Fraser Valley Regional District

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FVRD File: #9850-25-2024

Pest Management Plan
Nuisance Mosquito Control

1 April 2024 - 31 March 2029

Confirmation No. TBD

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1. INTRODUCTION

1.1 Purpose of this Plan

The Fraser River is a prominent and defining feature of the Fraser Valley. The Fraser River, as well as many of its tributaries in the region, experience fluctuating water levels from annual snowmelt or precipitation events either locally or upstream. As water levels rise, most commonly during the spring freshet, floodwaters and seepage waters wet the adjacent lowland areas producing huge swarms of floodwater, or "nuisance", mosquitoes each year. These mosquitoes can result in significant annoyance to residents, businesses, and visitors.

In an effort to provide relief from the abundance of floodwater mosquitoes, the Fraser Valley Regional District (FVRD) has operated an annual mosquito control program since prior to regional district amalgamation in 1995. The goal of this program continues to be to reduce the quantity and duration of floodwater mosquitoes to tolerable levels.

As most of the region's floodwater mosquito breeding habitat is located on public land, mosquito control activities are required to be conducted under a provincially-approved Pest Management Plan (PMP) as per the *Integrated Pest Management Act*. This PMP has been prepared to describe the FVRD's Nuisance Mosquito Control Program, and includes descriptions of the following elements:

- Plan area
- Pest identification
- Monitoring
- Treatment thresholds and methods
- Operational information (safe handling, etc.)
- Data management and reporting

It is important to note that the target of the FVRD's mosquito control program is the larvae of floodwater mosquitoes. While there may be future need for controlling other types of mosquitoes within the region, such as mosquito vectors involved in the transmission of West Nile Virus, doing so would be considered outside the scope of this PMP and would be conducted under the direction and authority of the Minister of Health.

1.2 Geographic Boundaries of Plan Area

The FVRD covers approximately 115,000 hectares in the southwest corner of BC (Figure 1). The region includes six municipalities (the Districts of Hope and Kent, the Cities of Abbotsford, Mission, and Chilliwack, and the Village of Harrison Hot Springs), and eight Electoral Areas (A-H). It is a vast area bisected by the Fraser River. Approximately 337,000 people (2021 census) live within the region, many of which are concentrated within a few kilometres of floodwater habitat that produces nuisance mosquitoes.

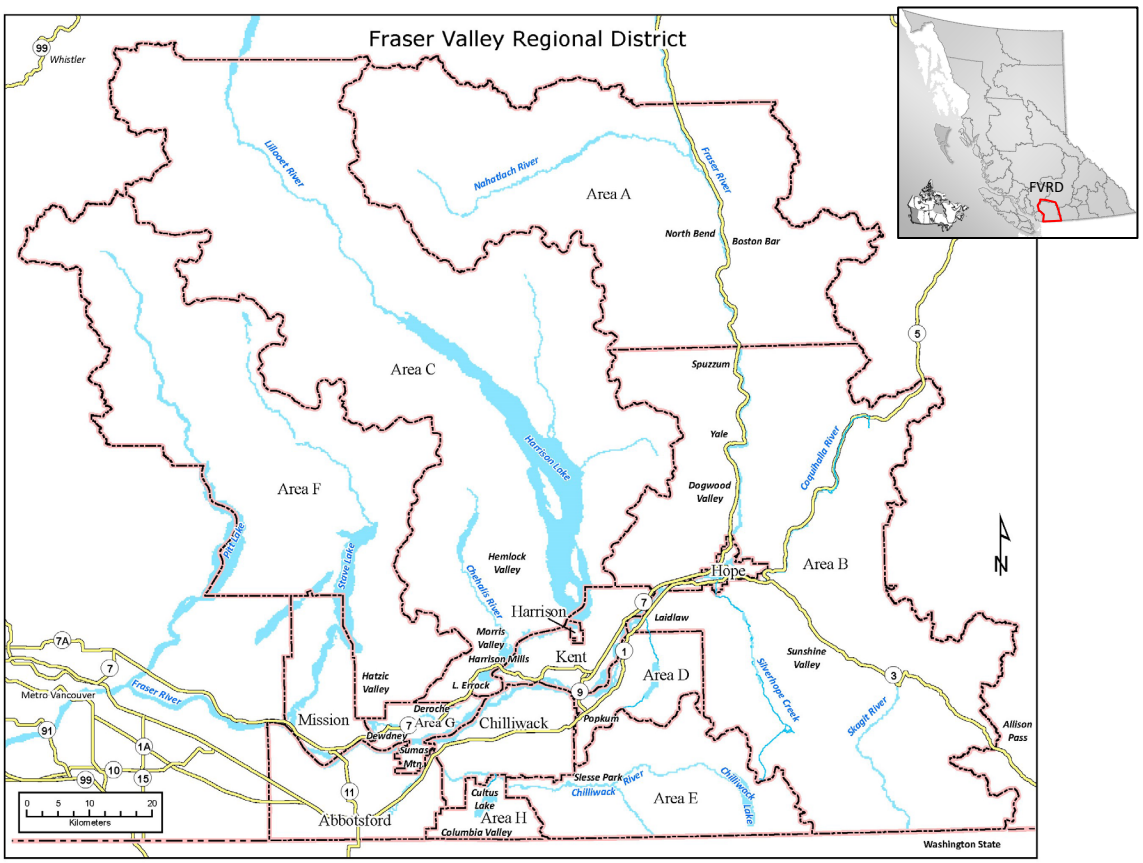

Figure 1. Map of the FVRD.

This Pest Management Plan (PMP) will cover all public lands throughout the FVRD where nuisance mosquitoes breed[1]. Maps of the floodplain, all of which are potential larval development sites where pesticides may be considered for mosquito control purposes under this PMP, are provided in Appendix I. These maps also show the location of known mosquito development sites that have been treated previously, but the specific locations of sites vary year-to-year based on water levels, flood occurrence, ground saturation, and precipitation.

1.3 Contact Information

The primary contact for information related to this Pest Management Plan is:

Fraser Valley Regional District
45950 Cheam Ave. Chilliwack, B.C. V2P 1N6
Email: mosquitoes@fvrd.ca, Phone 1-800-528-0061
Attn: Lance Lilley, Manager of Environmental Services

[1] Floodwaters that occur over private property may also be treated under this program with the approval of the landowner. Treatment may also be conducted on First Nation lands with the approval of the First Nation.

1.4 Term of Plan

This PMP covers a 5-year term from April 1, 2024 to March 31, 2029. All mosquito control activities carried out by the FVRD and its contractors will be in accordance with this PMP for its duration, subject to amendments.

2. INTEGRATED PEST MANAGEMENT ELEMENTS

The FVRD's Nuisance Mosquito Control Program is based on the principles of Integrated Pest Management (IPM). IPM is a decision-making process for managing pests in an effective, economical, and environmental sound way. This program's emphasis is on the mapping and monitoring of mosquito breeding sites and subsequent treatment of mosquito larvae. This program keeps with IPM principles by managing potential mosquito breeding sites, monitoring mosquito populations, and using a biological larvicide to reduce the number of larvae from hatching into adult mosquitoes.

There are several Acts, Regulations, and Guidelines that govern mosquito control, either directly or indirectly. Some of these are at a federal level, such as the *Pesticide Control Products Act*, which summarizes the registration and availability of pesticides and prohibits application under unsafe conditions. Some are at a local level (e.g., *FVRD Mosquito Abatement Bylaw #0468, 2001*, which provides statutory approval to the FVRD under the *Local Government Act* to provide mosquito control services – see Appendix II).

The primary regulatory tool governing the use of pesticides in BC, including requirements for Pest Management Plans, is the *Integrated Pest Management Act* (*IPMA*) and its associated *Regulation* (*IPMR*). Section 58(2) of the *IPMR* identifies the following six elements that are to be included within a PMP:

1. A strategy that will be used to prevent organisms from becoming pests.
2. The process that will be used to accurately identify pests targeted.
3. A description of the monitoring program.
4. The process for deciding when pesticide treatment is to be conducted (injury threshold).
5. A description of the treatment methods that will be employed.
6. A method for evaluating effectiveness of the treatments.

These six IPM components are described in the sections below.

2.1 Prevention

Preventing pests from occurring before they can become pests is the optimal method of pest management. Preventative actions with regards to floodwater mosquito management include decreasing mosquito breeding habitat, increasing the abundance of natural mosquito predators, and conducting public education.

Removing mosquito breeding areas

Floodwater mosquito habitat typically consists of low-lying floodplain or seepage sites along a river corridor that becomes periodically wetted during freshet or during snowmelt conditions. In prior decades, mosquitoes were so devastating that drastic and expensive large-scale measures were taken to reduce their numbers through any means necessary, including draining lakes and filling in wetlands. These large-scale projects are no longer conducted as part of pest control efforts, but smaller scale habitat modifications can still be considered to reduce local mosquito production.

For example, landowners who have floodwater mosquito breeding sites on their property may have the opportunities to reduce standing water by modifying the drainage of the site. These projects are encouraged if they can be conducted by following all local, provincial, and federal legislative requirements and they have no detrimental impact on other species. Other opportunities to reduce mosquito breeding areas is by working with local environmental groups undertaking salmonid enhancement projects that restore or enhance salmon habitat within the region. By encouraging the incorporation of design features into these projects, such as steep-sided banks that reduce the surface area of wetted soil exposed to water fluctuations, these projects can benefit local fish species as well as reduce mosquito breeding potential at the site.

However, there are relatively few instances in which habitat modification would be possible and would have a measurable impact on the region's mosquito populations. Consequently, this is not considered as a significant component of the FVRD's mosquito control program.

Increasing the abundance of mosquito predators

Restoring habitat features to increase the presence of natural mosquito predators helps to provide some level of control on local mosquito abundance. A single bat can eat hundreds of mosquitoes each night. Restoring natural habitat to increase the abundance and diversity of native amphibians, dragonflies, salmonids, etc. helps to reduce the population of mosquitoes by increasing the predation pressure on either adult mosquitoes or their larvae.

The FVRD encourages ecosystem enhancements that improve biodiversity and ecological resilience by controlling invasive species and by partnering with organizations such as the Fraser Valley Watersheds Coalition to restore and enhance habitat values. As with modifying mosquito breeding habitat however, these efforts may result in localized benefits on mosquito populations, but are not likely to result in a significant decline in region-wide floodwater mosquito abundance and do not replace the need for additional control such as regional larvicide treatments.

Public education

Informing residents about the program and measures they can undertake for their own protection are important aspects of the FVRD's mosquito control program. The primary methods for dissemination of information to the public are the media (both traditional and social) and personal communication.

- *Print and online messaging*: While local newspaper articles and advertising are still utilized, social media has become critical in disseminating information about the program. The FVRD or their mosquito control contractors maintain several social media pathways, including Facebook™,

X™, Instagram™, and Youtube™, which are used to provide updates about water levels, mosquito larvae conditions, tips for homeowners, and where the mosquito control technicians are conducting treatments. The FVRD's and contractor's website are also important sources of information, including program overview, contact info, updates, and the PMP.

- *Personal communication*: Residents with a variety of questions regularly approach Mosquito Control Technicians in the field or ask questions to contractors or FVRD staff. These interactions provide the opportunity to share information with residents regarding nuisance mosquitoes and their habitat, about the FVRD's Nuisance Mosquito Control Program, and about measures residents can take to reduce their mosquito exposure or to reduce mosquito breeding sites on their property. Homeowners and residents are also encouraged to consider habitat modifications to restore biodiversity on their property or reduce standing water.

In addition, the FVRD manages a dedicated email (mosquitoes@fvrd.ca) and hotline (1-888-733-2333) for members of the public who would like to report high levels of mosquito abundance or to obtain additional information about the program. This communication provides an opportunity to not only collect information on undiscovered habitat, but also to answer questions or to arrange site visits by field technicians. Contractors also attend many community events or farmers markets during the mosquito seasons to further engage the public.

2.2 Pest Identification

Accurate identification of the target pest is a critical element of an effective and efficient IPM program that avoids negative impacts on non-target species. There are approximately 3,100 species of mosquitoes worldwide, with at least 18 species within the FVRD (Table 1)[2]. The most predominant mosquito species in the Lower Mainland are *Aedes vexans* and *Aedes sticticus*, commonly known as floodwater mosquitoes or nuisance mosquitoes. These floodwater mosquitoes are the focus of the FVRD Nuisance Mosquito Control Program. Mosquitoes that breed in habitats other than the floodplain (e.g., storm drains), such as species of *Culex* which are known vectors of West Nile Virus, will be controlled, if needed, under the authority of Fraser Health and not under the purview of this PMP.

Table 1. Known mosquito species within the FVRD.

Species	Habitat	Predominant Prey
Aedes atropalpus	rock pools, artificial pools	Mammals
Aedes cinereus	semi-permanent mixed cattail / sedge marsh, sphagnum bog	Mammals
Aedes communis	forest pools / deciduous	Mammals
Aedes fitchii	most semi-permanent pools	Mammals
Aedes sierrensis	tree holes, artificial containers	Mammals
Aedes japonicus	artificial containers, tree holes, rock holes	Mammals
Aedes sticticus	floodwater pools and riparian margins	Mammals (including humans)
Aedes vexans	floodwater grasses	Birds, Mammals (including humans)
Anopheles earlei	wooded areas / pools with floating debris	Mammals

[2] The 18th species of mosquitoes identified within the region, *Aedes japonicus*, was only recently verified, but its distribution and abundance remains uncertain.

Anopheles punctipennis	wooded areas / pools with floating debris	Mammals
Coquillettidia perturbans	permanently wet marshes, cattails	Birds/Mammals
Culex pipiens	water containers, even sewage and manure polluted water	Birds
Culex tarsalis	permanent / semi-permanent ponds, irrigation, ditches	Birds/Mammals
Culex territans	permanent pools, artificial containers (see *C. tarsalis*)	Amphibians
Culiseta impatiens	semi-permanent pools / bogs, shaded forest pools	Mammals
Culiseta incidens	diverse – open or shaded pools, permanent streams / ditches	Mammals
Culiseta minnesotae	found in most water, containers, pools, ponds	Birds
Culiseta morsitans	found in most water, containers, pools, ponds	Birds

Aedes vexans and *A. sticticus* are active in the spring and summer following the spring freshet and successive high water events. A high water event is when water levels exceed the bankfull depth and moves into and/or past the first band of riparian vegetation. Within the Lower Fraser River and its tributaries, river level variation is primarily governed by snowmelt occurring in the upstream portions of the Fraser River basin. Frequent and large amounts of local precipitation can also affect river levels, though typically to a lesser degree than snowmelt. Other waterbodies in the region can also experience fluctuating water levels, such as the southern portion of Stave Lake due to the presence of the downstream dam, which can also trigger floodwater mosquito larvae activity.

A. vexans and *A. sticticus* lay their eggs on damp substrate in areas with high flooding potential (which is why they are referred to as "floodwater mosquitoes"). New hatches of mosquitoes can occur with each successive peak in the associated water level as more soil gets wetted and more mosquito eggs become activated.

The eggs lay dormant until water levels increase, but the eggs can survive for several years. When these areas flood, it triggers the eggs to rapidly hatch into larvae. Mosquito larvae remain within the water where they develop through four larval stages (instars). After the fourth instar stage, the larvae pupate, and then soon emerge as an adult mosquito. This usually occurs within 1-2 weeks after the water levels began to rise (Figure 2).

The most reliable and effective means of identifying target mosquito species is the habitat where the larvae is found and the time of year. The main mosquito habitats within the FVRD are floodwater habitats, seepage habitats, local habitats (e.g., swimming pools, used tires), and standing water habitats (e.g., stagnant ditches or swamps). Only floodwater and seepage habitats are significant for the breeding of nuisance mosquitoes (*A. vexans* and *A. sticticus*) in the Fraser Valley. Mosquito larvae observed in floodwater or seepage sites during the spring or early summer, shortly after river levels have begun rising during the annual freshet, is generally one of those two nuisance species.

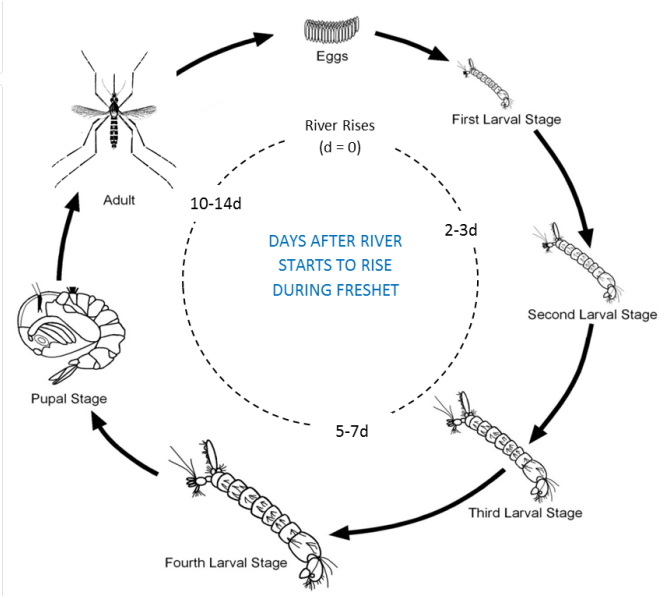

Figure 2. Mosquito life cycle. Note that times provided are approximate and may vary depending on weather conditions and water temperatures.

Floodwater Habitats

Of all the habitat types in the FVRD, floodwater habitats are by far the most productive for nuisance mosquitoes. Larval densities can reach more than 4,000 per litre of water, or approximately eighty million per hectare of floodwater area[3]. The mosquito species that breed in these areas are mostly of the genus *Aedes*, common human-biters. This is also the easiest habitat in which to predict activity, as it generally becomes active when the river levels rise.

Floodwater sites are prevalent along the Fraser River corridor and along many of the Fraser River's tributaries, providing abundant mosquito development habitat. As water levels rise, typically during freshet, areas along the banks of the Fraser River or its tributaries, or along the banks for other bodies of water in the region that can experience fluctuations (e.g., south end of Stave Lake), can become saturated, triggering mosquito hatching.

Seepage Habitats

As river levels rise, so do groundwater levels. Higher groundwater can manifest itself as surface water in low-lying areas on the protected sides of the dikes that surround the Fraser River, Vedder River, Nicomen Slough, and Norrish Creek. It can be challenging to predict mosquito activity within these sites because seepage is not necessarily correlated to Fraser River levels, which can be easily monitored with river gauges. Rainfall can exacerbate the water levels in seepage habitats - if the ground is already saturated, then the rainwater will sit on the surface creating even more breeding areas.

Seepage habitats tend to produce similar species of mosquitoes as floodwater habitats (i.e., *Aedes sp.*). These habitats tend to produce fewer overall mosquitoes, but the challenge these sites represent from

[3] Wood, Dang, and Ellis, 1979.

a treatment perspective is that the water in them is usually warmer. Warmer water leads to faster larval development, and hence decreases the window of opportunity to locate and treat these sites while mosquitoes are still in the larval stage. Although slightly less productive than floodwater habitats, mosquito annoyance due to seepage sites can be more noticeable since the sites may be closer to residential areas or where people are working outdoors.

2.3 Monitoring

Monitoring of water levels and mosquito larvae development is essential for an efficient and effective floodwater mosquito control program. Monitoring is the key component that allows field technicians to know where to treat as well as when to treat. If treatments are applied too early, the larvae will not have started feeding yet and the product will be wasted and ineffective. If applied too late, the larvae will be in the pupal stage (i.e., non-feeding stage) or will have already hatched into adults. Monitoring of water levels and larvae development is critical for the judicious and timely application of larvicide and for the flexibility to adjust applications as required.

This program conducts monitoring of environmental conditions, of larvae development, and of adult mosquito presence.

Monitoring Environmental Conditions

Fraser River levels are indirectly affected by ambient temperature and precipitation accumulation that occur near snow basins associated with the Fraser River. Weather stations at Mission, Hope, and Prince George serve as representative sites that provide up-to-date information on river levels. The Prince George region is a particularly important site to monitor because it is close in proximity to the headwaters of the Fraser River. Typically, weather experienced in Prince George during early spring/early summer will be reflected in Fraser River levels approximately a week later.

High ambient temperatures in snow basins associated with the Fraser River, such as those around Prince George, are also important to monitor as it can result in significant snowmelt in the early portion of the season. As such, a large volume of water is added to the Fraser River, increasing levels and leading to mosquito development site activation. Precipitation is also important to monitor as it can contribute to water levels, particularly in seepage sites or when the ground is already saturated.

Monitoring of environment conditions includes monitoring of local weather conditions, monitoring snow levels, and monitoring river and lake levels.

Monitoring Local Weather Conditions

In addition to monitoring environmental conditions that are predictive of larval mosquito abundance, local weather conditions are closely watched to inform decisions regarding whether or not to treat and the appropriate treatment method. As per IPM regulations (i.e. Section 35 (1)(i)), local weather variables that are monitored immediately prior to and during pesticide application events include:

- Wind speed and direction,
- Precipitation, and
- Air temperature

Treatments will be postponed in either ground or aerial-based cases if wind speeds will result in product drift outside targeted sites. Additionally, aerial application campaigns will be suspended if wind gusts present safety concerns. Significant local precipitation not only increases larval mosquito development sites but can also affect the severity of a mosquito season in a more indirect manner. If precipitation occurs during an aerial campaign, an operational delay may occur. Poor visibility will ground the helicopter until it is safe. Additionally, the pesticide cannot be disseminated during a rain event due to product coagulation and potential obstruction of the helicopter's hoppers. Further, wet foliage will reduce the amount of pesticide that reaches the target sites, as the pesticide adheres more strongly to the wet surface of the foliage.

Unlike wind speed and direction, or precipitation, air temperature does not affect the efficacy, safety, or application of the granular pesticide product specified within this PMP. Ambient temperatures do however potentially impact mosquito larval development as it may result in warmer water, which causes the mosquito larvae to develop at a faster rate.

Monitoring Snow Levels

Preseason monitoring of contributing snowsheds is an important planning exercise. The volume of snow in the system, combined with climactic factors, influences how quickly the snow comes out of the system and how quickly and severely water levels may rise during the freshet.

Monitoring Water Levels

FVRD staff and contractors reference the BC River Forecast Centre regularly as an additional planning tool. Higher water levels will increase overland flooding and seepage. Monitoring efforts increase as water levels rise. As water levels begin to recede, the monitoring efforts are shifted to seepage sites and to secondary treatments of previously active sites. Water level gauges along the Fraser River, along its tributaries, and on Stave Lake are routinely referenced during the season and are integral components of the environmental monitoring program.

Monitoring Larval Mosquitoes

While environmental conditions provide a valuable indicator of larvae development, sampling for, and counting, mosquito larvae is still essential. To maximize treatment success, it is important to know where nuisance mosquito larvae are located, their density, and their stage of development. This information allows technicians to be able to accurately plan when to conduct treatments.

Monitoring at sites directly associated with the Lower Fraser River begins when river levels start to increase in spring (usually beginning in April or May). Sites that are accessible by ground are monitored as required through to August, or until it has been determined by Mosquito Control Technicians that no more floodwater mosquito larvae are still present in the system. This determination is based on consistently declining water levels and repeated negative larvae samples taken from the site, showing that no additional mosquito larvae will emerge from the site unless water levels begin to increase again.

Known representative sites, which have been identified as sharing water level and mosquito larvae hatching characteristics with sites that are only accessible by boat or by helicopter, may be used as proxy sites for determining larval densities.

Mosquito larvae development sites not directly associated with the Lower Fraser River (e.g., Stave Lake) are regularly monitored when local gauges indicate elevated water levels, suggesting the potential for mosquito sites to have become activated. As with other monitoring, based on the assumption that no new larvae will emerge from a site after the eggs have already hatched unless water levels increase, regular monitoring continues until water levels recede and a lack of larvae presence is detected by previous samples. In this way, sites are adaptively monitored and treated to reflect changes in site-specific water and weather conditions.

During high water years, sites may be monitored more frequently, depending on environmental conditions (e.g., precipitation, ambient temperature). Using a standard dipper, field technicians record the number of larvae within the dip sample, describe the larval development stage (instar), the location (using GPS coordinates), the date, relevant weather information, the mosquito species (if possible), and make any field observations that might assist with the site assessment.

From these results, treatment appropriateness and timing can be determined. If the larvae have not yet hatched, or they are too early in their developmental cycle, a return date will be set to continue monitoring.

Monitoring Adult Mosquitoes

There are three main methods used to monitor adult mosquito populations: a) public complaints b) landing biting counts and c) adult trapping. These methods combine to give a good estimation of mosquito emergence, abundance, timing, and species distribution.

a) ***Public Complaints:*** During years of high water, the greater than normal mosquito activity often elicits a multitude of complaint phone calls to the FVRD's Mosquito Control Hotline. The address and contact information of these callers is recorded so that follow-up can be conducted. The numbers of calls received is often correlated with river levels, which relates to the relative abundance of mosquitoes emerging in a year. The calls can also indicate specific locations where adult mosquitoes are problematic, helping to identify hot spots of mosquito activity to direct staff to new, potentially unmapped, mosquito development sites.

b) ***Landing Biting Counts***: Landing biting counts entails a Mosquito Control Technician counting the number of mosquitoes that land on an exposed forearm in one minute. The standard measure used to signify high annoyance in three bites per minute. While not typically performed as a metric of adult mosquitoes, technicians use this method when discussing mosquito levels with the public as a way of determining relative abundance or trends.

c) ***Adult Mosquito Traps:*** The FVRD utilizes adult mosquito traps placed strategically around the region. Traps are monitored every few weeks throughout the season beginning as soon as adult nuisance mosquitoes emerge, and continues throughout the summer. The traps help to determine relative mosquito abundance, which acts as a quality assurance/quality control measure for larval mosquito control. The results are also used to compare intra- and inter-annual nuisance levels of mosquitoes, to determine the relative species composition within the region, and to note any changing trends or new species.

2.4 Injury Thresholds (i.e., Treatment Thresholds)

Mosquito development sites are evaluated for possible treatment based on a number of criteria and treatment thresholds, as described below.

Pre-Treatment Inspection Procedures

Pre-treatment inspection procedures are required for the identification of treatment boundaries. As specified in the *Integrated Pest Management Regulations* (IPMR; Section 71 (a, c)), approved and certified pesticide applicators will be provided with the boundaries of the proposed treatment area, personal protection requirements, and be informed of pesticide use procedures that are protective of environmental and human health. An approved, certified pesticide applicator will also inspect the treatment area to ensure compliance with regulatory requirements and use standards. The approved contractor will act as the confirmation holder's agent and provide information to all engaged parties.

Pre-treatment inspection procedures will include:

- Confirmation of the site locations based on training and maps provided (electronic and/or physical) (*ground applications*)
- Confirmation of site boundaries based on reconnaissance flight site identification (*aerial applications*)
- Confirmation of landowner permissions to treat the site if on private property (*ground and aerial applications*).
- Confirmation of treatment site above the high water mark and not considered permanent, fish bearing bodies of water or waters that have permanent, direct, surface-water connections with fish bearing bodies of water as per s78(1) of IPMR. *(ground and aerial applications)*
- Determination that no people are within the treatment area *(aerial applications)*

Mosquito Productivity

Mosquito productivity is measured as the number of mosquitoes produced during peak activity. This number is determined as the potential density of larvae[4] multiplied by the approximate size in hectares of the development site. Higher potential for mosquito infestation equates to a higher treatment priority. Many of the islands in the Fraser River are high priority based solely on size – many are more than 200 hectares and provide perfect development grounds for *A. vexans*, and *A. sticticus*. Treatment is considered if greater than five larvae of target mosquito species are recorded per dip.

Target Species Presence

Many mosquito species within the FVRD are not floodplain, or nuisance, mosquitoes. The target species of the FVRD Nuisance Mosquito Control Program are part of the floodwater complex belonging to the genus *Aedes*, known biters of people and livestock. These mosquitoes are found in flood and seepage water areas, mostly those associated with larger systems (Fraser River, Vedder River, Stave Lake, etc.).

[4] Density is measured as the number of larvae observed per standard 350 ml dip.

Species identification is confirmed during larval monitoring procedures (dip sampling) by field technicians.

Proximity to People

An adult floodwater mosquito has a dispersal limit of approximately 3 km from their larval development site. Consequently, larval development sites within 3 km of key residential, tourism, or agricultural areas are considered within the threshold to treat. Prevailing winds may extend this dispersal range, which is also taken into consideration.

Of the highly productive sites, priority is given to those that are closest to residential areas. For obvious reasons, these sites draw the most public complaint as the mosquitoes reduce enjoyment of their property or their community. Agricultural properties are also prioritized, as livestock, milk, and poultry production can be adversely affected during years of heavy mosquito infestations. Fruit and vegetable production is also affected from the harvesting perspective as many farmers find it difficult to hire and keep workers in a field that is inundated with adult mosquitoes. Also considered is proximity to sites used for recreation or tourism, such as campgrounds, boating, fishing, cycling, walking, or hiking. These activities, and the economic revenue they represent to the region and quality of life it offers, can be impacted during years with large mosquito populations.

Decision Making

As a general guideline, treatment shall be considered in sites that satisfy the above proximity requirements when water dip samples have confirmed the presence of late instar *Aedes sp.* larvae at or greater than the treatment threshold of 5 larvae per 350 ml dip. Exceptions may be made to this threshold however and a certified applicator working for the FVRD will provide their professional recommendation as to whether or not larval treatment is justified in an area.

The intent of the following flowchart (Figure 3) is to assist with decision-making regarding mosquito treatment for common nuisance or floodwater mosquitoes. Note that this chart is intended only for treatment of nuisance mosquitoes, not for purposes of disease reduction or public health.

Proposed Treatment Products

The two active ingredients approved for use under this PMP are *Bacillus thuringiensis israelensis* (*Bti*) and *Bacillus sphaericus* (*Bsph*). Both bacteria based active ingredients have been thoroughly studied and are commonly used in IPM programs as effective alternatives to chemical pesticides.

The primary product in use at the FVRD for controlling mosquitoes is *Bti*, a natural soil-borne bacterium that is specifically toxic to larvae of nuisance mosquitoes. It is added to the water where larvae are present, usually in a granular formulation where it is attached to an inert carrier (typically corn granules). When ingested by the larvae, the endotoxin produced by the bacteria is stimulated by the alkaline conditions of the mosquito gut, resulting in larvae paralysis and death. Because most aquatic invertebrates or predators do not have alkaline guts, ingestion of *Bti* pellets or infected mosquito larvae has no toxic effect. *Bti* only remains active in the water column for a few days, so accurate monitoring of larvae development is essential so that treatment occurs at the appropriate moment.

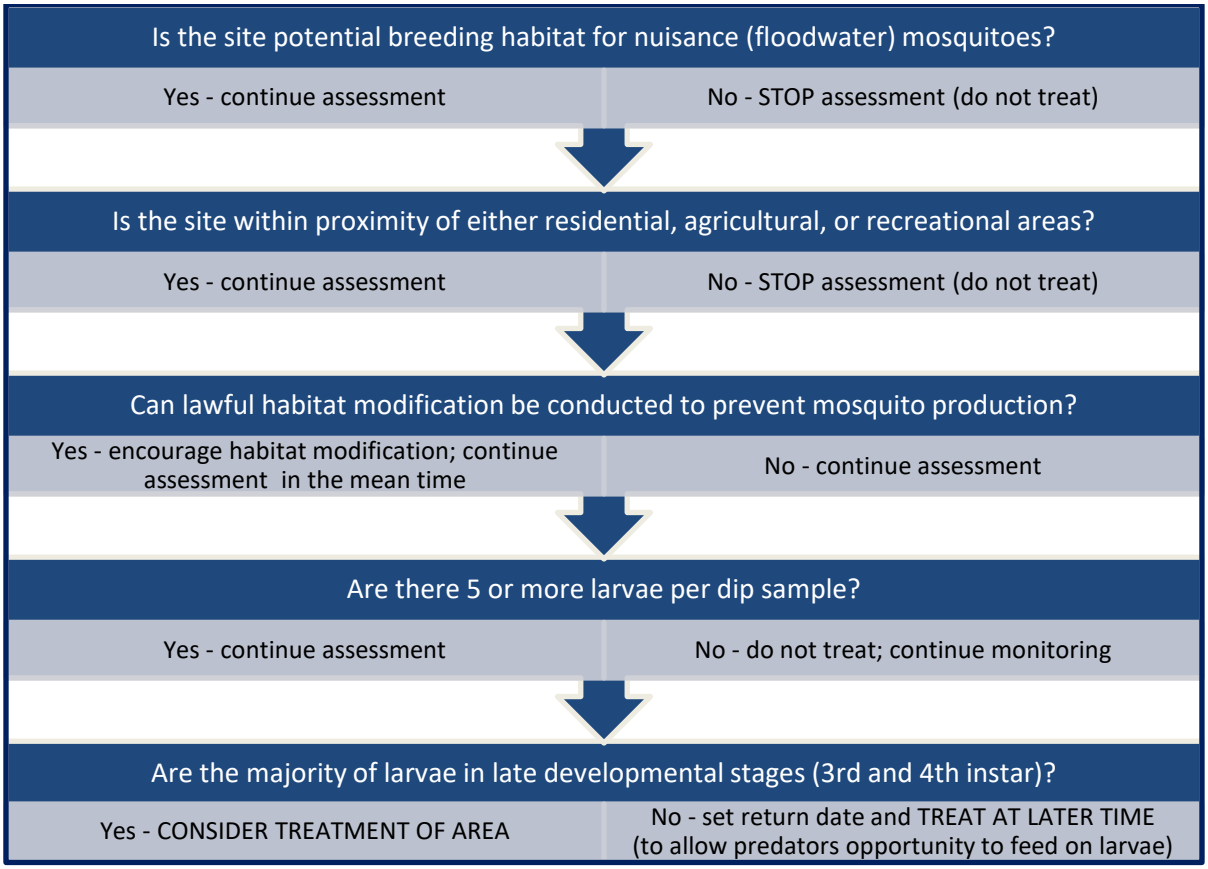

Figure 3. Environmental and site factors influence treatment decisions for when and where to provide larvicide treatments. The flowchart lays out some of the key decision-making factors used as part of this program.

Bsph is a secondary product considered by the FVRD. This product has a similar mode of action to *Bti* and is also very specific to mosquitoes; however, it exhibits greater residual activity meaning that it can persist in the receiving environment for a longer duration than *Bti*. While not previously used as part of the FVRD Nuisance Mosquito Control Program, this longer persistence allows *Bsph* to potentially be considered for select seepage sites that remain wetted, but it's use continues to be unlikely.

Table 2 summarizes the pesticide formulations for *Bti* and *Bsph* that may be used as part of this program. See Appendix III for Material Safety Data Sheets on these products.

The safety and specificity of both *Bti* and *Bsph* towards mosquito larvae, and their lack of effect on non-target fauna given allowable application rates is well documented.[5] While adverse effects have been recorded from these biological bacterial agents on a few invertebrate species, these impacts were only observed when application rates were many hundred times greater than the allowable application

[5] Mathavan & Velpandi, 1984; Mulla et al., 1984; Ali & Nayar, 1986; Aly & Mulla, 1987; Karch et al., 1990; Lacey & Mulla, 1990; and Mulla, 1990

rates.[6] Neither mammals (including humans), nor fish, are adversely affected by either bacterial species.[7]

Table 2. Pesticides approved for use by the FVRD under this Pest Management Plan [8]

Product Trade Name	Active Ingredient	PCP No.	Active Ingredient Concentration in Product	Application Rate of Product	Area to be Treated, approx. (ha)	# of Permitted Applications Per site	Quantity of Product
Vectobac 200G	Bacillus thuringiensis Serotype H-14	18158	200 ITU/mg	3.0-10.0 kg/ha	3,000	15	15,000 kg
Aquabac 200G	Bacillus thuringiensis Serotype H-14	26863	200 ITU/mg	2.5-20.0 kg/ha	3,000	15	15,000 kg
Aquabac XT	Bacillus thuringiensis Serotype H-14	26860	1,200 ITU/mg	300-2,400 ml/ha	3,000	15	5,000 L
Vectobac 1200L	Bacillus thuringiensis Serotype H-14	21062	1200 ITU/mg	0.25-1.0 L/ha	3,000	15	5,000 L
Vectolex CG	Bacillus Sphaericus, Strain 2362	28008	50 ITU/mg	5.6-16.8 kg/ha	3,000	TBD	TBD

All applicators working under this PMP are required to confirm treatment rates indicated on the label before planning any treatments. No control of adult mosquitoes (adulticiding) is within the scope of this PMP.

2.5 Treatment Methods

The FVRD Nuisance Mosquito Control Program focusses on controlling floodwater mosquitoes while they are still in a larval stage. If treatment thresholds are satisfied, the certified Mosquito Control Technician then decides, in collaboration with FVRD staff, if and how to treat. Treatments are conducted in strict accordance with rates indicated on the appropriate labels.

Ground Treatments

Hand, or ground, treatment is the process of applying larvicide into mosquito larvae breeding sites using a calibrated backpack applicator or other handheld device. Access to breeding sites is typically by foot or by boat. This treatment method is generally highly effective and efficient but depending on the size and accessibility of the site, can be relatively time-consuming and challenging.

Unless conditions require an alternative application method, ground treatments are preferred for a number of reasons: (1) application rates are lowered, thereby reducing pesticide use; (2) application timing can be more specific, thereby increasing efficacy; and (3) application precision is dramatically increased, again reducing pesticide use.

Aerial (helicopter) Treatments

[6] Lacey and Mulla, 1990
[7] Lacey and Siegel, 2000; Lacey and Merritt, 2003; Brown et al., 2004; Hurst et al., 2007; Sternberg et al., 2009
[8] Product use quantities are based on maximum potential needs and not anticipated needs. The lowest application rates and quantities possible will be used to achieve permit and *IPM Act* objectives.

When large areas become active simultaneously, particularly when water temperatures are warmer than usual creating faster larvae development, or when breeding sites are prohibitively difficult to access, treatment can be conducted by air rather than by ground or boat. Aerial application of larvicide within the FVRD must utilize a fixed hopper attached to a helicopter[9], calibrated to release pesticide at a pre-defined rate. This allows larvicide to be applied over large areas in a short amount of time and allows easier access to breeding sites that cannot be accessed by ground or boat. Aerial treatments are effective, but due to costs associated with helicopter usage and higher application rate (to penetrate vegetation hanging over the water) it is only conducted when necessary.

Remotely Piloted Aircraft Systems (RPAS) Treatments

A new technology available to mosquito control operations are Remotely Piloted Aircraft Systems (RPAS), commonly referred to as 'drones'. These are an important emerging technology in the mosquito control field. Current technology allows for small-scale application of liquid and granular payloads in areas that are deemed too small for traditional aerial applications (helicopters) and too large or otherwise inaccessible to ground treatments. All RPAS treatments need to be conducted under string adherence to Transport Canada Regulations and to all certification and training requirements. Only *Bti* products registered for this particular usage can be considered for this application.[10]

2.6 Evaluation

Evaluating treatment success is the remaining required element of an IPM approach. It is used to identify opportunities for improving and refining the program.

The most direct and effective method used to determine the success of mosquito larvicide treatment is to conduct follow-up larval sampling where the larvicide had been applied. Post-treatment monitoring is usually conducted within 24-48 hours of treatment using the same methods described for pre-treatment monitoring. Larvae counts collected post-treatment are compared to monitoring results collected pre-treatment, and depending on the information collected, treatment product or methods could be adjusted, and re-treatments may be conducted as necessary.

Treatment success can also be evaluated, albeit more indirectly, by adult mosquito trap counts and complaint calls received via the hotline. This information can help determine the effectiveness of control efforts and can help identify potentially previously unknown mosquito breeding sites.

The FVRD's Nuisance Mosquito Control Program's biological bacterial agents belong exclusively to the genus *Bacillus*. As these products have shown very limited or no adverse effects on non-target species when applied according to label directions, post-treatment evaluation of environmental effects is not typically undertaken as part of the program.

[9] Equipment classified as a slung load or a jettisonable load will not be utilized due to concerns about application efficiency and accuracy and safety in populated areas.
[10] RPAS use is not available at the time of writing this PMP; however, it is anticipated that Provincial regulators will be able to issue applicator certifications for RPAS use early in the term of this PMP.

3. OPERATIONAL INFORMATION

In addition to the elements described in the previous section, the *Integrated Pest Management Regulations* also require a PMP to include information pertaining to the handling, use, and disposal of the pesticides as well as strategies to ensure environmental protection (*IPMR 58(3)*).

Environmental stewardship is a key component of the FVRD's overall mandate. Table 3 outlines potential accidents (including pollution events), potential harm to the environment, and the preventative and mitigation procedures put in place as part of the program. Spills of any material (e.g., fuel) that result in impacts not authorized by or consistent with this permit will be immediately cleaned up and reported to the Provincial Emergency Program at 1-800-663-3456. The provincial administrator will be provided with reports on the spill, clean-up activities, and decontamination actions.

Table 3. Prevention and mitigative procedures identified to prevent and respond to potential accidents.

Accident	Activity	Impact	Prevention and Mitigation
Spill	Transportation, Storage, or Application	• Site contamination • Soil contamination	• Proper storage facility • Proper transportation equipment • Training all staff in Workplace Hazardous Materials Information System (WHMIS) • Appropriate containers • Minimize movement
Leak	Transportation, Storage, or Application	• Site contamination • Soil contamination	• Proper storage facility • Proper transportation equipment • Training all staff in WHMIS • Appropriate containers • Minimize movement • Complete equipment maintenance
Overspray	Application	• Damage to sensitive habitat • Residential/agricultural intake contamination	• Strict application procedures • All personnel holding Pesticide Applicator Certificate (Mosquito and Biting Fly)
Misapplication	Application	• Illegal application • Damage to sensitive habitat	• Strict application procedures • All personnel holding Pesticide Applicator Certificate (Mosquito and Biting Fly)

Mixing and handling of pesticides provides an opportunity for accidental spillage. The following instructions will be provided to all personnel involved in the handling of larvicide products to limit the potential for spills and to reduce wastage:

- Product will be stored in a dry, temperature-controlled facility that remains locked and with adequate signage.
- ALWAYS read and follow the label before starting. Follow label recommendations and best management practices for personal protection measures, application rates, and safety procedures.
- Open container bag with a sharp knife (do not tear).
- Transfer product to application equipment in a dry and stable location.
    - Do NOT transfer over water.
    - Do NOT allow product to become wetted before application.

- If a spill occurs, users are to stop immediately and collect the spilled product.
- Any spilled granules should be collected and used first via ground application (to avoid damaging application equipment).
- Dispose of container according to label recommendations.

Additional precautions that will be undertaken to ensure environmental protection include:

- Where treatment areas overlap with known identified Species at Risk Critical Habitat, contractors will refer to the appropriate Recovery Strategy or Action Plan and ensure that mosquito larvicide treatments using a *Bacillus* product is not listed as an activity likely to destroy the species' Critical Habitat or one that would likely harm or kill the species.
- The location of any community watersheds or drinking water source intakes within the PMP area will be determined using the Province's Community Watershed website[11]. No pesticide will be stored within the community watershed for more than 24 hours prior to their use and will be removed within 7 days of their use. If pesticide residues are detected at a community watershed water intake, larvicide applications will be discontinued until the local Medical Health Officer has been satisfied that all required measures have been implemented to preserve water quality.
- Due to the nature of the larvicides used and where they are applied, treatments conducted in accordance with this PMP will not cause contamination of food intended for human consumption and do not represent a risk to fish and aquatic organisms (other than mosquito larvae) or wildlife. As per the *Integrated Pest Management Regulations*, due to their low toxicity and limited environmental impacts, bacterial agents belonging to the genus *Bacillus* used for mosquito larviciding programs are exempted from both the no-treatment zones and pesticide-free zones requirements for protection of water sources and bodies of water.
- All treatment is conducted above the high water mark and not considered permanent, fish bearing bodies of water or waters that have permanent, direct, surface-water connections with fish bearing bodies of water (as per s78(1) of IPMR).
- Care will be taken to minimize potential impacts from field technicians working within riparian and wildlife habitat by staying on paths or existing trails and avoiding trampling native vegetation. There will be no re-fueling of machinery or application equipment, no mosquito larvicide mixing, and no disposal of unused larvicide or personal garbage, within 15m of riparian areas or sensitive wildlife habitat or fish bearing bodies of water that have permanent, direct, surface-water connections with fish bearing bodies of water.
- All pesticide application equipment used by FVRD contractors will be kept clean and in good repair and be kept calibrated appropriately for the larvicide being applied. Application equipment shall be re-calibrated when larvicide active ingredients or formulations are changed and immediately when variation in output is noticed.
- During inclement weather, the following precautions will also be undertaken:

[11] https://catalogue.data.gov.bc.ca/dataset/community-watersheds-current

- During aerial applications, higher winds limit the accuracy of applications. Consideration should be given to wind speeds, restricting application to low-wind scenarios.
- Ground applications with granules may occur at higher wind levels; however, it is up to certified applicators to ensure that the granules are hitting their target.
- All applications with granules during substantial precipitation events should be postponed – the granules can clump together when wet and will significantly reduce efficacy of the application equipment. Consider ground application of liquid products if treatments cannot be postponed.

4. REPORTING and NOTIFICATION

Under the *Integrated Pest Management Regulation*, the FVRD or its contractors are required to maintain records of pesticide applications, submit annual records and notices of intent to treat to the Province, and undertake prescribed consultation requirements as part of the PMP.

4.1 Records and Reporting

The FVRD will maintain records of all pesticide applications, including:

- Treatment locations
- Larvae monitoring results (both pre- and post-treatment)
- Treatment date and time
- Pesticide used
- Method of application
- Rate of application
- Total quantity of pesticide used
- Relevant meteorological conditions
- Reasons if treating within a non-treatment zone around a water supply intake or well used for domestic or agricultural purposes.

Annual Reports of Pesticide Use will be provided to the Province for all areas treated for mosquitoes under this PMP. These reports will include:

- Contractor and client contact information
- Pesticide application permit number
- Pesticide applicator license numbers belonging to all applicators
- Dates and times of pesticide applications
- Target mosquito species, the pesticide trade name and registration number
- Method and rate of application
- Total quantity used of each pesticide, environmental conditions during application (i.e., temperature, precipitation, wind velocity, etc.)
- Mosquito monitoring methods, and
- Treatment triggers.

Reporting of all mosquito control activities will be completed by the end of January for the preceding year that the activities took place. Permit non-compliance shall be reported to the provincial administrator within 48 hours of the infraction's discovery.

4.2 Notification

The FVRD's contractors will submit a 'Notice of Intent to Treat' to the Province prior to the start of each year's mosquito control program. This Notice will contain the name and address of the confirmation holder, a description or map of the proposed treatment locations, a description of the proposed treatment for each area, and the total area proposed for treatment.

In addition, written notification will also be given to the Province when any of the following conditions of this PMP change:

- The area of proposed control activities;
- The control methods;
- The pesticides available to, and used by, this program;
- Situations emerge that require control beyond the level permitted by the PMP, including but not limited to:
    - Extreme levels of mosquito activity
    - Emergence of vector-related disease
    - Identification of new significant mosquito species that requires treatment.

Notification will be given as soon as the triggering condition arises. Program activities will continue as the status quo until the Ministry has given approval for the change.

5. REFERENCES

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6. APPENDICES

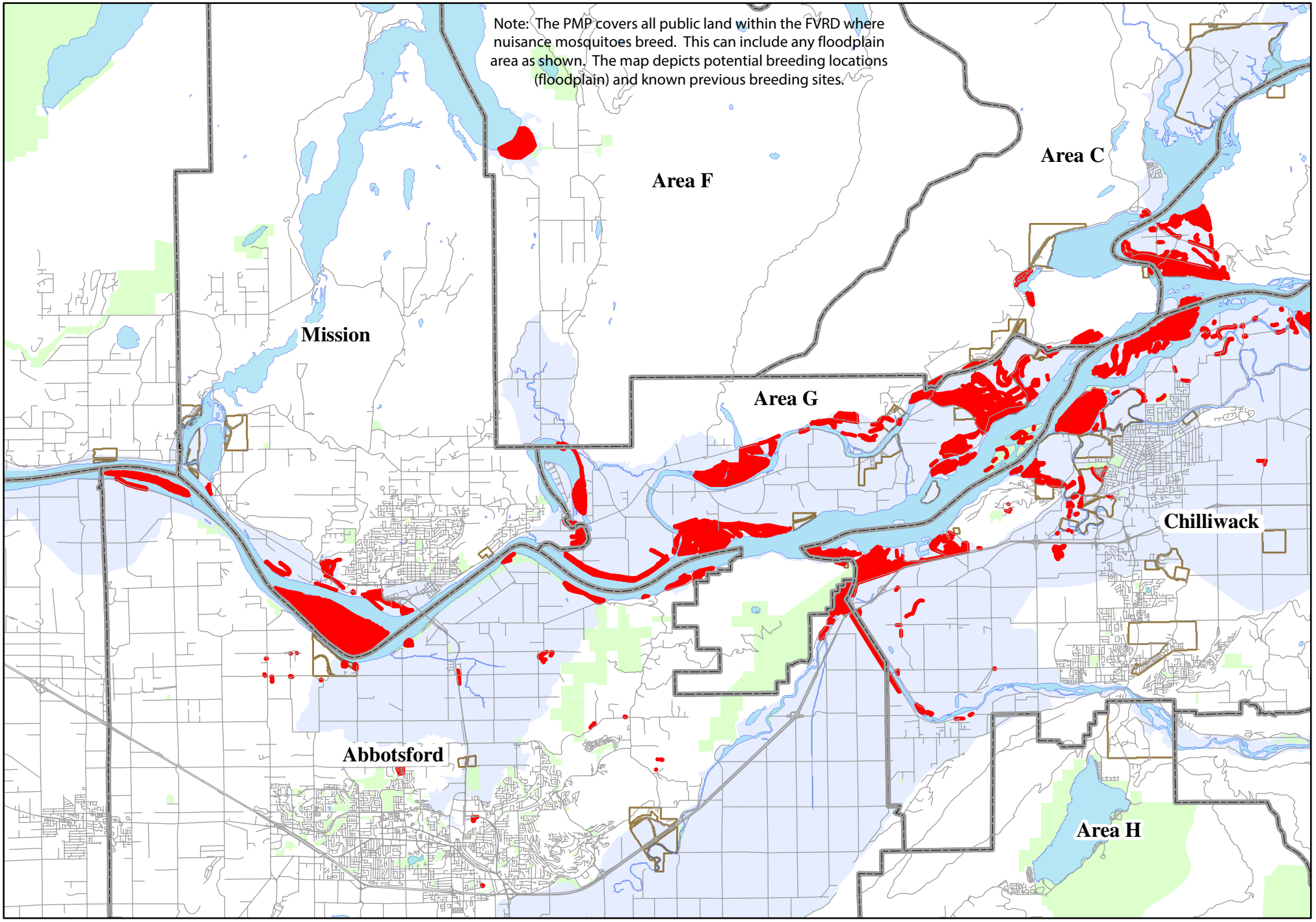
Appendix I: Mosquito Treatment Areas

Appendix II: FVRD Mosquito Abatement Bylaw No. 0468 (2001)

Appendix III: Material Safety Data Sheets (MSDSs)

Appendix IV: Confirmation of Receipt of Pesticide Use Notice

Appendix I: Mosquito Treatment Areas



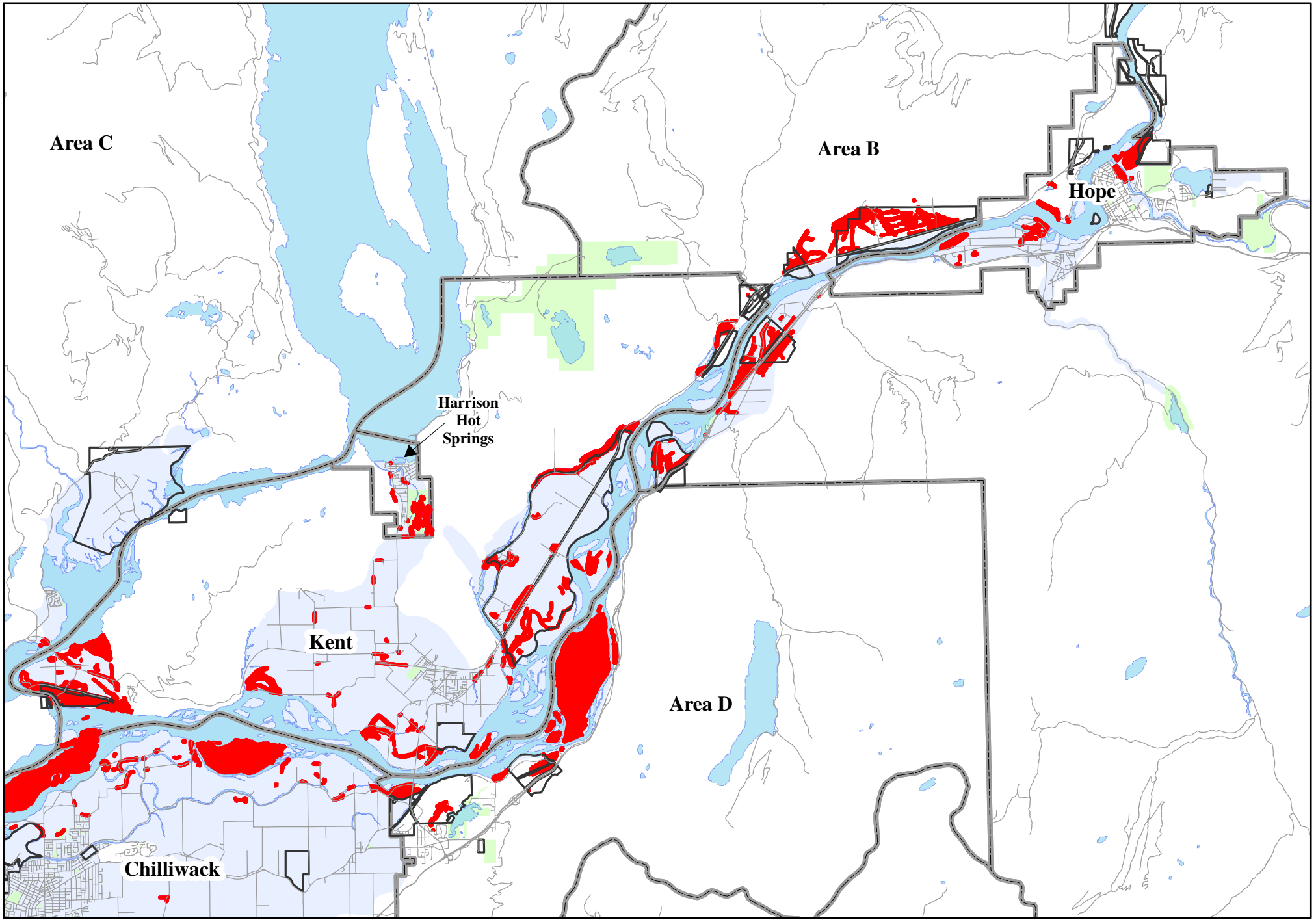
FVRD Mosquito Program
Pest Management Plan Area Map 1

Roads
Known Breeding Sites
Municipal Boundary
Waterbodies
Reserves
Parks & Protected Areas
Floodplain

N

0 2 4 8
Kilometers

Map produced by the FVRD GIS Department, Dec. 2023
Sources may include: FVRD, GISI Inc.,
BC Ministry of Environment, Morrow BioScience



FVRD Mosquito Program
Pest Management Plan Area Map 2

Roads
Known Breeding Sites
Municipal Boundary
Waterbodies
Parks & Protected Areas
Reserves
Floodplain

N

0 2 4 8
Kilometers

Map produced by the FVRD GIS Department, Dec. 2023
Sources may include: FVRD, GISI Inc.,
BC Ministry of Environment, Morrow BioScience

Appendix II: FVRD Mosquito Abatement Bylaw No. 0468 (2001)

FRASER VALLEY REGIONAL DISTRICT

BYLAW NO. 0468, 2001

A Bylaw to convert the former Dewdney Alouette Regional District Mosquito Control function and the former Central Fraser Valley Regional District Mosquito Control Function to separate Service Areas; and to then consolidate and merge the Dewdney Alouette Mosquito Control Service Area, the Central Fraser Valley Mosquito Control Service Area, and the Fraser-Cheam Mosquito Abatement Extended Service Area into one service area

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WHEREAS the Fraser Valley Regional District was incorporated by Letters Patent effective December 12, 1995;

AND WHEREAS Article 11 of the Letters Patent incorporating the Fraser Valley Regional District provides that all services of the former Central Fraser Valley Regional District, Dewdney Alouette Regional District, and Regional District of Fraser-Cheam, in force and effect at the time of dissolution, whether established by legislation, regulation, order in council, letters patent, supplementary letters patent or bylaw pursuant to the former *Municipal Act, RSBC Ch. 290,* are services of the Fraser Valley Regional District, except as to those services described in Section 11.4 of the Letters Patent;

AND WHEREAS the Central Fraser Valley Regional District was granted the Mosquito Control function pursuant to Supplementary Letters Patent dated April 10, 1975 and amendments thereto, said function to include all lands within the current boundaries of the City of Abbotsford and Electoral Area H of the Fraser Valley Regional District;

AND WHEREAS the Dewdney Alouette Regional District was granted the Mosquito Control function pursuant to Supplementary Letters Patent dated January 18, 1973 and amendments thereto, said function to include all lands within the current boundaries of Electoral Areas F and G and portions of C of the Fraser Valley Regional District and the District of Mission;

AND WHEREAS the Regional District of Fraser-Cheam Mosquito Abatement Extended Service Area was established by the Regional District of Fraser Cheam Mosquito Abatement Extended Service Area Establishment Bylaw No. 1030, 1991, said service area to include all lands within the current boundaries of the City of Chilliwack, the District of Kent, the District of Hope, the Village of Harrison Hot Springs and Electoral Areas D, E and portions of Electoral Area B of the Fraser Valley Regional District;

AND WHEREAS the Board of Directors of the Fraser Valley Regional District wishes to extend the boundaries of the Regional District of Fraser Cheam Mosquito Abatement Extended Service Area to include all of Electoral Areas A, B and C of the Fraser Valley Regional District;

AND WHEREAS in accordance with Section 774.2(3) of the *Local Government Act, RSBC Ch. 323, 1996 (the Act)*, the Board of the Fraser Valley Regional District wishes to convert the Dewdney Alouette Regional District and Central Fraser Valley Mosquito Control functions to separate Service Areas;

AND WHEREAS Section 802.1 of the *Act*, provides that the Board may, by Bylaw, provide for changes to the boundaries of a Service Area, including the merger of two or more service areas;

AND WHEREAS the Board of Directors of the Fraser Valley Regional District wishes to consolidate and merge the Dewdney Alouette Mosquito Control Service Area, the Central Fraser Valley Mosquito Control Service Area, and the Fraser-Cheam Mosquito Abatement Extended Service Area into one service area, thereby establishing the Fraser Valley Regional District Mosquito Control Service Area;

AND WHEREAS the consent of at least 2/3 of the participants has been obtained in accordance with Section 802 of the Act;

NOW THEREFORE in open meeting assembled, the Board of Directors of the Fraser Valley Regional District enacts as follows:

1. CITATION

This Bylaw may be officially cited for all purposes as the " Fraser Valley Regional District Mosquito Control Service Area Conversion, Merger and Establishment Bylaw No. 0468, 2001".

2. ENACTMENTS

i) The Dewdney Alouette Regional District Mosquito Control function granted pursuant to Supplementary Letters Patent dated January 27, 1976 is hereby converted to and established as a Service Area;

ii) The Central Fraser Valley Regional District Mosquito Control function granted pursuant to Supplementary Letters Patent dated January 18, 1973 is hereby converted to and established as a Service Area;

iii) The boundaries of the Dewdney Alouette Regional District Mosquito Control Service Area, the Central Fraser Valley Regional District Mosquito Control Service Area, and the Regional District of Fraser Cheam Mosquito Abatement Service Area as extended to include all of Electoral Areas A, B and C of the Fraser Valley Regional District, are hereby consolidated and merged into a separate Service Area hereinafter referred to as the "Fraser Valley Regional District Mosquito Control Service Area";

iv) The boundaries of the Fraser Valley Regional District Mosquito Control Service Area shall be the boundaries of the Fraser Valley Regional District;

v) The participants of the Fraser Valley Regional District Mosquito Control Service Area shall be all of Electoral Areas A, B, C, D, E, F, G, and H of the Fraser Valley Regional District and all of the City of Abbotsford, City of Chilliwack, District of Mission, District of Kent, District of Hope and Village of Harrison Hot Springs.

v) In accordance with Sections 800.1 and 803 of the *Act,* the annual costs of the service may be recovered by:

(a) property value taxes imposed and collected under Part 24, Division 4.3 of the Act; and/or

(b) the imposition of fees and other charges in accordance with Section 797.2.

vi) In accordance with Sections 800.1, 805.1 and 806.1 of the Act, the maximum amount that may be collected or requisitioned for the service shall be $600,000. or $.04 / $1,000.00 of the net taxable value of land and improvements within the service area, whichever is greater.

3. REPEAL

i) Regional District of Fraser Cheam Mosquito Abatement Extended Service Area Establishment Bylaw No. 1030, 1991 and any and all amendments attached thereto are hereby repealed.

4. READINGS AND ADOPTION

READ A FIRST TIME THIS 27th day of NOVEMBER, 2001

READ A SECOND TIME THIS 27th day of NOVEMBER, 2001

READ A THIRD TIME THIS 27th day of NOVEMBER, 2001

APPROVED BY THE INSPECTOR OF MUNICIPALITIES THIS 21st day of JANUARY, 2002.

ADOPTED THIS 26th day of FEBRUARY, 2001.

Chair/Vice Chair

Administrator/Deputy

5. CERTIFICATIONS

I hereby certify the foregoing to be a true and correct copy of the "Fraser Valley Regional District Mosquito Control Service Area Conversion, Merger and Establishment Bylaw No. 0468, 2001"." as read a third time on the 27th day of November, 2001. Dated at Chilliwack, BC this 27th day of November, 2001.

Administrator/Deputy

I hereby certify that this a true and correct copy of the "Fraser Valley Regional District Mosquito Control Service Area Conversion, Merger and Establishment Bylaw No. 0468, 2001 as adopted by the Board of Directors of the Fraser Valley Regional District on the 26th day of February, 2002.

Administrator/Deputy

BRITISH COLUMBIA

No. _____

Statutory Approval

Under the provisions of section 801(1)(a) and 802(3)

of the *Local Government Act*

I hereby approve Bylaw No. 0468

of the Fraser Valley Regional District ,

a copy of which is attached hereto.

Dated this 21st ***day***

of January ***, 2002***

Deputy Inspector of Municipalities

Appendix III: Material Safety Data Sheets (MSDSs)

Material Safety Data Sheets (MSDSs) for any of the *Bacillus*-containing mosquito larvicide products identified within this Plan can be provided upon request by contacting mosquitoes@fvrd.ca or through the links below.

- VectoBac 200G: https://www.valentbiosciences.com/publichealth/wp-content/uploads/sites/4/2017/02/SDS-VBC-0034R2-VectoBac-200G-Canada-05-08-19.pdf
- Aquabac 200G: https://cdn.commercev3.net/cdn.arbico-organics.com/downloads/1211150-1211155-1211175_Aquabac%20200G%20SDS_82817.pdf
- Aquabac XT: https://labelsds.com/images/user_uploads/Aquabac%20XT%20SDS%205-26-15.pdf
- Vectobac 1200L: https://www.valentbiosciences.com/publichealth/wp-content/uploads/sites/4/2017/04/SDS-VBC-0081R3-VectoBac-1200L-Canada-03-31-2020.pdf
- Vectolex CG: https://www.valentbiosciences.com/publichealth/wp-content/uploads/sites/4/2019/05/sds-vbc-0117r3-vectolex-cg-canada-03-31-2020.pdf?ver=1701975858

Appendix IV: Confirmation of Receipt of Pesticide Use Notice

(to be updated with PUN confirmation)