionally, there are links to MBL's Facebook account, so residents have access to real-time updates on MBL's activities.

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

The first outreach event attended by MBL staff was an open house at the Fort Langley Community Hall, 9 May, 2023. This meeting was well attended. MBL staff provided a comprehensive presentation on mosquito control in general and specifically with respect to efforts in the Fort Langley area. The event lasted approximately 1.5 hours and is available for viewing by searching "fort langley mosquitos" on youtube.

In 2023, MBL was able to attend five standard 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.

Image 5. Township of Langley May Day.

Specific MBL outreach events included:

- Goodbye Chums (Metro Vancouver Regional Parks, Kanaka Creek Regional Park, 29 April)
- Surrey Party for the Planet (Surrey - 29 April)
- Township of Langley May Day (Langley - 23 May)
- Pitt Meadows Day (Pitt Meadows - 5 June)
- Coquitlam Teddy Bear Picnic (Coquitlam - 11 June)

MBL staff was interviewed by CBC news (29 May 2023) and provided detailed information regarding its integrated pest management methodology and strategies used for the assessment of environmental conditions and larval treatment of floodwater mosquitoes considering the historic flooding and subsequent mosquito infestation of 2022 to the lower Mainland (specifically in the Fort Langley area). MBL posted the article on its website. (2 June).

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 Jan and 6 September 2023.

As of 20 November, no human cases of WNv were reported to Health Canada originating from British Columbia[8]. One case was reported in an Alert on 6 September, 2023; however, it is suspected that further analysis proved the source was otherwise identified (e.g. out of province travel.)[9]. No horse or bird cases were reported from British Columbia within 2023. Also of note, mosquito pool surveillance data are not reported to Health Canada from British Columbia, and it is possible that other information was not reported by the BCCDC to Health Canada.

As Washington State and Idaho State share a border with British Columbia, it is important to follow WNv activity in those areas, as well. As of 27 September, three human in-state cases of WNv were reported in Washington State[10]. 82 mosquito pools tested positive for WNv and two horses/other mammals or birds tested positive. Of note, warmer ambient temperatures from late April – August contributed to a higher number of degree days during 2023, which likely contributed to higher incidence of WNv activity.

As of 1 October, 29 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]

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 the east coast but tested negative for Zika. There is currently a low risk for Zika virus to circulate within British Columbia.

[8] Seasonal update - Mosquito-borne disease surveillance - Vector-borne disease surveillance in Canada — Canada.ca
[9] https://www.canada.ca/en/public-health/services/publications/diseases-conditions/west-nile-virus-surveillance/2021/week-37-38-september-13-26.html
[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

2024 Program Recommendations

- Systematic surveillance of the Kanaka Creek area to be 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 2024 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).
- Consider revision of MVRD Pest Management Plan to include the use of RPAS (Remotely Piloted Aircraft System – a.k.a "Drones") for larval treatments.
- 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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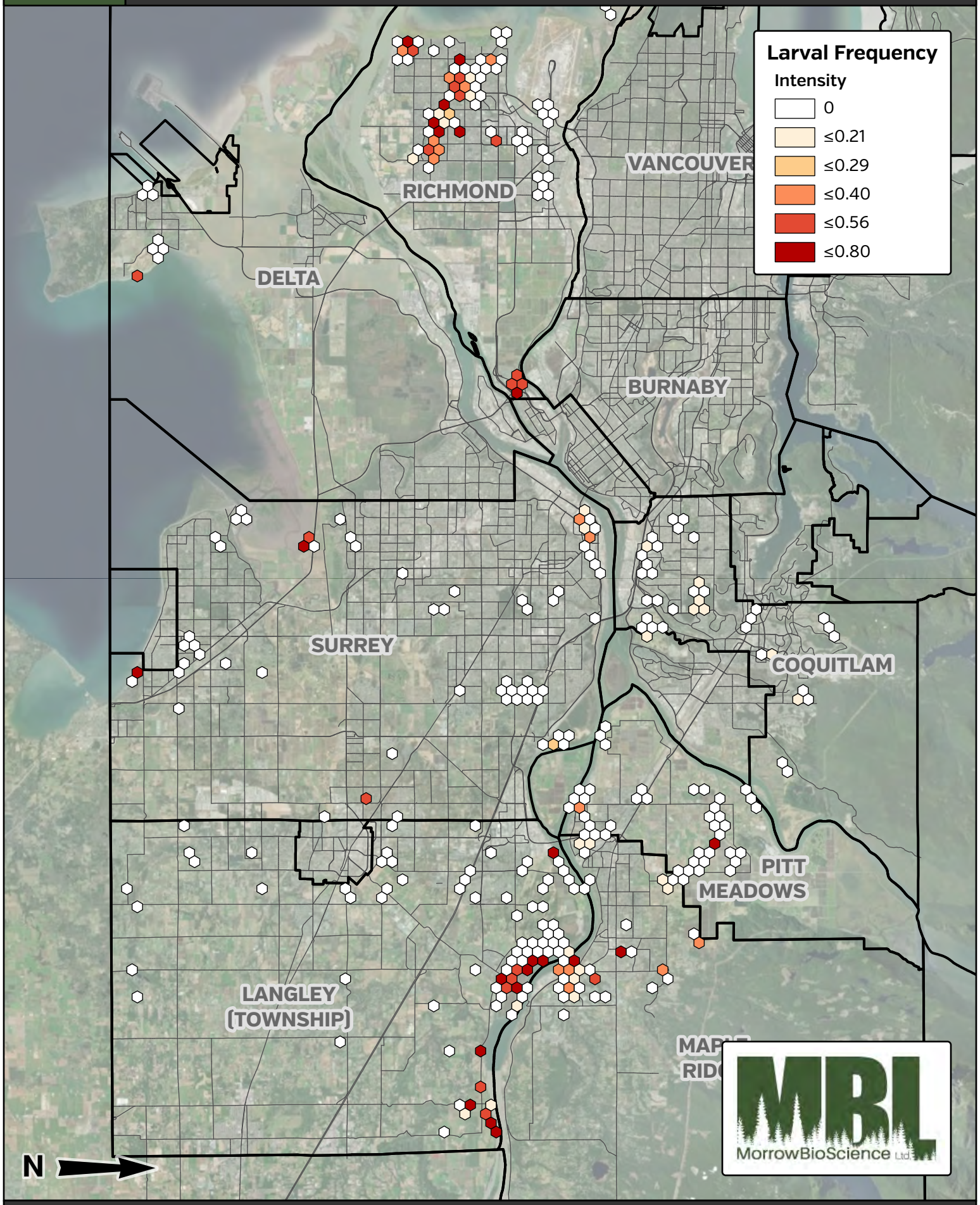
Appendix I-A

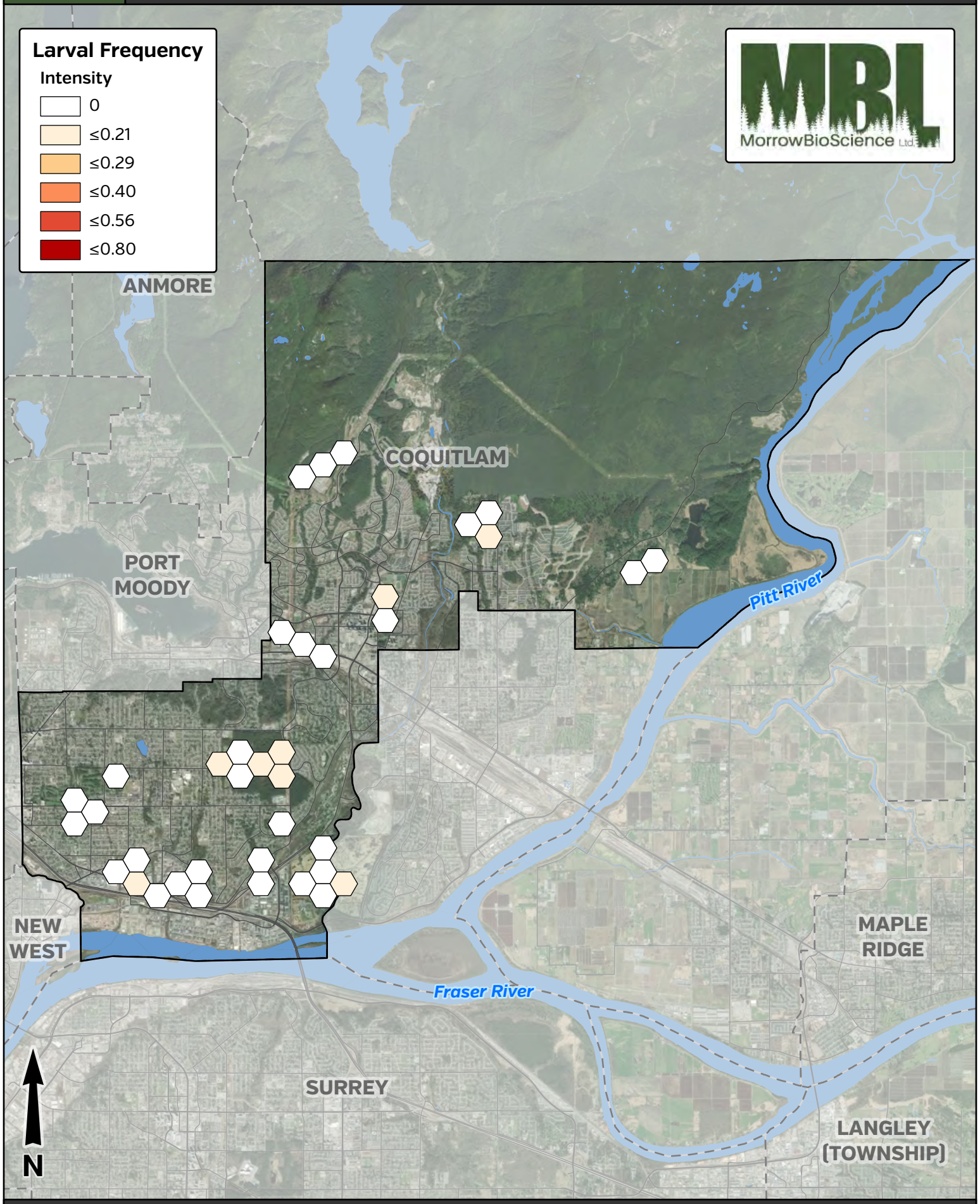
2023 MVRD Mosquito Larval Frequency



Scale = 1:230,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2023-12-19

Appendix I-B

2023 Larval Frequency - Coquitlam



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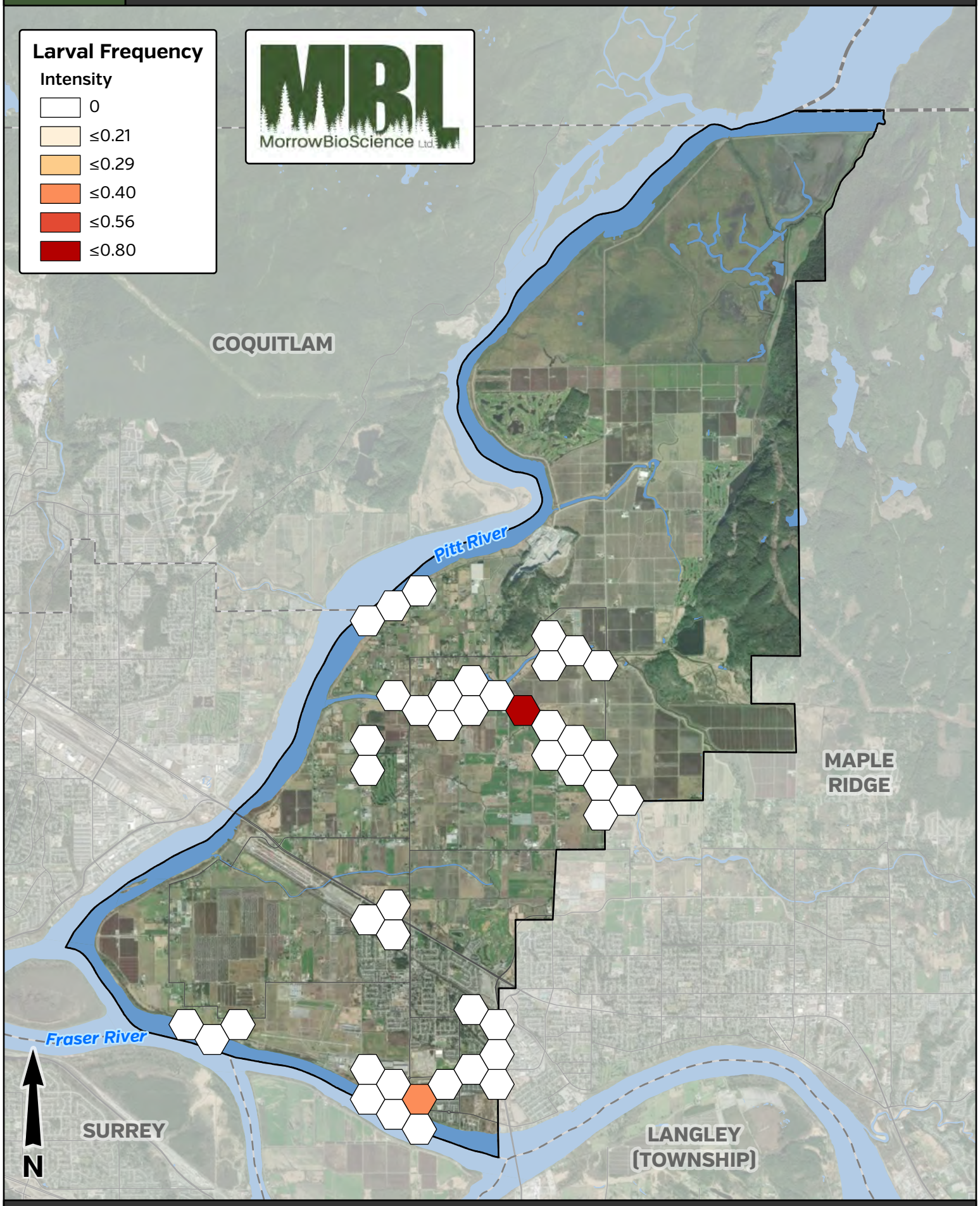
Appendix I-C

2023 Larval Frequency - Pitt Meadows



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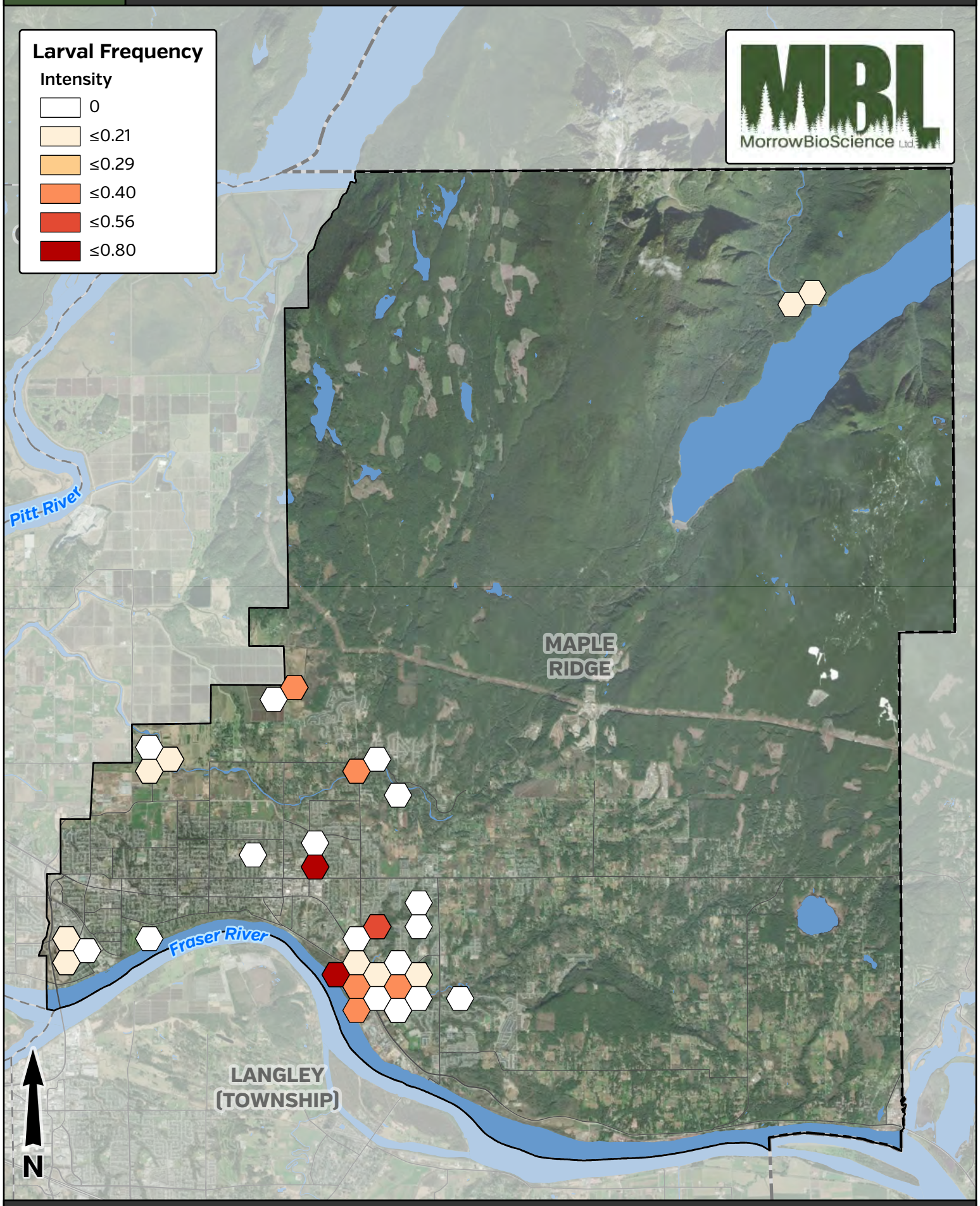
Appendix I-D

2023 Larval Frequency - Maple Ridge



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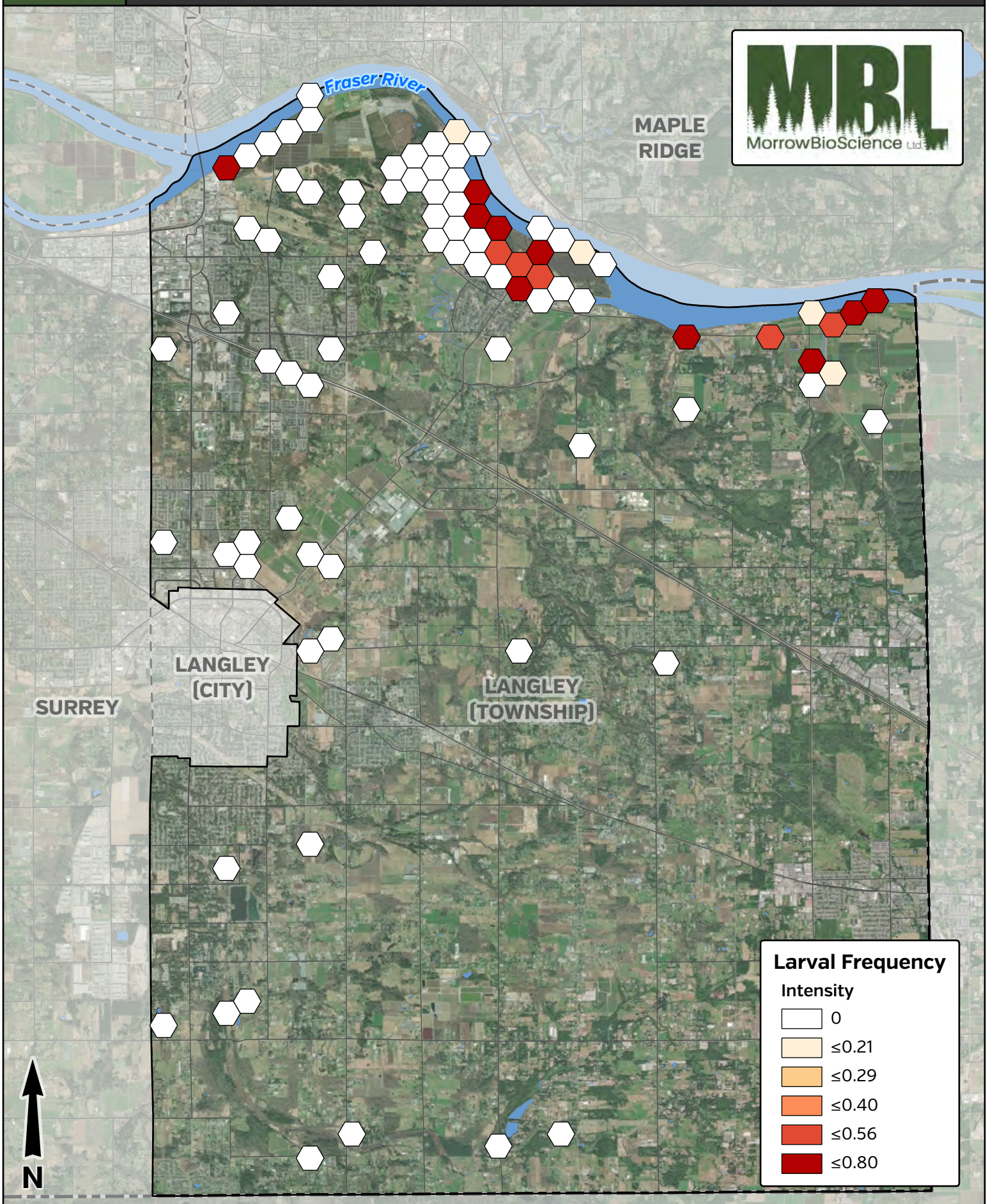
Appendix I-E

2023 Larval Frequency - Langley



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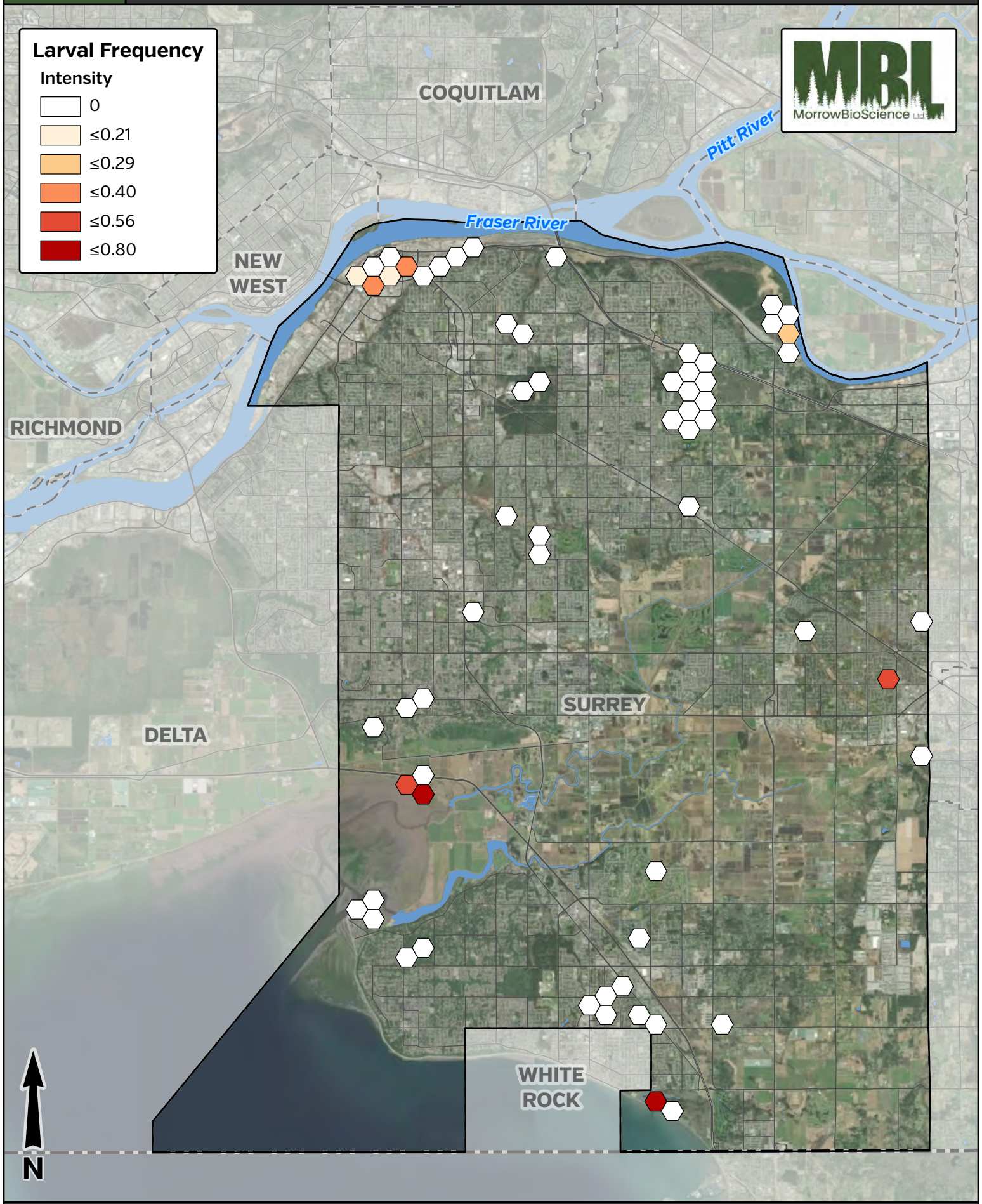
Appendix I-F

2023 Larval Frequency - Surrey



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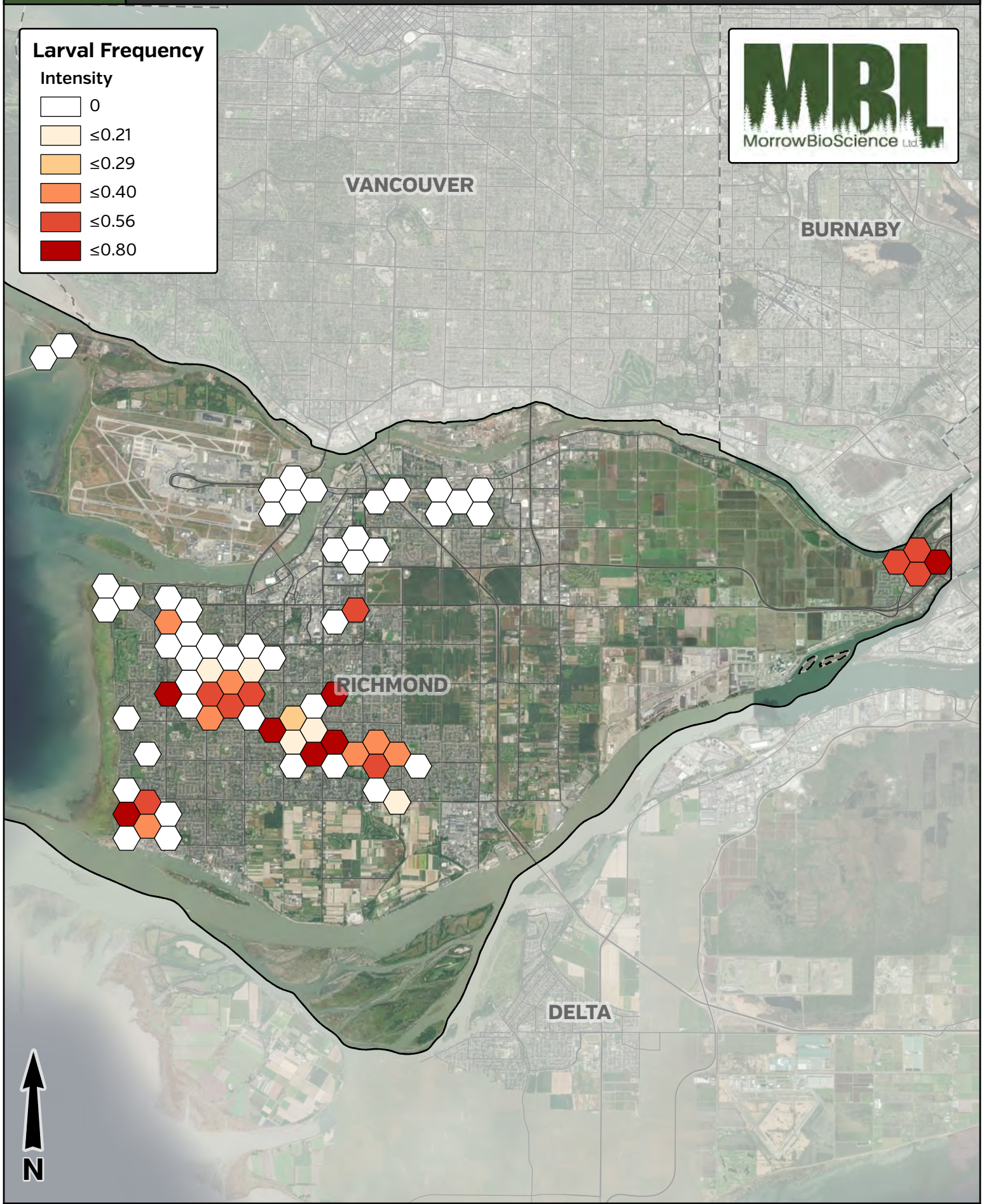
Appendix I-G

2023 Larval Frequency - Richmond



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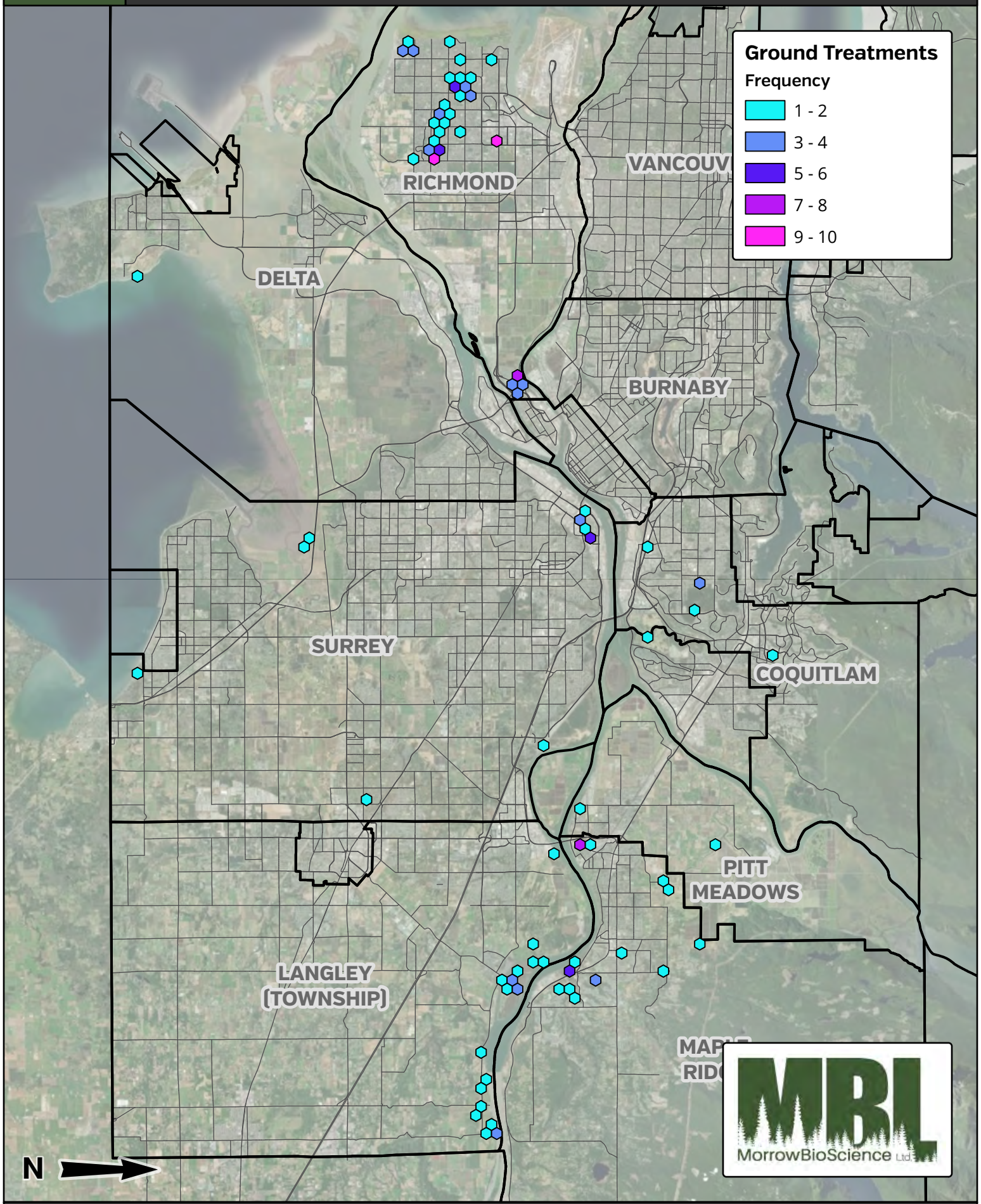
Appendix II-A

2023 MVRD Larvicide Treatment Frequency



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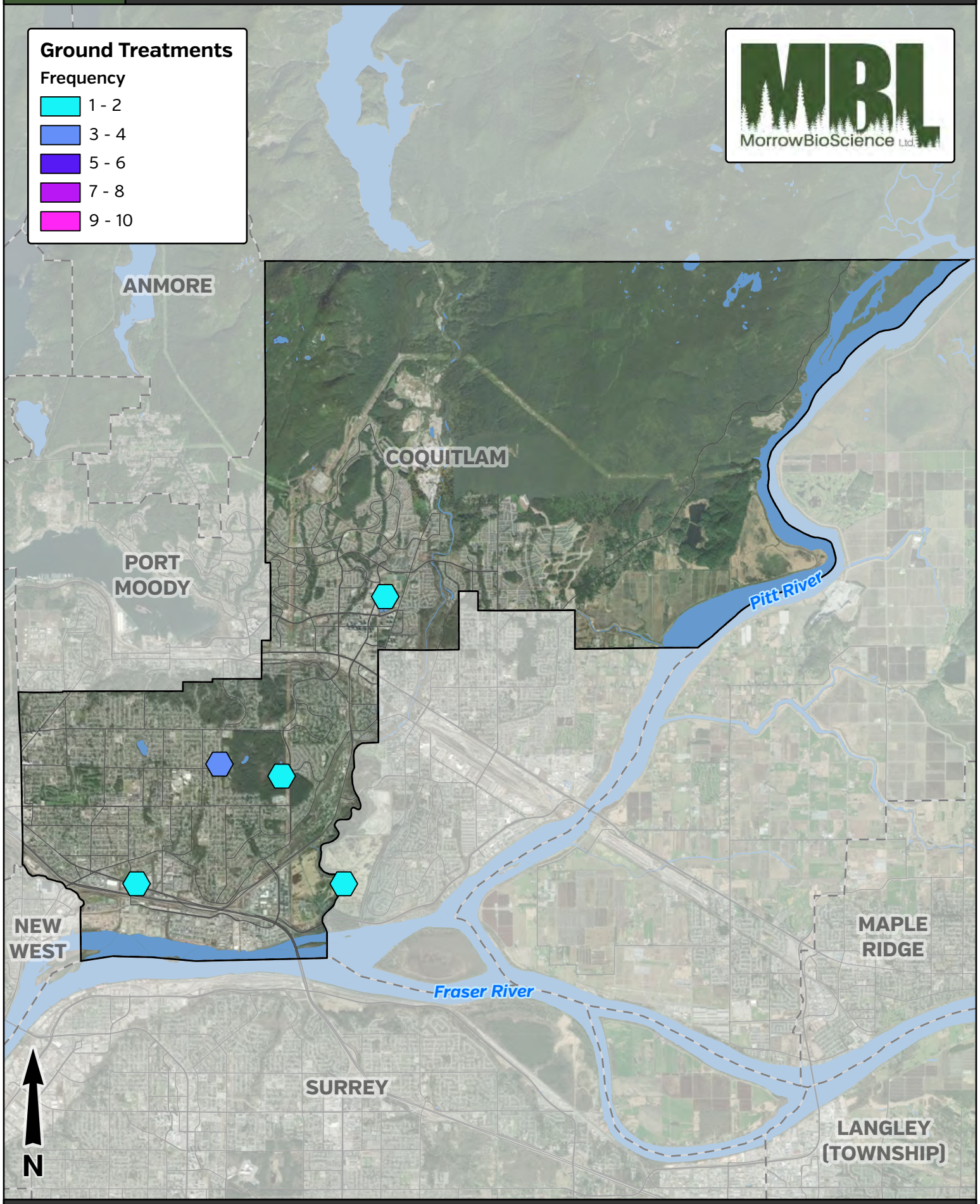
Appendix II-B

2023 Larvicide Treatments - Coquitlam



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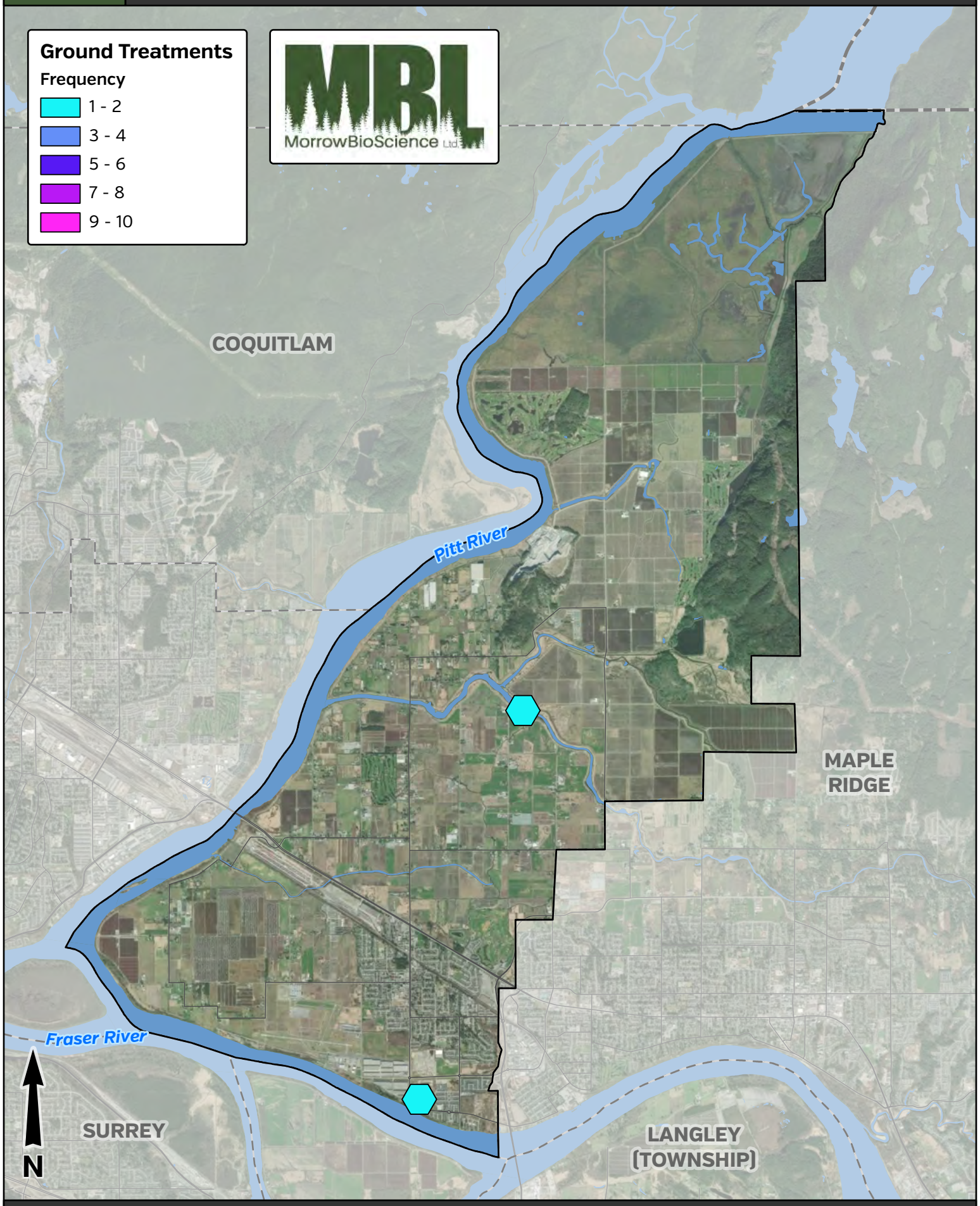
Appendix II-C

2023 Larvicide Treatments - Pitt Meadows



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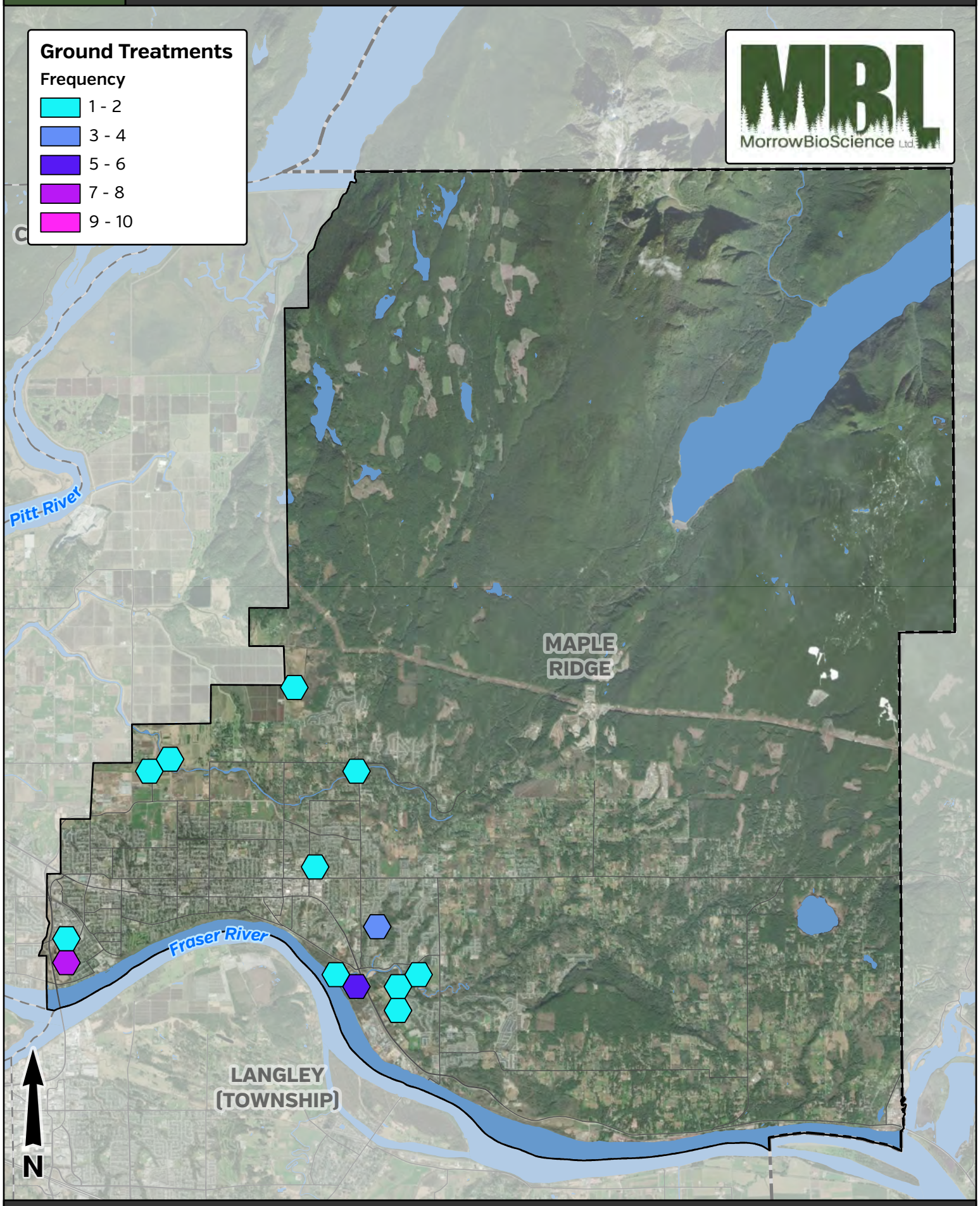
Appendix II-D

2023 Larvicide Treatments - Maple Ridge



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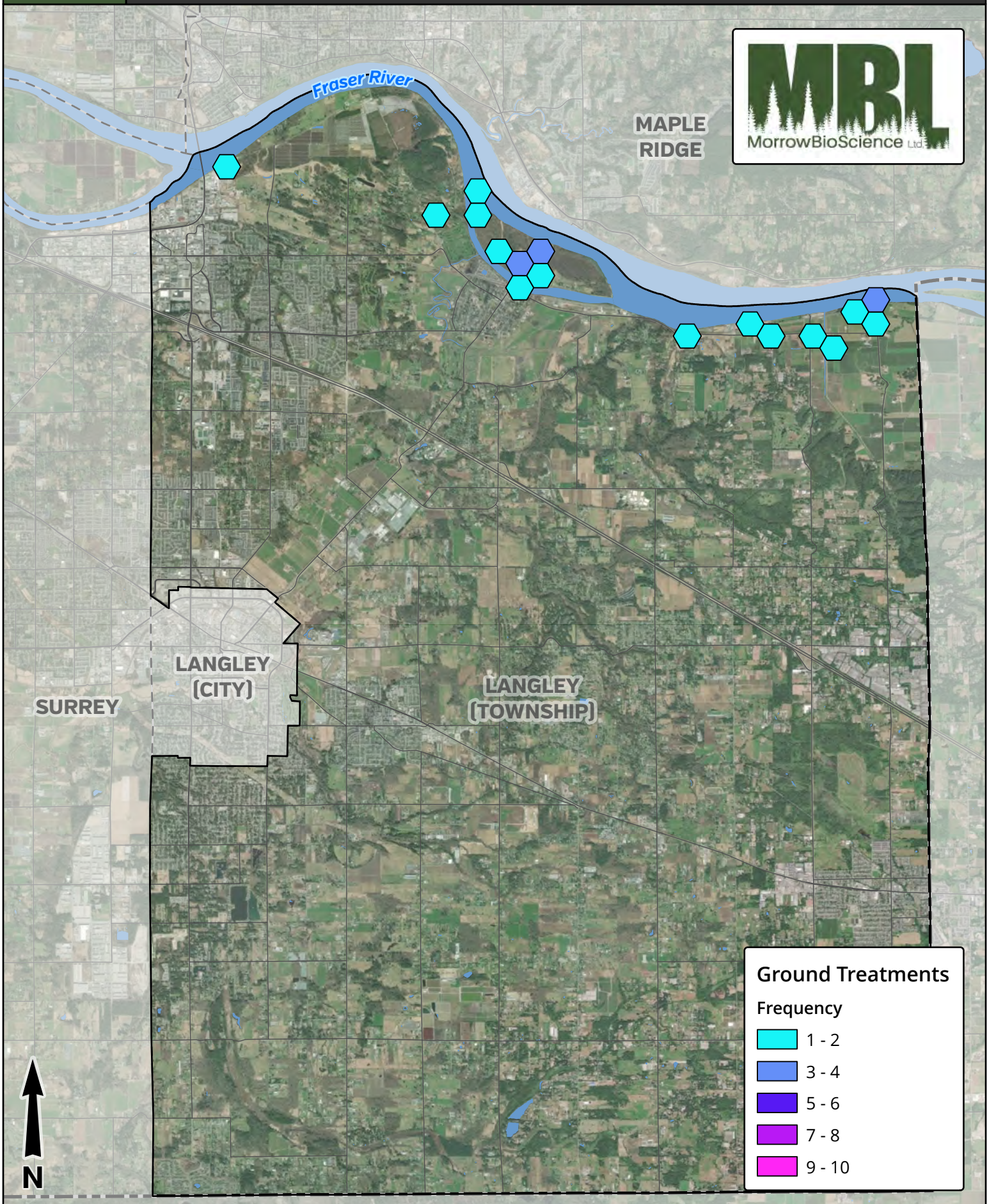
Appendix II-E

2023 Larvicide Treatments - Langley



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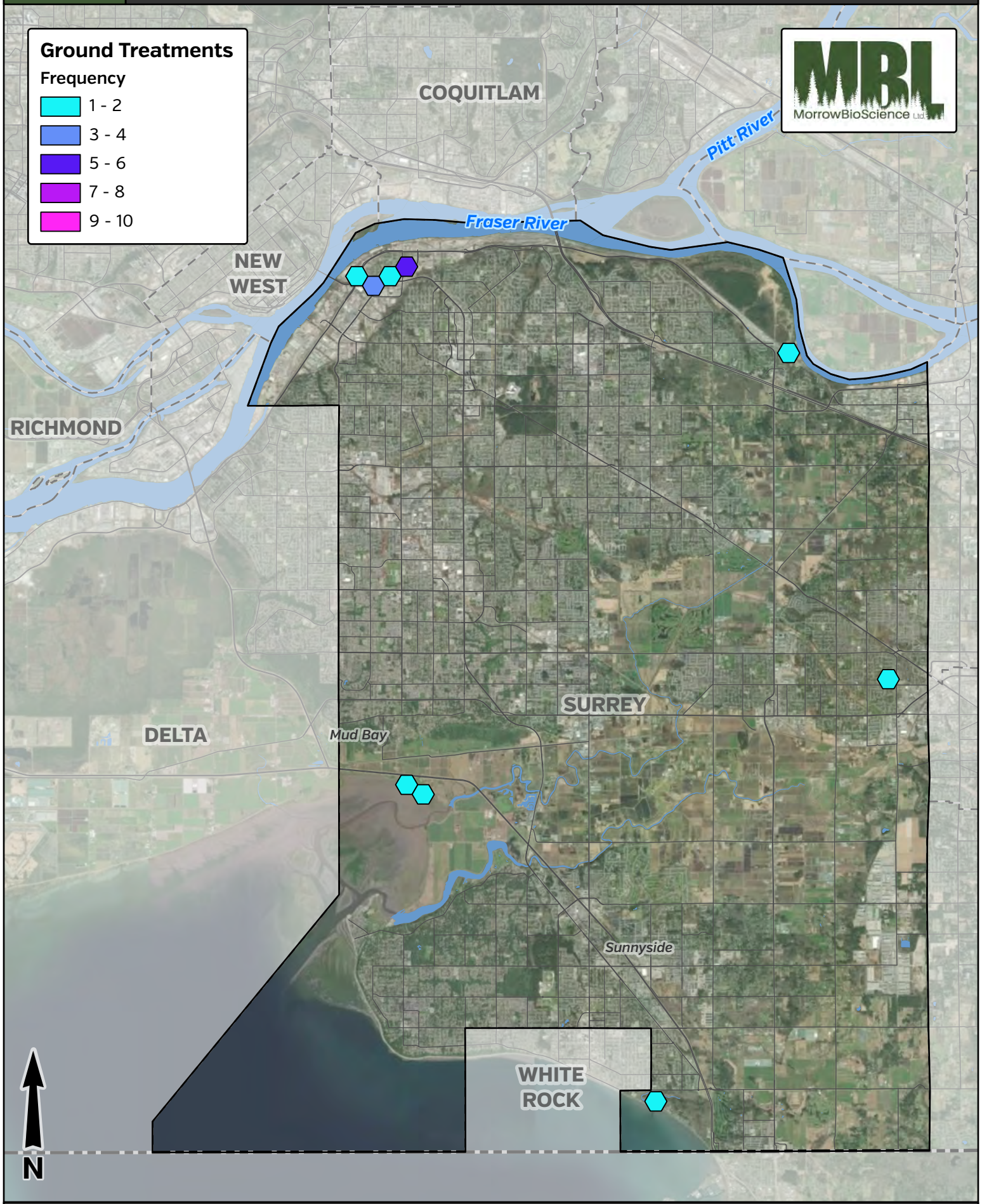
Appendix II-F

2023 Larvicide Treatments - Surrey



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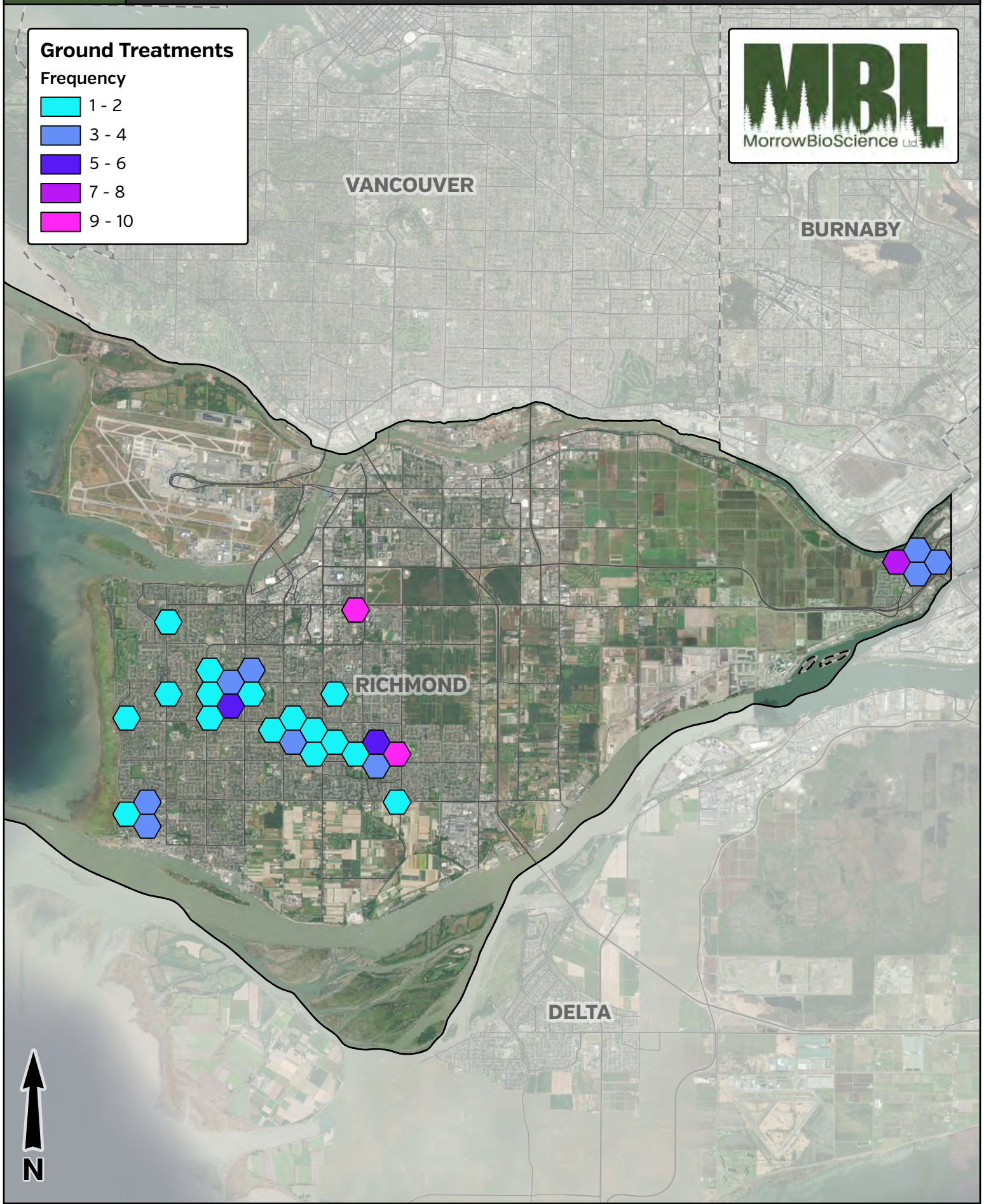
Appendix II-G

2023 Larvicide Treatments - Richmond



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Appendix III – Treatment Tables (2023)

Ground Treatments

Treatment Date	Site Code	Site Name	Treatment amount (kg)	Treatment area (ha)
2023-09-13	RICH-B2	B2	0.8	0.2
2023-09-11	RICH-A1	Richmond A1	0.2	0.05
2023-09-11	RICH-A1	Richmond A1	0.5	0.125
2023-09-11		Hunt St ditches	0.5	0.125
2023-09-06	RICH-B2	B1	0.3	0.075
2023-09-06		C2	0.25	0.0625
2023-09-04		B7	0.5	0.125
2023-09-03		C4	0.6	0.15
2023-08-30		Pacific Sprit Park	0.4	0.1
2023-08-21		C2	0.2	0.05
2023-08-21	RICH-A2	A2	1.5	0.375
2023-08-20		B7	0.3	0.075
2023-08-20		B7	1	0.25
2023-08-20		B7	0.5	0.125
2023-08-20		B7	0.3	0.075
2023-08-20		B7	0.4	0.1
2023-08-20		B7	0.5	0.125
2023-08-20		B7	0.2	0.05
2023-08-16		Ospring St Ditch	1.5	0.375
2023-08-13	RICH-A1	Richmond A1	0.2	0.05
2023-08-10	SR-606	128 St Ditches	0.3	0.075
2023-08-03	SR-103	112A Ave ditch continuation	0.4	0.1
2023-08-03	COQ-014	A&W Ditch	1	0.25
2023-08-03	COQ-013	Canadian Tire Ditch	1.5	0.375
2023-08-02	RICH-A2	A2	0.25	0.0625
2023-08-02	RICH-A2	A2	0.5	0.125
2023-08-02	RICH-A2	A2	0.2	0.05
2023-08-02	RICH-A2	A2	0.4	0.1
2023-08-02	RICH-B4	B4	0.8	0.2
2023-08-02	RICH-B4	B4	0.1	0.025
2023-08-02	RICH-B4	B4	0.3	0.075
2023-08-02	RICH-A2	A2	0.5	0.125
2023-08-02	RICH-A2	A2	0.8	0.2

2023-08-02	RICH-B4	B4	0.2	0.05
2023-08-02	RICH-B4	B4	0.5	0.125
2023-08-02	RICH-B4	B4	0.2	0.05
2023-07-26	RICH-B6	B6	0.3	0.075
2023-07-26		B7	0.8	0.2
2023-07-31		Landfill Pond	2	0.5
2023-07-26		Ospring St Ditch	0.8	0.2
2023-07-26		Ospring St Ditch	1.5	0.375
2023-07-26		Ospring St Ditch	0.5	0.125
2023-07-26		Ospring St Ditch	2	0.5
2023-07-19	RICH-B5	B5	0.3	0.075
2023-07-17	RICH-A1	Richmond A1	0.3	0.075
2023-07-17		Hunt St ditches	0.5	0.125
2023-05-25		Colony Farm	0.3	0.075
2023-07-12		Ospring St Ditch	1	0.25
2023-07-10		C4	0.4	0.1
2023-07-10		C2	0.5	0.125
2023-07-10	MR-513	Blaney Bog	4	1
2023-07-10		Maple Ridge Park	0.1	0.025
2023-07-06	SR-606	128 St Ditches	0.7	0.175
2023-07-06	COQ-001	Mundy Park	0.8	0.2
2023-07-03		C8	0.5	0.125
2023-07-03	RICH-B6	B6	0.5	0.125
2023-07-03	RICH-B6	B6	0.5	0.125
2023-07-03	RICH-B6	B6	0.4	0.1
2023-07-03	RICH-B6	B6	0.4	0.1
2023-07-04	SR-012	SR-Request site 3	0.01	0.0025
2023-07-03		Fletcher Ditch	0.3	0.075
2023-07-03		Fletcher Ditch	0.5	0.125
2023-07-03		Landfill Pond	1	0.25
2023-06-29	SR-606	128 St Ditches	0.2	0.05
2023-06-29	SR-103	112A Ave ditch continuation	1	0.25
2023-06-21		Ospring St Ditch	0.3	0.075
2023-06-21		Ospring St Ditch	0.8	0.2
2023-06-19		B7	1.2	0.3
2023-06-19		B7	1	0.25
2023-06-15	SR-600	Surrey Bend Ditch	1	0.25
2023-06-15	COQ-001	Mundy Park	1	0.25

2023-06-14		Hunt St ditches	0.35	0.0875
2023-06-14	MR-161	Kanaka Creek Park	2.5	0.625
2023-06-12	RICH-B5	B5	1	0.25
2023-06-12	RICH-B5	B5	0.5	0.125
2023-06-12	RICH-B5	B5	0.3	0.075
2023-06-12	RICH-B5	B5	0.4	0.1
2023-06-12	RICH-B5	B5	0.15	0.0375
2023-06-12	RICH-B5	B5	0.2	0.05
2023-06-12		C4	0.4	0.1
2023-06-12	RICH-B2	B2	0.2	0.05
2023-06-12	SR-012	SR-Request site 3	0.02	0.005
2023-06-05		Lisa’s House	2	0.5
2023-06-08	SR-606	128 St Ditches	0.8	0.2
2023-06-08	SR-103	112A Ave ditch continuation	1	0.25
2023-06-07	RICH-B6	B6	0.4	0.1
2023-06-07	RICH-B6	B6	0.1	0.025
2023-06-07	RICH-B6	B6	0.3	0.075
2023-06-07	RICH-B6	B6	0.3	0.075
2023-06-07	RICH-B6	B6	0.1	0.025
2023-06-07	RICH-B6	B6	0.05	0.0125
2023-06-07	RICH-B6	B6	0.8	0.2
2023-06-07	RICH-B6	B6	0.6	0.15
2023-06-07	RICH-B6	B6	0.35	0.0875
2023-06-07	RICH-B6	B6	0.5	0.125
2023-06-07	RICH-B6	B6	0.4	0.1
2023-06-07	RICH-B6	B6	0.4	0.1
2023-06-05		Ospring St Ditch	1	0.25
2023-06-05		Ospring St Ditch	1.5	0.375
2023-06-03		Maple Ridge Park	0.7	0.175
2023-06-03		Kanaka Creek Floodwater	2	0.5
2023-06-02		Ditches in area dividing all farm land	1	0.25
2023-06-02		Ditches in area dividing all farm land	1.5	0.375
2023-06-01		Parking lot	1	0.25
2023-06-01	COQ-030	LaFarge Lake	1	0.25
2023-05-31		C11	0.2	0.05
2023-05-31		C8	0.15	0.0375

2023-05-31		C8	1	0.25
2023-05-31	RICH-B4	B4	0.25	0.0625
2023-05-31	RICH-B4	B4	0.4	0.1
2023-05-31	PM-058	Harris Landing Park	0.2	0.05
2023-05-31	MR-503	Jerry Sulina Park	1	0.25
2023-05-30		Katzie FN channel	16	4
2023-05-30		Katzie FN behind	8	2
2023-05-29		Drive way	9	2.25
2023-05-29	RICH-A2	A2	0.6	0.15
2023-05-29	RICH-A2	A2	0.6	0.15
2023-05-29	RICH-A2	A2	0.8	0.2
2023-05-29		C7	0.25	0.0625
2023-05-29		C7	0.25	0.0625
2023-05-29		B7	0.4	0.1
2023-05-29		B7	0.2	0.05
2023-05-29		B7	0.9	0.225
2023-05-29		B7	0.2	0.05
2023-05-29		B7	0.5	0.125
2023-05-29		Landfill Pond	1	0.25
2023-05-29		Rainbow bridge	1.5	0.375
2023-05-29	MR-095	Trans Canada Trail Stream	1.5	0.375
2023-05-29		Kanaka Creek Floodwater	2.5	0.625
2023-05-28		Drive way	0.2	0.05
2023-05-28		Drive way	0.01	0.0025
2023-05-28		Flooded grass	2	0.5
2023-05-28		Flooded areas	0.1	0.025
2023-05-28	TOL-1077	River/Mavis corner swamp	0.5	0.125
2023-05-28	TOL-160	Pond	2	0.5
2023-05-28	TOL-656	TOL-656	0.5	0.125
2023-05-28		Farm field	5	1.25
2023-05-28		Water channel 88	1.5	0.375
2023-05-27		Nathan Water Channel	16	4
2023-05-27		Pasture	2	0.5
2023-05-27		Glen Valley Park Seepage Area	18	4.5
2023-05-27		Glen Valley Park Seepage Area	3	0.75
2023-05-27		Glen Valley Park Seepage Area	6	1.5

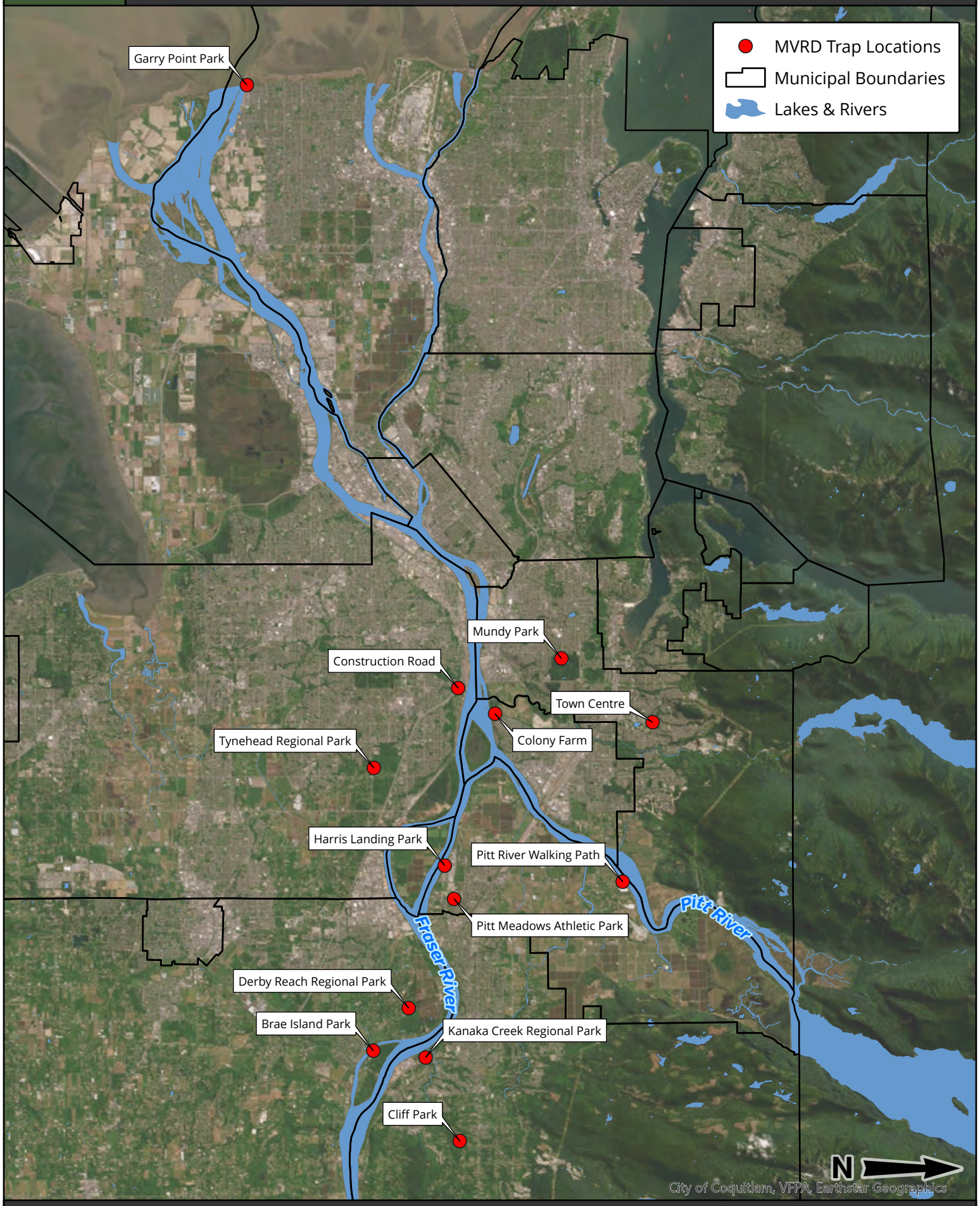
2023-05-27		Glen Valley Park Seepage Area	14	3.5
2023-05-27		Ditch 264	1	0.25
2023-05-27		Hillary's property	3.5	0.875
2023-05-25	SR-630	Mud Bay Park 2	1.5	0.375
2023-05-25	SR-630	Mud Bay Park 2	0.4	0.1
2023-05-25	SR-046	Mud Bay Park	0.4	0.1
2023-05-25	SR-046	Mud Bay Park	1.5	0.375
2023-05-24	RICH-B2	B2	0.2	0.05
2023-05-24	RICH-B5	B5	0.25	0.0625
2023-05-24	RICH-B5	B5	0.4	0.1
2023-05-24	RICH-B5	B5	0.25	0.0625
2023-05-24	PM-049	Trans Canada Trail 5	2	0.5
2023-05-22	RICH-A1	Richmond A1	0.45	0.1125
2023-05-22		Pleasant st ditches	0.25	0.0625
2023-05-22	TOL-004A	Seepage FN Site	14	3.5
2023-05-22		Further seepage	4	1
2023-05-22	MR-503	Jerry Sulina Park	1	0.25
2023-05-22		Kanaka creek pond	0.5	0.125
2023-05-22	MR-161	Kanaka Creek Park	1.5	0.375
2023-05-22		Kanaka Creek Floodwater	2.5	0.625
2023-05-19		Hillary's property	4	1
2023-05-15		Creek access point	2	0.5
2023-05-19		Boundary Bay Park Pond	2	0.5
2023-05-18	SR-204	Industrial ditches.	1	0.25
2023-05-18	SR-606	128 St Ditches	0.8	0.2
2023-05-18	SR-104	124 St/112A Ave Ditches	0.4	0.1
2023-05-18	SR-104	124 St/112A Ave Ditches	1.2	0.3
2023-05-18	COQ-001	Mundy Park	1.5	0.375
2023-05-17	PM-058	Harris Landing Park	1	0.25
2023-05-15		Rainbow bridge	4	1
2023-05-15	MR-559	Kanaka Creek	0.3	0.075
2023-05-15	MR-161	Kanaka Creek Park	0.5	0.125
2023-05-15	TOL-004	Brae Island Park / Fort Camping	4	1
2023-05-15		Pipeline to slough	3	0.75
2023-05-12		C1	5	1.25
2023-05-09	COQ-001	Mundy Park	0.1	0.025

Aerial Treatments

Treatment Date	Treatment Location	Treatment Amount (kg)	Treatment Area (ha)
2023-05-17	Brae/Fort Camping	72.8	7.28
2023-05-23	Brae/Fort Camping and Kwantlen FN	873.6	87.36

Appendix IV

2023 MVRD Mosquito Trap Locations



Scale = 1:220,000 | NAD 1983 UTM Zone 10N | Contains information licensed under the Open Government Act - Canada | Printed: 2023-12-19

Appendix V – Hotline call and email summary

Date	Municipality	Call/Email	Specific location	Comments
2023-02-10	Maple Ridge	Phone	Creek behind house	Mosquitoes were bad last year. What can be done this upcoming season?
2023-03-30	Langley	Email	Fort Langley	Wanted to know what the prediction was for this coming season and what we can do to help reduce mosquito numbers.
2023-04-11	Maple Ridge	Email		The mosquitoes last year were not good, what is the plan for this season?
2023-04-26	Langley	Email	Fort Langley	Mosquitoes are all ready coming out. What can be done.
2023-04-28	Langley	Phone		Are we still planning to stop by his place this coming season.
2023-04-28	Maple Ridge	Email		Granddaughter is covered in mosquito bites
2023-04-28	Maple Ridge	Email	Ditches along his street	Ditches are filling with water and have larvae
2023-05-01	Langley	Phone	Walnut Grove	Mosquitoes are already coming out and is worried that it will only get worse
2023-05-14	Langley	Email		We live close to Fraser River and am wondering what the plan is this year with mosquitoes. Also, any advise about traps
2023-05-29	Langley	Phone	Yorkson Creek area	Mosquitoes are awful right now and something needs to be done. Was bitten all over the place the other night and reacted to it.
2023-05-30	Langley	Phone		Wondering if we have come around to see if mosquitoes are coming out from her street
2023-06-06	Langley	Phone		Can someone come out?
2023-06-06	Langley	Phone	Glen Valley	Mosquitoes are out and bothering us. They might be coming from creek, can you come get rid of them.
2023-06-07	Langley	Phone	Fort Langley	Can someone stop by and check at my pond?
2023-06-14	Langley	Phone		Wondering if anything can be done at my place to reduce numbers

2023-06-20	Maple Ridge	Phone		Live in condo and am wondering where mosquitoes are coming from
2023-06-28	Langley	Phone		The mosquitoes are terrible here. Just letting you know
2023-07-05	Langley	Phone		Mosquitoes are relentless. Can't sit in patio
2023-07-06	Langley	Phone	Creek causing mosquitoes	Lots of mosquitoes. Can something be done
2023-07-17	Richmond	Phone	Manoah Steve's School Park	In the forested area getting lots of bites. Can something be done.
2023-07-22	Surrey	Phone		Quite a few mosquitoes. So bad. Can't go outside. We need to spray
2023-08-17	Richmond	Phone		Concerned about mosquitoes in the area.
2023-08-25	Richmond	Phone	By the dyke	Worst it's been in years
2023-08-25	Richmond	Email	Around elementary school	Quite a few mosquitoes
2023-08-25	Richmond	Email	Iona Beach Regional Park	Residents noticing an increase in mosquito activity.
2023-08-28	Richmond	Phone	Ditch in front of house	Lots of mosquitoes.
2023-08-31	MV-Parks	Email	Pacific Spirit Park	Mosquitoes are bad there. Can someone stop by.
2023-09-05	Richmond	Phone		Lots of mosquitoes