

Larval Mosquito Reduction

Introduction

The most efficient and cost effective method of reducing mosquito populations is targeting the larval stage and the sites where they can develop. This offers an opportunity to reduce the number of mosquitoes in an efficient way before the adult mosquitoes emerge and become widely dispersed. Once mosquitoes become flying adults, reducing mosquito populations is more difficult and expensive.

A larval reduction program was first undertaken in Peel in 2003. This program was expanded and enhanced in 2004. The purpose of this program was to reduce the abundance of WNV vector mosquitoes, in particular the *Culex* species.

Although 38 species of mosquitoes were found in Peel in 2004, only a few are capable of transmitting WNV. *Culex pipiens* and *Culex restuans* are the most important mosquito species in the local transmission of WNV. They are one of the most common mosquitoes found in urban and suburban areas. They breed quickly and use standing or slow-moving water containing decaying organic matter to lay their eggs. Prime breeding sites include roadside catch basins, ditches, discarded tires left outdoors, unused swimming pools and containers left outdoors to collect water. Catch basins are an especially important environment since the majority of catch basins inspected in Peel have been found to contain mosquito larvae. This is supported by findings in other nearby jurisdictions.

Breeding of mosquitoes can be prevented by either eliminating breeding sites containing stagnant water (source reduction), changing the environment to be less hospitable for mosquito breeding, or treating the water with larvicide to prevent mosquitoes from developing. Habitat modification can include changing the physical environment or introducing predators. In 2004, Peel conducted a study by stocking a pond with fathead minnows to determine if the fish would be effective in reducing mosquito larvae. Peel Public Health staff also worked with municipal departments in identifying mosquito breeding sites on public property that could be remediated or modified. Peel Public Health's educational material provided homeowners with guidelines to reduce mosquito breeding sites on residential property.

Where *Culex* or other vector mosquito species could not be effectively reduced by other means, larvicides were employed. The larvicides that were used in Peel were *Bacillus thuringiensis* var. *israelensis* (Bti) and methoprene (Altosid®).

Methoprene is a synthetic insect growth regulator which interferes with the development of mosquito larvae into adults.⁴ It has been widely used over a period of many years, and its effectiveness and environmental impact have been extensively studied and documented. It has been investigated and approved by

the federal Pest Management Regulatory Agency (PMRA) for mosquito larviciding in Canada. Methoprene has very little non-target species toxicity, and poses no risk to the health of mammals, including humans. It degrades rapidly in water, particularly in the presence of sunlight. In 2003, the Ontario Ministry of the Environment (MOE) conducted WNV monitoring studies in conjunction with the University of Western Ontario, Ryerson University, the City of Toronto, Peel Region, Halton Region, Environment Canada and local conservation authorities. Previous studies suggested that methoprene, once it leaves storm sewers and enters the environment, will break down in a short period of time. The 2003 WNV monitoring studies confirmed that the larvicides used to reduce mosquitoes did not harm streams, rivers and drinking water in treated areas and that the pesticides were effective in reducing mosquito larvae. Overall, these studies collected and analyzed approximately 1,200 water samples.¹⁴

In 2004, methoprene was the only larvicide which the MOE would permit to be used to treat catch basins.¹⁵ Methoprene has a number of features which makes it the preferred larvicide for catch basins. It is highly effective against the mosquitoes found in catch basins (*Culex pipiens* and *Culex restuans*) and works well in water containing high organic matter. Four applications of methoprene pellets were applied to approximately 75,000 roadside catch basins in Brampton, Mississauga, and in the towns, villages and rural subdivisions of Caledon. In 2004, catch basins located in the green spaces of municipal parks were included in the larviciding program as were catch basins on properties owned or managed by Peel. Methoprene briquets which received temporary registration by the PMRA in 2004 were used primarily in the park catch basins. A single application of briquets was undertaken in these catch basins as the label indicated they were to provide season long control of mosquito larvae. Peel Public Health participated in a study with the MOE to determine the effectiveness of the briquets. The final results of the study were not available at the time this report was written.

Catch basins which drained directly into environmentally sensitive areas such as Rattray Marsh or Cawthra Park were treated by a device called a 'Larvasonic®'. The Larvasonic® generates acoustic energy which causes trauma to the internal organs of the larvae resulting in their death.

In addition to catch basins, Peel's larval reduction program includes the treatment of surface water breeding sites that are located on public lands. In 2004, a total of 138 surface water breeding sites were treated in Peel. Decisions to larvicide these sites were based on larval surveillance activities and response to stagnant water complaints. The MOE only permitted the larvicide Bti (*Bacillus thuringiensis israelensis*) to be used on surface water.¹⁵ Bti is a biological pesticide which kills mosquito larvae before they develop into adults. Like methoprene, Bti has been extensively used, studied and regulated. It is more selective for mosquito larvae than methoprene, and so has less impact on other insect species. However, it is also less effective and more difficult to use,

particularly in catch basins. Bti breaks down quickly in the environment and needs to be reapplied regularly to obtain adequate mosquito reduction.

Peel Public Health developed a computerized program to track the mosquito breeding sites throughout the Region. This program was used to guide both larval surveillance and larval reduction activities.

Methods

Prior to the initiation of the larviciding program, permit applications were prepared by the WNV team and submitted to the MOE for review and approval. Four permits were issued for Peel's larviciding program. A permit was issued to allow three applications of Altosid® pellets (methoprene) to the roadside catch basins (Figure 21) and to apply Altosid® XR Briquets (methoprene) to catch basins located in parkland and on Peel owned and/or operated properties. An amended permit was issued to allow a fourth round of Altosid® pellets to be applied to the roadside catch basins. Another permit was issued allowing the use of Bti larvicide (Vectobac® or Aquabac™) at surface water sites located on public lands. A permit specific to the treatment of stagnant pools located in the Rattray Marsh and Cawthra Woods was also issued. These two sites are designated as protected wetlands by the Ministry of Natural Resources and required a special approval process and separate permit. Bti was the only larvicide permitted for use in wetlands.

Pestalto Environmental Products Inc. was contracted by Peel to provide the mosquito larval reduction services. The contract involved locating and mapping catch basins and surface water breeding sites, monitoring larval activity prior to the larvicide application, applying the larvicide and collecting larvae or pupae samples to determine larvicide efficacy. In 2004, Peel Region staff was provided larviciding treatment information on a daily basis through "real-time" access to data on Pestalto's website database.

Pestalto applied four rounds of Altosid® pellets (methoprene) to the municipal roadside catch basins in Peel during 2004. These catch basins were larvicided at approximately 21 day intervals. Each catch basin received 0.7 grams of pellets as per the MOE permit requirement.¹⁵ Teams of two people treated the catch basins. One person was responsible for driving the truck and the other was responsible for the application and marking the catch basin grate with a non-permanent paint. A coloured dot was painted on each catch basin grate to identify that larvicide was applied. A designated colour represented each round of application (round 1-blue, round 2-white, round 3-orange and round 4-green). The catch basin colour coding scheme was implemented as a result of a recommendation in the 2003 WNV evaluation report.⁶

Catch basins that were treated with briquets received one application and were marked with red dot.

Catch basins that drained directly into sensitive areas were treated by the Larvasonic® device that uses ultrasound to kill the mosquito larvae rather than using Altosid® pellets.¹⁶ Sensitive area catch basins were marked with a yellow dot.

Larval surveillance conducted by Peel Public Health staff resulted in a number of stagnant surface water sites being referred to our licensed applicator, Pestalto Environmental Products, for larviciding. The applicator applied granular Bti products to sites that contained moderate to high densities of larvae as per the MOE guidelines. They primarily used the Bti product Aquabac™ 200G, but used a similar product, Vectobac® 200G at one site.¹⁶

The application of Bti was carried out using two methods. The first involved the use of a calibrated grass seed spreader (Figure 22). This was used to distribute the product evenly over a large surface area. The second method involved manual application. The product was measured using a graduated cylinder and measuring spoons and scattered by hand evenly over a water surface. This method was used on small water bodies such as culverts or tire tracks. A public notification sign (Figure 23) was posted at each surface water site immediately before the application and for at least 48 hours after the application as per the MOE permit requirements.

Results

Catch Basin Treatments

Round one of the roadside catch basin program began on June 14th and was completed by July 2. A total of 72,484 catch basins were treated during this round.¹⁶

Round two began on July 5th and was completed on July 23rd. A total of 75,831 catch basins were treated in round two.¹⁶

Round three commenced on July 26th and finished on August 13th. In round three a total of 74,774 were larvicided.¹⁶

Round four began on August 16th and was completed on September 3rd. A total of 74,021 catch basin received treatment in this round.¹⁵



Figure 21: Catch Basin Grate

Source: Photo taken by Peel Public Health WNV Team

The variation between the numbers of catch basins treated each round was primarily due to Pestalto not treating catch basins in the zones where catch basin vacuuming was being undertaken.

A total of 209 kilograms of Altosid® pellets was used to treat the catch basins in Peel Region. This total includes 1,863 treatments of catch basins located on Peel owned and operated properties, one catch basin in a public park and 37 in private backyards.¹⁶

A total of 1,463 Altosid® XR Briquets (methoprene ingots) was applied to catch basins: 1,284 in public parks, 72 on Peel owned or operated properties, 33 on highways and 74 to private back yards.¹⁶ Back yard catch basins were treated upon the request of the home owner and required a signed consent form prior to the application.

One hundred and fifty-one catch basins were treated with the Larvasonic® device. These catch basins required treatment numerous times over the summer as the Larvasonic® did not provide any residual activity.

Surface Water Site Treatments

In 2004, 138 surface water sites received a total of 226 Bti treatments in Peel.¹⁶ Mississauga had 96 sites of which 32 had more than one treatment; Brampton had 16 sites of which six received more than one application; Caledon had 26 sites of which 13 received additional applications.¹⁶ In 2003, 68 surface water sites received a total of 131 larvicide treatments in Peel.¹⁷ The increase in the total number of sites treated can be attributed to a quicker referral process, as some sites were referred for treatment prior to larval identification. In addition, the historical site data gathered in 2002 and 2003 assisted staff in identifying sites that had previously supported larvae.

As noted in 2003, the man-made structures such as ditches and culverts were the site types that were larvicided most frequently (Figures 24 to 27). In 2004, sites were treated under the wetland permit for the first time. Two woodland pools were treated in Cawthra Woods in late June.



Figure 22: Surface Water Larviciding Application using Bti

Source: Photo taken by Peel Public Health WNV Team



Figure 23: Public Notification Sign

Source: Photo taken by Peel Public Health WNV Team

Figure 24: Surface Water Site Types Treated, Region of Peel, 2004

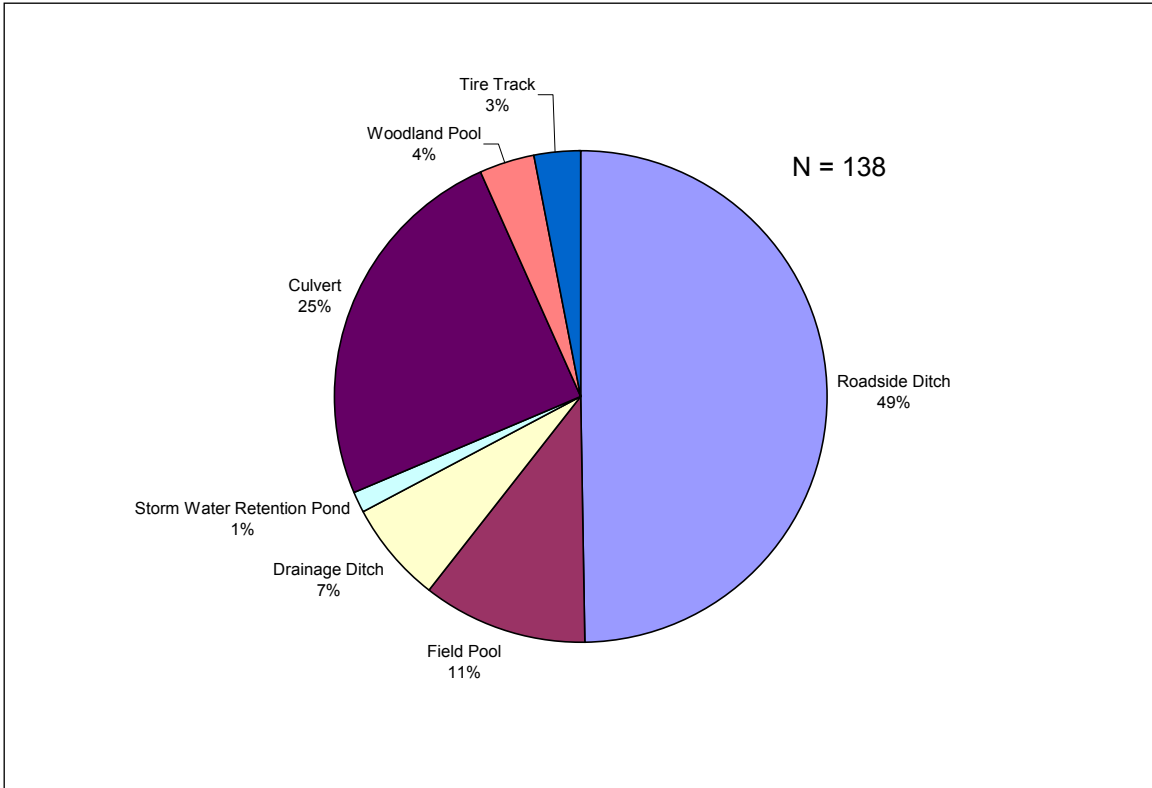


Figure 25: Surface Water Site Types Treated in the Municipality of Mississauga, Region of Peel, 2004

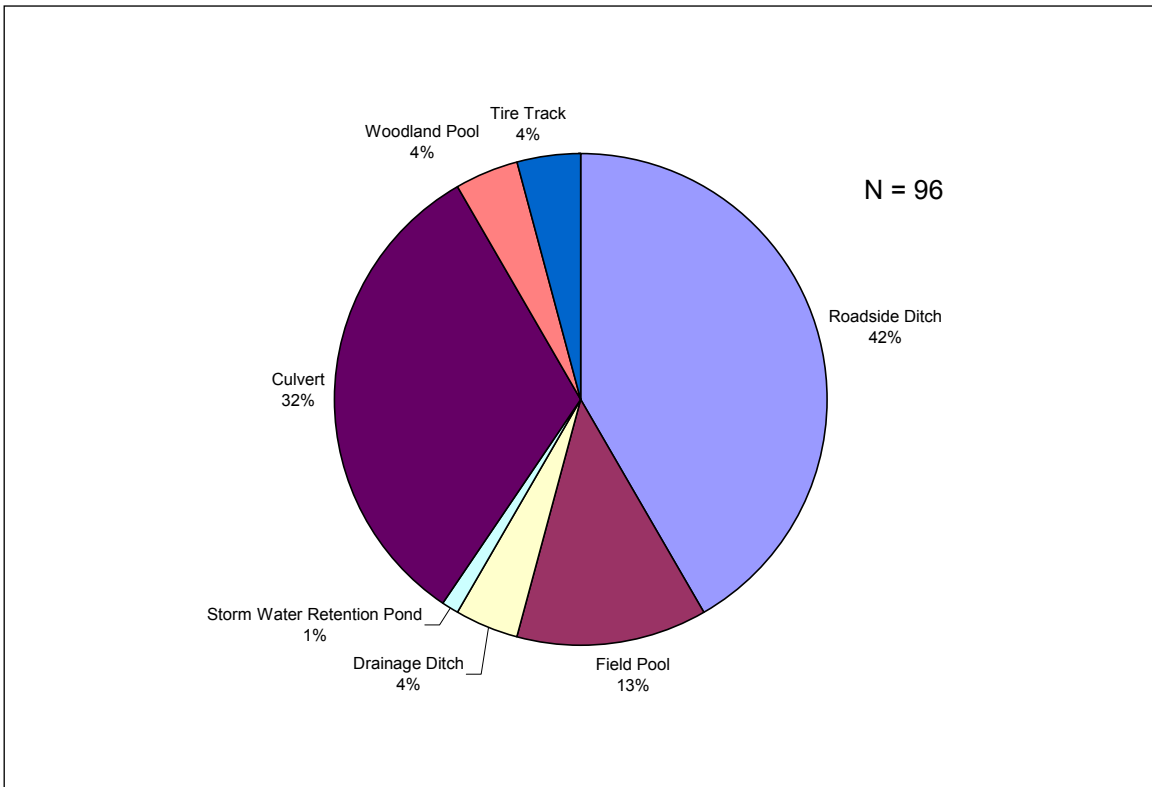


Figure 26: Surface Water Site Types Treated in the Municipality of Brampton, Region of Peel, 2004

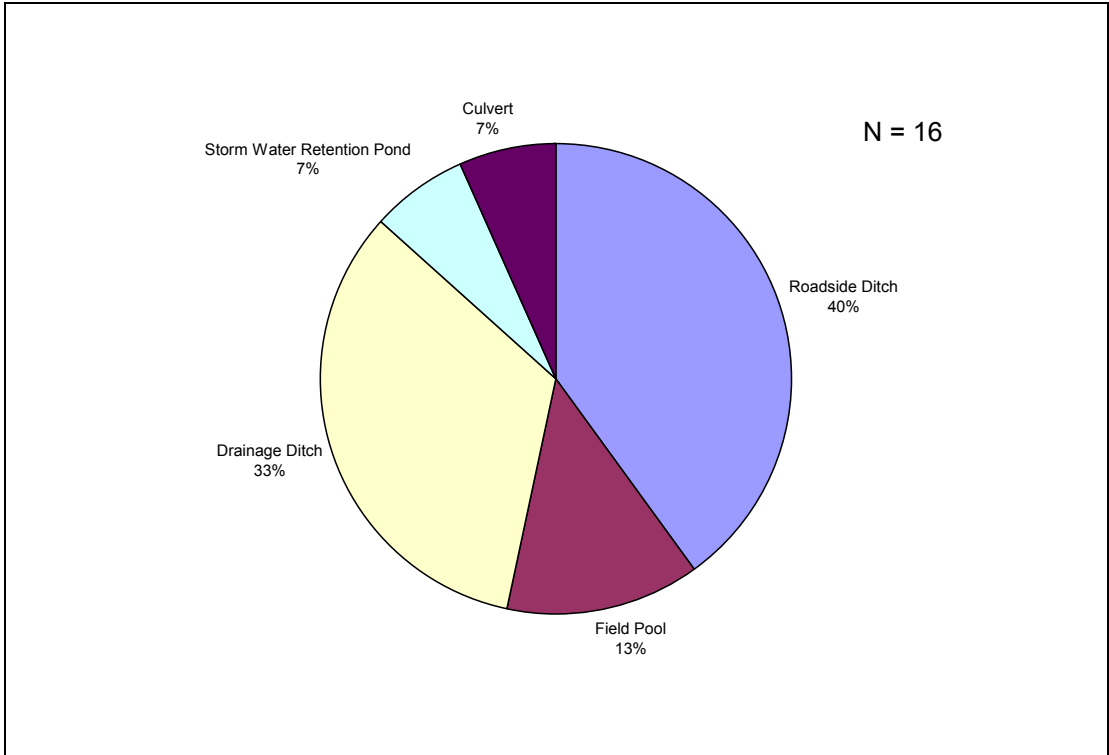
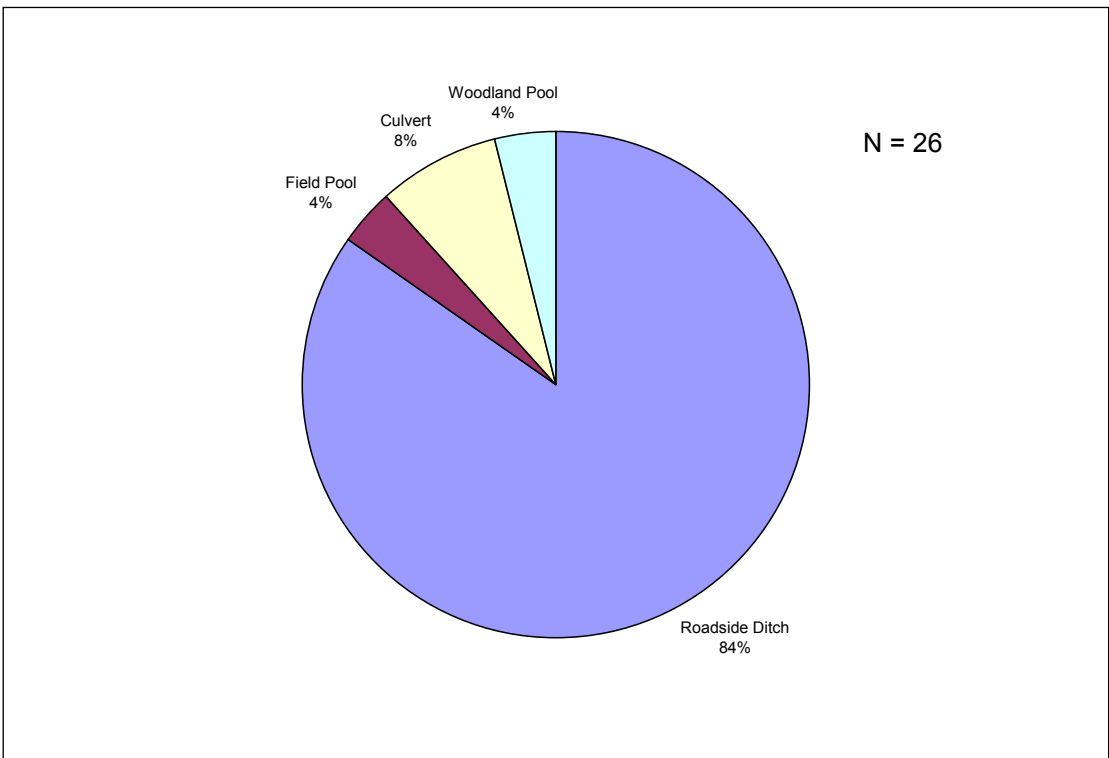


Figure 27: Surface Water Site Types Treated in the Municipality of Caledon, Region of Peel, 2004



Effectiveness of Treatments

A random sample of 35 catch basins located throughout Peel was monitored by Pestalto to determine the efficacy of the Altosid® pellets. The MOE monitoring protocol requires that mosquito pupae and water be collected at approximately seven day intervals following the application of the pellets. The pupae are kept in mason jars and observed daily to see if viable adults successfully emerge over a period of 30 days. The post-treatment pupal monitoring indicated this product's efficacy rate was over 90% and was particularly effective in the first 21 days after application.¹⁶

Peel Public Health and MOE staff carried out a joint study to determine the efficacy of methoprene briquets. The federal PMRA issued a temporary registration for methoprene briquets. The label advised that the briquets would effectively reduce mosquito larvae for up to 150 days.¹⁸ If the briquets did remain effective for 150 days then catch basins would only need to be treated once during the summer. The need to only treat catch basins once during the summer promised savings in manpower over the pellets which need to be added to catch basins three or four times. The study was intended to determine the actual residual activity and efficacy of these briquets in catch basins.

A MOE report of this study will be provided at a later date once the results have been reviewed in detail. Based on the initial data provided by this study, it appears that the ingots did not provide effective efficacy for 150 days. The results indicate that catch basins treated with the briquets had emergence rates varying between 45% to 75% (average 60%) and that the briquets were effective for approximately 60 days.¹⁹

Several factors could have adversely affected the efficacy of the briquets. Rainfall in the summer of 2004 exceeded normal summer rainfall level.²⁰ This could have affected its dissolution properties making it effective for only 60 days instead of 150 days. The increased rainfall could also have flushed the briquets out of the catch basins, as they were not able to be recovered from the catch basins at the end of the study. Lastly, many catch basins contained upwards of two feet of leaves at their base. Burial of the briquets in this organic matter may have reduced their ability to dissolve. These are just theories based on the preliminary data and further investigation will be needed.

The efficacy of the Larvasonic®, which was used in catch basins that drain directly into sensitive wetlands, was also monitored. Pestalto used the standard MOE mosquito larval sequential sampling protocol to determine pre- and post-treatment counts in each of the 151 catch basin where the device was used.¹⁶ The results revealed that mortality occurred more rapidly with larvae in the later stages of development, compared to larvae in the earlier growth stages. However, these larvae in the earlier stages of development eventually died when

they matured. Thus, the overall efficacy of the Larvasonic® was approximately 91%.¹⁶

The efficacy of the Bti granular products used to treat stagnant surface water sites was also conducted by Pestalto. Pre- and post-treatment counts from 10 treatment sites were used to illustrate the effectiveness of Bti. Vectobac® 200G provided 100% control at the one site it was applied in Peel.¹⁶ Aquabac™ 200G was found to reduce mosquito larvae numbers by an average of 76.5% in the nine selected efficacy monitoring sites.¹⁶

Biological Control

Fathead Minnow Project

Peel Public Health stocked a storm water management pond at the Caledon Wellness Centre in Bolton with fathead minnows (Figure 28) in an attempt to reduce mosquito larvae in the pond. In 2003, Peel Public Health staff identified WNV vector larvae in this pond. That year, the pond was treated with the biological larvicide Bti on two occasions.

The Ministry of Natural Resources determined that the fathead minnow is the best species to stock in storm water management ponds. This native species is abundant, widely distributed, an omnivorous feeder and is salt and temperature tolerant. Fathead minnows have been shown to consume 100-160 mosquito larvae a day in a laboratory environment.²¹

The storm water management pond was stocked in late May with 1,440 fathead minnows. The pond was monitored on a weekly basis. Initial monitoring results revealed that the minnows appeared to be controlling the larvae. In late July, larval surveillance at the pond indicated an increase in the number of mosquito larvae. The increase in larval activity in the pond coincided with a reduction of fathead minnows being observed in the shallow waters. Tests conducted by the Toronto Region Conservation Authority (TRCA) revealed that the majority of the adult minnows had died. This was attributed to low levels of dissolved oxygen in the pond. An overabundance of aquatic vegetation in the pond was the likely cause of the oxygen depletion. In late August, vector mosquito larvae were found at this site and it was larvicided with Bti by Pestalto.

Although this study was unsuccessful, Peel Public Health will consider stocking fathead minnows in the future if a more suitable site can be located. Peel Public Health may need assistance from other government agencies such as TRCA and MNR (Ministry of Natural Resources) in determining whether a particular breeding site is suitable for biological control.

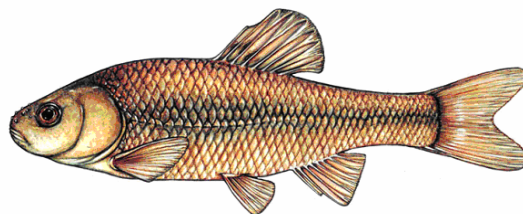


Figure 28: Fathead Minnow

Source: illustration by Ted Walke, PFBC
www.fish.state.pa.us

Summary

The 2004 larval mosquito reduction program involved several approaches, some of which were more efficacious than others.

Four rounds of methoprene pellets were applied to the roadside catch basins in Peel, with the number of treatments totalling 297,110.¹⁶

An additional 1,863 methoprene pellet treatments were conducted to catch basins on Peel owned and operated properties, one catch basin in a public park and 37 backyard catch basins.¹⁶

A random sample of catch basins was evaluated and results showed that methoprene pellets were effective in reducing the emergence of viable adult mosquitoes, with an efficacy rate of over 90%.¹⁶

A total of 1,463 Altosid® Briquets (methoprene ingots) were applied to catch basins in public parks, on Peel owned or operated properties, and in private back yards.¹⁶ Preliminary results from a joint study with the MOE determined that a one-time application of briquets was not as effective as claimed, with efficacy rates of 45-75% lasting for a total of 60 days, rather than the stated 150 days.¹⁹

One hundred and fifty-one catch basins that drained directly into sensitive areas were treated by the Larvasonic® device that uses ultrasound to kill the mosquito larvae.¹⁶ This device was found to have an efficacy of approximately 91%.¹⁶

A total of 226 Bti applications were performed at 138 surface water sites throughout Peel. The efficacy of Bti was determined to be between 76-100%, based on pre- and post-treatment larval counts.¹⁶

Peel Public Health undertook a pilot project to attempt to biologically reduce mosquito larvae in a storm water management pond in Caledon. This site supported WNV vector mosquito larvae in 2003 and was larvicided on two occasions in 2003. In May, Peel Public Health stocked this site with fathead minnows. In late July, an increase of larval activity was noted which coincided