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CITY OF SALMON ARM

INTEGRATED PEST MANAGEMENT PLAN
PMP # 501-0007-25/30

MOSQUITO SURVEILLANCE AND CONTROL PROGRAM
2025 – 2030

Common Blue Damsel fly (*Enallagma cyathigerum*) resting

Prepared by
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Langley, BC

For the
City of Salmon Arm
Salmon Arm, BC

01 October 2024

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1.0 PEST MANAGEMENT PLAN SUMMARY

The City of Salmon Arm, located adjacent to Shuswap Lake, in the southern interior of British Columbia, contains an abundance of natural features and resources which enhance the outdoor enjoyment of residents and visitors to the area. Summer pursuits include walking, running, mountain biking, camping, ATVs and motorbikes, horseback riding, field sports, gardening and socializing around bar-b-ques and on restaurant patios. Adult mosquito annoyance can often conflict with these activities. Besides the negative impacts on the lifestyle and potential health of residents, there can be considerable economic impact from mosquito annoyance on local businesses. The goal of the mosquito surveillance and control program is to provide residents, workers and visitors to the City with the prevention of widespread, extreme, or persistent adult mosquito nuisance and reduction of potential disease vectors.

The annual mosquito surveillance and control program has been provided for the benefit of City of Salmon Arm residents, businesses and visitors for over twenty years and employs a comprehensive, and sustainable, Integrated Pest Management (IPM) approach to control. This approach focuses on the timely detection and suppression of larval mosquito populations using biological products and methodologies. Where possible, and appropriate, physical or cultural controls are recommended, and implemented, that reduce larval habitat and enhance, or conserve natural mosquito predators and their environments. Where required, larval mosquito populations would be controlled using the bio-rational larvicide product VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis, Strain AM65-52,* PCP #18158), or equivalent, and VectoLex (*Bacillus sphaericus, Strain 2362,* PCP #28008, 28009).

This Pest Management Plan (PMP) reviews mosquito biology, the types of larval mosquito habitats affecting the program area and the local mosquito species complex. An integrated PMP approach to mosquito population management and control can reduce overall adult mosquito annoyance. This PMP outlines the procedures and methodologies which will reduce local mosquito populations and habitat for the purpose of preventing mosquito annoyance for area residents and visitors. It is not designed to control mosquito vectored disease. This is a responsibility coordinated through regional and local health authorities.

All treatments would be completed in accordance with the *Integrated Pest Management Act and Regulations* and the methodologies and procedures prescribed in the BC Ministry of Environment-accepted Pest Management Plan (PMP) for Mosquito Control (this document), prepared for the City of Salmon Arm for the years 2025-2030. This PMP outlines the procedures and methodologies of an Integrated Pest Management (IPM) approach which will suppress local mosquito populations. Important biological concepts, operational procedures and protocols are purposely repeated throughout the document.

1.1 Geographic Boundaries of this Pest Management Plan

City of Salmon Arm, is located in the Columbia Shuswap area of Southern BC, some 109 kilometres east of Kamloops on Highway 1, and 109 kilometres north of the City of Kelowna on Highway 97. The community is located on the southernmost arm of Shuswap Lake.

The City has a total area of 155.3 km^2 and population of 17,706 (2016). Its main industries are Agriculture, Forestry, Lumber manufacturing and Tourism. It is the Business centre for the area and is the location of the Columbia Shuswap Regional District administrative offices. Outdoor activities include both winter and summer pursuits such as snowmobiling, skiing, golfing, cycling, boating and camping.

The geographical area covered under the PMP is contained within the municipal boundaries and includes both public and private (with permission) properties. Mosquito control services are concentrated in rural areas and farm fields located within City boundaries. The majority of larval mosquito habitat is affected flooding and seepage water accumulations resulting in large part from snowmelt-influenced Salmon River and Shuswap Lake levels. Additional habitats includes natural cattail (*Typha* sp.) marshes and ponds, and smaller, manmade habitats such as catch basins, ditches, tire ruts and excavations. Over 100 hectares of potential larval mosquito development habitat and +1700 roadside catch basins exist within control program boundaries. Some of these sites are active with mosquito development on more than one occasion, or for several weeks, and as such multiple treatments may be required.

1.2 Mosquito Biology

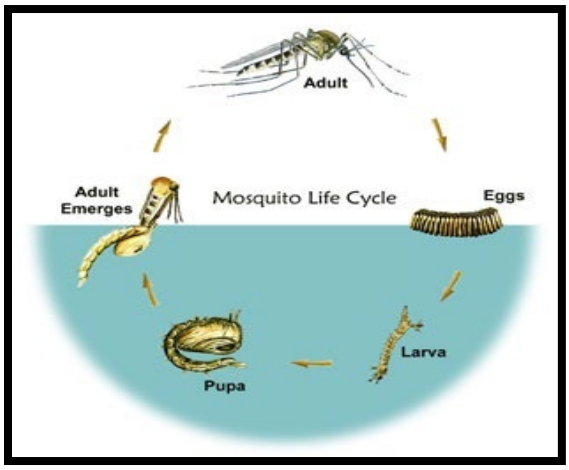
Mosquitos are found world-wide in standing water of all possible descriptions. Mosquitos belong to the order Diptera, along with other pests such as the common house fly and the black fly. There are four predominant genera of mosquitos common to British Columbia. These are *Aedes*, *Culex*, *Culiseta* and *Anopheles.* They have differences in life cycles, habitat preferences and the time of the year when they predominate as larvae and adults. There are over sixty species common to Canada and over thirty are found in British Columbia.

Mosquitos undergo four distinct development stages; egg, larvae, pupae and adult. Larvae and pupae are aquatic. Eggs are laid on the water surface or on soil and vegetation adjacent to water. The eggs of some species of mosquitos, such as *Aedes*, can survive for upwards of 20 years and will hatch after a period of winter freezing and upon being wetted. Mosquito larvae undergo four larval instars (or moults), each time emerging larger, but virtually unchanged from the previous instar. This is the feeding stage of the aquatic mosquito. The mosquito pupa, like a butterfly chrysalis, is a

non-feeding stage and is where the once aquatic, larval mosquito undergoes metamorphosis to emerge as the winged, terrestrial adult mosquito.

Adult mosquitos feed on plant juices and it is only the female which requires a blood meal to complete the development of her eggs. Female mosquitoes will typically fly less than 0.5-1km in search of a blood meal, although distances of 5 km are not uncommon. Mosquitos have been found 30 km from their origin and at heights of 10,000 meters. While these are the extreme, and rare distances, the impact of winds on mosquito dispersal can be significant.

Mosquito development occurs in a wide range of larval habitats ranging from snowmelt and precipitation-influenced flood and seepage water pools and channels along rivers and lakes to permanent freshwater, ponds, marshes, ditches and similar water-holding depressions. Bird baths, plugged rain gutters, livestock watering troughs, stored equipment, irrigation and surface water run-off collection ponds, ditches and any man-made container capable of holding water for a period of 7 to 21 days can provide suitable larval mosquito habitat.



Mosquitos are best known as vectors of 'tropical' diseases such as malaria and yellow fever. Although these exotic afflictions are extremely rare in British Columbia, mosquitos can still pose a serious health concern. Extreme allergic reactions or secondary infections from mosquito bites can occasionally require hospitalization. Diseases such as canine heartworm, Western Equine Encephalitis (WEE) and West Nile virus (WNv) are transmitted from some mosquito species to family pets, humans, and livestock.

Since mosquitos capable of vectoring diseases to man are often the source of annoyance (human-biting), the control of mosquito populations known to cause nuisance also contributes to the protection of public health by controlling mosquito species also having the potential to vector disease. A few years ago, the mosquito-associated flavivirus disease caused by Zika virus (ZIKV) became a prominent health concern in several areas of the world, including the southern USA. The current status of WNv and ZIKV in British Columbia, Canada and elsewhere in North America is available at www.BCCDC.ca and Health Canada at www.canada.ca/en/health-canada or www.Hc-sc.gc.ca.

The BC Centre for Disease Control (Vancouver) and local health authorities are responsible to coordinate the surveillance, identification and reporting of these diseases and their mosquito vectors. As part of this planning the BCCDC has developed the *Arbovirus Surveillance and Response Guidelines for British Columbia* (2005), and the BCCDC has a provincial database

containing mosquito, bird and human health surveillance data relating to WNv and vector mosquito species.

Due to the low and stable incidence of West Nile virus (WNv) it was decided by the BCCDC in the fall of 2014 that it was no longer necessary to conduct active surveillance of mosquitos or other indicators. The provincial decision to eliminate this surveillance was reached at the BC Communicable Disease Policy Advisory Committee meeting in February 2015. Since 2015, WNv surveillance in BC has been conducted through testing horses, birds that are sick or dead, and humans who have symptoms compatible with WNv. Human clinical testing continues as part of routine blood and organ donor programs. Specific details on the response guidelines, surveillance, permitting, and other related information is available online through www.BCCDC.org.

1.3 Need for Mosquito Control

In addition to negative impacts on the lifestyle and general health of residents, a large population of mosquitos can have a negative economic impact on local businesses. Worker safety, comfort and efficiency can be compromised by adult mosquito annoyance and distraction. Milk, beef, and egg production in farming or ranching communities can be reduced when animals are unable to feed or rest because of extreme mosquito annoyance or through a reaction to mosquito saliva-borne toxins or disease. Reduced use and enjoyment of hotel and restaurant outdoor patios, sports fields, golf courses, campgrounds and cycling or hiking trails by residents and area visitors directly affects business operations and revenues.

The purpose of an annual mosquito surveillance and control program is to provide residents, workers and visitors in the defined (PMP) areas of the City with relief from extreme and/or persistent adult mosquito annoyance. The control program is not intended to, nor is it possible to eradicate local mosquito populations. Despite the best of efforts, some adult mosquito annoyance may still occur during the summer months. Residents are encouraged to avoid areas of mosquito harbourage (typically treed, forested or landscaped areas) during certain times of day and to use approved adult mosquito control devices, products and repellents, as per label directions.

Although not a common occurrence in most areas of British Columbia, mosquitos are capable of transmitting (vectoring) diseases. An effective, pro-active mosquito control program which focuses on the identification, prevention and timely control of larval mosquito populations is important to limit the potential for both disease transmission and widespread adult mosquito annoyance. Uncontrolled larval mosquito development in the flood and seepage water accumulations in the forest and swamp areas adjacent the community can produce an enormous number of adults mosquitos and cause reportable nuisance for residents. While the absence of adult mosquitos may go unnoticed, adult mosquito annoyance does not, and return visits to a particular area are governed accordingly.

The City of Salmon Arm Mosquito Surveillance and Control Program Pest Management Plan, described in detail below, is presented in a format which adheres to the requirements of *Integrated Pest Management Act and Regulation,* including amendments, and the *Mosquito Management Sector Review Paper*. Copies of these documents are available through the BC Ministry of Environment at www.env.gov.bc.ca/epd/epdpa/ipmp/pestact/index.html. Common themes of larval development prevention, identification and control necessary to achieve the program goal of reduced adult mosquito populations, while ensuring environmental conservation, are repeated throughout this document.

This Pest Management Plan is 'owned' by the City of Salmon Arm. It would remain in place for the purposes of mosquito population management and control for the five-year period, 15 April 2025 to 14 April 2030. The goal of the annual mosquito surveillance and control program is to reduce the potential of widespread, or persistent, adult mosquito annoyance for the benefit of residents, workers and visitors to the program areas. This is achieved using an Integrated Pest Management (IPM) approach which concentrates on larval prevention and control initiatives. The methodologies and procedures described within this PMP are a hybrid of approaches adapted through collaboration with mosquito and vector control professionals worldwide. It has been carefully and specifically designed for the unique conditions of the program areas and is a model of environmental compatibility. The methodologies and operational procedures described within this Pest Management Plan are the industry standard.

A professional, experienced, environmental services firm (the consultant) is retained by the City of Salmon Arm to provide guidance, training and coordination of these very specialized services and to ensure adherence to the PMP. The consultants for the City of Salmon Arm annual mosquito surveillance and control program would have Registered Professional Biologists (R.P.Bios.,) as program managers and senior biologists. All program personnel would be appropriately certified as pesticide applicators with the BC Ministry of Environment, Integrated Pest Management Program.

Public relations and ongoing program education would be accomplished through regular contacts with residents, businesses and community visitors. Information on mosquitos, their control, and prevention, may be available to the general public in a variety of forms including notice boards, informational brochures, websites, newspaper articles, websites, social media, open-houses and farmer's markets etc. Resident, business and visitor requests for service and / or information are followed up with telephone contact and site inspection, as appropriate. Physical reduction, elimination or alteration of larval mosquito development habitats is an important aspect of the control program. Wherever possible, and practical, property owners will be advised of measures they could undertake to reduce mosquito development. Public works personnel maintenance of flow in ditches, grading of tire ruts and filling of depressions along roadsides and in vacant areas, removes potential development sources.

1.4 Term of the Pest Management Plan

A five-year period, tentatively extending from 15 April 2025 to 14 April 2030. The designated contact for this Plan is Mr. Darin Gerow, Manager of Roads and Parks, City of Salmon Arm. Telephone # 250-803-4088, email dgerow@salmonarm.ca

2.0 MOSQUITO CONTROL PROGRAM BACKGROUND

Organized mosquito control has been provided for the benefit of residents and businesses since 2004 by public works employees and aerial contractors. VectoBac 200G, a granular formulation of the biological mosquito larvicide-containing bacterium *Bacillus thuringiensis* var. *israelensis,* (*Bti*), Strain AM 65-52 (PCP # 18158) has been exclusively for all larvicide applications completed for mosquito control since this time.

The Mosquito Surveillance and Control program developed for the City of Salmon Arm and proposed in this Pest Management Plan employs a pro-active, Integrated Pest Management (IPM) approach. The methodologies and operational procedures described within this Pest Management Plan are endorsed by the City of Salmon Arm.

The geographical area covered under the PMP is coarsely defined as the municipal boundaries of the City of Salmon Arm. Larval mosquito habitats at Salmon Arm include impounded waterbodies such as roadside ditches, temporary and permanent ponds, river level-influenced flood and seepage water-filled depressions old river back channels or oxbows, and low-lying forested areas, farm fields and undeveloped areas. Filling with water in response to snowmelt or precipitation run-off and collection, shallow pools and ponds can form in depressions scattered throughout the forested areas adjacent the Shuswap Lake and Salmon River, which flows south to north through farmlands in the southeast portion of the City. Additional larval development habitats include temporary sites such as water-filled catch basins, tire ruts, depressions, un-used or abandoned wading pools or fountains, uncovered boats or canoes, tires, buckets and containers located on private and business properties.

The most effective means of reducing adult mosquito populations and the potential for annoyance or disease transmission is through an Integrated Pest Management (IPM) approach focused on limiting larval mosquito development. This protocol consists of five components:

1) Public Education/outreach to explain the program and to receive input and public feedback;
2) Surveillance to identify mosquito species occurrence and their distribution;
3) Timely implementation of mosquito controls and preventative measures;
4) Adaptive management of operations during a season in response to observations; and,
5) Review of results, program evaluation and assessment to ensure sustainable, effective controls are achieved.

Control program operations have always sought to reduce adult mosquito annoyance for residents, businesses and visitors to the City of Salmon Arm to acceptable, tolerable, levels. Over its twenty seasons of operation, the annual program has continued to evolve to increase its environmental compatibility, its effectiveness, and its affordability for residents.

The majority of mosquito control efforts for the annual program since its activation were focused exclusively on nuisance mosquito control. Beginning in 2004, as was done elsewhere in the province of BC, mosquito control efforts were expanded to address a potential disease concern, West Nile virus (WNv). With funding support from the Provincial Government, and technical support from the BC Centres for Disease Control and local health authorities, surveillance, development site identification, mapping and the inclusion of new habitats, such as catch basins, were investigated and documented, as appropriate, as potential disease vector habitats. Surveillance and pre-emptive control of WNv vector mosquitos by participating communities was suspended province-wide in 2010 with the elimination of provincial funding and support. The BC Centres for Disease Control (BCCDC) remains responsible for coordinating the province's response should WNv occur in BC.

The annual mosquito control program provided by the City of Salmon Arm focuses on mosquito population surveillance and control efforts in areas where larval populations are known to occur and where past, occasionally notable, adult mosquito annoyance was documented. Mosquito control services are provided to residential and rural property owners, businesses, municipal and regional parks, sports fields, campgrounds, golf courses and other outdoor recreational and tourist facilities. Mosquito control services will be concentrated on suppressing larval mosquito development occurring in lake shore and river flood and seepage water-influenced habitats occurring in low-lying farm fields, forest and undeveloped lands adjacent the Shuswap lake and Salmon River. The Figure delineates control program boundaries and primary sources of larval mosquito development. Over 100 hectares of potential larval mosquito development habitat exist within control program boundaries.

2.1 Primary Land Use

The primary land uses of the areas contained within the City of Salmon Arm control program are residential, retail/commercial, hotels and restaurants, industrial, forestry, hobby and agricultural lands. In addition to sports activities such as soccer and baseball, outdoor recreational activities include fishing, boating, water-skiing, horseback riding, golfing, motorbike, and mountain bike riding. It is a tourist town in the summer, with many beaches, camping facilities, golf courses and houseboat rentals.

2.2 Mosquito Species Identified Within the Area

Mosquito development occurs in a wide range of larval habitats ranging from snowmelt and rain pools, to floodwater and seepage sites, permanent ponds, ditches and excavations. Plugged rain

gutters, tarped equipment or woodpiles, watering troughs, boats and buckets or any other container or depression capable of holding water for a period of 7–21 days can provide suitable larval mosquito habitat. undetected, larval mosquitos will complete their development to the adult stage within this time span.

Approximately thirty-two different mosquito species have been collected from the Salmon Arm area over the past 20 years of program operation and over 70% of collected mosquitos are from the genus *Aedes*. *Aedes* females will bite once and then lay their eggs in moist soil along the edges of recently flooded areas where the eggs can lay dormant for upwards of twenty years. Snowmelt species rely on increasing water temperatures to hatch. Following a period of wetting, and drying, eggs become "primed" to hatch. Larvae, once inundated, particularly with flood and snowmelt species, can hatch out in large numbers, with populations typically ranging from 50-100 larvae/350ml dip sample, although +200 larvae/dip sample isn't uncommon. Developing in response to fluctuating water levels and river freshet flooding occurring with snowmelt and precipitation run-off, *Aedes* mosquitos are typically the most numerous during the first half of the season, from mid-April through July. Receding water levels, increasing temperatures, evaporation and decreased precipitation causes many of these habitats to dry, drain and disappear.

Culex and *Culiseta* comprise the balance (30%) of mosquito pest species for the area. Larval populations normally range from 1-20 larvae/dip sample and multiple, or recurring hatches each season are possible with additional egg laying by adult females. They typically develop later in the season, from June through August, and require a different set of cues to initiate the onset of larval development, including increasing day length and temperatures. *Culex* and *Culiseta* prefer permanent and slow-draining, or frequently-refilled sites including natural and man-made ponds, ditches and containers such as stored tires, boats and buckets or livestock watering troughs. They overwinter as adults and females and can bite multiple times, a variety of hosts (mammals, birds) and lay eggs several times in a season.

Species such as *Culex tarsalis* are able to withstand brackish waters and a high degree of pollution. They can inhabit areas with high organic content, including septic field seepage, sewage lagoons and livestock hoof prints around barns, feed lots and along creeks. *Culex pipiens*, the "house mosquito", can use a large variety of natural and man-made freshwater habitats including containers.

Anopheles are large mosquitos which prefer permanent sites or slow draining and flowing ditches or stream margins. They are not very common and are often the least numerous of the mosquito species occurring in the area. Although their populations and individual development sites are not usually as large as the synchronous hatching *Aedes* mosquitos, they can be a source of reportable annoyance since their preferred habitats are common to residential, commercial,

recreational and agricultural properties. All of the species collected locally are able to develop as multiple hatches during a typical season. They are all capable of causing reportable and often extreme annoyance, particularly *Aedes,* and *Ae. vexans* and *Ae. sticticus* are potential West Nile virus (WNv) vectors. *Culex* and *Culiseta* mosquitos are not only a source of annoyance, but they too are also recognized as vectors of several diseases, including WNv. *Culex tarsalis, Culex pipiens* and *Culiseta incidens* are identified by the BC Centre for Disease Control (BCCDC) and the Center for Disease Control (Atlanta, USA) as three of the primary vector vectors of WNv in North America.

Mosquito pest species collected from the City of Salmon Arm and area, include:

Aedes aloponotum
Aedes campestris
Aedes cataphylla
Aedes communis
Aedes diantaeus
Aedes dorsalis
Aedes euedes
Aedes excrucians
Aedes fitchii
Aedes flavescens
Aedes hexodontus
Aedes impiger
Aedes implicatus
Aedes intrudens
Aedes mercurator
Aedes pionips
Aedes provocans
Aedes punctor
Aedes riparius
Aedes spencerii
Aedes stumulans
Aedes sticticus
Aedes vexans
Anopheles earleii
Anopheles freebornii
Anopheles punctipennis
Culex pipiens
Culex tarsalis
Culiseta alaskaensis
Culiseta impatiens
Culiseta incidens
Culiseta inornata

Control of locally occurring *Aedes*, *Culex* and *Culiseta* mosquitos not only prevents widespread nuisance for the benefit of residents, workers and visitors, but also contributes to the protection of public health.

Mosquito surveillance, collection and identification are components of an ongoing operational and effective control program. The mosquito species listing and development site database would be updated as required.

3.0 MOSQUITO CONTROL PROGRAM METHODOLOGIES

The objective of the annual control program is to reduce the potential for widespread adult mosquito annoyance for residents, workers and visitors to the program areas. A program of this scope is not intended to eradicate the mosquito population. The total eradication of a widespread, fecund insect pest is not feasible.

The prevention or control of larval development is preferred over control of the often widely dispersed and mobile adult mosquito since larvae are concentrated in one place, they must remain there for 5-21 days, and they are very susceptible to the bio-rational control products VectoBac 200G and VectoLex CG. Regular monitoring of established mosquito development habitats, and surveying for new or previously undetected sites, ensures that larvae are controlled before they complete their development and cause adult mosquito annoyance.

The need to coexist with a dynamic aquatic habitat necessitates that an integrated approach to mosquito control be undertaken. This approach requires an assessment of the problem, an in-depth understanding of factors influencing the situation, followed by the use of appropriate control. Measures employed in an IPM approach to mosquito control typically include a combination of elements directed at the elimination or modification of mosquito-producing habitat and control of larvae (larviciding) through predators, parasites or other bio-rational means.

Drainage or other physical alterations to larval mosquito development sites is the preferred and permanent control method. Once done it often requires no further attention. Physical control can be integrated into routine, local public works activities such as roadside grading and ditch or culvert maintenance and cleaning. Private and business property owners can contribute to mosquito control efforts by eliminating, reducing or modifying sources of mosquito development. Removal of buckets, draining of plugged eaves troughs or unused bird baths and regular changes of water in livestock watering troughs reduces local mosquito populations. Wherever practical, during the course of monitoring, residents and businesses were advised of options for physical control of mosquito development habitats located on their property.

Adult mosquito populations may be monitored at select locations within the control program and in response to resident requests for service. When adult mosquito annoyance is identified, surveillance for potential, and unknown development sites can be undertaken, and controls completed, to reduce mosquito populations before they can disperse to cause increased annoyance. Since different species of mosquitos use different habitats for development, adult mosquito sampling and identification can help determine, or confirm, the source of localized mosquito nuisance. Routine adult mosquito control applications (adulticiding) for the purposes of nuisance mosquito control **are not** a component of the annual City of Salmon Arm Mosquito Surveillance and Control Program, or this Pest Management Plan.

The mosquito control program and methodologies developed for the City of Salmon Arm are a hybrid of approaches developed through collaboration with mosquito and vector control professionals worldwide. It has been carefully and specifically adapted for the unique conditions of the program area and is a model of environmental compatibility. The components of this successful control program may include the following activities, as detailed in Sections 3.1, through to Section 4.5 of this document.

3.1 Public Information and Education

The general public is regularly advised of control efforts in their area and provided with the opportunity to have input to their mosquito control program and it's PMP. This is essential since, in the final analysis, it is the general public which must be satisfied with control efforts.

The *Integrated Pest Management Act and Regulation* requires public notification of Pest Management Plan preparation through newspaper notices. These must be published once each week, for two weeks in row, starting at least 45 days before submission of a notice to the BCMOE confirming that a Pest Management Plan has been prepared according to the legislation. The general public, first nations and other stakeholders are invited through these advertisements, or direct contact (First Nations) to provide comments on the PMP and to consult with the PMP holder or their designate, on the proposed mosquito control program. In addition, those individuals or groups which had requested information, or who have supplied input when the local mosquito control program was last approved, are contacted directly each time the PMP is renewed.

Considerable value can be obtained through promotion of the control program and interactions with the public. For example, public contact can result in the locating of new mosquito development sites, thus augmenting overall program efficacy. Suggestions for physical removal or source reduction on private property allows the owner to participate on a smaller scale. Once accomplished, physical source reduction, especially the removal of artificial containers, grading of depressions or filling of tire ruts eliminates the need for further attention.

The annual mosquito control program is well known and supported by area residents and businesses. In operation for over twenty years, it has been providing mosquito surveillance, monitoring and larval control services for the benefits of residents, businesses and visitors. During this time, newspaper articles and advertisements, brochures, posters and interactions with field personnel have provided the general public with regular and frequent information on mosquitos and program service access.

Movement of adult mosquitos, either by active flight or passively by wind, from outside of treated areas into built up and developed areas is always a possibility given the nature of local geography. Public education further encourages residents and businesses to undertake actions for excluding adult mosquitos and modification of personal behaviours which will reduce the potential for annoyance. Through eliminating development sites on their property and learning to reduce adult mosquito annoyance through preventative actions, residents can actively participate in their program. In addition to providing residents with information on how they can reduce larval development and annoyance around their properties, education initiatives help residents understand that the control program can only suppress mosquito populations, not eradicate them, and that some adult mosquito annoyance may be anticipated at certain locations, times of day and during some years.

Examples of some various public education and information initiatives which have been successfully employed, or which could be deployed for this program in future years include:

- *Informational Brochures* – these review mosquito biology and control, mosquito "myths", program operations and contact information for program biologists.
- *Web-based* program information and service contact details
- *Facebook, X accounts* (social media) – another method of public access/information
- *Laminated posters* – durable. Installation along walking trails, picnic and camping areas.
- *Newspaper Display Advertisements* – placement in local newspapers from April – September. Provides monthly program updates and contact/access information.
- *Presentations at Council meetings - (Power Point™).*
- *News media interviews* – provides opportunities to update the public on program operations and status, mosquito biology and additional public outreach
- *Public information booth @ Open houses, farmers markets*
- *Radio, television and newspaper interviews and /or articles*

As part of annual control program start-up in early April and May, program personnel would contact property owners, residents and facility operators to determine site status and confirm program participation and property access. Ongoing interactions and conversations with property owners, residents and general public provides opportunities to discuss program operations, goals and allow for the distribution of public education and outreach materials. Office and field personnel response to service requests received from the general public provide additional opportunities for public education and information sharing of program operations.

Occasionally individuals may wish to be excluded from the mosquito control program for personal reasons. A record of "AVOID" areas is maintained and updated as required. Meetings and input with concerned residents and special interest groups ensures that activities of control personnel do not conflict with those of residents. By staying informed of community events such as baseball games, tournaments, rodeos and the like, control personnel can increase efforts prior to an event to reduce potential adult mosquito annoyance.

The cooperation and support of local businesses, farmers, business, facility operators and other property owners is indicative of true community spirit and support for a successful program which benefits workers, residents and visitors to the Salmon Arm area. Prevention of adult mosquito annoyance through pro-active, larval mosquito control provides significant benefit to residents, outdoor workers and recreational users. Control of locally occurring *Aedes*, *Culex* and *Culiseta* populations not only prevents widespread adult mosquito nuisance for the benefit of residents, businesses, workers and visitors, but also contributes to the protection of public health.

3.2 Protection of Archaeological Sites

Archaeological sites on both public, or private land are protected under the Heritage Conservation Act (HCA) and must not be altered without a permit. Archaeological sites are non-renewable and have cultural, historical, scientific and educational value. The HCA automatically protects all archaeological sites that predate AD 1846, with exception of burial sites and rock art sites which are protected regardless of age.

Any individuals working in the annual City of Salmon Arm Mosquito Surveillance and Control Program that believe they may have encountered materials or items of archaeological importance will follow the procedures below:

- All work in the vicinity of the items/objects will cease immediately and any archaeological and/or human remains will not be disturbed.
- Will contact their supervisor/program manager.
- No excavation or removal of soil from the area will occur.
- Will isolate, mark and protect the area from disturbance.
- Take pictures of the artifact, the immediate and adjacent areas.
- Note location (GPS coordinates, location description) and leave all discoveries in place.
- The City of Salmon Arm and provincial Archaeology Branch (email: Archaeology@gov.bc.ca, or 250-953-3334) will be contacted.

3.3 Mosquito Control Program Data Collection and Reporting

At the conclusion of each annual mosquito control program season the City of Salmon Arm provides a summary report, typically prepared by the program's environmental consultants on their behalf, detailing all activities and pesticide treatments completed under the PMP. All necessary pesticide use reporting required under the Pesticide Control Act, the *Integrated Pest Management Act and Regulation,* the approved PMP, and as requested during the season by government regulatory agencies including the BC Ministry of Environment is provided. The following information would be collected, updated and reviewed as required.

- A mosquito development site database with information including property ownership, address, contact telephone number, development site maps and or photographs, public access information (paths, trails, roadways), records of past and current monitoring and treatment activities, pesticide use daily operation records and other relevant information related to the control program.

- A list, and/or maps, of properties identified as 'AVOID' areas, where the owner or residents have indicated through telephone, written, verbal (in person conversation) or electronic (e-mail, facsimile) communication, their wish to be excluded from the mosquito control activities on their property. The District will update this list as required during the term of the PMP.

- A list and/or maps identifying, where necessary, areas such as fish-bearing waters, potable surface water intakes or areas of environmental sensitivity, including provincial or regional parks, habitat conservation areas, archaeological sites, and other identified or designated speciality management areas. When the status of a waterbody or other area of potential environmental concern (e.g. bird nesting sites) is unknown, a local representative of the Department of Fisheries and Oceans (DFO) Canada or the BC Ministry of Environment (BCMOE), or other agencies as appropriate, may be consulted.

The development site database is updated at the beginning of each control season when control program personnel typically meet with residents, business owners and facility operators. Property ownership, access, development site status and control program operations are reviewed. Regular contact is maintained with these individuals throughout the season to provide updates on control program operations and to provide opportunities for input and comment on the control program. Ongoing activities related to surveying, monitoring and mosquito control operations are recorded in the historical data section of the database as they occur. Database information would be used to respond to any requests for program information from the public, District representatives or government regulatory agencies.

3.4 Surveying and Monitoring of Mosquito Populations

As part of the annual program start-up, and throughout the season, field personnel conduct regular surveys of the City of Salmon Arm and surrounding areas. The goal of these surveys is to confirm the extent and locations of existing, known mosquito development sites and to identify any new, unknown, potential larval habitats.

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos and the need for control. Ground-based monitoring confirms observations made during aerial surveys and allows an accurate update of records from previous seasons. Larval habitats would be monitored throughout the season using a standard 350ml larval mosquito dipper to assess the relative abundance and species of larval mosquitos. Preserved larval specimens are forwarded to the laboratory for identification to species wherever possible.

Mosquito development varies from year to year and throughout the season depending on environmental conditions and habitat availability. Environmental cues interact to affect both the timing and magnitude of mosquito development, and adult mosquito survival. These factors include winter snowpack accumulations and rate of melt, soils, temperatures, humidity, and precipitation.

Monitoring and correlation of meteorological and hydrological data with larval sampling information collected over several seasons allows for the determination of 'thresholds' which aid in the prediction of larval development and distributions. Review of weather conditions, winter snowpack, river and lake levels combined with a sound knowledge of mosquito biology and local development site types is necessary to ensure surveying and monitoring activities occur to detect

mosquito development. Failure to timely survey and monitor could allow unchecked development of larvae which will result in adult mosquito annoyance. Larval habitats would be monitored throughout the season to assess the relative abundance and species of larval mosquitos found in these habitats. When investigating reports of adult mosquito annoyance or potential larval development sites, a thorough survey of each area would be performed to locate the source of annoyance, and any previously unidentified larval habitat.

In addition to providing pre-application information essential to timely control applications, surveying and monitoring following treatment, 'post-treatment monitoring' allows for an evaluation of the degree of control achieved from a particular larvicide application or site modification. Environmental compatibility and cost effectiveness of a control program is dependent on effective implementation of control measures directed only to those areas requiring them. Post-treatment monitoring to confirm to larval mortalities is typically completed within hours of application.

3.4.1 Larval Mosquito Populations

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos and the need for control. Routine sampling of development habitats is ideally completed on a 6-10 day basis, depending on conditions and observations, throughout the season, typically mid-April to mid-September. Larval mosquito populations as small as one larvae/dip in an area as small as a backyard swimming pool (5m x 10m) can produce thousands of adult mosquitos over the course of a season. Located adjacent to outdoor recreational facilities including golf courses, parks, sports fields, picnic areas, campgrounds and residential and commercial areas even small development sites can be a source of notable mosquito annoyance.

Pre-treatment surveys determine the extent of larval development which ensures that control measures are directed only to those areas containing larvae. In addition to providing pre-application information essential to timely control applications, surveying and monitoring following treatment, 'post-treatment monitoring' allows for an evaluation of the degree of control achieved from a particular larvicide application or site modification procedure. Environmental compatibility and cost effectiveness of a control program is dependent on the effective application of control or larval preventative measures directed only to those areas requiring, or appropriate for them.

3.4.2 Adult Mosquito Populations

Adult mosquito populations and annoyance are routinely monitored during the season by field personnel during larval surveying and monitoring activities. Monitoring at select locations may also be completed where indicated by reports of mosquito annoyance.

Monitoring of harbourage areas adjacent to larval development sites and near population centres is conducted on a routine basis throughout the season. This pro-active approach performs two important functions; firstly, it complements larvicide applications, since it is impossible under even

the best conditions to achieve 100% larval mortalities. And secondly, it allows for an objective measurement of the success and effectiveness of larviciding efforts in reducing adult mosquito populations.

To objectively measure the success and effectiveness of larviciding efforts in reducing adult mosquito populations, two internationally accepted sampling methods may be employed. The first, a standard biting/landing count, measures the number of mosquitos which land, to bite, on the exposed forearm (from wrist to elbow) in a one-minute period. Adult biting counts of three or more per minute, measured between the wrist and exposed forearm, is intolerable for most people. Beyond three bites per minute, outdoor enjoyment and worker performance and safety are affected, and negative economic impacts on recreation and tourism can be expected. Although it is the accepted world-wide standard, it must be noted that bite counts are not without bias. Clothing and body physiology make some people more or less attractive than others. Also, daily timing for collection is crucial as mosquitos are most active at dusk and dawn, when temperatures are lower and humidity generally higher. For these reasons, collection timing, locations and clothing worn by the observer are standardized as much as possible. When reviewed in conjunction with anecdotal reports from residents, this data is a useful measure of mosquito annoyance levels and facilitates the collection of mosquito species that actively seek a human blood meal.

The second method used for adult mosquito population assessments uses either Standard New Jersey or Center of Disease Control (CDC, Atlanta) Adult Mosquito Light Traps. Both types of traps use a normal incandescent light source as an infra-red attractant and are programmed to start collections at sunset and terminate at sunrise. Samples are typically retrieved the following morning and forwarded to the laboratory for enumeration and identification. These traps can be augmented (baited) with CO_2, in canisters, or as dry ice, to increase capture rates as it is another key attractant for female mosquitos. Information gathered from light trap captures can be used to give an indication of the mosquito population size, species complex and type of development habitat.

New Jersey or CDC Light traps may be deployed to monitor adult mosquito populations in areas with a history of adult mosquito annoyance problems. Benefits associated with these traps include the collection of a much greater number of specimens than with un-baited traps, or from biting counts, and they provide an objective, reproducible sampling method. These collections complement bite count sampling for annoyance by allowing field personnel to more effectively identify the mosquito

species present in a particular area. Correlation of this data over several years with larval monitoring and adult mosquito biting count data allows for continued, increased forecasting of mosquito populations.

Larval and adult mosquitos would be identified according to the taxonomic keys of Darsie and Ward (1981) and Wood, Dang and Ellis (1979), and others as appropriate.

3.4.3 Mosquito Development in the Salmon Arm area

A total of up to 100 hectares of potential larval mosquito development habitat have been identified within the City of Salmon Arm (Figure). Snowmelt-influenced ponds, sloughs and marshes, man-made ponds, reservoirs, ditches, and small, isolated roadside ponds provide recurrent mosquito development during a season with typical weather conditions. Varying in size from less than $10m^2$, to several hectares in total area, these sites can become infested with mosquito development as temperatures rise over the season and for as long as they contain water.

Persistence of these sites is influenced by a number of factors including duration and magnitude of snowmelt, river/lake freshets, area substrates, the frequency and amounts of precipitation, daily temperatures and humidity. Next to snowmelt and precipitation, temperatures have the single greatest impact on the onset and rate of larval development. Depending on local weather conditions, temporary and slow-draining, or permanent ponds provide ideal conditions for mosquito development.

Producing predominantly *Aedes* mosquitos from late April through late June, they are a recognizable source of adult mosquito nuisance for area residents. Subsequent larval development, which includes *Culiseta, Culex* and *Anopheles,* also have the potential, if left untreated, to cause localized annoyance which may extend through July and into August.

Smaller depressions and non-flowing drainage ditches, tire ruts and artificial containers such as livestock watering troughs, old tires landscape, and display and irrigation ponds provide the remainder of larval mosquito habitats for the area. Although these sites may often be small, their locations and distribution near outdoor work sites, recreational areas, businesses and residential properties makes them important sources of localized adult mosquito annoyance if not effectively monitored and controlled. Notable pest and vector species collected from manmade and natural, freshwater development sites locally include: *Aedes vexans, Aedes sticticus*, *Aedes implicatus*, *Culex pipiens*, *Culex tarsalis, Culiseta incidens* and *Culiseta inornata.*

The great majority (~70%) of mosquitos developing within the defined boundaries of the City of Salmon Arms annual Mosquito Surveillance and Control Program are *Aedes*. They are at their most numerous early in the season, April, May and June. *Culex* and *Culiseta* species are the predominant larvae occurring during late June, July and August.

3.5 Mosquito Control Options

Simple, but established key elements of a sound integrated pest management for this, and every effective, and environmentally compatible nuisance and vector mosquito surveillance and control program are:

1) Assessment of need for control using scientifically sound evaluations,
2) Development and application of site-specific controls, and;
3) An assessment of results and adaptation of approach, as required.

Each mosquito development site will have its own unique requirements and treatment options. The PMP for this mosquito control program uses a combination of techniques, and an Integrated Pest Management approach, to achieve the management and control of mosquito populations. The best choice for control reduces both mosquito populations, and the potential for adverse effects on people, domestic animals, livestock and natural ecosystems. Sometimes, particularly with man-made habitats such as ditches, irrigation or display ponds and containers, larval mosquito populations can be reduced, or effectively limited using physical or natural controls.

Many of the possible physical and biological control options suggested below may be supported and possibly implemented by local public works personnel and landowners. Private property owners are best motivated to become involved in their control program through public education initiatives and through consultations with program personnel. Once educated about mosquitos and their habitats, property owners can undertake steps to reduce or eliminate larval mosquito habitat and adult mosquito annoyance on their property.

The preservation or enhancement of balanced wetland habitats has the best opportunity for a meaningful long-term contribution to overall mosquito control program success through reduction of mosquito populations and enhancement of natural controls including insect, fish and birds. Elimination of stagnant water and enhancements in natural or created ecosystems will be of benefit to overall control program efficacy through increasing habitat for natural mosquito predators. The use of a biological control products such as *Bacillus thuringiensis* var. *israelensis* (VectoBac 200G) and *Bacillus sphaericus* (VectoLex) maximizes the effectiveness and environmental compatibility of the program.

Mosquito control programs of the type described herein are routinely conducted throughout British Columbia. Such IPM-focused mosquito control programs do not have deleterious effects on humans, domestic pets and livestock, wildlife, fish and their food and are routinely conducted throughout British Columbia. There are three larval mosquito control options available to the program. These are physical, biological and bio-rational product oriented.

3.5.1 Physical Source Reduction and Site Modification

A continued focus for the control program technicians and public education initiatives would be the identification, and reduction or elimination, of larval mosquito development habitats wherever possible. Residents and business operators are encouraged to remove, or alter, standing waters which provide suitable habitat for larval mosquito development. For most property owners this involves eliminating water-holding containers, such as buckets and boats or canoes and the draining, or regular changes of water in bird baths, livestock watering troughs, unused wading pools and display ponds.

When done by the homeowners, this permits residents an opportunity to actively participate in their control program. This can be especially important for residents, as two of the most common West Nile virus vector mosquitos, *Culex tarsalis* and *Culex pipiens,* make ready use of manmade habitats, including containers. Installation and maintenance of window screens, mosquito magnets™ (adult mosquito traps) and the use of mosquito repellents by individuals provides additional protection from adult mosquito annoyance and potential disease transmission. Residents, workers and visitors should minimize outdoor activity at dusk and dawn, wear light-coloured, loose-fitting clothing and minimize the use of fragrant shampoos, perfumes and colognes to further reduce potential adult mosquito nuisance.

Maintaining permanent ditches so they are clear of obstructions or vegetation, replacing failed culverts or grading to effect flow may increase flow, drainage or access by fish or aquatic insect predators. Ditching, grading or filling of roadside depressions may be a suitable solution to decreasing, or preventing, larval development by reducing an area's potential to retain water. When completed as part of routine maintenance activities by public works crews they can be effective means of suppressing local mosquito populations. Any such activities along public roadways, in parks or other publicly owned properties would be coordinated through the appropriate public works and engineering departments. The BCMOE, DFO and other government regulatory agencies, as appropriate, may also need to be consulted prior to any such planned work in area ditches.

Removal or alteration of mosquito producing habitat does not necessarily mean drainage resulting in habitat destruction for other organisms and natural predators such as birds and fish. As part of a comprehensive approach to mosquito control, property owners are encouraged to manage stagnant and non-flowing waters to minimize their use as sources for mosquito development. For example, the removal of emergent shoreline vegetation, combined with either water level management at greater than one metre in depth or a shoreline groomed to a gradient of 3:1 or steeper, effectively eliminates mosquito production in irrigation and settling ponds or other water impoundments. The installation of fountains in man-

made golf course and park ponds can reduce their suitability and use as larval mosquito development habitat.

Mosquitos require water to develop, and any efforts to reduce or eliminate standing or stagnant waters, particularly in depressions, tire ruts and containers will prevent larval development and subsequent adult mosquito nuisance. Source reduction around homes and businesses can be easily achieved by residents and owners, allowing them to actively participate in their mosquito control program.

Adult mosquito collection devices such as Mosquito Magnets™, which use propane to generate CO_2 will collect adult mosquitos and are marketed by several companies for use by property owners. With a collection range of about ½ hectare (one acre), their ability to reduce mosquito populations sufficiently to provide relief from annoyance on a community level is unlikely without the deployment of numerous units. Their use at a single property/residence though, can have a noticeable impact by collecting adult mosquitos and reducing annoyance.

3.5.2 Biological Control

Biological control involves the use of predators, pathogens, and parasites to reduce mosquito populations. Insect predators, both aquatic (i.e. dragon flies, beetles, backswimmers, amphibians, fish) and terrestrial (i.e. dragon flies, spiders, wasps, birds, bats), contribute to the natural mortalities of both larval and adult mosquitos. Conserving, or enhancing natural habitats wherever possible, allows these predators to contribute to control program effectiveness.

Control options involving the relocation of mosquito predators such as insects or fish is not a practical or feasible solution for most natural development habitats. Regan *et al.* (1980) evaluated the effects of three-spined stickleback fish (*Gasterosteus aculeatus*) on mosquito larvae located in the Fraser Valley. They were found to be effective in reducing larval populations. Their natural fecundity combined with their ubiquitous nature makes these fish an ideal natural (biological) control agent. They are a common occurrence in many ditch systems.

Where applicable, and where permitted by local bylaws and provincial or federal environmental regulations, the ditching of habitats or clearing of obstructions in ponds or man-made ditches may increase access or use by fish or aquatic insect predators. Such activities might, however, also have a detrimental impact on established plant and animal communities or land uses and may cause an

unexpected increase in larval mosquito development habitat. Professional engineers, hydrologists and biologist input is required and will require long-term commitment for monitoring in order to assess the impacts on mosquito and other species populations. The BC Ministry of Environment, the Department of Fisheries and Oceans and other government regulatory agencies, as appropriate, may need to be consulted prior to any such planned works.

Introduction of fish (Koi, goldfish) to manmade, self-contained outdoor display or irrigation ponds may also reduce, or eliminate larval mosquito development in such habitats. Most practical in the warm, lower mainland Fraser Valley and Vancouver Island, in areas with very cold winters, this type of control requires considerable work and cost which many include the over-wintering of fish indoors or annual replacement. The relocation, or introduction of fish to any natural water course requires approval and permitting through various governmental agencies including Department of Fisheries and Oceans and the BC Ministry of Environment.

Although flying insects can form a large component of the diet for flying insectivores (*eg.* bats, swallows, Purple Martins), there is no evidence which suggests they provide a detectable level of mosquito control. Both birds and bats are also opportunistic feeders and adult mosquitos have been identified as a small component (<2%) of their diet, (Fang 2010 and Gonsalves *et.al.*, 2013). They are not however, scientifically recognized as able to provide any real impact on mosquito populations when used solely as a mosquito population control option.

A one-hectare site, the size of 2 football fields, having a larval population density of just 1 larvae/dip sample, can produce 4,285,714 mosquitos. Reported to eat up to 300 mosquitos a day, a total of some +13,300 birds and/or bats would be required to consume the mosquitos emerging from just one hectare of habitat. Larval populations in much of the program area average between 10-30 larvae/dip sample and in floodwater sites can often exceed 100 larvae/dip sample. With between 50 – 100+ hectares of treated habitat, and much of it located within 100-200m of residents and businesses, the sheer potential for adult mosquito populations, likely in the billions, would make a reliance on solely natural controls unlikely to have a noticeable impact on annoyance levels for area residents.

Interested residents would still be encouraged to install bird nesting boxes or bat houses though since it allows individuals to contribute to a comprehensive, integrated mosquito control program, and in some cases may provide residents with a sense of reduced adult mosquito annoyance. Additional predators for adult mosquitos include insects such as wasps, deer flies, dragonflies, damsel flies, etc. and spiders.

Pathological agents such as viruses and certain parasites have received much research attention, but none of these are commercially available or approved for use in Canada. The naturally occurring soil bacteria, *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *Bacillus sphaericus* (*Bsph*) have highly

specific insecticidal properties. They are commercially available, have been successfully, and safely employed worldwide since the early 1980s. They are discussed below.

3.5.3 Bio-rational Control

The mosquito surveillance and control program at Salmon Arm would use VectoBac 200G, or equivalent, and VectoLex larvicides products for larval mosquito control. VectoBac and VectoLex are the closest form of a natural or biological control agent currently available for routine use in operational mosquito control programs. The use of these products maximizes the environmental compatibility of the annual mosquito control program when used in circumstances where other control options such as physical or natural (biological) control are not practical. They support an IPM approach to control.

VectoBac 200G (PCP # 18158) contains spores and crystals produced by the bacterium (*Bacillus thuringiensis* var. *israelensis*, *Bti, Serotype H-14, Strain AM65-52*) and, as such it is classed as a bio-rational, rather than conventional, pesticide. A naturally-occurring soil bacteria, it has no residual activity, is species-specific, does not bio-accumulate and has no impact on other organisms found in aquatic habitats. It is recommended for use in standing water habitats such as temporary and permanent pools in pastures and forested areas, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons.

VectoBacs mode of action is on the larval mosquito stomach, and it must be eaten to be effective. It is very specific, producing rapid lethal effects (within hours) in larval mosquitos. It has no residual activity, does not bio-accumulate and has no impact on beneficial organisms found in mosquito development habitats. Negative or toxic effects on mammals, birds or other wildlife have not been observed. Formulated as a corn cob granule it requires no mixing and is ready to apply by hand, backpack blower or by helicopter. The granule allows the larvicide to penetrate vegetative covers and reach the water surface where the *Bti* is “released” for consumption by mosquito larvae.

Similar to VectoBac 200G, VectoLex CG (PCP # 28008) also contains a naturally occurring, spore-forming soil bacterium. VectoLex contains spores and crystals produced by *Bacillus sphaericus.* It also is classed as a bio-rational, rather than conventional, pesticide. Like VectoBac, VectoLex larvicides acts on the larval mosquito stomach and must be eaten to be effective. VectoLex is very specific and produces lethal effects in a narrow range of mosquito species, including *Aedes vexans* and most *Culex* mosquito species. It does not have any effects on man or animals, fish and other insects which may use these aquatic habitats.

Operationally, the important differences between VectoLex and VectoBac are speed of action and persistence in the larval habitat. Larval mortality can take several days for VectoLex versus

several hours with VectoBac 200G. VectoBac often requires re-application to control additional larval development occurring several days after treatment. VectoLex achieves this extended control because the *B. sphaericus* toxin is more stable, has a slower settling rate in the water column and the unique ability for its spores to germinate, grow and reproduce in the dead mosquito larvae. This is known as recycling and is the mechanism which allows VectoLex to provide long-term, extended control (upwards of 28 days) of recurring larval mosquito development. VectoLex CG is recommended by the manufacturer for use in standing water habitats including temporary and permanent pools in pastures and woodlots, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons.

Both *Bti* and *Bsph* products are species (target) selective and non-toxic to other aquatic organisms which co-exist in these habitats, including insects, fish and amphibians. Their use maximizes the environmental compatibility of the annual mosquito control program. When used in circumstances where other control options such as physical or natural (biological) control are not practical, they support the principles of an IPM approach to control. Extensive product information can be found at the manufacturer's website www.valentbiosciences.com or through the Health Canada, Pest Management Regulatory Agency (PRMA) website www.pmra-arlc.gc/ca. and the Pesticide Label Search www.hc-sc.gc.ca.

3.5.4 Chemical Control

Chemical control products and equipment are predominantly used for the purposes of reducing adult mosquito populations. As with most adult insect control programs, adult mosquitos are typically controlled using a broad-spectrum (adulticide) insecticide. Although there are 'natural' adult mosquito control products make from chrysanthemum flower extracts (pyrethrins) and their synthetic equivalents, all adulticides only provide temporary control and are typically broad spectrum, having a deleterious effect on any insect which may come in contact with them. Unless regular and routine treatment of 'problem areas' is completed, uncontrolled adult mosquitos developing in other areas will often move into these treated areas to again cause annoyance.

Routine adulticide applications **ARE NOT** a component of the proposed mosquito control program at Salmon Arm. The annual mosquito control program described within this PMP does not utilize any chemical control methods for the abatement (control) of larval or adult mosquitos.

- ***Pesticides and repellants***

Citronella candles, mosquito coils, Konk™ Automatic Aerosol Sprayers and other such products are marketed as mosquito repellants, or for adult mosquito or biting insect control. These

are readily available to residents, campers, and property owners. Property owners may also use items such as these, as required, and as instructed on the product labels.

3.6 Mosquito Control Program Operations

The well-organized, pro-active, integrated pest management approach to mosquito control developed for the City of Salmon Arm reduces the potential for adult mosquito annoyance. It focuses efforts on the identification and timely control of larval populations occurring within the boundaries of the City.

In situations where physical alteration of development habitats are impractical or undesirable, or where natural controls are insufficient to reduce nuisance mosquito populations, VectoBac and VectoLex applications would be completed to control larval populations. Control of larvae at their source reduces annoyance levels for area residents and visitors.

3.6.1 Larval Mosquito Surveillance, Treatment Thresholds and Applications Rates

VectoBac and VectoLex are only applied when larval mosquitos are present. VectoBac and VectoLex are only applied when larval mosquitos are present. Larval mosquito populations would be controlled by air and ground using VectoBac 200G and where appropriate, with VectoLex CG. VectoLex CG could also be used to control developing larval mosquito populations occurring in roadside catch basins. Section 3.5.3 above discusses VectoBac 200G and VectoLex CG further. To review or print product labels and Material Safety Data Sheets please see www.valentbiosciences.com

- ***Larval Surveillance***

Larval mosquito surveillance and control protocols focus efforts on the timely identification and treatment of larval mosquito populations, with control efforts targeting 1st through 3rd instar larvae. In addition to treating the most actively growing and feeding instars, this approach also allows for retreatment (touch-up) of sites, or portions of sites, that may not have been treated as completely as desired because of conditions on the day, changing water levels or because of subsequent hatching. Another benefit is that application rates can be lower, and therefore material costs, and overall mosquito larvicide use rates in the environment are reduced. Even though the products Vectobac 200G (*Bti*) and VectoLex (*Bsph*) have the safest environmental profiles of any bio-rational larvicides in common use, decreasing any volume of control product is beneficial and maximizes environmental compatibility.

Treatments and surveillance targeting mosquito populations with later 3rd or 4th instars under the guise of allowing natural predators to impact some level of control is not encouraged. While there may be predation of some mosquito species occurring in permanent ponds, such as *Culex* or *Culiseta*, the two most common genera in these types of sites, this strategy is wholly

impractical for *Aedes* mosquitos. *Aedes* hatch in large numbers, typically +100/dip, and inhabit temporary pools created by snowmelt, precipitation or river flood and seepage waters which may only last several days or weeks. These types of temporary habitats seldom have established natural predators and where they may occur they are typically inadequate to deal with larval populations of such extreme magnitude.

Delaying treatments to target populations with later 3rd or 4th instars is also not ideal as the potential for reduced feeding rates of later instar larvae may provide incomplete control, and may result in a number of undesirable outcomes;

- That larvae develop into the untreatable pupal stage, and then onto nuisance causing adults;

- That field staff may not be able to return at an appropriate time to treat them before pupation occurs. Changing weather conditions and temperatures over a few days can dramatically accelerate larval development rates; and lastly

- Product manufacturers recommend that later instar larvae are treated with higher application rates, upwards of 10kg/ha (1 gm/M^2), thereby requiring more larvicide, increased helicopter or personnel field treatment time, reduced environmental compatibility, and increased cost ($) per hectare treated.

Typically 5 - 10 dip samples per development site, depending on site size, would be the completed. Larger sites will have a greater number of dip samples. Larval mosquito dip samples averaging from 1-3 larvae/350ml sample in sites containing predominantly 2nd and 3rd instar larvae would be the minimum treatment threshold for mosquito larvae found in permanent sites which typically contain a high proportion of *Culex* and *Culiseta* mosquito larvae. A treatment threshold of five, 1st instar larvae/350ml dip sample is utilized when monitoring synchronous, extensive *Aedes sp*. larval development common to early-season snowmelt, seepage water and similar temporary habitats. The threshold for 2nd and 3rd instar *Aedes* larvae would be 1-3 larvae/dip sample. Fluctuating water levels in many of these sites cause recurrent larval development requiring repeated treatment.

These thresholds are based on the "industry standard" used by operational mosquito control programs in the Northwest Mosquito and Vector Control Association (NWMVCA) and American Mosquito Control Association (AMCA).

- ***Larvicide Applications***

VectoBac 200G and VectoLex CG are the larvicides of choice for aerial and ground-based larvicide applications. These products maximize the environmental compatibility of the City's mosquito control program since they are currently the most effective, selective, and least persistent larval control agents available.

VectoBac and VectoLex larvicide are only applied when larval mosquitos are present. All VectoBac 200G and VectoLex CG application rates would be within those recommended by the manufacturer. These rates range from 2.5 to 10.0 kilograms per hectare with applications completed under this PMP to be conducted at rates ranging from 4.0 to 8.5 kilograms per hectare. Typically, VectoBac and VectoLex application rates average 7.0-8.0 kg/ha for ground applications and 4.25-5.0 kg/ha for aerial (helicopter) applications. These application rates have been demonstrated as effective under the conditions encountered at Salmon Arm. Factors influencing application rates include application method (aerial or ground) the density and type of vegetation cover at treatment areas (grasses, deciduous forest), organic matter, water depths etc. All applications are followed with post-application monitoring to confirm the effectiveness of treatments.

Rapid, synchronous larval development over an expansive area, largely inaccessible from the ground, may require aerial larvicide applications to ensure control program success. Aerial (helicopter) applications are not a routine component of control program activities.

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Aerial larvicide applications are most commonly completed by rotary winged aircraft (helicopters) fitted with under-slung granular application equipment. There are two primary makers of this equipment, Simplex ™ and Chadwick™. Both manufacturers make use of a fiberglass 'hopper' to hold the granules and an externally mounted Honda™ or Briggs and Stratton™ 5 HP motor which operates the 'disc gate' or 'piston/ram' and the rotary, granule dispersal impeller. Both buckets are suspended below the aircraft, and from its secure cargo hook. The certified pilot or applicator, through a direct wire connection, controls the on and off operation of the bucket and the opening and closing of the application gate or ram. All aerial larvicide application equipment is supplied and maintained by the aerial contractor and is calibrated as directed by the equipment and product manufacturers.

The application rate is calculated by using the equipment's measured swathe width (impeller dispersal), the speed of the aircraft during application and the volume of granular material/per minute dispensed through the adjustable ram or gate opening. The distance of the ram or the disc opening can be adjusted to achieve the desired flow rate. The swath width is constant and is a function of the granule size. This equipment is specifically designed for the application of 'dry' products including grass seed, fertilizers and granular pesticides used for agriculture, forestry and public health.

Prior to aerial larvicide applications, pilots are accompanied on reconnaissance flights by control program personnel to review treatment and any avoidance areas. Treatment site locations are confirmed by GPS (Geographical Positioning System) coordinates provided by on-board navigation

equipment. These maps are unique, and constructed with multiple layers, including individual development site polygons, site identification, areas of avoidance and other features of note.

Maps can be uploaded into a computer tablet which is mounted in the helicopter prior to each treatment campaign. Using a moving map display technology, these maps, and the active tracking of flight paths which result, guides the application pilots to individual sites, displays their boundaries, and allows the pilot to visually monitor and record their treatments (swaths), as they complete them, and in real-time. This "live report" and the resultant digital record generated allows the pilot to visually confirm effective coverage of specified, targeted treatment areas. In addition to the tracking (plotting) of the entire flight path, additional data recorded includes elevation, distance, speed, time etc. Continuous radio contact is maintained between pilots and management personnel during all aerial larvicide applications.

A relatively new (<10 years), innovative method for applying mosquito larvicides by air is through the use of an emerging technology called Unmanned Aerial Vehicles (UAV) or Remotely Piloted Aircraft Systems (RPAS), more commonly known as "drones". These devices could be used when development sites are too small for aerial (helicopter) treatments and/or ground access is too difficult or dangerous. All UAV treatments would be conducted with adherence to Transport Canada Regulations, certifications and training requirements. Application rate using this technology would be similar to those employed for other aerial (helicopter) applications. Treatment areas are typically mapped prior treatment using a "scouting" drone and this information uploaded to the application drone. A digital record of the treated areas is generated by this equipment. It provides similar information to that of a traditional aerial application.

All ground-based larvicide applications to small and accessible sites are completed, where required, by hand broadcast or motorized back-pack type (leaf blower) applicator. Certified applicators achieve the label recommended application rates (kg/ha) by applying the larvicide granules and at the appropriate concentrations of granules/ft^2. For VectoBac 200G and VectoLex CG with application rates of 4.25 kg/ha, it is ~3 granules/ft^2, and for 7.5 kg/ha, it is ~5 granules /ft^2. These application rates have been demonstrated as effective under the conditions encountered at Salmon Arm. Individual catch basins would be treated using a single 10gm satchel of VectoLex WSP.

Before treating an area, applicators review available site maps, estimate the site size (m^2) and then perform a calculation to determine the volume of VectoBac 200G to be applied. With an application rate of 7.5 kg/ha, and a site size of 1000m^2, the applicator would measure out 750gms of VectoBac. Applicators then do their best to distribute the granules equally across the water surface while they move around the perimeter of larger and deeper sites, or as they walk through shallower (<30cm deep) sites and as they broadcast the granules by hand or with a back-pack applicator. The desired application rate is achieved by modifying the walking or throttle speed,

when using a backpack applicator, or by adjusting the frequency and number of "hand broadcasts" for granules being thrown across the surface by applicators.

As required by the BC *Integrated Pest Management Act* all larvicide applications are completed by personnel certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement*, or equivalent.

Larval mortalities of at least 95% would be considered successful. If required, and where indicated by post application sampling, additional, or expanded treatments of nearby areas would be completed to achieve desired efficacy.

3.6.2 Public, Worker and Environmental Protection During Mosquito Control Operations

To ensure public and worker safety, all conditions and restrictions governing pesticide applications covered under an approved PMP would be followed. Pesticide applicators will comply with regulations contained in the Pest Control Products Act, the Transportation of Dangerous Goods Act, the Integrated Pest Management Act, and other relevant government regulations.

WorkSafeBC regulations for occupational health and safety apply to workers who are registered or are required to be registered by WorkSafe BC. The regulations cover conditions of workplaces such as general safety procedures, hazardous substances, pesticides, confined spaces, protective clothing and equipment, tools and machinery.

The *"Workplace Hazardous Materials Information System"* (WHMIS) is a national system designed to protect Canadian workers from the adverse effects of hazardous materials by providing relevant information. All pest control products intended for use in a workplace require this information on the label or need to have a Material Safety Data Sheet (MSDS) prepared to be eligible for registration.

Pesticide handling, storage and application procedures would conform with those detailed on product labels, Material Safety Data Sheets and endorsed in the '*Pesticide Applicators and Dispensers Handbook*' and associated reference materials supplied through the BC Ministry of Environment. VectoBac 200G and VectoLex CG granules would be used for exclusively for aerial and ground-based mosquito control.

The District of Elkford has ensured that the mosquito control program is well advertised to area residents and business operators during its thirty years of annual operation. Many homeowners are long-time residents and very familiar with the control program. Brochures, newspaper articles and regular interaction with control program personnel provides the public with current and accurate information on program operations. Treatment site histories including treatment maps and data tables are accessible to the public through City of Salmon Arm offices.

Landowner permission to survey, monitor and treat infested larval mosquito habitats located on private property is confirmed each season. Treatment of developing larval mosquito populations in waterbodies on public lands are permitted under this approved PMP.

Program personnel will take all practical precautions to protect application personnel, the environment and the general public during all pesticide applications. Prior to any pesticide application field personnel:

- Confirm the boundaries and/or locations of 'AVOID' areas, including surface (drinking) water intakes or wells, which would be physically marked with flagging tape, ribbons or suitable equivalent, if required.

- Confirm AVOIDANCE areas, including private properties wishing exclusion from program operations, permanent, flowing fish-bearing waters or areas of identified, protected areas of environmental sensitivity (ie. bird nesting sites, amphibian refuge areas). Where appropriate, identify the locations or boundaries with flagging tape, ribbons, or suitable equivalent.

- Community watersheds will be determined by accessing the BC Ministry of Environment Community Watershed listings and informational website:
  www.gov.bc.ca/wsd/data_searches/comm_watersheds/index.html

- A listing of registered groundwater Wells and Aquifers and an interactive map of active wells is available at:

www2.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers

- Larvicides will not be applied to finished drinking water and no Pesticide Free Zones are required for bacterial pesticides as indicated in Section 71(12) of The Integrated Pest Management Act and Regulations. Potable (drinking) water well locations and water intakes will be identified with the property resident/owner prior to any VectoBac 200G treatments.

- Review pesticide product label and comply with recommended precautions regarding pesticide handling and application, safety gear, weather restrictions (wind, temperatures, etc) and other listed precautions.

Applications of VectoBac 200G and VectoLex CG to within 10 metres of fish-bearing waters, or waters contiguous to fish–bearing waters, and potable waters or wells is anticipated. Waters contiguous with fish bearing water may be treated, as permitted on the Health Canada, Pesticide Regulatory Management Agency (PRMA) approved product labels.

3.6.3 Post Application Monitoring

Larval dip sampling, light trap collections and landing/biting counts completed by field personnel, where appropriate, would be employed to evaluate post-application larval control results.

Within hours (typically 02-96) after (post) treatment with VectoBac 200G, larval mosquito mortalities would be confirmed through monitoring using a standard 350 ml mosquito dipper. The goal is for larval population reductions of 95%, or to levels averaging less than <<1 larvae/350ml dip sample.

Post-application monitoring confirms treatment success and allows for the 'touch-up' treatment of any areas which may have, for reasons of geography, vegetative cover or access, received inadequate application coverage. Additional, or expanded treatments of nearby areas would be completed to achieve desired efficacy.

VectoLex post-application monitoring is completed 5-10 days following application, and then weekly to determine if additional treatment is required. VectoLex mortality is not as immediate as VectoBac, and its effectiveness is determined by the absence of developing fourth instar larvae when monitored post application. Because of its recycling in dead mosquito larvae, the appearance of fourth instar larvae indicates that concentration of VectoLex is insufficient to effect control.

In addition, adult mosquito populations may be monitored at select locations, both within, and outside control program boundaries to compare populations within the 'controlled area' with those outside. Given the difference in individual tolerances to mosquito annoyance, determining the success of larval controls in limiting adult mosquito nuisance would also include resident reports, interviews and requests for service. The goal of the District of Elkford Mosquito Control Program is to reduce adult mosquito nuisance populations to tolerable levels.

4.0 QUALIFICATIONS OF PROGRAM PERSONNEL

This annual program would be managed by environmental consultants experienced in integrated pest management. Control program management personnel would be Registered Professional Biologists (RPBio's). Field personnel typically include University and College graduates or senior Co-Operative Education students studying within the disciplines of biology and environmental science.

The environmental consultant will have the necessary Pesticide Vendor and Service Licenses to work with the City of Salmon Arm in delivering safe, effective and sustainable mosquito control services. All personnel working in the annual mosquito control program will be certified in the appropriate category as pesticide applicators through the BC Ministry of Environment.

5.0 LARVICIDE HANDLING AND APPLICATION

As required by the *Integrated Pest Management Act* (*IPM Act*), all personnel handling and applying larvicides for the annual mosquito control program would be certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement or, Ground Application of Bacterial Pesticides for Mosquito Control*. Application pilots will be certified by the BCMOE in the category of *Aerial Application of Granular Bacterial Pesticides for Mosquito Control,* or equivalent. Larvicide applicators will comply with regulations contained within the Pest Control Products Act, the IPM Act, the Transportation of Dangerous Goods Act and other relevant government regulations.

Larvicide handling, storage and application procedures would conform with those detailed on product labels and endorsed in the '*Pesticide Applicators and Dispensers Handbook*', the "*Canadian Pesticide Education Program Applicator Core Manual*" and associated reference materials supplied through the BCMOE. This PMP does not attempt to duplicate all the information contained within this handbook and other references. The 'Acts', handbook, product labels and any other resource materials detailed above, and in other sections of this PMP would be reviewed before handling, transporting, storing or applying larvicides.

The following sections provide details on procedures and protocols which will protect the public and the environment during larvicide transportation, storage, handling and applications. Only bacterial larvicide products are proposed for use in this mosquito surveillance and control program. No Pesticide Free Zones (PFZs) are required for bacterial pesticides as indicated in Section 71(12) of *The Integrated Pest Management Act and Regulations.*

Prior to any larvicide application field personnel are responsible to:

5.1 Larvicide Transportation

During transportation, all larvicides would be secured to prevent an accidental spillage or theft. Granular larvicide (VectoBac 200G, VectoLex CG products would be secured and handled to prevent tearing of bags, spillage and exposure to adverse weather conditions such as precipitation.

Applicators would typically only transport the minimum amounts of pesticide required to complete the proposed treatments. With granular products, it is common for field personnel to require less than forty kilograms of VectoBac 200G or VectoLex CG for a typical workday. The exception to this rule is during aerial applications where larger volumes, typically 450-500 kg of larvicide may be transported from its secure storage area to the helicopter staging areas.

Larvicides would not be transported in the passenger compartment of a vehicle and would remain separate from food, clothing or similar items during transport. Any applicator who has product

stolen or removed from his/her vehicle would follow the notification procedures for the appropriate authorities immediately, including police.

5.2 Larvicide Storage

The City of Salmon Arm can provide secure, dry, well-ventilated pesticide storage space for mosquito control program larvicides within their secure public works facility. The majority, over 95% of larvicide required for each season is delivered in late April and consumed between May and July. No large volumes of larvicide are stored on-site over the winter. In an average year, less than 200 kg of VectoBac and VectoLex, are stored and available for program start-up in late April.

Emergency telephone numbers for police, fire, ambulance, Canutec, Dangerous Goods Emergency Spills, Poison Control, and the BC Ministry of Environment are posted on-site at the storage facility and available at Public Works offices

5.3 Larvicide Mixing and Loading

Applicators will follow the directions and precautions provided by the manufacturer on product labels and for pesticide use as described above and in other, relevant references. Any avoidance areas, pesticide free zones or buffer zones would be identified prior to larvicide application.

VectoBac and VectoLex granular larvicides are 'ready to apply'. No larvicide mixing is required. All used and empty bags would be disposed of in municipal or regional landfills as directed by the manufacturer on the Pesticide Management Regulatory Agency-approved pesticide label and MSDS sheets.

All handling of pesticides would be conducted in level, well ventilated, outside areas under conditions or minimal winds and no precipitation. VectoBac and VectoLex bags are emptied directly into the 'hopper' when it is on the ground and between aerial applications. In the event of accidental spillage personnel would follow accepted spill containment, clean-up and reporting procedures. With granules this typically involves recovery with brooms and dustpans or shovels. This 'recovered' larvicide would be used for the treatment of intended habitats.

If implemented, aerial larvicide applications would be completed by a minimum two-person team. UAV drone applications would be completed with adherence to Transport Canada guidelines which. at time of writing requires a 3 person team. Larvicide applications to smaller sites would be completed by hand broadcast or backpack applicator. Field personnel would wear appropriate safety gear, including the appropriate respirator, ear protection, rubber gloves, boots, non-absorbent coveralls and other protective equipment as indicated by pesticide labels, MSDS, WorksafeBC, the City of Salmon Arm, and the manufacturer.

All work staging (bucket loading) areas are located as close to proposed treatment sites as possible. These areas may include secure, fenced and gated private and business properties, public and private airfields, farm fields and publicly inaccessible, or limited access areas, with permission.

5.4 Equipment Maintenance and Calibration

Ground-based applications of VectoBac 200G and VectoLex CG are completed by hand broadcast or motorized backpack (leaf blower) applicator. VectoLex WSP, is a pre-measured (10gm) pouch, applied directly to water holding catch basins through the grates.

All aerial (helicopter) larvicide application equipment is supplied and maintained by professional third parties and the aerial contractor. Application equipment is calibrated immediately prior to use by the pilot and/or certified program personnel.

5.5 Larvicide Application Procedures

Pesticide application protocols and procedures, including public education, surveying and monitoring, larval identifications, site assessment, pesticide handling and treatment methods detailed in the various sections of this Pest Management Plan, the various legislations, regulations and as recommended in reference materials would be followed to ensure the safe and effective control of mosquito populations.

The control program is not intended to eliminate the mosquito population, nor could it, and as such landowners and residents who want to be excluded from the control are recorded and their wishes respected. Since the majority of larval mosquito habitats are located on private property, landowner permission to survey, monitor and treat is confirmed each season.

Weather forecasts would be consulted, and current weather conditions (wind speed, temperature, precipitation) would be noted, and recorded, during all larvicide (ground or aerial) applications. In the event that wind speeds during larvicide applications are sufficient to cause the displacement, or drift, of granular larvicides outside of the treatment area, applications would be suspended until suitable conditions return. Similarly, should precipitation be sufficient to cause larvicide (corn cob) granules to clump and clog equipment, aerial applications will be suspended until suitable conditions return. Ground-based applications are seldom impacted, except in conditions of heavy or extreme precipitation and under those conditions applications could be suspended until suitable conditions reoccur. Extreme thunder and or lightning conditions would result in the suspension of aerial, and possibly ground-based applications until suitable conditions return.

Due to the low toxicity of bacterial larvicides, applications may be conducted within riparian areas and sensitive wildlife habitat. Applications of VectoBac and VectoLex to within 10 metres of fish-bearing waters and potable (drinking) water sources is anticipated and as permitted on the Health Canada, Pesticide Regulatory Management Agency (PRMA) approved product labels. Pesticide free

zones are not required and applications of VectoBac 200G and VectoLex CG may be completed in ephemeral waterbodies that are intermittently contiguous with fish-bearing waters (*i.e.* Impounded, receding flood or seepage waters).

6.0 MOSQUITO CONTROL PROGRAM SYNOPSIS

The mosquito control program developed for the City of Salmon Arm utilizes a pro-active, integrated approach which focuses on larval mosquito surveillance and controls. The City of Salmon Arm larval mosquito control program is not intended, nor would it be possible, to eliminate the local mosquito population. An appropriate scope of operations and timely treatment of larval mosquitos, at their source, will suppress overall mosquito populations and potential adult mosquito nuisance.

Public education during the term of this PMP could involve regular news media exposure, public information meetings, pamphlets and notice boards, field personnel interaction with residents, farmers and business operators. These contacts ensure ongoing public awareness of program operations and encourage the general public to report mosquito annoyance, potential larval development sites and input into their control program.

Regular monitoring and treatment of larval mosquitos is a key element to control program success. Upwards of 100 hectares of slow draining sloughs, natural ponds and snowmelt or precipitation-filled mosquito depressions located in fields, forested and undeveloped areas adjacent to the City are a source of extensive mosquito development. These areas must be identified early and regularly surveyed during a control season to ensure timely detection of larval development. Additional permanent larval mosquito development habitat includes landscape and irrigation or display ponds, ditches and standing pools.

The total winter snowpack accumulated in area mountains affects the extent of snowmelt runoff and subsequent larval development in low-lying fields, swamps, sloughs, and depressions in area fields and forests. The persistence and size of these sites is influenced by a number of factors including drainage, soils, precipitation, daily temperatures and humidity. These weather parameters also have an effect on adult mosquito activity and survival rates. The greatest cause of adult mosquito mortality is desiccation as a result of high temperatures and low humidity. Snowpack accumulations, rate of melt, and its effect local river, lake and creek levels is continually monitored beginning in January of each season. Local weather conditions and their effects on larval and adult mosquito populations are assessed throughout the season.

Surveying, monitoring and control of larval mosquito infestations would begin as early as April and continue through August. Program methodologies would continue to concentrate on larval control initiatives with a goal to reduce the extent of standing water development habitats and the application of the biorational larvicides, VectoBac 200G and VectoLex CG. These larvicides are the

safest and most effective products available for use in the City of Salmon Arm Mosquito Surveillance and Control Program. VectoBac 200G, VectoLex CG maximize the environmental compatibility of the mosquito control program since they are the least toxic, least persistent mosquito control products available. They would be used in circumstances where control is essential and other options such as physical or cultural control are not practical.

Evaluation of the program in terms of effectiveness and ability to satisfy the needs of the general public is conducted as an on-going process. Adult mosquito population monitoring and feedback from area residents and businesses would be collected as part of control program operations. It allows for the evaluation of larvicide efficacy and provides control personnel with information useful in the location of any previously undetected larval development habitat.

The cooperation and support of local businesses, farmers and property owners for this annual program is indicative of true community spirit and support for a successful program which has benefited workers, residents and visitors to Salmon Arm for over twenty years.

7.0 LITERATURE REVIEWED AND BIBLIOGRAPHY

American Mosquito Control Association 1973. Elements of Comprehensive Mosquito Control. Mosquito News. Vol. 3, No. 18, 86pp.

BC Centre for Disease Control (BCCDC), 2002. Draft 2.1: Arbovirus Surveillance and Response Guidelines for British Columbia, BCCDC, Vancouver, BC, 2pp.

BC Centre for Disease Control website: `http://www.bccdc.org`

B.C. Ministry of Agriculture and Food, 1984. Mosquito Control Guide. Queens Printer, Victoria.

B.C. Ministry of Environment 2016. Pesticide Applicators and Dispensers Handbook and all associated reference materials supplied by the Pesticide Management Branch of the BCMWLAP. Queens Printer, Victoria.

Belton, P., 1983. The Mosquitos of British Columbia. British Columbia Provincial Handbook No. 41, 189pp. also Belton, P. @ website: http://www.sfu.ca/~belton/

Darsie, R., 1981. Identification and Geographical Distribution of the Mosquitoes of North America, North Mexico, American Mosquito Control Association, 313pp.

Duka Environmental Services Ltd. 2018-2019, City of Salmon Arm, Nuisance and Vector Mosquito Control Program Summary Reports.

Duka Environmental Services Ltd. 2020-2024, City of Salmon Arm, Nuisance and Vector Mosquito Control Program Summary Reports.

Duka Environmental Services Ltd, April 2020: City of Salmon Arm. Pest Management Plan; Mosquito Surveillance and Control Program, PMP # 501-0006-2020/2025. BCMOE Pesticide Use Notice Confirmation # 501-0006-20/25, expiry 15 April 2025

Ellis, R.A., 1985. Survey of Approaches Taken to Mosquito Control by other North American Jurisdictions, City of Winnipeg Parks and Recreational Branch, 19pp.

Ellis, Roy., 21 May 2001. Municipal Mosquito Control Guidelines, Health Canada Bureau of Infectious Diseases, 54 pages.

Environment Canada: http://climate.weatheroffice.ec.gc.ca/climateData/dailydata

Fang, Janet. 2010. Ecology. A World without Mosquitos. Nature 466: 432-434

Fyfe, M., 2004. Arbovirus Surveillance and Response Guidelines for British Columbia, Draft 4.1., BC Centre for Disease Control, Vancouver, BC, 46p., www.bccdc.org

Gonsalves, Leroy., Brian Bicknell, Brad Law, Cameron Webb & Vaughn Monamy. 2013. Mosquito Consumption by insectivorous bats. Does Size Matter. PloS one 8 (10) 00;e77183

Lacey, L.A., M.S. Mulla., 1988. Safety of Bacillus Thuringiensis ssp. Israelensis and Bacillus Sphaericus to Nontarget Organisms in the Aquatic Environment, 19pp.

Regan, D.G., et al., 1980. Investigations into the Use of Three Spined Stickleback Fish as a Mosquito Control Agent. Appendix to Lower Mainland Regional Districts' Mosquito Control Board Report, 18pp.

Regan, D.G., Harvey, D. et al., 1982. Use of Bacillus var. israelensis as a mosquito control agent. Can. Journ. Env. Hlth. Review, 14pp.

Service, R., 1976. Mosquito Ecology: Field Sampling Methods. Halsted Press, Toronto, 583pp.

Walker, N., 2003. Presentation at Oct. 5-8 2003 Meeting of Society of Vector Ecology annual Conference. Coeur d'aLene, Idaho.

Wood, D.M., Dang, P.T., Ellis, R.A., 1979. The Insects and Arachnids of Canada; Part 6, Diptera; Culicidae. Canadian Government Publishing Centre, Ottawa, 390pp

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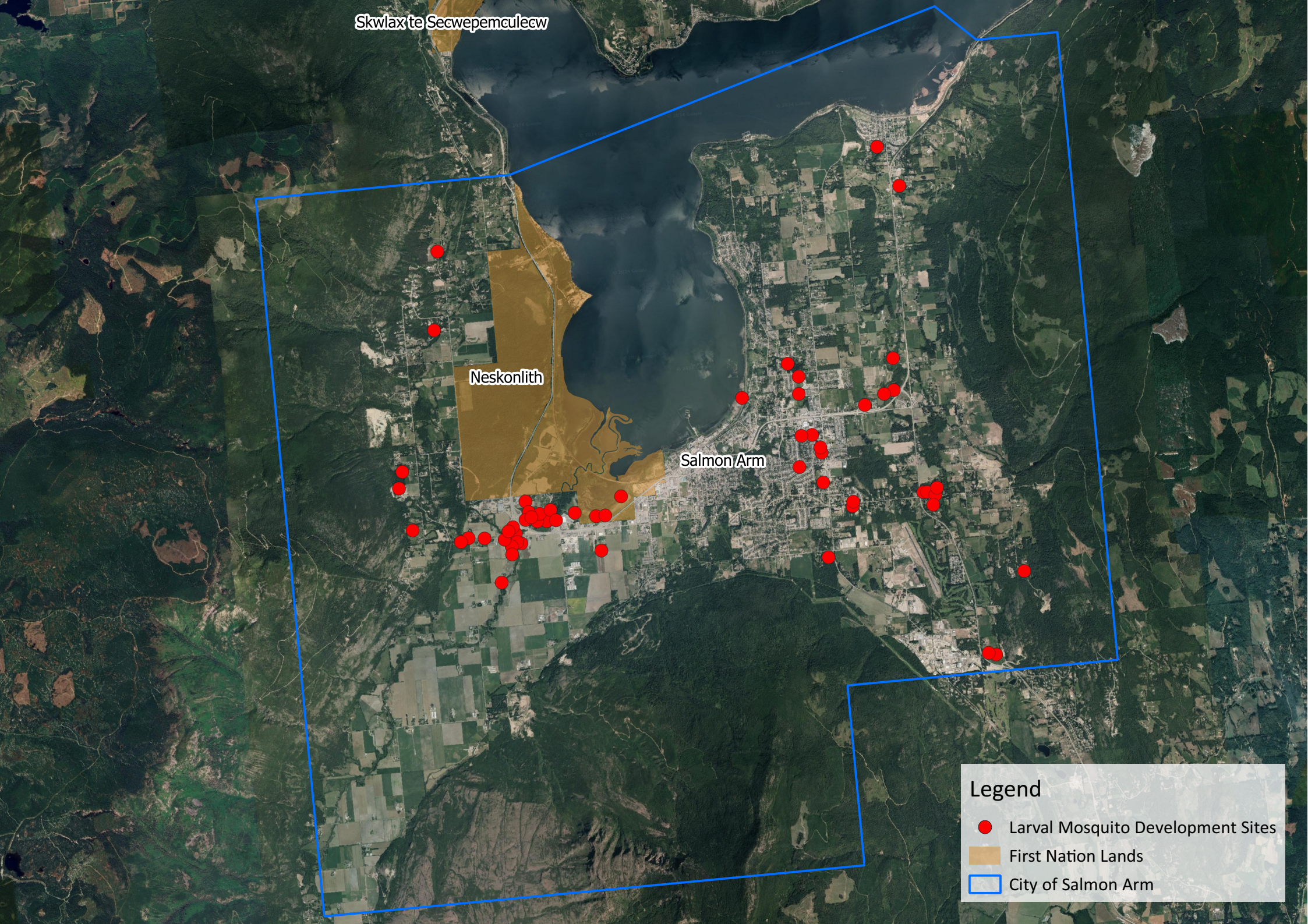
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