CITY OF DELTA

MOSQUITO POPULATION MANAGEMENT AND CONTROL PROGRAM

INTEGRATED PEST MANAGEMENT PLAN

2026 – 2031

PMP # 700-0006-26/31

Plan Prepared by

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Surrey, BC

Prepared for
The City of Delta
Climate Action and Environment
Delta, British Columbia

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TABLE OF CONTENTS

1.0 PEST MANAGEMENT PLAN SUMMARY

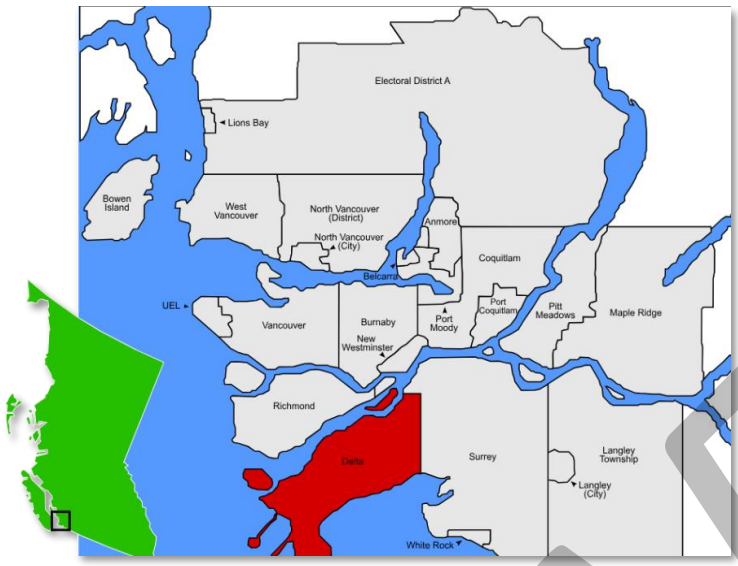
The City of Delta and surrounding area has significant recreational and environmental value, providing residents and visitors with many outdoor summer activities and employment. Walking, running, cycling, bird watching, outdoor sports, golfing and gardening are just a few of these. Adult mosquito annoyance can often conflict with these activities and potentially impact public health. Besides the negative impacts on the lifestyle and well-being of residents, there can also be considerable economic impact from mosquito annoyance on local businesses. An integrated pest management (IPM) approach to mosquito population management and control can reduce overall annoyance levels and co-exist with these valuable resources.

The annual mosquito population management and control program provided by the City of Delta (Delta) would employ a comprehensive, Integrated Pest Management (IPM) approach to control. This approach focuses on the timely detection and treatment 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. Where required, larval mosquito populations would be controlled using the bio-rational larvicide product VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis,* PCP #18158) and VectoLex (*Bacillus sphaericus,* PCP # 28008, 28009). All treatments would be completed in accordance with the methodologies and procedures prescribed in the BC Ministry of Environment-accepted Pest Management Plan for Mosquito Population Management and Control, prepared by *Duka Environmental Services Ltd.* on behalf of the City of Delta for the years 2026-2031.

Mosquito control services are provided to residential and rural property owners, businesses, municipal and regional parks, sports fields, golf courses and other outdoor recreational and tourist facilities located within the municipal boundaries of Delta. The goal of the annual mosquito control program is to reduce the potential for widespread adult mosquito annoyance for the benefit of residents, workers and visitors to Delta. The mosquito control program proposed for the years 2026-2031 is largely unchanged from that of past seasons and focuses on larval control and reduction of populations. This Pest Management Plan (PMP) meets all the requirements of the *Integrated Pest Management Act* and will replace the previously approved, and soon to expire (April 2026), PMP # 700-0005-21/26.

PMP # 700-0006-26/31 reviews mosquito biology, the types of larval mosquito habitats affecting the program area and the local mosquito species complex. An IPM 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 their habitat, where appropriate, for the purpose of preventing mosquito annoyance for area residents and visitors. Important biological concepts, operational procedures and protocols are purposely repeated throughout the document.

1.1 Geographic Boundaries of this Pest Management Plan



Delta is located within the Fraser Valley Lower Mainland, south of the Fraser River and the Municipality of Richmond, and west of the City of Surrey. It encompasses a total area of some 364 km^2 or 36,400 hectares and is home to over 100,000 people. Larval mosquito habitats within this area include river flood and seepage areas, freshwater marshes, ponds and ditches located in low-lying forested areas, farm fields, undeveloped areas, along roadsides and salt marsh habitats located along the Boundary and Mud Bay areas. Additional larval development habitats include roadside catch basins and temporary sites such as water-filled tire ruts, depressions, un-used or abandoned pools or boats, canoes and containers.

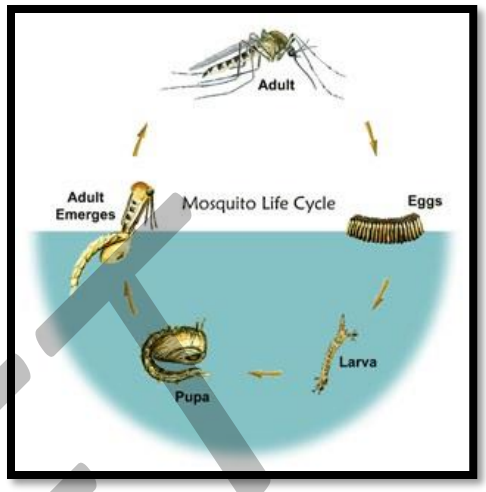
The southern and western boundaries of Delta are defined by Point Roberts (USA) and the Pacific Ocean: Boundary Bay and Mud Bay to the south and Roberts Bank to the west. With a rich farming and agricultural history, Delta contains three distinct community centres where residential, commercial and light industrial businesses are concentrated. These are Ladner, Tsawwassen and the North Delta /Tilbury areas.

These four distinct areas provide a varied mixture of farmlands, sport fields and parklands, golf courses, natural forested areas, creeks, swamps, ponds, coastal beaches, mudflats and salt marshes. The largest raised peat bog (Burns Bog) in North America is located roughly in the centre of Delta, between the Fraser River to the north and Boundary Bay to the south, and between the communities of Ladner and North Delta. Recreational summer activities include organized sports (baseball, football) camping, hiking, fishing, boating, bird watching, swimming, sight-seeing, photography, cycling and golfing. Widespread annoyance from adult mosquitos detracts from outdoor enjoyment and worker safety.

In addition, the Tsawwassen First Nation (TFN) is located adjacent to Delta, south of Roberts Bank and near the BC Ferries terminal. TFN is a distinct community outside of the municipal boundaries of Delta and is approximately 660 hectares in size and home to about 2200 residents. Residential and commercial development on TFN lands has added upwards of 1500 additional residents and a large shopping mall development. TFN operates a nuisance mosquito control program for the residents and businesses of their own community, independent of the City of Delta.

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 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 inundated.

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 necessary blood meal to complete the development of her eggs. Any container, pond, or depression, either natural or manmade, which is capable of holding water for several days, to a few weeks, can provide development habitat for larval mosquitos.

Mosquito development occurs in a wide range of larval habitats ranging from salt marshes, snowmelt and precipitation-influenced flood and seepage water pools and channels along rivers and lakes to 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.

1.3 Need for Mosquito Control

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. A few years ago (2019), 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. Locally in British Columbia, the recent discovery (July 2025) of a

"cluster" of Jamestown Canyon virus and Snowshoe Hare virus infections in several residents of Squamish, BC (BCCDC, July 2025) has increased concerns for invasive species and disease range expansions.

The BC Centre for Disease Control (Vancouver) and local health authorities are responsible to coordinate the ongoing surveillance, identification and reporting of WNv, ZIKV, and new or emerging diseases, and their mosquito vectors. As part of this planning the BCCDC has developed the *Arbovirus Surveillance and Response Guidelines for British Columbia,* and the BCCDC has a provincial database containing all mosquito, bird and human health surveillance data relating to WNv with ongoing updates for other, new vector mosquito species.

Due to the low and stable incidence of 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. Human clinical testing will continue. Human clinical testing continues as part of routine blood donor collection programs. Dead birds such as crows and ravines are tested when WNv is suspected and horses are also tested, on a case-by-case basis, by provincial veterinarians. Specific details on the response guidelines, surveillance, permitting, and other related information is available online through http://www.bccdc.ca/. 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 purpose of the annual mosquito control program provided by the City of Delta for its' residents, workers and visitors is for relief from extreme, and/or persistent adult mosquito annoyance. This is achieved through larval control initiatives and the resultant suppression of local mosquito populations. The annual control program is not intended to, nor is it possible to eradicate local mosquito populations.

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. 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.

Although not a common occurrence in most areas of British Columbia, but as noted above, locally occurring mosquitos are capable of transmitting (vectoring) diseases. A well organized and effective larval mosquito control program is important to limit the potential for both, widespread adult mosquito annoyance, and potential for disease transmission. Despite the best of efforts though, some adult mosquito annoyance may still occur during the months of June through August, and residents are encouraged to avoid areas of mosquito harbourage (typically treed, forested or

landscaped areas) during certain times of day, and to use repellents and approved adult mosquito control devices and products as per label directions.

The goal of the annual mosquito control program is to provide residents and visitors to the City of Delta area with relief of adult mosquito annoyance through proactive larval mosquito control using an Integrated Pest Management (IPM) approach to surveillance and control. However, since mosquitos capable of vectoring diseases to man are often the source of localized annoyance (human biting), the control of mosquito populations known to cause nuisance also provides the benefit of controlling mosquito species having the potential to vector disease, including WNv. An effective, pro-active mosquito control program which focuses on the identification, prevention, or timely control of larval mosquito populations, also contributes to the protection of public health.

The City of Delta Mosquito Population Management and Control Program Pest Management Plan, PMP # 700-0006-26/31, described in detail below, is presented in a format which adheres to the requirements of *Integrated Pest Management Act and Regulation*, including amendments, the *Mosquito Management Sector Review Paper* and BC Ministry of Environment, Integrated Pest Management Program (2007) Guidelines for IPM Proponents Conducting Consultations with First Nations. Copies of these documents may be accessed through the BC Ministry of Environment home page at https://www2.gov.bc.ca/gov/content/environment/pesticides-pest-management. Common themes of larval development identification, prevention and control necessary to achieve the program's goals, while ensuring environmental protection, are repeated throughout this document.

The Pest Management Plan is 'owned' by the City of Delta. It would remain in place for the purposes of larval mosquito population management and control for the five-year period, 15 April 2026 to 14 April 2031. The mosquito control program and methodologies developed within this PMP are a hybrid of approaches adapted from 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.

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 professional, experienced, environmental services firm (the consultant) is retained by the City of Delta to deliver these very specialized services and to ensure adherence to the Pest Management Plan. The consultants for the City of Delta annual mosquito control program would have Registered Professional Biologists 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, is available to the general public in a variety of forms including notice boards, informational brochures, websites, newspaper articles, websites open-houses, council meetings and farmer's markets etc. Resident requests for service are followed up with telephone contact and site inspection. Physical reduction, elimination or alteration of larval mosquito development habitats is an important aspect of the control program. Wherever possible, and practical, property owners were advised of measures they could undertake to reduce mosquito development and annoyance from adult mosquitos. 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 (PMP)

A five-year period, extending from 15 April 2026 to 14 April 2031.

The designated contact for this Plan is Ms. Sarah Howie, Manager, Climate Action and Environment, City of Delta, 4500 Clarence Taylor Way, Delta V4K 3E2. Telephone # 604-946-3279.

2.0 MOSQUITO CONTROL PROGRAM BACKGROUND

Mosquito control in Delta was first undertaken in 1980-1981 when in-house Environmental Department personnel completed initial surveys and treatments using Abate 2G (Temephos, an organophosphate) in Tsawwassen and Mud Bay salt marshes in response to resident reports of nuisance by area residents. Beginning in 1982 the City began to contract the work to outside environmental consultants with specific pest management experience.

Control program operations have always sought to reduce adult mosquito annoyance for residents in North Delta, Ladner and Tsawwassen to acceptable, tolerable, levels. Over these forty-five seasons the annual program has continued to evolve to increase its environmental compatibility, its effectiveness, and its affordability for Delta residents. The City of Delta annual mosquito control program has always been one of innovation and adaption.

Delta has been involved in several larvicide research trials including Federal regulatory agencies such as the Environmental Protection Service (EPS), Agriculture Canada, the Pest Management Regulatory Agency (PMRA) and the provincial BC Ministry of Environment, Integrated Pest Management Branch, with regards to the Canadian Pest Control Products Act (PCP) registration of the bio-rational larvicides VectoBac (*Bacillus thuringiensis* var. *israelensis*) and VectoLex (*Bacillus sphaericus*). These products are now the most widely used bio-rational larvicides in North America and developed countries throughout of the world. The establishment of predictive indices for larval mosquito development, particularly for *Aedes* mosquitos, using river freshet and tidal height

fluctuations were first developed at Delta, and modified over the past forty seasons to effectively forecast the onset of larval eclosion (hatching) and distributions, both temporal and by location.

The first 21 years of mosquito control at Delta were focused exclusively on nuisance mosquito control efforts. Beginning in 2003, mosquito control was expanded with increased surveillance, development site identification, mapping and the inclusion of new habitats, such as catch basins, which had previously never been considered for routine larval mosquito control. These expansions of surveillance and control activities occurred province-wide and with provincial funding support for the purposes of preventing disease occurrence, specifically, West Nile virus. 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) is responsible for coordinating the province's response should WNv occur in BC.

The annual mosquito control program provided by the City of Delta focuses 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.

The largest sources of mosquito development within Delta, totalling some +20 hectares, are two salt marsh habitats located along Boundary Bay and Mud Bay. Another large saltmarsh habitat exists at the TFN adjacent, and to the north of the BC Ferries Highway 17 causeway. Additional habitats include Fraser River flood and seepage areas, natural sloughs, marshes, ponds and manmade irrigation and display ponds, ditches, roadside catch basins and temporary habitats along public roadsides, in parks, on private properties and in farm fields and undeveloped lands. Figures 1–4 present the primary sources of larval mosquito development (salt marshes) and other, smaller larval habitats known in the Delta.

Approximately 80 hectares of potential nuisance mosquito development habitat have been identified within control program boundaries. There are over 100 larval development site locations and some +120 sites, excluding the multiple pools, ponds and channels of salt marsh habitats.

The mosquito control program and methodologies (the PMP) developed for Delta 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. A variety of monitoring and control methods, including physical site reduction or modification and the use of biological control products support the principles of an Integrated Pest Management (IPM) approach to mosquito control. They are the most effective means of reducing adult mosquito populations and the potential for annoyance or disease transmission. This IPM protocol consists of five components:

1) Public Education which explains mosquitos, the program, and how the public can contribute to successful operations.
2) Surveillance and identification of mosquito species and their distribution.
3) Timely implementation of mosquito controls and preventative measures.
4) Review of results achieved and adaptive management during a season.
5) Evaluation and assessment to ensure sustainable, effective controls have been achieved.

The annual mosquito control program focuses 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.

2.1 Primary Land Use

The primary land uses of the areas contained within the control program are agricultural, residential, light industrial and commercial properties (lumber yards, landscaping, shopping malls), recreational (golf courses, passive parks, sport and playing fields, etc.), forested and undeveloped lands. In addition to organized sports activities, outdoor summer recreational activities include walking, hiking, photography, golfing, camping, fishing, boating, sight-seeing and bike riding.

2.2 Mosquito Species Identified within Delta

Mosquito development occurs in a wide range of open water larval habitats, ranging from tidally influenced flood and seepage water pools and channels to permanent freshwater, ponds, marshes, ditches and similar water-holding depressions. Birdbaths, plugged rain gutters, livestock watering troughs, irrigation and surface water run-off collection ponds, ditches and any other man-made container or excavation capable of holding water for a period of at least seven to ten days can provide suitable larval mosquito habitat. Left undetected, larval mosquitos will complete their development to adult within this time span.

Mosquito species collected locally from Delta include:

Aedes communis	*Aedes pullatus*	*Anopheles earlei*
Aedes dorsalis	*Aedes riparius*	*Coquillettidia perturbans*
Aedes implicatus	*Aedes sticticus*	*Culiseta alaskaensis*
Aedes nigripes	*Aedes vexans*	*Culiseta impatiens*
Aedes provocans	*Anopheles punctipennis*	*Culiseta incidens*

Culiseta inornata *Culex pipiens* *Culex territans*

Culiseta morsitans *Culex tarsalis*

Aedes mosquitos comprise 20-40% of annual sample collections, depending on environmental conditions. They are aggressive biting pests which prefer both permanent or recurring habitats, such as salt marshes (*Ae. dorsali*s), and temporary habitats (*Ae. vexans, Ae. sticticus, Ae. increpitus*), including surface water runoff, freshwater seepage, floodwater, and precipitation accumulations in low-lying fields, backwater sloughs, marshes, and deciduous forests. *Aedes* mosquitos lay their eggs in moist soil along the edges of recently flooded areas, where the eggs can lay dormant for upwards of twenty years. Following a period of wetting, and drying, eggs become "primed" to hatch. *Aedes* larvae, once inundated can hatch out in large numbers with populations typically ranging from 50-100 larvae/dip sample although + 200 larvae/dip sample isn't uncommon. Developing in response to fluctuating water levels occurring with river freshet and regular tidal fluctuations, *Aedes* mosquitos are the most numerous during the first half of the season, from late April through July. Receding river levels, decreasing tides and increasing ambient temperatures, evaporation and decreased precipitation typical to late July and August causes many of these habitats dry, drain and disappear.

Culex and *Culiseta* mosquitos 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 day length and temperatures. They prefer permanent and slow-draining, or frequently refilled sites including natural and man-made irrigation and display ponds, ditches and containers such as stored tires, boats and buckets or livestock watering troughs. *Anopheles* mosquitos prefer permanent sites or slow draining and flowing ditches or stream margins. Larval populations typically range from 1-20 larvae/dip sample and multiple, or recurring hatches are possible with additional egg laying by adult females. 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 freshwater habitats including manmade containers and they are the predominant (+99%) mosquito developing in catch basins.

Culex, Culiseta and *Anopheles* are the most numerous during late summer when drier conditions and warmer conditions typically exist. Although their populations and individual development sites are not usually as large as the synchronous hatching *Aedes* mosquitos, *Culex* and *Culiseta* mosquitos are capable of producing several generations in a typical season. 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 above are able to develop as multiple hatches during the season. With the exception of *Cu. territans*, all are capable of causing reportable and often extreme annoyance, particularly *Aedes,* and locally collected *Ae. dorsalis*, *Ae. vexans* and *Ae. sticticus* are all 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 Centres for Disease Control (BCCDC) and the Centres for Disease Control (Atlanta, USA) as three of the primary vector vectors of WNv in North America. Control of locally occurring *Aedes*, *Culex* and *Culiseta* mosquitos not only prevents widespread nuisance for the benefit of residents, businesses and visitors, but also contributes to the protection of public health.

2.3 Mosquito Control Program Implementation

In response to resident, workers and visitor reports of recurring adult mosquito annoyance, the City of Delta has worked to provide an effective nuisance mosquito control program for residents, workers and visitors, annually for nearly forty years. During this time the program has evolved to become an example of environmentally sound, and sustainable mosquito control using an IPM approach. This methodology incorporates public education, development site identification and categorization, surveillance, prescriptions for alteration or modification, and where required, larval mosquito control completed using the safest, most effective biological control agents available.

Ongoing mosquito development site surveys, monitoring and identification of larval and adult mosquito specimens updates the local mosquito species complex and development site database. Identified mosquito habitats are monitored throughout the season, typically from late April through August, to assess the abundance and species of mosquitos developing in them. New Jersey or CDC (Atlanta) light traps and standardized mosquito biting and landing counts are used to sample and monitor adult mosquito populations. During the course of program operations many development habitats have been eliminated and many others created.

Over one hundred natural and man-made larval mosquito development habitat areas, several with many individual sites, have been identified within the City of Delta, Figures 1 - 4. Ranging in size from less than $10m^2$ to over 25 hectares in total treatment area, these sites vary in description from a single, roadside ditch, irrigation or golf course display pond to salt marsh habitats which may contain a hundred or more individual, temporarily filled ponds, ditches and depressions. Flooding and seepage water accumulations from spring and summer tides provide extensive habitat for repeated *Aedes dorsalis* larval development in area salt marshes. Stagnant and non-flowing ponds and ditches, most of them manmade or influenced, provide ideal freshwater larval mosquito development habitat and often have the greatest diversity of species. Catch basins are located throughout the community along roadsides, in parking areas and in non-playing and passive grass areas at sports fields and ball diamonds.

Other habitats such as bird baths, buckets, stored boats, livestock watering troughs, tires are not treated as part of routine control program operations. When discovered, physical control of these habitats can be easily accomplished by removal of the container or for bird baths or watering troughs, regular drainage and refilling. This prevents larval mosquito development and subsequent adult mosquito annoyance. Public education activities encourage property owners to survey their properties and identify these types of habitat.

Adult and larval mosquito population monitoring is conducted as part of ongoing operational mosquito management and control programs. This allows for an assessment of larval control effectiveness in reducing nuisance mosquito populations, updates the local species record and larval mosquito development site database.

2.4 Control Products (Larvicides) Proposed for Use

The City of Delta mosquito population management and control program reduces adult mosquito populations by focusing on the identification and suppression of larval mosquito development using an IPM approach. This approach includes site modification or elimination, the conservation and enhancement of natural predators and controls, and when these are ineffective, or inefficient, the use of only biological and bio-rational control products.

The bacterial mosquito larvicides VectoBac 200G (PCP # 18158) and VectoLex CG (PCP # 28008) and VectoLex WSP (PCP # 28009) are the only control products (larvicides) which have been used in the City of Delta mosquito surveillance and control program during its last +25 years of operation. A similar product to VectoBac 200G, AquaBac® 200G (PCP #26368) is also available for use in Canada and may be used by the program contractor, with approval of the City of Delta. Because of their previous, long-term and exclusive use locally, their safety profiles and proven efficacy, the PMP will focus on VectoBac and VectoLex larvicide use.

VectoBac 200G and VectoLex contain spores and crystals produced by *Bacillus,* a naturally occurring soil bacteria and as such they are classed as a bio-rational control. They are very specific to mosquito larvae and have no impact on non-pest insects, fish, amphibians, birds, reptiles and mammals. Extensive product information can be found for VectoBac and VectoLex at the manufacturer's website www.valentbiosciences.com. Additional product information for them, and AquaBac 200G, can be found through the Health Canada, Pest Management Regulatory Agency (PRMA) website https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and the Pesticide Label Search https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php.

3.0 CONTROL PROGRAM METHODOLOGIES

The objective of the annual mosquito control program is to reduce the potential for widespread adult mosquito annoyance for residents, workers and visitors to Delta and its community centres of Ladner, Tsawwassen and North Delta. A program of this scope is not intended, nor could it, eliminate the local mosquito population. The total eradication of a widespread, fecund insect pest such as mosquitos is not feasible.

The potential impacts of control products and activities, combined with a need to coexist with a delicate 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.

Control of or prevention of larval mosquito development is preferred over control of the often widely dispersed and mobile adult mosquito. Mosquito larvae are concentrated in one place, must remain there for 7-21 days, and are very susceptible to the bio-rational control (larvicide) products, VectoBac and VectoLex. Drainage, filling of depressions, restoration of flow in ditches or other physical alterations to appropriate larval mosquito development sites is the preferred and permanent control method. Physical control can be integrated into local public works and construction activities such as roadside grading, ditch maintenance and cleaning. For home and business owners it can include the removal of water-holding containers such as buckets and unused pools, or the regular draining and refilling of livestock watering troughs and bird baths.

Only the most environmentally compatible, least toxic and persistent control products would be deployed for use within this annual program. Specifically, the bio-rational larvicides, VectoBac 200G and VectoLex both made with the *Bacillus* sp. bacterium are the larval control products of choice.

Routine adult mosquito control applications (adulticiding) for the purposes of nuisance mosquito control **are not** a component of the City of Delta Mosquito Population Management and Control Program and this Pest Management Plan.

The operational components of the PMP and the successful, annual, City of Delta Mosquito Population Management and Control Program may include the following activities, as detailed in Sections 3.1 through to Section 4.5.

3.1 Public Information and Education

The general public must be advised of control program efforts in their area and provided with the opportunity to have input to their mosquito control program. Public input is invaluable to any community function, and it is a key component of all successful, pro-active mosquito control programs. 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 which must be published twice in a two week period starting at least 45 days before submission of a notice 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 to provide comments on the PMP and to consult with the PMP holder or his or her designate, on PMP contents and the proposed mosquito population management and control program. In addition, those individuals or groups which had requested information or who have supplied input when the Pest management plan was last renewed are contacted directly.

The annual nuisance mosquito control program is well known and supported by area residents and businesses. Its highly visible nature using field biologists working along roadsides, in parks, golf courses, along dykes and salt marshes has ensured that property owners, facility managers and residents remain familiar with their annual program. In annual operation for over thirty years, it has been providing mosquito surveillance, monitoring and larval control services for the benefits of residents, businesses and visitors to the area. Throughout this time, newspaper, television and radio interviews, 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.

Considerable value can be obtained through exposure 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 efficacy. Residents are encouraged to contact control program consultants through Delta municipal offices (604-946-3253 or www.delta.ca) to report potential sources of larval mosquitos (a waterbody) or adult mosquito annoyance. Suggestions for physical removal or source reduction on private property allow 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.

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 the City of Delta in future years include:

- Informational Brochures – these review mosquito biology and control, mosquito "myths", program operations and contact information for program biologists.
- Web-based (www.delta.ca) program information and contact details.
- Facebook account – another method of public access/information.
- Laminated posters – durable. Can provide basic information on protection from annoyance. Installation along walking trails, picnic and camping areas is possible.
- Mosquito Monthly poster board - a 'flip chart' type of display board for placement in public access and reception areas of City Hall, at libraries, Recreation Centres, including pools and ice rinks etc.

- Newspaper Display Advertisements – placement in local newspapers from April – September. Provides public information relevant to each month and program contact/access information.
- Cardboard Doorknob Hangers - these "Sorry we missed you" doorknob messages are left when residents aren't home during property inspections. They summarize field biologist site observations and have return contact information for resident use.
- Newsmedia interviews – provides opportunities to update the public on program operations and status, mosquito biology and additional public outreach.
- Presentations at Council meetings - (Power PointTM).
- Information booths at 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 listed in the database 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 and information. Office and field personnel response to service requests, by telephone, email, and in

person 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 and 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 area. Prevention of adult mosquito annoyance through pro-active, larval mosquito control provides significant benefit to outdoor worker and recreational uses.

3.2 Protection of Archaeological Sites

Archaeological sites on both public and 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 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 Delta 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

The environmental consultant (contractor) managing the annual mosquito control program for the City of Delta is responsible to follow the data collection and reporting requirements of the PMP and the *Integrated Pest Management Act and Regulations.*

The City of Delta, Office of Climate Action and Environment would be regularly informed of control program activities of this contractor/consultant through personal contact, telephone, facsimile or e-mail with consulting program managers and field personnel. In addition, written progress reports summarizing weather conditions, surveying and monitoring results, treatment areas and interactions with the public are typically prepared by program consultants and submitted to the City on a regular basis during the operational phases of the control program.

At the conclusion of each annual nuisance mosquito control program season, a summary report detailing all activities and pesticide treatments completed under the PMP and its BCMOE issued Confirmations is produced. All pesticide use reporting required under the *Integrated Pest Management Act*, the approved PMP and as requested during the season by government regulatory agencies including the BC Ministry of Environment, Integrated Pest Management would be completed by the consultant (as agents for the City), as requested and necessary.

At a minimum, the consultant would maintain the following information for their use in managing the program and to complete the reporting and information requirements of the City, the PMP, the Pesticide Use Confirmation, the *Integrated Pesticide Management Act and Regulations*, and the BC Ministry of Environment:

- A mosquito development site database with information including property ownership, address, contact telephone number, maps, photographs, GPS identification, public access information (paths, trails, roadways), records of monitoring and treatment activities, pesticide use daily operation records and other relevant information related to the control program.
- A record 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 with the contractor, or the City, their wish to be excluded from the mosquito control program. The city will forward any such requests for program exclusion (avoidance) to the contractor who will confirm the request.
- A list and/or maps identifying, where necessary, 'AVOID' areas such as fish-bearing waters or other areas of environmental sensitivity, including provincial or regional parks, habitat conservation areas 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 where appropriate, would be consulted.

The development site database and avoid area lists are updated during each field season when control program personnel meet with residents, owners and operators of the farms, businesses and recreational facilities. Property ownership, access, development site status, areas of concern and control program operations are reviewed at this time. Regular contact is maintained with these individuals throughout the season to provide updates on control program operations and 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, City representatives or government regulatory agencies.

The consultant is responsible to ensure that all private and personally identifiable information within the database is managed in a secure, ethical, and legally compliant manner. This includes, but is not limited to, names and contact information linked to individuals or private properties, and any other data that could reasonably be used to identify a person. All handling of such information must adhere to the requirements set out in both the Personal Information Protection and Electronic Documents Act (PIPEDA) and the Personal Information Protection Act (PIPA). These Acts govern how private-sector organizations collect, use, disclose, and protect personal information in the course of commercial activities.

3.4 Surveying and Monitoring of Mosquito Populations

As part of the annual program start-up, and throughout the season, program field biologists conduct regular, comprehensive surveys of Delta by ground and air, as appropriate. The goal of these surveys is to confirm the extent and locations of existing, known mosquito development sites and to identify any new, or previously undetected, larval habitats.

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos, the need for control and allows for regular update of the database. Where observed, larvae are collected and enumerated using a standard 350 ml white larval mosquito dipper. Preserved larval specimens are identified.

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. Provincial and regional snowpack accumulations, river levels, tidal heights, precipitation and temperatures are reviewed as necessary to ensure timely surveying to detect mosquito development.

Monitoring and correlation of fluctuating temperatures and precipitation levels over several seasons allows for the determination of 'thresholds' which aid in the prediction of larval development and distributions. Review of river levels, tidal fluctuations and summer weather conditions, 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.

3.4.1 Larval mosquito monitoring

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos and the need for control. Larval habitats would be monitored throughout the season using a standard 350ml white larval mosquito dipper to assess the relative abundance and species of larval mosquitos found in these habitats. Routine sampling of development habitats is completed on a 6-10 day basis, depending on conditions and observations, throughout the operational season, typically mid-April to mid-September.

Larval mosquito populations as small as one larva per 350ml dip sample 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 established outdoor recreational facilities including golf courses, sports parks, water slides, picnic areas, campgrounds and nearby residential and commercial areas, salt marsh and permanent sites (ponds, ditches, catch basins) are a major source of potential mosquito annoyance and a primary focus of the annual mosquito control program.

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 application. Environmental compatibility and cost effectiveness of a control program is dependent on proper pesticide use through the application of control measures directed only to those areas requiring them. Post-treatment monitoring to confirm to larval mortalities is typically completed within 2-96 hours of larvicide ~200 larvae/350 dip sample application.

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.

3.4.2 Adult mosquito monitoring

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 are 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 infrared 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 $C0_2$, 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 the type of development habitat.

New Jersey or CDC Light traps would 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 collect and identify 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 Delta

The largest mosquito development sites in Delta are tidally influenced ponds, channels, ditches and temporarily flooded depressions in salt marsh habitats located in two primary locations: outside the Boundary Bay dyke south of 64th street, south of 72nd street, and south of 112th street (Mud Bay). The extent and frequency of *Aedes dorsalis* larval development in these habitats occurs in response to a number of influences including precipitation, temperature, tidal fluctuations and resultant seepage. Developing in a synchronous response to fluctuating water levels *Ae. dorsalis* mosquitos hatch throughout the Boundary Bay salt marshes are most numerous during the first half of the season when flooding is also greatest, typically April through July.

In addition to the Delta salt marsh sites there is the Tsawwassen First Nation (TFN) salt marsh which is the most prolific salt marsh mosquito development site in the area. Although largely contained within a dyking system, direct connection to Georgia Strait is permitted through five large culverts, ditches and a large, natural channel.

Several days of sustained tides exceeding 4.0 metres (measured at Point Atkinson), fills the expansive 'culvert and ditch' system. Resultant lateral and vertical seepage produces water accumulations in ponds and isolated channels scattered throughout the marsh. With extreme tidal

heights (greater than 4.5m), or frequent rainfall, much of the expansive, low-lying grassy areas in the marsh become flooded. Egg eclosion (hatching) occurs within hours of inundation and over the next several days larval development occurs throughout the Tsawwassen salt marsh, and is at its greatest during tides in excess of 4.5 m.

The Tsawwassen salt marsh will be covered under a separate PMP with larval surveillance and control to be provided by the Tsawwassen First Nation, independent of Delta. Delta and TFN share information on treatment and monitoring efforts that have implications across their jurisdictional boundaries.

The salt marsh habitats important to area residents and businesses, including golf courses, light industrial operations and the Boundary Bay Airport are those located at Mud Bay, and the end of 72nd Street and 64th street. Each salt marsh is located outside the Boundary Bay dyking system adjacent to large, largely un-vegetated mud flats. They contain numerous depressions, winding channels and a perimeter of grasses along the dyke edge. Because they are located outside the dyke, there are no barriers to rising tidal waters.

Tidal heights as low as 3.0m (as measured at Pt. Atkinson) produce flooding sufficient for larval development. Higher tides (4.0m and greater) produce water accumulations in the driftwood and grassy areas adjacent the dyke. Larval development in these sites is often delayed, typically occurring 1-2 days after 'mud flat' and margin areas and can be protracted since the deeper waters do not often recede or evaporate rapidly.

Regular monitoring of salt marsh habitats and correlations with tidal heights during the season ensures that larval mosquito development does not proceed unchecked. With larval populations averaging between 50-100 larvae/350ml dip sample, multiple hatches in a season, and an area amounting to upwards of 50% of the total mosquito development habitat in Delta, the control of larval development in the Boundary Bay salt marshes is essential to prevent widespread adult mosquito annoyance.

Irrigation, display and water run-off/collection ponds and ditches located on farmlands, residential properties, public parks and area golf courses also provide ideal habitat for larval development.

Largely permanent, these sites fluctuate in size and depth throughout the season in response to seepage and surface water runoff accumulations from precipitation and human activities including field irrigation, equipment and vehicle washing, dust control and site clean-up. These development sites can support larval mosquito populations for as long as they contain water.

Species collected locally from manmade and natural, freshwater development sites during the past few years include: *Aedes increpitus, Aedes vexans, Culex pipiens, Culex tarsalis, Culiseta incidens* and *Culiseta inornata.* Although their populations and individual development site sizes are not usually as large as the synchronous hatching *Aedes* mosquitos in salt marsh flood and seepage water habitats, the distribution of freshwater mosquito development sites near outdoor work sites, recreational areas, businesses and residential properties makes *Culex* and *Culiseta* mosquitos important, recurrent sources of localized adult mosquito annoyance if not effectively monitored and controlled.

Culex and *Culiseta* larvae also make use of catch basins and containers such as stored tires and equipment, livestock watering troughs, buckets and bird baths. When discovered by field personnel during site inspections these man-made sites would be brought to the attention of property owners for removal, drainage or regular water changes which would eliminate their potential as sources of mosquito development and annoyance.

In response to resident and user reports (2013-2014) of adult mosquito annoyance at a number of Delta sports fields and parks, catch basins (CBs), located within the fields and parking lots at several sports fields and parks in Tsawwassen, Ladner and North Delta were first sampled in August 2014, and larval development was confirmed. Routine sampling of some 250+ CBs, located in 18 municipal parks had been completed annually during June, July, and August each year since. Field irrigation, precipitation, and water run-off cause many of these to hold water during a typical season. Larval sampling confirms the predominant species occurring in catch basins is *Culex pipiens.*

3.5 Mosquito Control Options

Simple, but established key elements of a sound IPM approach 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 applications of the best site-specific controls, and;
3) As a feedback mechanism, assess the results achieved and adapt as required.

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 development site water levels, fluctuations, water and ambient temperatures, humidity, and precipitation.

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 IPM 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. These control options would be considered as a potential solution prior to any larvicide applications.

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 with mosquito development habitat 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. A reduction in larval populations contributes to the overall decrease in adult mosquito annoyance.

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 bio-rational control products such as *Bacillus thuringiensis* var. *israelensis* (VectoBac 200G) and *Bacillus sphaericus* (VectoLex CG and WSP) maximizes the effectiveness and environmental compatibility of the program.

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. Insects predators, both aquatic (i.e. dragon flies, beetles) and terrestrial (i.e. spiders, wasps), 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.

Of all the various predator control methods tested, only larvivorous fish are used operationally in widespread programs. Regan *et al.* (1982) 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 of ditch systems.

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 may 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 (*e.g.* 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, however, not 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 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 if they wish, 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.

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 and are discussed below.

3.5.3 Bio-rational Control

The mosquito control program at Delta would use VectoBac 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 the principles of an IPM approach to control.

Property owners would be consulted with prior to any larvicide applications and for any recommended physical of biological/natural methods. Product brochures, labels, MSDS sheets and website addresses would be supplied and reviewed to ensure residents, business, and facility operators understand, are comfortable with, and approve, proposed treatments. In the event that a property owner wishes exclusion from the control program this request would be honoured and noted in the development site database.

The product VectoBac 200G contains spores and crystals produced by the bacterium *(Bacillus thurinigiensis* var*. israelensis,* Serotype H-14 Strain AM65-52*; Bti)* and, as such, 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. Negative or toxic effects on mammals, birds or other wildlife have not been observed. 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.

VectoBac's mode of action is on the larval mosquito stomach and must be eaten too effective. VectoBac 200G is very specific, producing rapid lethal effects (within hours) in larval mosquitos. Formulated as a corn cob granule it requires no mixing and is ready to apply by hand or backpack blower. The granule allows the larvicide to penetrate vegetative covers and reach the water surface where the *Bti* is "released" for consumption by mosquito larvae.

VectoBac 200G is recommended by the manufacturer for use in standing water habitats including 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.

Similar to VectoBac 200G, VectoLex CG also contains a naturally occurring, spore-forming soil bacterium. VectoLex CG contains spores and crystals produced by *Bacillus sphaericus.* It also is classed as a bio-rational, rather than conventional, pesticide.

Like VectoBac, VectoLex 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* and *Culiseta* mosquito species. It has also been found to be an effective control for *Coquillettidia perturbans,* an aggressive adult pest of humans. Known as the "cattail mosquito" because of the unique adaption of the larval siphon and pupal "trumpets", which are serrated, for attachment to young cattails, they can access the air in these hollow plants as a source of oxygen. Because there are not "free swimming" like most other larvae they are not generally collected in larval sampling.

Several areas in Delta (Tilbury, Ladner and North Delta) have a significant amount of cattail (*Typha* sp.) swamps. The use of VectoLex CG and VectoLex WSP in several of these sites has greatly reduced

anecdotal reports of adult mosquito annoyance. Like VectoBac, VectoLex larvicides do 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. This occurs because *B. sphaericus* 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 dead mosquito larvae. This is known as recycling and is the mechanism which allows VectoLex to provide long-term, extended control (in excess of 28 days in the Fraser Valley, Lower Mainland) 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. In permanent ponds and stagnant ditches with difficult access because of thick, overgrown, or dense vegetation (i.e. blackberries and *Typha* sp. cattails), the long-acting VectoLex WSP may be used for treatments. These 10gm satchels (2cm X 2cm) can be readily thrown into these sites where the bio-degradable, glucose-based bag quickly dissolves, and the granules disperse across the water surface.

Catch basins in municipal parks, typically located in the grass areas and spectator seating areas between sport fields and baseball diamonds, and others around picnic and parking areas could also be treated with VectoLex WSP. Applied as one 10gm satchel per catch basin, typically two applications per summer season have been required.

The use of *Bti* and *Bsph* maximizes the environmental compatibility of the annual mosquito control program since both products are species (target) selective and non-toxic to other aquatic organisms which co-exist in these habitats including insects, fish and amphibians. When used in circumstances where other control options such as physical or cultural control are not practical, they support the principles of an IPM approach to mosquito 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.

Typically applied from the ground using cold aerosol sprayers or misters, and much less commonly, from the air using helicopters of fixed-wing aircraft their mode of action is on the nervous system following contact with the organism and absorption across through the exoskeleton. Because they are applied to the air, and the fact they are non-specific, such applications will not only control adult mosquitos which come in contact with the spray mist, but other non-target organisms such as moths, flies, flying beetles and other insects. Restrictions on applications include habitat type, timing of applications, mosquito population thresholds, weather conditions and areas of identified avoidance.

Because of the variable dispersion patterns of mosquitos, geography, types of vegetation encountered and ambient weather conditions at the time of treatment, it is difficult to provide any more than temporary control of localized adult mosquito annoyance. Unless regular and routine treatment of 'problem areas' is completed, uncontrolled adult mosquitos developing in other areas will often expand into these treated areas to again cause annoyance.

Adulticide applications **ARE NOT** a component of the annual mosquito control program at Delta. The 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 repellents***

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. The City of Delta mosquito control program would continue to use only the least toxic, most environmentally sound control products available. As new products become available and registered in Canada, their suitability for use in annual control program will be reviewed.

3.6 Mosquito Control Program Operations

The well-organized, pro-active, integrated pest management approach to mosquito control developed for the City of Delta 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.

As required by the *BC Integrated Pest Management Act and Regulations*, all larvicide applications would be completed, and/or supervised by, personnel certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement*, or equivalent. All larvicide treatments would be completed using application rates, equipment and methods recommended by the pesticide manufacturer.

3.6.1 Public, Worker and Environmental Safety During Mosquito Control

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.

WorkSafe BC 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 Safety Data Sheet (SDS) 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 City of Delta mosquito control program is intended to provide residents, workers and visitors relief from extreme or persistent adult mosquito annoyance. The control program is not intended

to eliminate the mosquito population and as such landowners and residents who want to be excluded from the control are recorded and their wishes respected.

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 larvicide applications. Prior to any larvicide application field personnel:

- Verify property ownership, treatment site boundaries, public points of access (paths, trails, roadways), pest presence and population size, both pre- and post-treatment.
- Confirm the boundaries and/or locations of 'AVOID' areas such as properties wishing to be excluded from program operations
- Identify fish-bearing waters or areas of environmental sensitivity (i.e. bird nesting sites) and the need for avoidance of these areas, particularly for ground nesting birds,
- When necessary, community watersheds will be determined by accessing the BC Ministry of Environment Community Watershed listings and informational website:
    - https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/community-watersheds
- Similarly, a listing of registered groundwater Wells and Aquifers and an interactive map is available at:
    - www.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers
- Review larvicide product label and comply with recommended precautions for handling and application, safety gear, weather restrictions (wind, temperatures, etc.) and other listed precautions.
- Larvicides will not be applied to finished drinking water. Wells and surface water intakes for potable water will be identified, where appropriate, with the property resident.
- Inform the public of impending applications through public notices, news media articles, advertisements and ongoing personal contact.

3.6.2 Larval Mosquito Control, Treatment Thresholds and Application Rates

VectoBac and VectoLex are only applied when larval mosquitos are present. Larval mosquito surveillance and control protocols would focus efforts on the timely identification and treatment of larval mosquito populations with surveillance and control efforts targeting 1st through 3rd instar larvae.

In addition to treating the most actively growing and feeding instars, it 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. Also, 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*), proposed for use in the program 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 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. It is not recommended on *Bti* or *Bsph* product labels, or by the *Municipal Mosquito Control Guidelines (Ellis, 2005)*. Using biorational larvicides to control mosquito larvae at their source, and as 1st through 4th instar larvae still contributes to the "food web". Dead larvae become food for many other organisms, including insect detritivores, fungi and bacteria which in turn become food for other aquatic insect and vertebrate predators and grazers. While there may be predation of some mosquito species such as *Culex* or *Culiseta,* which occur in permanent ponds, and are the two most common larvae in these sites, there are typically zero, to very few natural predators in *Aedes* mosquito habitats.

Aedes hatch in large numbers, typically +300/dip sample, and inhabit temporary pools created by snowmelt, precipitation, river flood and seepage waters or salt marsh inundations 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. A pond the size of a back yard swimming pool ($50m^2$), with a larval population of just 1 larvae/350ml dip sample, can produce over 24,000 larvae. A one hectare site, about the size of 2 football fields, with a larval population density of 1 larvae/dip sample can produce 4,285,714 mosquitos. This "strategy" of allowing time for non-existent predators to affect some level of control on *Aedes* larval populations is wholly impractical and ineffective.

Delaying treatments to target mosquito populations with later 3rd or 4th larval instars is not ideal, in addition to inadequate, or no natural predation, the potential for reduced feeding rates of later (4th) instar larvae may provide incomplete control, reduced efficacy and may result in a number of other undesirable outcomes

1) That larvae develop into the untreatable pupal stage, and then onto nuisance causing adults
2) That field staff may not return at an appropriate time to treat them before this occurs. Changing weather conditions and temperatures over a few days can dramatically accelerate larval development rates; and lastly
3) Product manufacturers recommend that later instar larvae are treated with higher application rates, upwards of 10kg/ha (1 gm/metre), thereby requiring more larvicide, increased field personnel time and reduced environmental compatibility.

Different species of mosquito larvae have different, preferred habitat types. Aedes mosquito prefer temporary, snowmelt, seepage water and river level influenced habitats. Culex and Culiseta mosquitos will use more diverse habitats including temporary sites and permanent habitats such as natural and manmade ponds, marshes, swamps and water-filled ditches etc. Some species will also use containers. Typically, upwards of 10 dip samples per development site, depending on site size, are completed. Larger sites will have a greater number of dip samples.

VectoBac 200G larvicide is only applied when larval mosquitos are present. Typically, upwards of 5 - 10 dip samples per development site, depending on site size, are completed. Larger sites will have a greater number of dip samples completed. Larval mosquito dip samples averaging from 1-3 larvae/350ml dip 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, river flood and seepage water or salt marsh and similar temporary habitats. The threshold for 2nd and 3rd instar *Aedes* larvae would be 1-3 larvae/dip sample.

VectoLex larvicides which are largely ineffective against *Aedes* mosquitos would only be utilized to control developing larvae in those permanent and temporary sites having *Culex, Culiseta* and *Coquillettidia perturbans* larvae. Larval populations averaging 1-3 larvae/350ml dip sample will be the threshold for treatment using VectoLex larvicides.

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 larvicides 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. VectoBac 200G and VectoLex CG application rates typically average 7.5 kg/ha which has been demonstrated over +30 years of annual operation to be effective under the conditions encountered at Delta. 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.

A relatively new, 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 large for effective treatment coverage or where ground access is too difficult or dangerous. All RPAS treatments would be conducted with adherence to Transport Canada Regulations, certifications and training requirements.

Prior to any RPAS aerial larvicide applications, pilots and control program personnel 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 the RPAS flight controller/computer station. These maps, and the active tracking of flight paths which result, can guide the application pilots to individual sites, displays their boundaries, and allows the RPAS to be programmed to 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 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.

VectoBac 200G and VectoLex CG are approved by the Pesticide Management Regulatory Agency (PMRA) for application by RPAS and select, targeted, applications may be made using this application method. When RPAS are used for the application of these products for mosquito control, the pilot must be certified in the use of RPAS for mosquito control by the BC Ministry of Environment (BCMOE), which is a separate category from ground or aerial (helicopter, fixed wing) certification. BCMOE certification was not available at the time of writing this document (Fall 2025) but expected to become available in the coming years.

All ground-based larvicide applications to small and accessible sites are completed, where required, by hand broadcast or backpack spreader during the mosquito control season. Fluctuating water levels in many of these sites cause repeated larval development requiring repeated treatment. 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 Delta

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. Inaccessible and larger sites may be treated by air using remotely piloted aircraft systems (RPAS) once full approval and certification processes are finalized with the BCMOE.

During RPAS operations, aircraft are not to be flown directly over private properties and will focus on designated public lands, open spaces, and wetlands where mosquito breeding habitats have been identified. This restriction is in place to ensure the protection of privacy and avoid potential disturbances to residents. Potential areas of consideration for RPAS applications are indicated in the maps at the end of this document, Figures 1 through 4.

For catch basins, VectoLex WSP 10gm satchels, are applied as one per CB. Alternatively, VectoLex CG can be applied to catch basins. If used, VectoLex CG would be applied using a standard measuring spoon to deliver 10 gm of granules/catch basin. VectoLex WSP used for the treatment of cattail swamps and similar, difficult to access sites, would be applied at a rate of one 10gm satchel for every 10m2 surface water.

Applications of VectoBac 200G and VectoLex CG to within 10 metres of 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. All application rates would be within the ranges, and recommendations of the PMRA-approved manufacturers labels. All applications are followed with post-application monitoring to confirm the effectiveness of treatments.

Larval dip sampling, light trap collections and where appropriate, adult mosquito emergence traps, would be employed to evaluate post-application larval control results. 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.

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 an equivalent, appropriate category.

3.6.3 Post Application Monitoring

Within 2-96 hours after (post) treatment with VectoBac 200G, larval 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 with sampling results mostly measured at zero larvae/350ml dip sample and averaging much 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. Because larval mortality from VectoLex can take several days to occur, and can continue to occur for several weeks, treated larval habitats would be monitored on a regular basis with re-treatment completed as required.

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.

Adult mosquito populations would be monitored in harbourage areas adjacent to treated larval development habitats to confirm the effectiveness of larval controls in reducing adult mosquito annoyance. In addition, adult mosquito populations could be monitored at select locations to compare adult mosquito populations between various locations and community centres. Given the difference in individual tolerances to mosquito annoyance the success of larval control in limiting adult mosquito populations would also be determined through resident reports, interviews and requests for service.

The goal of the annual City of Delta Mosquito Population and Control Program is to decrease larval mosquito populations sufficiently to reduce, and/or prevent, adult mosquito annoyance for residents, workers and visitors. Property owners, residents and businesses are also expected to implement protective measures that limit their exposure to adult mosquito annoyance. These include repellent use, clothing choices (long sleeves, light coloured), avoidance of perfumed personal hygiene products (shampoos), temporal or location avoidance measures (minimize activity at dusk and dawn) and window screens.

4.0 QUALIFICATIONS OF PROGRAM PERSONNEL

This annual program would be managed by environmental consultants experienced in integrated pest management and will have all necessary Pesticide Vendor and/or Pest Control Service Licences. As required, the consultant's management personnel will be certified as pesticide vendors in the category of "*Commercial Pesticides*" and all field personnel will be certified as pesticide applicators

in the category of '*Mosquito and Biting Fly Abatement*' or equivalent, as accepted by the BC Ministry of Environment.

Consultant mosquito control program management personnel would be Registered Professional Biologists. Field personnel would include University and College graduates or senior Co-Operative Education students studying within the disciplines of biology and environmental science or equivalent practical experience with mosquito population management practices and training.

5.0 LARVICIDE HANDLING AND APPLICATION

As required by the BC Integrated Pest Management Act, all personnel handling and applying larvicides for the annual mosquito control program must be certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement*, or equivalent. Pesticide applicators will comply with regulations contained within the *Pest Control Products Act*, the *Integrated Pest Management Act*, the T*ransportation 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 '*Canadian Pesticide Education Program Applicator Core Manual*', the '*Pesticide Applicators and Dispensers Handbook*' and associated reference materials supplied through the BC Ministry of Environment. This PMP does not attempt to duplicate all the information contained within this handbook and other references. The 'Acts', the Handbook, product labels, manufacturers' websites and any other resource materials detailed above, and in other sections of this PMP would be reviewed, as appropriate, before handling, transporting, storing or applying pesticides.

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.*

5.1 Larvicide Transportation

During transportation, all pesticides would be secured to prevent an accidental spillage or theft. Granular VectoBac 200G and VectoLex CG larvicide 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. Applicators will carry within their vehicles a suitable spill clean-up kit, basic first aid and appropriate personal protective safety gear and supplies, as required. For granular products, this is typically a broom and dustpan. Any spilled larvicide would be recovered and applied to active larval treatment sites.

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 Delta would provide secure, dry, well-ventilated pesticide storage space for mosquito control larvicide (VectoBac 200G, VectoLex CG) within their secure public works facility. No large volumes of larvicide are stored on-site over the winter. In an average year, less than 200 kg of VectoBac and VectoLex larvicide is stored on-site to be 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, Loading and Application

Applicators will follow the directions and precautions warranted by larvicide use as described above and in relevant references.

VectoBac and VectoLex granular larvicides are formulated as 'ready to apply' and supplied in thick, plastic bags. No 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 SDS sheets. Field personnel would wear suitable safety gear, including the appropriate respirator/dust masks, ear protection, rubber gloves, boots and other protective equipment as indicated by larvicide labels, SDS sheets, and manufacturer instructions.

All handling of pesticides would be conducted in level, well ventilated, outside areas under conditions or minimal winds and no precipitation. 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 (RPAS/UAV) applications would be completed with adherence to Transport Canada guidelines which, at time of writing (Fall 2025) requires a minimum 2 person team. Larvicide applications to smaller sites would be completed by hand broadcast or backpack applicator.

Property owners would be consulted with prior to any larvicide applications and for any recommended physical or biological/natural methods. Product brochures, labels, SDS sheets and website addresses would be supplied and reviewed to ensure residents, business, and facility operators understand, are comfortable with, and approve of proposed treatments. In the event

that a property owner wishes exclusion from the control program this request would be honoured and noted in the development site database.

All RPAS staging (larvicide loading, landing, flying) areas would be located as close to proposed treatment sites as possible, which can be viewed in figures 1 through 4 at the end of this document. 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.

Weather forecasts would be consulted, and current weather conditions (wind speed, temperature, precipitation) would be noted, and recorded, during all larvicide applications. RPAS treatments would be suspended 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. Similarly, should precipitation be sufficient to cause larvicide (corn cob) granules to clump and clog RPAS equipment, backpack blowers, or similarly affect hand broadcast applications, treatments would 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 (RPAS) 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, seepage or tidal waters).

5.4 Equipment Maintenance and Calibration

Ground-based applications of VectoBac 200G and VectoLex CG are completed by hand broadcast or motorized back-pack type (leaf blower) applicator. VectoLex WSP, is a pre-measured (10gm) pouch, applied directly to water holding catch basins through the grates, or too difficult to access permanent surface water sites that have been identified as producers of *Culex* or *Culiseta* mosquito larvae.

Applicators would adjust their walking speed, and throttle speed if using backpack blowers, to ensure they are achieving the correct application rate/density of granules per square foot of water surface. For an application rate of 7.5 kg/ha, this is 4-5 granules per square foot.

All aerial larvicide application equipment (RPAS) is supplied and maintained by professional third parties and the aerial contractor. Application equipment calibration is confirmed prior to, during use, by the pilot and/or certified program personnel.

6.0 CONTROL PROGRAM SYNOPSIS

The mosquito population management and control program developed for the City of Delta utilizes a pro-active, integrated approach which focuses on larval mosquito control. The City of Delta mosquito population management and control program is not intended, nor would it be possible, to eliminate the local mosquito population. An appropriate scope of operations and the prevention or timely treatment of larval mosquitos at their source will reduce local adult mosquito populations.

Public education during the term of this PMP will involve regular news media exposure, public information meetings, pamphlets, doorknob hangers and notice boards, field personnel interaction with residents, visitors and business operators. These initiatives increase the general public's awareness of program operations and goals and encourages the general public to report adult mosquito annoyance, potential larval development sites and to have input into their control program.

Regular monitoring and treatment of larval mosquitos is a key element to mosquito control program success. These development habitats must be identified and regularly surveyed during a control season to ensure timely detection of larval mosquito development. Surveying, monitoring and control of larval mosquito infestations would begin in April and continue through August, and possibly September, depending on conditions. Program methodologies would continue to concentrate on larval control initiatives with a goal to reduce the extent of standing water development habitats. Developing larval mosquito populations would be controlled through the application of the bio-rational larvicides VectoBac 200G, VectoLex CG and VectoLex WSP.

Adult mosquito population monitoring would be conducted as part of routine 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.

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. The cooperation and support of local businesses, ranchers, and property owners is indicative of true community spirit and support for a successful program which benefits workers, residents and visitors to Delta.

A well organized, pro-active, integrated pest management approach which concentrates on larval mosquito control ensures a safe, effective and environmentally compatible program.

7.0 REFERENCES AND BIBLIOGRAPHY

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

BC Centre for Disease Control, March 2004. Arbovirus Surveillance and Response Guidelines for British Columbia. www.BCCDC.org

BC Centre for Disease Control, 03 July 2008 ,. BC WNv Mosquito Control Working Group. excerpt: BC provincial Mosquito Pest Management Plan.

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

BC Centre for Disease Control, 29 May 2015. Email from Marsha Taylor, Epidemiologist, BCCDC.

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

Belton, Peter. The Mosquitos of British Columbia. Victoria: Handbook (British Columbia Provincial Museum) No 41, 1983, 189 pages.

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

D.G. Regan and Associates Ltd., Corporation of Delta, 2003-2015 Nuisance Mosquito Control Program Summary Reports. Supplied annually.

D.G. Regan and Associates Ltd., Corporation of Delta, 2005-2010 West Nile virus Control Program Summary Reports. Supplied annually.

Duka Environmental Services Ltd., City of Delta, Pest Management Plan for 2016-2020 Nuisance and Vector Mosquito Control Programs. March 2016.

Duka Environmental Services Ltd., City of Delta, Pest Management Plan for 2021-2026 Nuisance and Vector Mosquito Control Programs. January 2026.

Duka Environmental Services Ltd., City of Delta, 2016-2020 Nuisance and Vector Mosquito Control Program Summary Reports. Supplied annually

Duka Environmental Services Ltd., City of Delta, 2021-2025 Nuisance and Vector Mosquito Control Program Summary Reports. Supplied annually

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.

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

Lacey, L.A., M.S. Mulla., 1988. Safety of Bacillus thuringiensis ssp. israelensis and Bacillus sphaericus to Nontarget Organisms in the Aquatic Environment, 19pp.

Muhammad Morshed, BCCDC. Sampling/identification of all specimens recommended. Email 13 February 2015

Mahmut Dogramaci, et al. A method for Subsampling Terrestrial Invertebrates Samples in the Laboratory: Estimating Abundance and Taxa Richness, March 2010

Rebekah Sudia, Public Health Ecologist, Multnomah County Vector Control District, Portland Oregon. Random sampling and procedures for adult mosquito sample identifications. Email 17 February 2015

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.

Schleier, J.J., 2008. Are Mosquito fish safe? – An ecological Risk Assessment for use in the Northwest., Montana State University, Bozeman, Montana. Presentation 48th Annual Northwest Mosquito and Vector Control Association meeting, Coeur d'Alene,

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

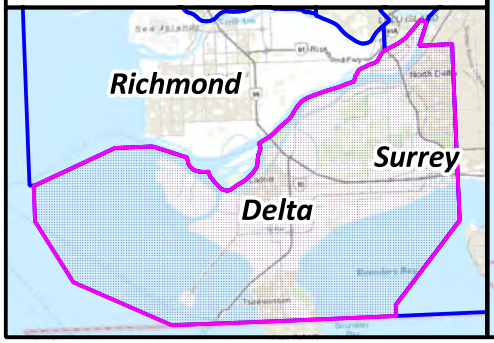
FIGURES

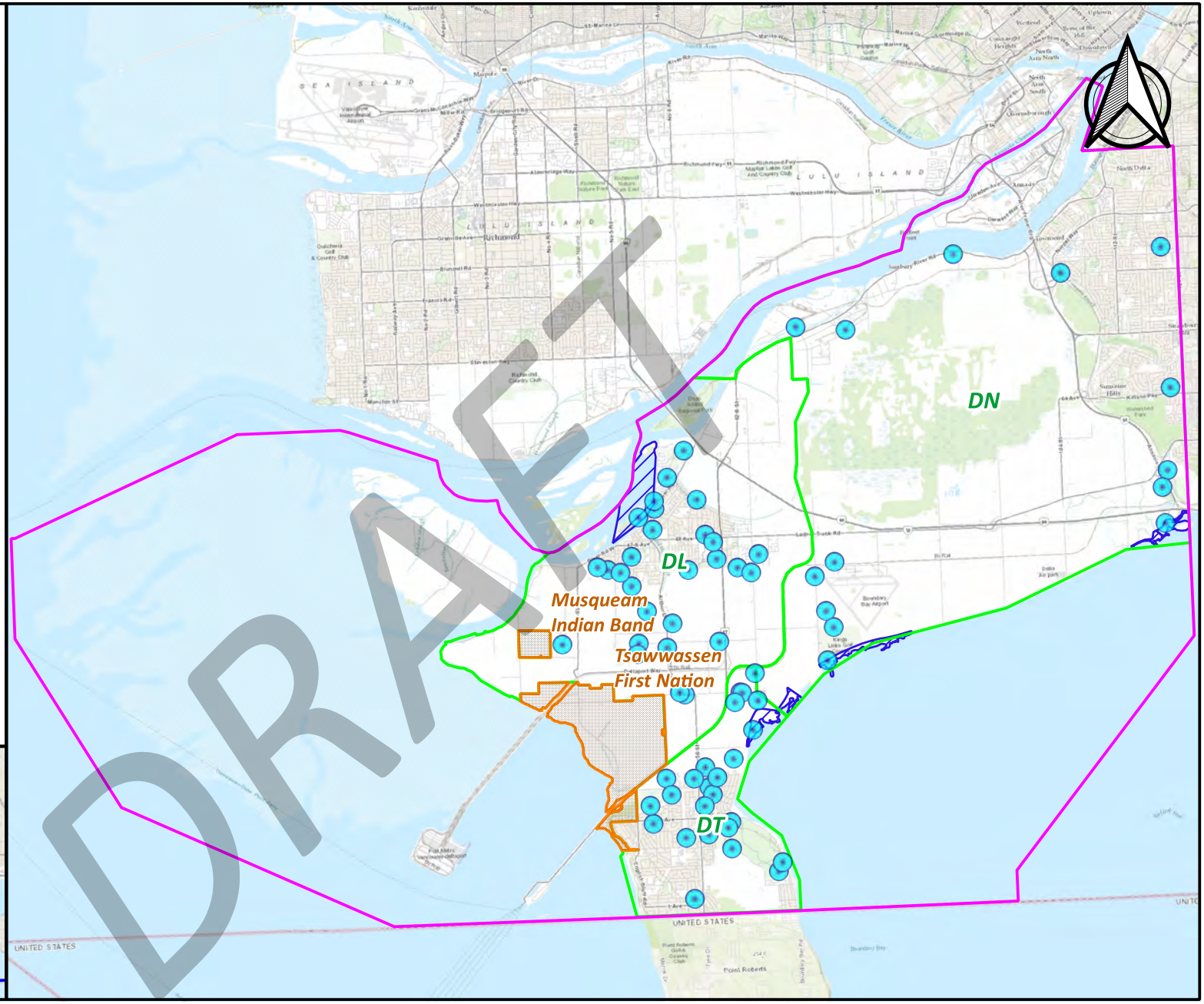
Figure 1

City of Delta
Mosquito Control Program
Larval Development
Site Locations

City of Delta
Overview

- First Nation Lands
- Delta PMP Coverage Area
- Program Operation Areas
  - Ladner (DL)
  - North Delta (DN)
  - Tsawwassen (DT)
- Potential RPAS Application Areas





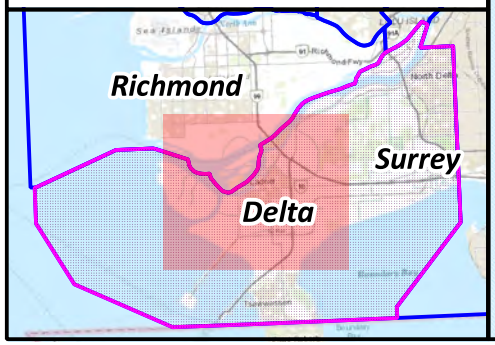
0 3 6 9 12 15 km

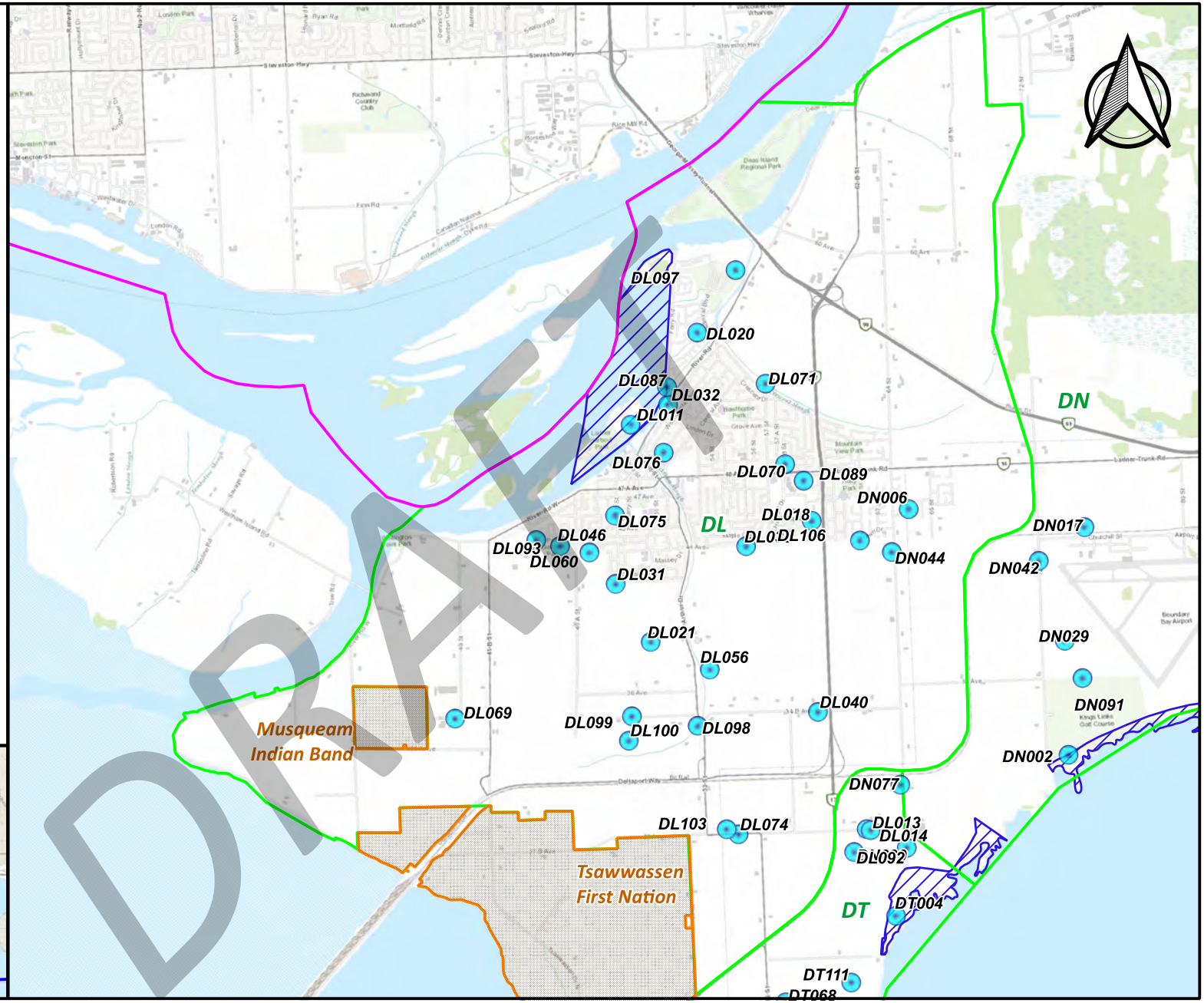
Figure 2

City of Delta
Mosquito Control Program
Larval Development
Site Locations

Ladner
Overview

- First Nation Lands
- Delta PMP Coverage Area
- Program Operation Areas
  - Ladner (DL)
  - North Delta (DN)
  - Tsawwassen (DT)
- Potential RPAS Application Areas





0 1 2 3 4 5 km

Figure 3

City of Delta
Mosquito Control Program
Larval Development
Site Locations

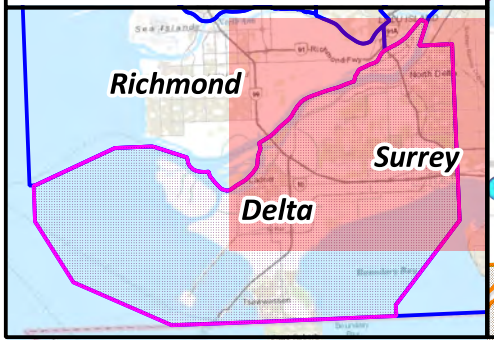
North Delta
Overview

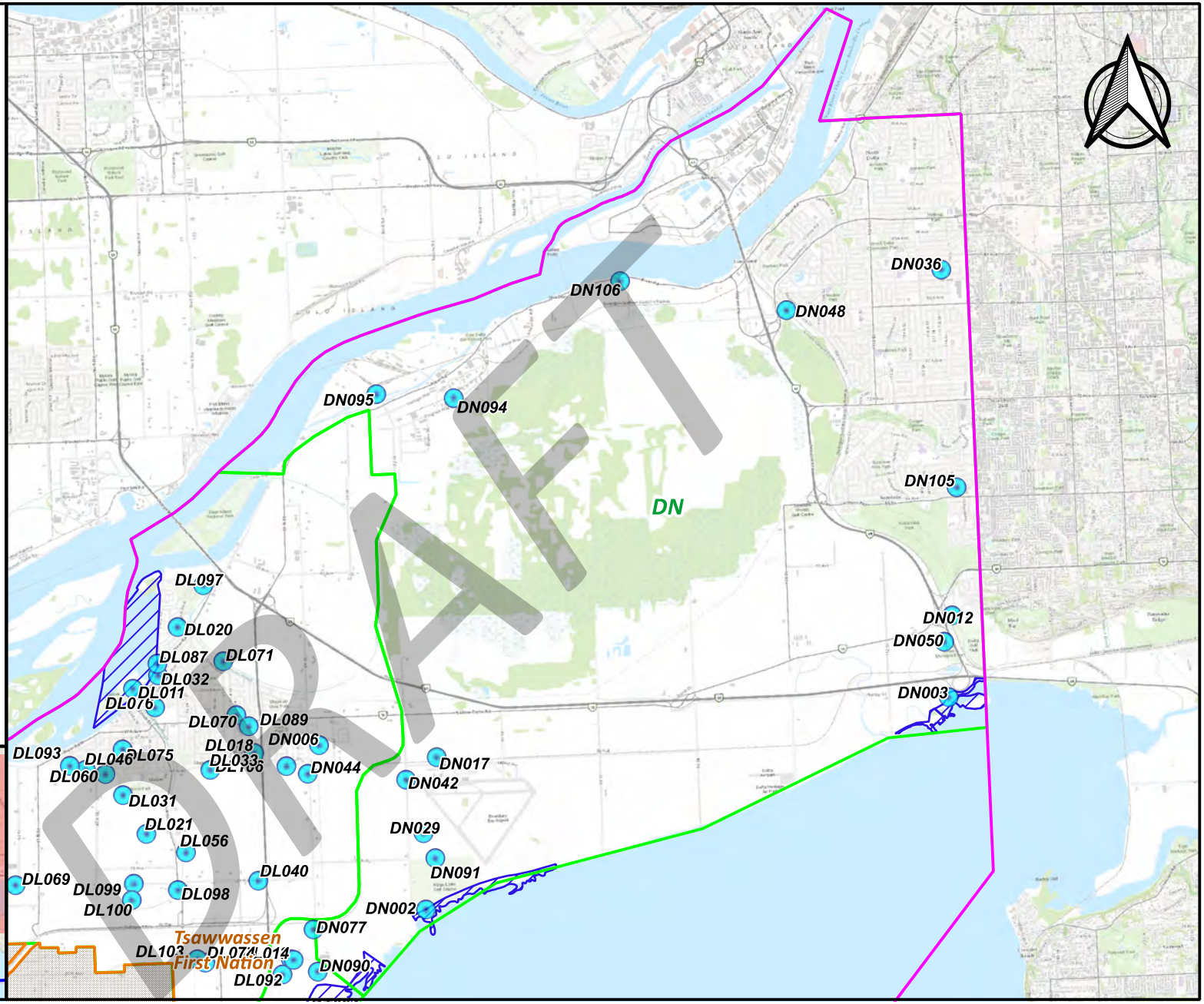
First Nation Lands

Delta PMP
Coverage Area

Program Operation Areas
- Ladner (DL)
- North Delta (DN)
- Tsawwassen (DT)

Potential RPAS Application Areas





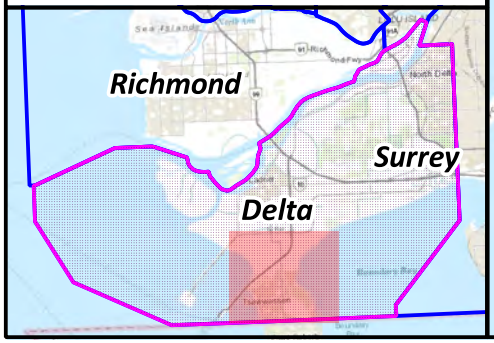
0 1 2 3 4 5 km

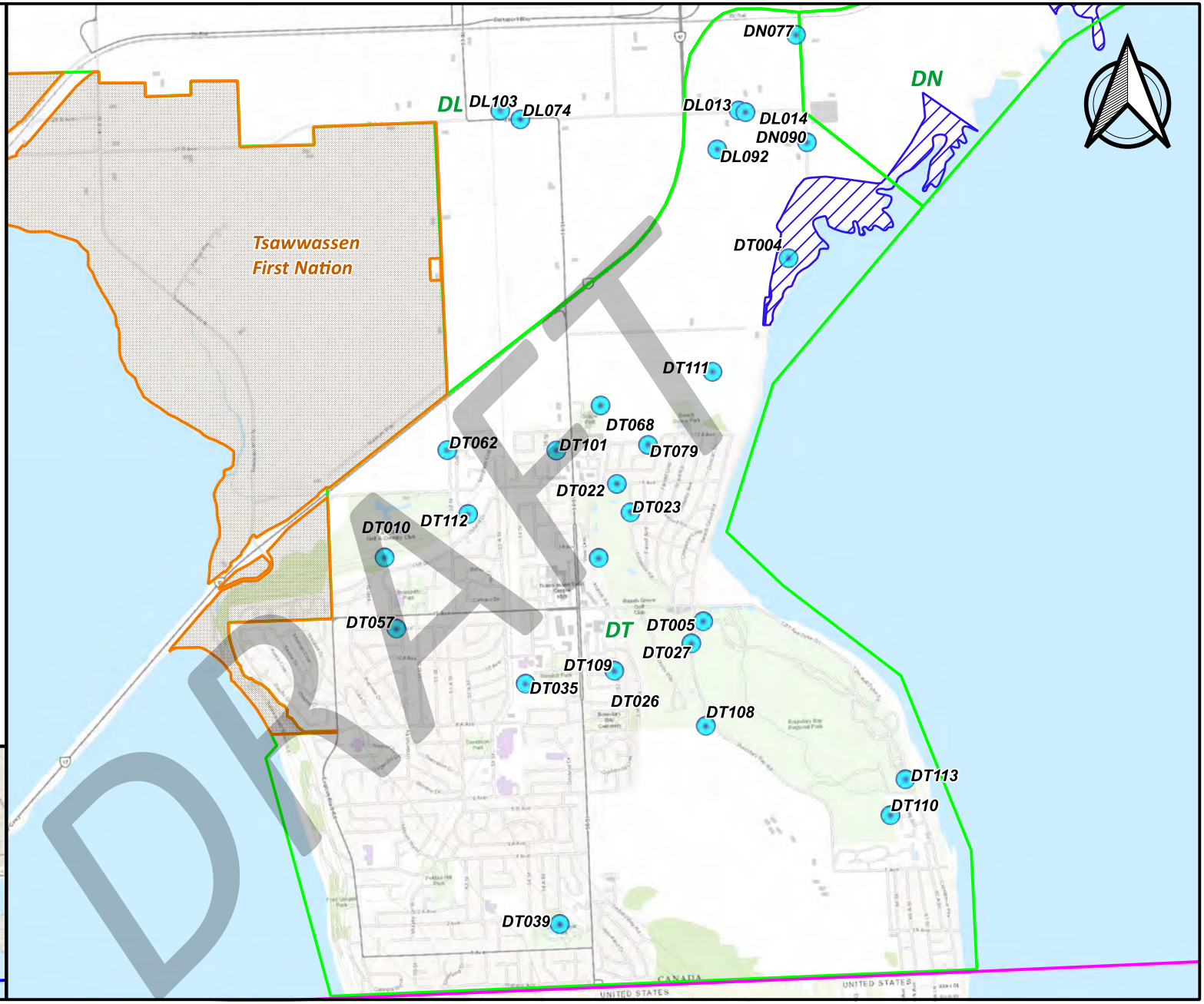
Figure 4

City of Delta
Mosquito Control Program
Larval Development
Site Locations

Tsawwassen Overview

- First Nation Lands
- Delta PMP Coverage Area
- Program Operation Areas
  - Ladner (DL)
  - North Delta (DN)
  - Tsawwassen (DT)
- Potential RPAS Application Areas





0 0.7 1.4 2.1 2.8 3.5 km