West Nile Virus Vector Mosquito Monitoring Report- 2017

Toronto and Region Conservation for The Living City®

March 15, 2018

Acknowledgements

TRCA recognizes the contribution of all our staff who worked diligently on the West Nile Virus Monitoring Program. We would also like to thank our regional public health partners for their support in 2017. This report was prepared by Jessica Fang, Biologist, and reviewed by Scott Jarvie, Associate Director, Environmental Monitoring and Data Management. The West Nile Virus Surveillance and Monitoring Program is a part of TRCA's Regional Watershed Monitoring and Reporting Program, which is funded by the following partners:

City of Toronto

Region of Durham

Region of Peel

Region of York

Toronto Remedial Action Plan

Executive Summary

West Nile Virus in Our Region

West Nile virus (WNV), primarily a bird pathogen, was first discovered in the West Nile district of Uganda in 1937. Since then, WNV has spread into most parts of the world. West Nile virus was first introduced into United States in 1999, and then appeared in Ontario in 2001. According to Public Health Ontario (PHO), a total of 155 human cases were reported in Ontario, the third highest number since the introduction of the virus in 2001; within Toronto and Region Conservation Authority's (TRCA's) jurisdiction, there were 51 human WNV cases.

Research results suggest that two key mosquito species, *Culex pipiens* and *Culex restuans*, are primarily responsible for spreading WNV to humans in Ontario. Both mosquito species are among the most common mosquitoes found in urban areas. Forecasting a WNV outbreak is challenging, because mosquito population dynamics are influenced by unpredictable biological and environmental factors. Management strategies undertaken by the provincial and regional health agencies focus on prevention through education and mosquito source reduction.

TRCA's Mosquito Surveillance Program

TRCA established the WNV Larval Mosquito Surveillance and Monitoring Program in 2003. The program has a three-pronged approach, which includes prevention through education, collaboration with regional public health units, and larval mosquito monitoring. The objective of the program is to identify WNV mosquito hotspots, take appropriate intervention measures to reduce risk for people, and ultimately to protect our wetlands.

A WNV mosquito hotpot is recognized when a large number of vector mosquito species are collected at a site. **Vector** WNV species are those mosquitoes that are capable of transmitting WNV. Traditionally, wetlands are considered mosquito-friendly habitats, therefore posing serious WNV threats. However, TRCA's 15-year monitoring data have shown that wetlands generally do not support large vector mosquito populations. Nonetheless, occasionally these hotspots have been detected through our surveillance program. Appropriate control measures are taken to eliminate mosquito larvae from these hotspots if warranted.

Results of Surveillance Activities in 2017

The amount of precipitation in the spring of 2017 caused a significant increase in mosquito population in the region. TRCA collected our highest numbers of mosquito larvae in 15 years. In total, 13,036 mosquito larvae were collected from 49 monitoring sites. Compared to the previous years, we collected 67% more mosquitoes in 2017 than the average number of mosquito collected from 2012 to 2016 (n=7,796).

Amongst the 14 different species of mosquitoes collected, the most dominant and widespread species overall was *Culex territans* (a non-vector species), which inhabited 33 of the 49 monitoring sites. The dominant species in wetland in 2017 was *Culex territans* (48%), and in stormwater management ponds (SWMPs), *Culex pipiens* (a main WNV vector) comprised 77% of the larvae collected.

Similar to previous years, monitoring results showed that most wetlands posed minimal risk for harbouring WNV vector mosquitoes. Nevertheless, WNV vector hotspots continued to occur. In total, five wetlands and two SWMPs were identified as hotspots. With the assistance of our regional health partners and TRCA's larvicide contractor, larvicide treatments were applied to reduce mosquito larvae at these sites.

Mosquitoes can only carry WNV after biting an infected bird. Mosquito larvae do not feed on blood thus do not carry the virus. When a site is identified as a hotspot, it simply indicates the presence of vector species which could potentially spread WNV after they emerge as adult mosquitoes, not the presence of the virus itself

Collaboration

TRCA's collaboration efforts with our regional public health partners involved providing larval mosquito identification training, notification of hotspots and participating in WNV advisory committees. Collaboration with our partners is a crucial in effectively managing WNV on TRCA properties. City of Toronto, Peel Region, and York Region have assisted TRCA in applying larvicide treatments on selected TRCA properties in the past years.

In addition, TRCA contributed data and worked in partnership with researchers from York University, resulted in the publication of the paper "The impact of weather and storm water management ponds on the transmission of West Nile virus" in The Royal Society Journal in 2017.

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1. Introduction

West Nile virus (WNV) was first discovered in the West Nile district of Uganda in 1937. Since then, WNV has spread into most parts of the world. West Nile virus was first introduced into United States in 1999, and then appeared in Ontario in 2001. It primarily exists between birds and bird-biting mosquitoes. Humans can also be infected through the bite of a mosquito which had fed on infected birds. The majority of people who become infected with WNV will have no symptoms. However, severe cases of WNV illness, including the development of meningitis and encephalitis, are extremely rare but can be fatal. To date, no human-to-human transmission of WNV through casual contact has been documented (World Health Organization, 2017).

Most mosquito species in Ontario do not pose serious WNV threats. Mosquito species that are capable of carrying and transmitting WNV are referred to as **vector** species. Studies (Kilpatrick *et al*. 2005; Hamer *et al*. 2009) suggest that two species *Culex pipiens* and *Culex restuans* are the primary species that spread the disease into the human populations. These species are also among the most common mosquitoes found in urban areas. Another study (Tiawsirisup *et al*., 2008) also indicated that vector competence of *Aedes vexans*, approaches that of the *Culex* species for carrying and spreading WNV.

The Toronto and Region Conservation Authority (TRCA) owns over 17,000 hectares of land, including natural and constructed wetlands, woodland pools, reservoirs, and ponds. These aquatic ecosystems are considered mosquito friendly as a result of the permanent availability of standing water (Knight *et al*. 2003; Gingrich *et al*. 2006; Rey *et al*. 2006). The WNV Surveillance and Monitoring Program was initiated in 2003 as a measure of due diligence, and at the request of TRCA's regional public health partners (Regions of Peel, York, Durham and the City of Toronto). Selected natural habitats (collectively referred to as "wetlands" in this report) and stormwater management ponds (SWMPs) have been monitored in the summer months for the presence of vector mosquito larvae since the launch of the program in 2003. Data collected have been used to identify sites of potential concern or vector mosquito hotspots, which may require following-up with appropriate management actions.

The objectives of the WNV Vector Mosquito Larval Monitoring and Surveillance Program are to reduce WNV risk and protect wetlands on TRCA properties through the following approaches:

- **Education and communication:** To respond to public inquiries on WNV related issues and address standing water complaints.
- **Collaboration with regional public health units:** To participate in WNV advisory committees and share information and data.
- **Routine monitoring:** To identify sites of potential concern through larval mosquito monitoring and take appropriate control measures if deemed necessary.

2. Public Education and Communication

Our public education and communication efforts focus on prevention through increasing public awareness and addressing standing water concerns on TRCA properties.

2.1 Increasing public awareness of West Nile virus

In 2017, TRCA continued to increase public awareness of WNV by:

- Responding to media requests and presenting information on television, radio programs and newspapers
- Working with TRCA's content marketing staff to produce an informative video about TRCA's WNV monitoring program
- Providing information, and making the annual reports available on TRCA website https://trca.ca/conservation/environmental-monitoring/aquatic-habitat-and-species/west-nile-virus/
- Sharing tips on personal protection against mosquito bites with staff and displaying posters in TRCA offices and Conservation Areas.

2.2 Standing Water Complaints

Complaints or inquiries regarding standing water or mosquito activities are addressed according to TRCA's Standing Water Complaint Procedure (Appendix A). In 2017, TRCA received seven standing water complaints: one complaint was filed by a resident who resides adjacent to a TRCA owned property; another was forwarded by our regional public health partner; and the other five were brought to our attention by TRCA staff. All of these inquiries resulted in appropriate control measures being taken to eliminate vector mosquito larvae.

3. Collaboration

The collaborative efforts with our regional public health partners involved providing training, notification of hot spots and participating in WNV advisory committees. TRCA provided larval mosquito identification training to Durham Region Public Health, Halton Region Public Health, and City of Hamilton Public Health Units. Throughout our monitoring season, when we identify a hotspot, the respective public health unit is notified of our findings.

Participation in regional West Nile virus advisory committees is an important part of liaising with public health partners. In addition, an Order from the Peel Region Medical Officer has been issued to TRCA annually under the *Health Protection and Promotion Act*, R.S.O. 1990, c. H.7 to facilitate all mosquito reduction activities within the Heart Lake Wetland Complex in Brampton. TRCA anticipates receiving a similar Order from the Medical Officer again in 2018.

4. Larval Mosquito Monitoring

4.1 Methods

4.1.1 Monitoring Site Locations

The 2017 larval mosquito monitoring program began on June 1, sampling 43 wetlands and 6 SWMPs across TRCA's jurisdiction including: Durham Region (8 sites), Peel Region (10 sites), City of Toronto (12 sites), and York Region (19 sites) (Figure 1). Most monitoring stations were selected initially based on their popularity and proximity to residential areas. A few additional stations were added based on the standing water complaints TRCA received over the years. Two new monitoring stations were added in York Region to monitor a newly created wetland complex in Vaughan. We will also remove one station in Albion Hill Conservation Area from future sampling as standing water is no longer present; the area has been re-channelized and re-naturalised as part of the *Albion Hills Conservation Area Master Plan*.

4.1.2 Sampling and Identification of larval mosquitoes

Each monitoring station was sampled five times in approximately two to three-week intervals from June 1 to August 31. The waterbody at each station was divided into four comparatively equal quadrants, and one sample was taken within each quadrant. Each sample consisted of dipping with a standard mosquito dipper 10 times. During sampling, the field technician used several dipping techniques to ensure that different types of mosquito habitats were sampled. Collected mosquito larvae were taken back to the lab, enumerated, and reared until they reached maturity (fourth instar stage). The larvae were then preserved in 70% ethyl alcohol and identified under a dissecting microscope using mosquito taxonomic keys (Wood et al., 1979; Darsie and Ward, 2005). Larvae that died before reaching maturity were not identified.

4.1.3 WNV Risk Assessment

WNV risk ranking was assessed for each site based on the number of vector larvae found in a sample, according to the modified Wada's method of ranking (Wada, 1956):

- Sites with no vector larvae were ranked as "***Nil***" risk;
- Sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk;
- Sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk;
- Sites with >31 vector larvae per 10 dips were ranked as "***High***" risk sites.

Risk ranking was applied to each species independently, instead of the cumulative number of all larvae found due to species variation in WNV transmission abilities. Sites with high risk ranking hotspots were addressed, the respective regional health unit was informed and if warranted, the sites were treated with larvicide by a licensed contractor.

Figure 1 Location of West Nile Virus Monitoring Stations, 2017

4.1.4 WNV Risk Assessment

WNV risk ranking was assessed for each site based on the number of vector larvae found in a sample, according to the modified Wada's method of ranking (Wada, 1956):

- Sites with no vector larvae were ranked as "***Nil***" risk;
- Sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk;
- Sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk;
- Sites with >31 vector larvae per 10 dips were ranked as "***High***" risk sites.

Risk ranking was applied to each species independently, instead of the cumulative number of all larvae found due to species variation in WNV transmission abilities. Sites with high risk ranking hotspots were addressed, the respective regional health unit was informed and if warranted, the sites were treated with larvicide.

4.2 Results

4.2.1 Mosquito diversity and distribution

In total, 13,036 mosquito larvae representing 14 species were identified from 49 routine monitoring stations (Figure 2). Compared to the previous years, we collected 67% more mosquitoes in 2017 than the average number of mosquito collected from 2012 to 2016 (n=7,796). Mosquito larvae that died prematurely (n=599; 4.6%) were not identified, thus excluded from the analyses and risk assessment in the following sections.

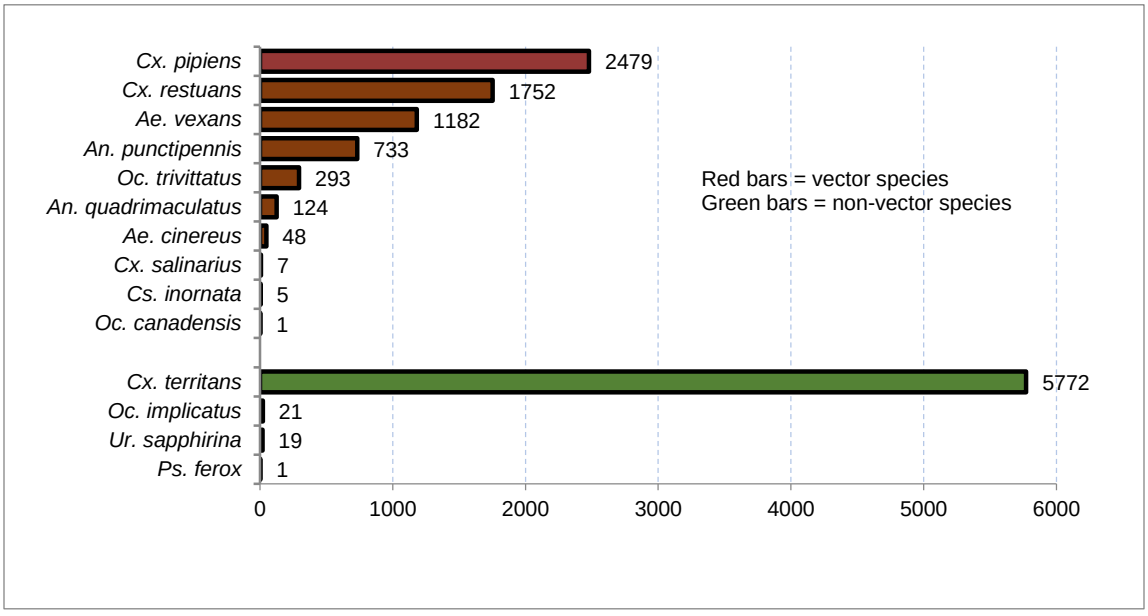


Figure 2 Total number of mosquitoes collected in 2017

Similar to previous years, the most dominant and widespread species was *Culex territans,* a non-vector species, which inhabited 33 of the 49 monitoring sites (Figure 2; Figure 3). The two key WNV vectors, *Culex pipiens* and *Culex restuans,* were the most abundant vector species (Figure 2); they were found at 16 and 10 sites respectively (Figure 3). The most wide-spread vector species was *Anopheles punctipennis,* which was found in 31 sites (Figure 3). Although study suggested that this species is capable of carrying West Nile virus, its competence in transmitting WNV to human is much lower than the *Culex* mosquitoes (Belton, 2007). As in previous years, higher mosquito diversity was observed in wetlands compared to SWMPs. This finding may be attributed to the facts that more wetland sites were sampled, and wetlands generally provide more diverse habitats and shelter.

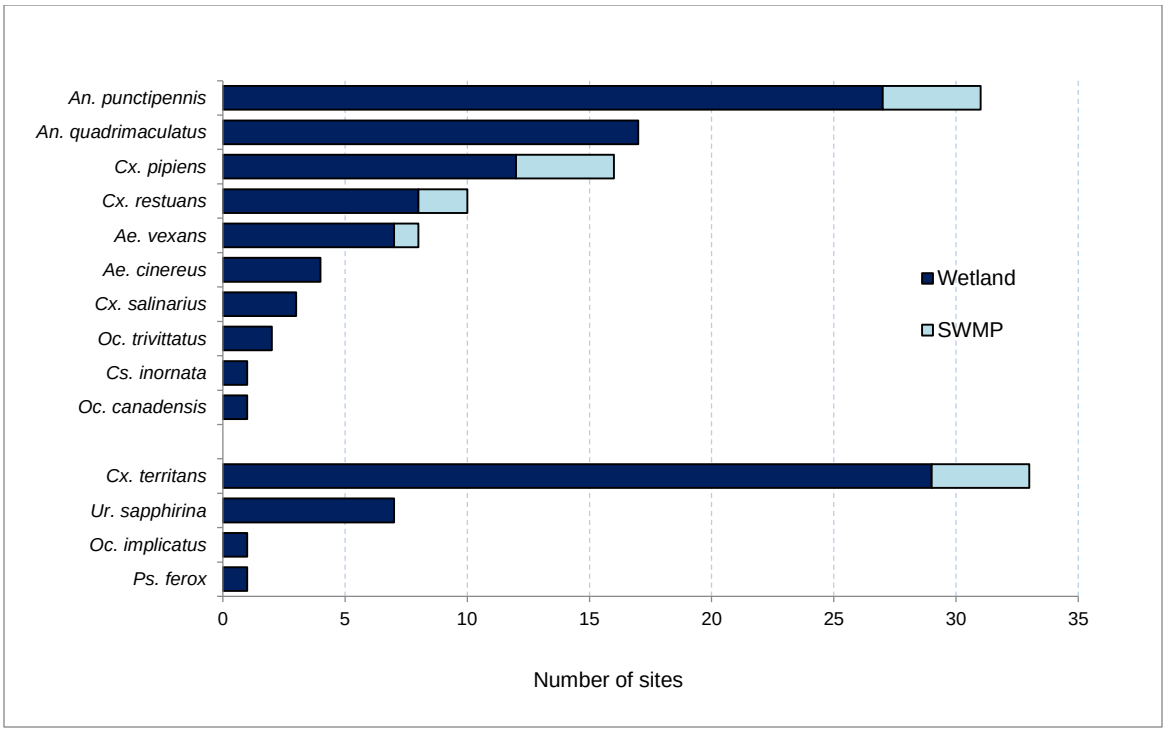
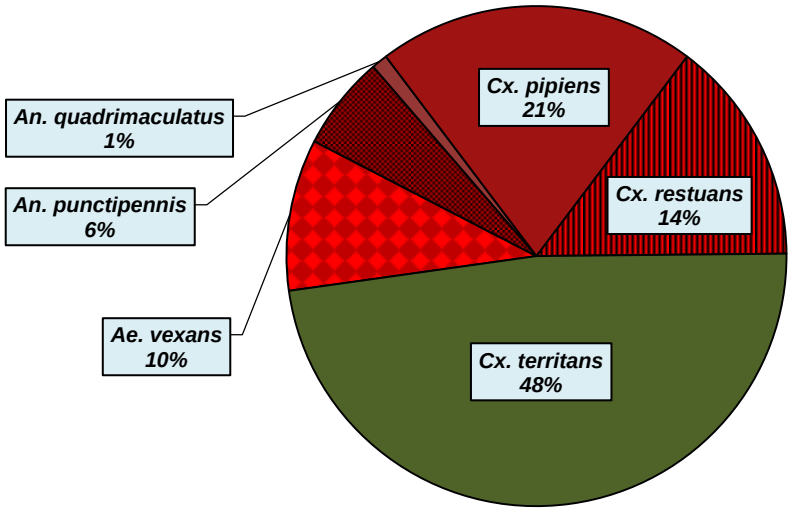


Figure 3 Number of sites each species was found in 2017

4.2.2 Wetlands

In total, 10,138 mosquito larvae of 14 species were identified from 43 wetlands. In 2017, due to the amount of precipitation and flood conditions, we saw a significant increase in number of inland floodwater mosquitoes (*Aedes vexans*) across our monitoring stations. *Culex territans*, a non-vector species continued to be the dominant species in wetlands, representing 48% of all the mosquitoes collected (Figure 4). The two most important WNV vectors, *Culex pipiens* and *Culex restuans*, represented 21% and 14% of the mosquitos collected respectively (Figure 4).



Note: Other species collectively represented less than 1% of the mosquito collected, and are excluded from the chart.

Figure 4 Mosquito species composition in wetlands in 2017 (non-vector species are in green and vector species are in red)

Similar to previous years, monitoring results showed that most wetlands (88%) posed minimal risk for harbouring WNV vector mosquitoes. Nevertheless, West Nile virus vector hotspots continued to occur sporadically. The five wetland hotspots identified in 2017 were: Altona Forest, Claireville wetland, McMichael wetland, and two unnamed wetlands in York Region. These hotspots occurred earlier in the season compared to previous years. Altona Forest was identified as a hotspot for *Culex restuans* on June 1, and McMichael was identified as a hotspot for *Culex restuans* and *Culex pipiens* on June 16. Claireville wetland and the two unnamed wetlands were identified as hotspots for floodwater mosquitoes, *Aedes vexans* following significant rainfall events in the summer.

Altona Forest and an unnamed wetland on highway 27 were treated by TRCA's larvicide contractor. McMichael wetland and Claireville wetland were treated with the assistance from York Region and Peel Region Public Health respectively. Environmentally friendly larvicide, *Bacillus thuringiensis israelensis* (*Bti*) was used to treat all the hotspots listed above. *Bti* is a bacterium found naturally in soils, and since 1982, it has been used successfully worldwide as a biological pest control agent to combat mosquitoes and black flies (Health Canada 2011). The unnamed wetland in Maple was untreated since it dried up prior to receiving larvicide treatment.

Since mosquitoes can only carry WNV after biting an infected bird, mosquito larvae do not feed on blood thus do not carry the virus. When a site is ranked as high-risk or a "hotspot", it does not imply that the virus is present and poses immediate threat to the public. The risk ranking simply indicates the presence of vector mosquito species which could potentially spread WNV to human populations after they emerge as adult mosquitoes, not the presence of the virus.

None of the hotspots identified in 2016 (*i.e.* Grenadier Pond in High Park, Woodland Pond, Topham Pond and Keffer Marsh) reoccurred as a hotspot in 2017. These results confirmed that the occurrence of a hotspot is unpredictable. Full larval mosquito monitoring risk assessment results for each monitoring station can be found in Appendix B-1 to B-4.

4.2.3 Stormwater Management Ponds (SWMPs)

From the six monitored SWMPs, we collected 2898 mosquitoes, which consisted of 88% of vector species and 12% non-vector species (Figure 5). Similar to previous monitoring results, *Culex pipiens* was the dominant mosquito species (77%; Figure 5). The majority of *Culex pipiens* (96.7%) were collected from SWMP 88.2, one of the two identified SWMP hotspots. The other identified hotspot was L'Amoreaux Park - North Pond. Both hotspots received larvicide treatments and most mosquitoes were eliminated after multiple applications. In subsequent sampling events post treatments, we collected very limited quantity (up to six) of mosquitoes at these stations.

SWMP 88.2 had reoccurred as a hotspot in previous years (2006, 2011, and 2015), L'Amoreaux - North Pond, had also been identified as a hotspot in most years. TRCA will continue to monitor these two sites closely amongst other SWMPs in 2018. Full mosquito monitoring risk assessment results for each SWMP station can be found in Appendix B-1 to B-4.

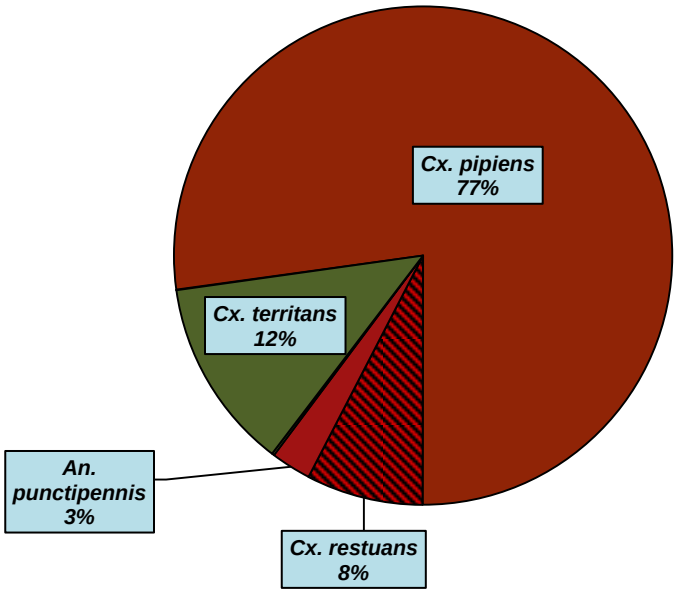
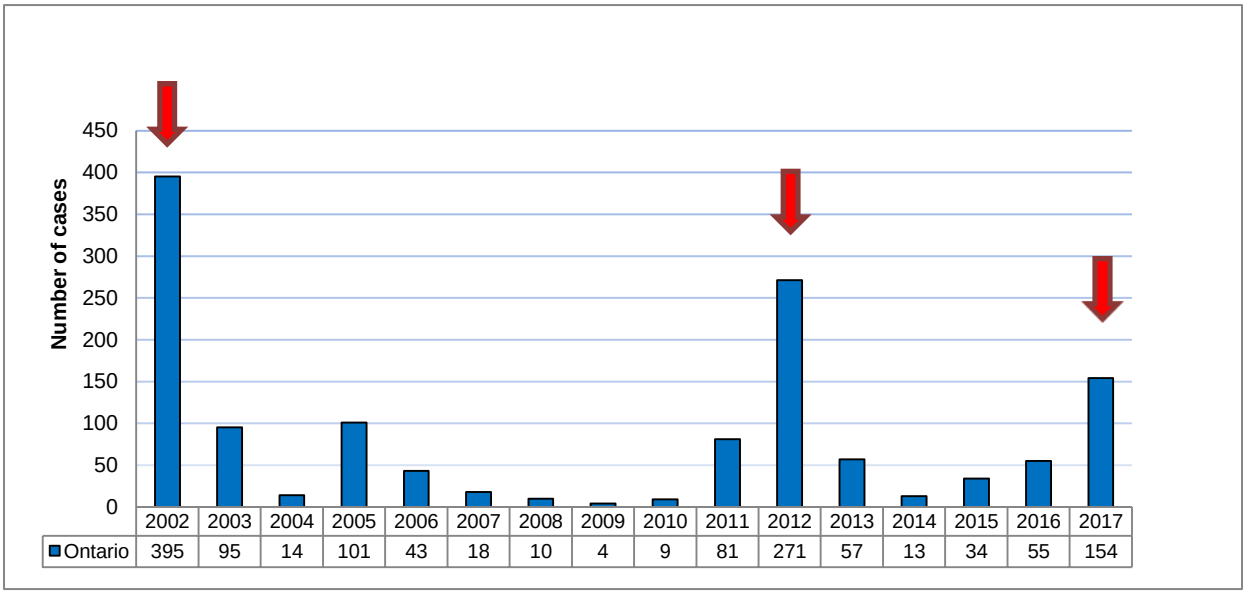


Figure 5 Mosquito species composition in stormwater management ponds, 2017
(Non-vector species are in green and vector species are in red)

5. West Nile virus in the GTA and in Ontario

Ontario's provincial and regional health agencies continue to monitor adult mosquitoes, larval mosquitoes, and human cases as part of the WNV surveillance programs. Adult mosquitoes monitoring is crucial for determining the immediate risk of humans contracting WNV. Larval mosquito surveillance provides information allowing regional public health units to eliminate/reduce mosquito larvae through larvicide application. Human surveillance information is used to alert the health care professionals of an outbreak, and provides clues about who may be at higher risk for serious health effects from WNV. The dead bird surveillance program had been terminated since 2009 in Ontario, but The Canadian Wildlife Health Cooperative continues to test dead birds for WNV in collaboration with Ontario laboratories and The National Microbiology Laboratory in Winnipeg. Most human cases were reported in urban areas in Ontario because of the large numbers of catch basins, which are the preferred development site for the *Culex* mosquito species. Public Health Units continued to treat these catch basins on a regular basis in the summer months (4-5 treatments to be repeated at 3-week intervals).

In Ontario, the number of human WNV cases fluctuates annually, driven by complex environmental and biological factors. In 2017, number of WNV human cases increased to 154 cases from 55 cases in 2016 in Ontario, the third highest number since the introduction of West Nile virus in 2001 (Figure 6). Within TRCA's jurisdiction, 51 human WNV cases were reported in 2017: City of Toronto, 20 cases; York Region, 11 cases; Peel Region, 9 cases; and Durham Region, 3 cases.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ontario	395	95	14	101	43	18	10	4	9	81	271	57	13	34	55	154

Figure 6 Human West Nile virus cases in Ontario, 2002 – 2017

6. Conclusions

The results from the 2017 program supported the findings from the previous TRCA studies. Generally, wetlands do not pose threats of WNV transmission. Monitoring results showed that most wetlands posed minimal risk for harbouring WNV vector mosquitoes. Nevertheless, West Nile virus vector hotspots continued to occur; seven hotspots were detected and treated with the assistance provide by the City of Toronto Public Health, and York Region Public Health. Collaboration with Regional Public Health units is crucial in managing WNV vector hotspots in a timely manner.

Compared to 2016, a rise in WNV infection rate in humans was observed in Ontario possibly associated with the amount of precipitation we received in the spring. It is difficult to predict the level of WNV activity in a given year, therefore the ability to detect hotspots, and subsequently take appropriate control measures continue to highlight the importance of regular and continuous seasonal monitoring of mosquito abundance.

7. Recommendations

Larval surveillance and control is the most effective method to control mosquito populations because when mosquitoes are eliminated prior to becoming adults, they cannot pose a nuisance or disease problem. As vector mosquito hotspots continued to occur in our jurisdiction, TRCA staff should continue to monitor in wetlands and SWMPs, to address standing water complaints from the public, and to take appropriate control measure if deem necessary.

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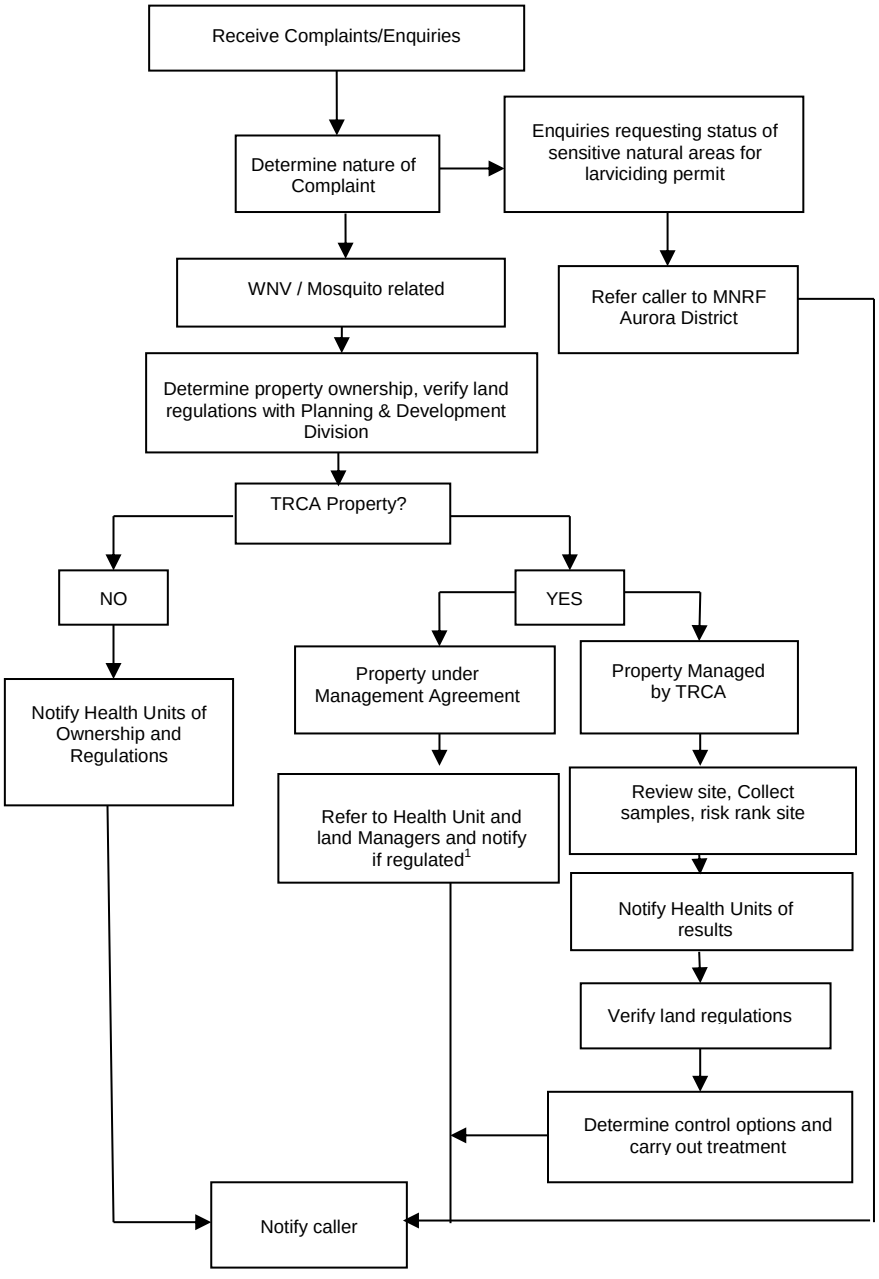
Appendices

Appendix A. TRCA Standing Water Complaint Procedure



Appendix B-1 Monitoring and Risk Assessment Results in Durham Region- 2017

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Site	Sample Date	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*
Carruthers Swamp Complex	01/06/2017 20/06/2017 18/07/2017 02/08/2017 21/08/2017	No risk: no larval mosquito collected				
Claremont Wetland-1	02/06/2017	Nil	Nil	Low	Nil	Nil
	26/06/2017	Nil	Moderate	Low	Nil	Nil
	18/07/2017	Nil	Moderate	Nil	Nil	Nil
	03/08/2017	Nil	Moderate	Nil	Nil	Nil
	22/08/2017	Nil	Moderate	Nil	Nil	Nil
Claremont Wetland-2	02/06/2017	Nil	Nil	Nil	Nil	Nil
	26/06/2017	Nil	Low	Nil	Nil	Nil
	18/07/2017	Nil	Low	Low	Nil	Nil
	22/08/2017	Nil	Low	Moderate	Nil	Nil
	03/08/2017	Nil	Low	Moderate	Nil	Nil
Altona Forest	01/06/2017	Low	Nil	Nil	Nil	High
	21/06/2017	Nil	Moderate	Low	Moderate	High
	14/07/2017	Nil	Nil	Nil	Moderate	High
	02/08/2017	Nil	Moderate	Moderate	Moderate	Nil
	21/08/2017	Nil	Moderate	Nil	Nil	Nil
Frenchman's Bay Promenade	01/06/2017 20/06/2017 14/07/2017 02/08/2017 21/08/2017	No risk: no larval mosquito collected				
Greenwood Marsh	01/06/2017	Nil	Nil	Nil	Nil	Nil
	26/06/2017	Low	Low	Nil	Moderate	Moderate
	18/07/2017	Nil	Moderate	Nil	Low	Nil
	03/08/2017	Nil	Moderate	Moderate	Nil	Nil
	22/08/2017	Nil	Moderate	Nil	Nil	Nil
Greenwood Pond	02/06/2017	Nil	Nil	Nil	Nil	Nil
	21/06/2017	Nil	Nil	Nil	Nil	Nil
	18/07/2017	Nil	Moderate	Nil	Nil	Nil
	03/08/2017	Nil	Nil	Nil	Nil	Nil
	22/08/2017	Nil	Moderate	Nil	Nil	Nil
Lower Duffins	01/06/2017	Low	Nil	Nil	Nil	Nil
	20/06/2017	Nil	Nil	Nil	Nil	Nil
	14/07/2017	Nil	Nil	Nil	Nil	Nil
	02/08/2017	Nil	Moderate	Low	Nil	Nil
	21/08/2017	Nil	Moderate	Nil	Nil	Nil

Appendix B-2 Monitoring and Risk Assessment Results in Peel Region - 2017

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Site	Sample Date	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*
Albion Hills Pond-1	12/06/2017 04/07/2017 24/07/2017 09/08/2017 24/08/2017	No risk: no larval mosquito collected				
Albion Hills Pond-2	12/06/2017	Nil	Nil	Nil	Nil	Nil
	04/07/2017	Nil	Low	Nil	Low	Moderate
	24/07/2017	Nil	Moderate	Nil	Nil	Nil
	09/08/2017	Nil	Low	Nil	Nil	Nil
	24/08/2017	Nil	Moderate	Nil	Nil	Nil
Claireville Wetland-1	09/06/2017	Nil	Nil	Nil	Nil	Nil
	28/06/2017	Nil	Moderate	Low	Nil	Nil
	21/07/2017	Nil	Low	Nil	Nil	Nil
	15/08/2017	Nil	Moderate	Nil	Nil	Nil
	29/08/2017	Nil	Nil	Nil	Nil	Nil
Claireville Wetland-2	09/06/2017	Nil	Nil	Nil	Nil	Nil
	28/06/2017	High	Nil	Nil	Nil	Nil
	21/07/2017	Nil	Nil	Nil	Nil	Nil
	15/08/2017	Nil	Nil	Nil	Nil	Nil
	29/08/2017	Nil	Nil	Nil	Nil	Nil
Glen Haffy Trout Pond-1	12/06/2017	Nil	Moderate	Moderate	Nil	Nil
	04/07/2017	Nil	Moderate	Low	Nil	Nil
	24/07/2017	Nil	Moderate	Low	Nil	Nil
	09/08/2017	Nil	Moderate	Moderate	Nil	Nil
	24/08/2017	Nil	Moderate	Nil	Nil	Nil
Glen Haffy Trout Pond-2	12/06/2017	Nil	Nil	Nil	Nil	Nil
	04/07/2017	Nil	Moderate	Low	Nil	Nil
	24/07/2017	Nil	Moderate	Low	Nil	Nil
	09/08/2017	Nil	Low	Nil	Nil	Nil
	24/08/2017	Nil	Nil	Nil	Nil	Nil
Heart Lake New Site	09/06/2017	Nil	Nil	Nil	Nil	Nil
	28/06/2017	Nil	Nil	Nil	Nil	Nil
	20/07/2017	Nil	Nil	Nil	Nil	Nil
	15/08/2017	Nil	Moderate	Nil	Nil	Nil
	29/08/2017	Nil	Low	Nil	Nil	Nil
Marie Curtis	08/06/2017	Nil	Nil	Nil	Nil	Nil
	05/07/2017	Nil	Nil	Nil	Nil	Nil
	25/07/2017	Nil	Low	Nil	Nil	Nil
	10/08/2017	Nil	Low	Moderate	Nil	Nil
	25/08/2017	Nil	Nil	Low	Nil	Nil
SWMP 174	12/06/2017	Nil	Nil	Nil	Nil	Nil
	04/07/2017	Nil	Nil	Nil	Nil	Nil
	31/07/2017	Nil	Moderate	Nil	Nil	Nil
	17/08/2017	Nil	Moderate	Low	Nil	Nil
	29/08/2017	Nil	Moderate	Nil	Nil	Nil

Appendix B-3 Monitoring and Risk Assessment Results in Toronto - 2017

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Site	Sample Date	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*
Brickworks Pond 1	15/06/2017	Nil	Nil	Nil	Nil	Nil
	07/07/2017	Nil	Nil	Nil	Nil	Nil
	26/07/2017	Nil	Low	Nil	Nil	Nil
	14/08/2017	Nil	Nil	Nil	Nil	Nil
	28/08/2017	Nil	Nil	Nil	Nil	Nil
Col. Samuel Smith Main Pond	08/06/2017	Nil	Nil	Nil	Nil	Nil
	05/07/2017	Nil	Nil	Nil	Nil	Nil
	25/07/2017	Nil	Nil	Nil	Nil	Nil
	10/08/2017	Nil	Nil	Nil	Nil	Nil
	25/08/2017	Nil	Low	Nil	Nil	Nil
Col. Samuel Smith Mini Pond	08/06/2017	Nil	Nil	Nil	Nil	Nil
	05/07/2017	Nil	Nil	Nil	Nil	Nil
	25/07/2017	Nil	Low	Nil	Moderate	Nil
	10/08/2017	Nil	Low	Nil	Nil	Nil
	25/08/2017	Nil	Moderate	Moderate	Nil	Nil
High Park Grenadier Pond	08/06/2017 05/07/2017 25/07/2017 10/08/2017 25/08/2017	No risk: no larval mosquito collected				
L'Amoreaux North Pond	16/06/2017	Nil	Nil	Nil	Nil	Nil
	10/07/2017	Nil	Nil	Nil	Nil	Nil
	26/07/2017	Low	Nil	Nil	High	Moderate
	11/08/2017	Nil	Nil	Nil	Nil	Nil
	28/08/2017	Nil	Low	Nil	Nil	Nil
L'Amoreaux South Pond	16/06/2017	Nil	Nil	Nil	Nil	Nil
	10/07/2017	Nil	Nil	Nil	Nil	Nil
	26/07/2017	Nil	Nil	Nil	Nil	Nil
	11/08/2017	Nil	Low	Nil	Nil	Nil
	28/08/2017	Nil	Low	Nil	Low	Nil
Milne Hallow	15/06/2017 10/07/2017 26/07/2017 11/08/2017 28/08/2017	No risk: no larval mosquito collected				
Mimico Amphibian Pond	08/06/2017 05/07/2017 25/07/2017 10/08/2017 25/08/2017	No risk: no larval mosquito collected				
Topham Pond	08/06/2017	Nil	Nil	Nil	Moderate	Moderate
	10/07/2017	Nil	Nil	Nil	Nil	Nil
	28/07/2017	Nil	Nil	Nil	Low	Nil
	17/08/2017	Nil	Nil	Nil	Nil	Nil
	30/08/2017	Nil	Nil	Nil	Nil	Nil
TTP Goldfish Pond	14/06/2017	Nil	Nil	Nil	Nil	Nil
	07/07/2017	Nil	Nil	Nil	Nil	Nil
	28/07/2017	Nil	Nil	Nil	Nil	Nil
	14/08/2017	Nil	Nil	Nil	Moderate	Nil
	28/08/2017	Nil	Nil	Nil	Low	Nil
TTP Triangle Pond	14/06/2017 07/07/2017 28/07/2017 15/08/2017 28/08/2017	No risk: no larval mosquito collected				
Woodland Pond	08/06/2017	Nil	Nil	Nil	Nil	Nil
	10/07/2017	Nil	Low	Nil	Moderate	Nil
	28/07/2017	Nil	Low	Nil	Moderate	Nil
	17/08/2017	Nil	Low	Low	Moderate	Low
	30/08/2017	Nil	Moderate	Nil	Moderate	Nil

Appendix B-4 Monitoring and Risk Assessment Results in York Region - 2017

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Site	Sample Date	Ae. vexans	An. punctipennis	An. quadrimaculatus	Cx. pipiens	Cx. restuans
Boyd Conservation Area	16/06/2017	Nil	Nil	Nil	Nil	Nil
	11/07/2017	Nil	Nil	Nil	Nil	Nil
	31/07/2017	Nil	Low	Nil	Nil	Nil
	17/08/2017	Nil	Nil	Nil	Low	Nil
	30/08/2017	Nil	Nil	Nil	Nil	Nil
Boyd Granger Wetland North	13/06/2017	Nil	Low	Nil	Nil	Nil
	11/07/2017	Nil	Low	Low	Nil	Nil
	31/07/2017	Nil	Low	Nil	Nil	Nil
	15/08/2017	Nil	Low	Low	Nil	Nil
	30/08/2017	Nil	Moderate	Nil	Nil	Nil
Boyd Granger Wetland South	13/06/2017	Nil	Nil	Nil	Nil	Nil
	11/07/2017	Nil	Low	Nil	Nil	Nil
	31/07/2017	Nil	Moderate	Nil	Nil	Nil
	15/08/2017	Nil	Low	Nil	Nil	Nil
	30/08/2017	Nil	Low	Nil	Nil	Nil
Bruce's Mill	07/06/2017 27/06/2017 19/07/2017 08/08/2017 23/08/2017	No risk: no larval mosquito collected				
Cold Creek Pond	13/06/2017	Nil	Nil	Nil	Nil	Nil
	06/07/2017	Nil	Nil	Nil	Nil	Nil
	31/07/2017	Nil	Nil	Nil	Nil	Nil
	16/08/2017	Nil	Low	Nil	Nil	Nil
	29/08/2017	Nil	Low	Low	Nil	Nil
Cold Creek Wetland	13/06/2017	Nil	Nil	Nil	Nil	Nil
	06/07/2017	Nil	Nil	Nil	Nil	Low
	31/07/2017	Nil	Low	Low	Nil	Nil
	16/08/2017	Nil	Moderate	Nil	Nil	Nil
	29/08/2017	Nil	Moderate	Nil	Nil	Nil
Earth Rangers Wetland	19/06/2017	Nil	Nil	Nil	Nil	Nil
	12/07/2017	Nil	Moderate	Nil	Nil	Nil
	01/08/2017	Nil	Moderate	Nil	Nil	Nil
	18/08/2017	Nil	Moderate	Nil	Nil	Nil
	30/08/2017	Nil	Moderate	Low	Nil	Nil
Keffer Marsh	05/06/2017	Nil	Nil	Nil	Nil	Nil
	06/07/2017	Nil	Nil	Nil	Nil	Nil
	21/07/2017	Nil	Nil	Nil	Nil	Nil
	18/08/2017	Nil	Moderate	Nil	Nil	Nil
	31/08/2017	Nil	Nil	Nil	Nil	Nil
Kortright Centre Marsh	12/07/2017	Nil	Low	Low	Nil	Nil
	16/06/2017	Nil	Nil	Nil	Nil	Nil
	01/08/2017	Nil	Nil	Moderate	Nil	Nil
	18/08/2017	Nil	Nil	Nil	Nil	Nil
	30/08/2017	Nil	Nil	Nil	Nil	Nil
Stouffville Reservoir	07/06/2017	Nil	Nil	Nil	Nil	Nil
	26/06/2017	Nil	Nil	Nil	Nil	Nil
	19/07/2017	Nil	Nil	Nil	Nil	Nil
	08/08/2017	Nil	Nil	Nil	Nil	Nil
	23/08/2017	Nil	Nil	Nil	Moderate	Nil
Toogood Pond	07/06/2017 22/06/2017 19/07/2017 08/08/2017 23/08/2017	No risk: no larval mosquito collected				

Appendix B-4 Monitoring and Risk Assessment Results in York Region – 2017 (Continued)
Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Site	Sample Date	Ae. vexans	An. punctipennis	An. quadrimaculatus	Cx. pipiens	Cx. restuans
Elgin Mills Site	05/06/2017	Nil	Nil	Nil	Nil	Nil
	27/06/2017	Nil	Nil	Nil	Nil	Nil
	17/07/2017	Nil	Nil	Nil	Low	Nil
	18/08/2017	Nil	Nil	Nil	Nil	Nil
	31/08/2017	Nil	Nil	Nil	Nil	Nil
Cardish Site	11/07/2017	Nil	Nil	Nil	Nil	Nil
	19/06/2017	Nil	Nil	Nil	Nil	Nil
	27/07/2017	Low	Moderate	Nil	Low	Nil
	16/08/2017	Nil	Low	Nil	Moderate	Nil
	29/08/2017	Nil	Low	Nil	Nil	Nil
Salamander Site	05/06/2017	Nil	Nil	Nil	Nil	Nil
	27/06/2017	High	Nil	Nil	Nil	Nil
	17/07/2017	Nil	Nil	Nil	Nil	Nil
	18/08/2017	Nil	Nil	Nil	Nil	Nil
	31/08/2017	Nil	Nil	Nil	Nil	Nil
Hwy. 27 Site	13/06/2017	Nil	Low	Nil	Nil	Low
	11/07/2017	Nil	Moderate	Nil	Nil	Nil
	27/07/2017	High	Moderate	Nil	Nil	Nil
	18/08/2017	Nil	Nil	Nil	Nil	Nil
	30/08/2017	Nil	Nil	Nil	Nil	Nil
SWMP 139	05/06/2017	Nil	Nil	Nil	Nil	Nil
	27/06/2017	Nil	Nil	Nil	Nil	Nil
	17/07/2017	Nil	Nil	Nil	Nil	Nil
	18/08/2017	Nil	Nil	Nil	Low	Nil
	31/08/2017	Nil	Nil	Nil	Low	Nil
SWMP 88.2	07/06/2017	Nil	Nil	Nil	Moderate	Moderate
	22/06/2017	Nil	Nil	Nil	Moderate	Moderate
	26/07/2017	Nil	Moderate	Nil	High	Moderate
	08/08/2017	Nil	Low	Nil	Moderate	Nil
	23/08/2017	Nil	Nil	Nil	Low	Nil
Killian Lamar	05/06/2017	Nil	Nil	Nil	Nil	Nil
	06/07/2017	Nil	Nil	Nil	Nil	Nil
	21/07/2017	Nil	Nil	Nil	Nil	Nil
	18/08/2017	Nil	Nil	Low	Nil	Nil
	31/08/2017	Nil	Nil	Low	Nil	Nil
McMichael Wetland	11/07/2017	Nil	Nil	Nil	Nil	Nil
	16/06/2017	Nil	Low	Nil	High	High
	31/07/2017	Nil	Nil	Nil	Nil	Nil
	16/08/2017	Nil	Nil	Nil	Nil	Nil
	29/08/2017	Nil	Low	Low	Nil	Nil