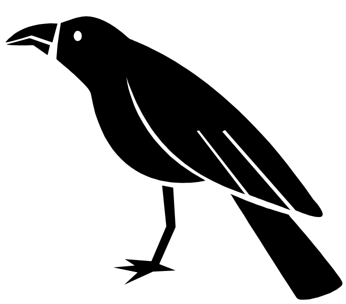
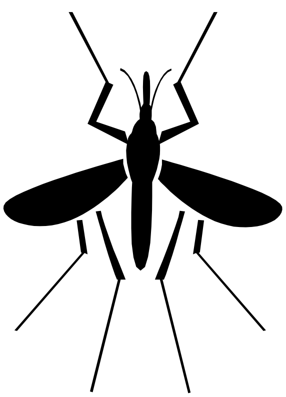
West Nile Virus Activity in British Columbia: 2007 Surveillance Program Results

Executive Summary

Despite advancing westward across the US and Canada since it's introduction to North America's east coast in 1999, West Nile Virus (WNv) has thus far not been detected in British Columbia in five years of intensive surveillance. In 2007, endemic WNv activity was noted in central and western Canada including Ontario, Manitoba, Saskatchewan, and Alberta and in states bordering British Columbia (Montana, Idaho and Washington State) (Figure 1). 2007 exceeded 2003 as the worst year for WNv transmission in the history of the virus in Canada, with the majority of human infections occurring in the Prairie Provinces, and Saskatchewan in particular (Table 1).

Table 1: Human WNv infections in North America, 2003-2007.

	2003	**2004**	**2005**	**2006**	**2007**
Canada	1388	20	239	127	2353
United States	9862	2344	2949	4052	3404

Sources: Public Health Agency of Canada and US CDC as of Dec 20, 2007

Evidence of the virus in mosquito populations has been demonstrated earlier each successive year in the Prairie Provinces and in Oregon. The later arrival of vector populations in BC, the relative size of these populations, microclimate differences, biologic diversity/land use patterns may be limiting factors to the establishment of efficient viral transmission in the province. These and other comparisons between BC and jurisdictions where the virus is present are being evaluated. This report, however, summarizes surveillance findings from human, avian and mosquito populations in 2007. Recommendations for substantial changes in surveillance activities will be determined through meetings with Health Authority partners in early 2008 and shared at the annual WNv planning meeting in the spring.

Nineteen travel-related infections were diagnosed in BC residents in 2007, including two diagnosed through CBS blood donations. 10 (53%) were classified as WN-non-neurological syndrome (WN-non-NS), 8 (42%) as WN neurological syndrome (WNNS) and 1 (5%) as unknown. All acquired their infections in the Prairies and were ill between July 25th and August 28th.

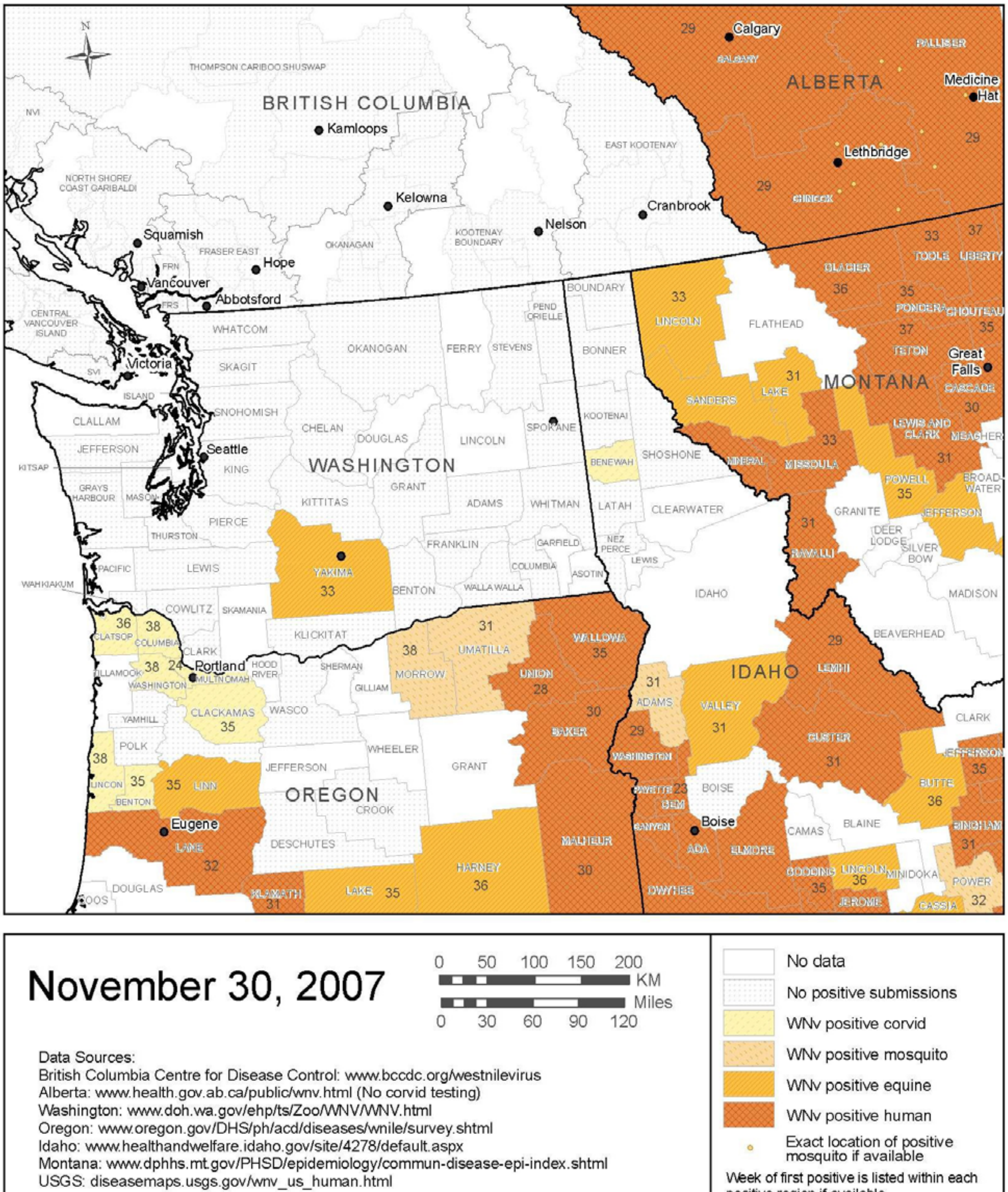
Annual corvid collections have steadily decreased over the last five years, signaling a waning public interest and/or local public health emphasis on this surveillance activity. Corvid reporting in 2007 was consistent throughout the summer, and actually increased in August, the period of greatest risk, relative to previous years. However, collections were sparse in areas bordering US states with WNv activity. On average, 13/16 Health Service Delivery Areas (HSDAs) received corvid test results within one week of identifying a dead corvid (based on median lag times in collection, shipping and laboratory testing), two less than previous years.

In contrast to the hot/dry summers of 2003 and 2004, mosquitoes have been more abundant over the last three years in response to more normal temperatures and precipitation. The provincial average number of *Culex pipiens*/trap night has increased over the last three years: 5.1 in 2005, 8.6 in 2006 and 14.3 in 2007. When considering a fixed number of traps with stable placement from year to year, this increase appears most apparent in Fraser Health. These increases are due to the development of good breeding habitat through extensive snow melt and flood conditions across the province. In contrast, provincial average *Culex tarsalis* counts declined in 2007. The combined median turn around time from collection of a sample in the field to receipt of mosquito test results was 6 days.

The arrival this year of BC's first travel-related human cases since 2003 allowed successful testing of the newly developed communications fan-out document. New public educational materials were developed in the form of a poster on the appropriate choice of insect repellents for adults and children. A modest re-design of the BCCDC WNv site occurred.

Many interesting advances in our understanding of WNv have occurred in recent years. A summary of research, both undertaken in BC and published in the literature, has been compiled within this report on topics touching surveillance, knowledge/attitudes/beliefs, climate, vector biology and transmission, mosquito control and prevention.

Figure 1: West Nile Virus Activity in the Pacific Northwest, 2007



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Summary of Surveillance Activities

Surveillance activities for West Nile virus (WNv) focused on three target groups – humans, dead corvids and mosquitoes. The objectives for WNv surveillance were two-fold:

1. To monitor WNv activity in various species in British Columbia in order to:
   A) Predict increased risk to human health
   B) Inform public health decisions
   C) Guide communication strategies
   D) Monitor the effectiveness of control measures

2. To optimize mosquito control decision-making by identifying:
   A) The geographic and temporal distribution of potential vector species in BC
   B) Mosquito breeding sites

Human surveillance involved several stakeholders including BCCDC Epidemiology and Laboratory Services, the Canadian Blood Services (CBS) and the BC Transplant Society. Physician requests for West Nile testing received by BCCDC labs were tracked. Data sharing protocols with Canadian Blood Services were developed to ensure prompt deferral of blood collected from suspected WNv-infected persons and to allow BCCDC to monitor asymptomatic infections identified through screening of the blood supply. From May-November, all organs intended for transplant were screened by BCCDC labs prior to transplantation. In the low risk period (December through April) only organs from donors with a travel risk were screened.

Information on probable human cases was communicated to the requesting physician as well as to public health to enable administration of a case questionnaire to collect information on symptoms, travel history, and likely mode of transmission. Cases were classified as a case of West Nile non-Neurological Syndrome (WNnon-NS) or West Nile Neurological Syndrome (WNNS) according to self-reported symptoms as well as clinical information collected from the patient's physician. Cases were further categorized as probable or confirmed depending on the level of specificity associated with the laboratory test performed. Case definitions can be found at http://www.phac-aspc.gc.ca/wnv-vwn/hmncasedef_e.html.

The human testing algorithm entailed screening acute serum samples for Flavivirus EIA -IgM. Convalescent sera were requested and tested in parallel with the acute sample for both IgM and IgG. Hemagluttinin Inhibition testing was performed on both positive IgM and/or IgG samples, as required. All possible and probable positive cases were referred to the National Microbiology Laboratory (Winnipeg) for the confirmatory PRNT assay. Cerebral spinal fluid, plasma and samples from organ transplant donors were tested by PCR. All submissions of cerebral spinal fluid from patients admitted for encephalitis/meningo encephalitis (regardless of test requested) were also tested for WNv by PCR.

Corvid surveillance was achieved through two mechanisms. A sample of dead corvids from across the province was collected each week for West Nile virus testing. Health Authorities collected birds in a number of different ways - some employed city Parks Department staff, others used the SPCA as a collection point and still others hired designated staff to respond to public calls and collect birds for testing. This testing was performed at the Animal Health Centre, Animal Health Branch, BCMAL in Abbotsford using a commercially available dipstick test (VEC test). In addition to birds tested, an on-line form was available at the BCCDC website (http://westnile.bccdc.org/) for the public to report sightings of dead corvids. With few exceptions, dead corvids sighted by the public and reported through the on-line form were different from those picked up for testing. The locations of birds tested and reported on-line were used to create corvid density maps for regions of the province with sufficient data. These will be used as baseline values against which to assess excess corvid mortality in future years, a potential indicator that virus has been introduced into an area.

Mosquito surveillance has focused on the identification and distribution of adult mosquitoes. Based on several years of baseline data, the start of mosquito surveillance activities was delayed until June 1st from 2006 forward (was previously May 1st). Some traps were operated in more than one location on two different days of the week. Traps were run overnight and the catches sent in coolers to BCCDC for identification and WNv testing. The BCCDC laboratory separated them into sex and taxonomic groupings: 1) *Aedes,* 2) *Anopheles,* 3) *Coquilletidia,* 4) *Culiseta* and 5) *Culex*. Mosquitoes were sorted on a chill table (to prevent denaturation of any viral RNA) and identified to genus or, in the case of *Culex*, to species. If mosquitoes were not trapped for any reason, the information (i.e. trap malfunctioned, no mosquitoes trapped or trap was not run) was faxed to the lab and recorded. Beginning in 2006, only female *Culex* mosquitoes were tested for the virus in groups of up to 50 mosquitoes/pool by PCR. The remaining mosquitoes were identified but not tested. When traps contained more than 500 mosquitoes, the entire sample was sorted to selectively pick out all the female Culex mosquitoes for PCR testing. 500 mosquitoes from large volume traps were initially identified and reported; the remainder was saved for identification at the end of the season. A fraction of the remainder (1/2, ¼, 1/8, etc.) was identified and the total number for each genus in the trap extrapolated.

Ongoing, prospective, cumulative temperature degree-day maps were used to help forecast higher risk areas for WNv. Degree day assessments can assist in predicting the number of generations of mosquitoes expected in a given area.

Mosquito, bird, geographic and temperature data were integrated using an interactive on-line mapping tool. This was developed to assist users with geo-spatial risk assessment to help target appropriate mosquito control activities. Larval data, collected by independent mosquito control contractors was included in this mapping tool in 2006 for use by health authorities when making mosquito control decisions. Unlike adult surveillance data, larval data is not available to the public and viewing is limited to personnel in the region where the data has been collected.

Those involved in WNv surveillance and control activities included BCCDC epidemiology and Laboratories, Canadian Blood Services staff, BCMAL staff, Regional Health Authority staff, municipalities and regional government staff, mosquito experts from BCCDC, mosquito control contractors and academic centres, wildlife biologists, and communications personnel. All were included in bi-weekly teleconferences to discuss emerging surveillance issues. Surveillance results from BC, across Canada and the United States were summarized in a weekly surveillance report distributed to BC stakeholders, including members of the surveillance group, infectious disease physicians, medical microbiologists and those involved in the provision of blood products and transfusion services.

Surveillance Results

Results at a Glance

Table 2: Summary of BC Surveillance Statistics, 2007

	Human[1]	Corvids Submitted[1]	Corvids Sighted[1]	Mosquito Pools[2]
# Tested	805	740	562	2568
# Positive	19(*19)	0		0

1. Suveillance started on June 1st.
2. A pool may contain up to 50 mosquitoes that are tested at one time.

* The number of cases in brackets denotes the number of cases considered to be travel-related. For example, 6 (*2) would indicate a total of 6 probable cases, 2 of which are travel-related.

Surveillance of WNv in Humans

Epidemiology of Travel-Related Infections

Nineteen travel-related infections were diagnosed in BC residents in 2007. 10 (53%) were classified as WN-non-neurological syndrome (WN-non-NS), 8 (42%) as WN neurological syndrome (WNNS) and 1 (5%) as unknown. All had acquired their infections in the prairies: 1 had travelled to Alberta, 17 to Saskatchewan and 6 to Manitoba (note: 5 cases had travelled to more than one province). All cases experienced symptoms over a 1-month period between July 25th and August 28th (Figure 2). 58% of cases were female. Cases ranged in age from 10 to 77 years. Although not significant given small numbers of cases, as in other jurisdictions, WN neurological syndrome cases tended to be older (mean age: WNNS 55.4 years; WN-non-NS 40.3 years; p=0.96). 63% of WNNS cases were hospitalized compared with no cases of WN-non-NS. No deaths occurred. 50% of WNNS cases presented with encephalitis; other presentations included meningitis (14%), meningoencephalitis (14%), movement disorders (14%) and polyradiculopathy (14%). As expected from the experience of other Canadian jurisdictions, only 50% of WN-Non-NS cases actually experienced fever as a symptom (Figure 3). While Canadian case definitions were broadened after the 2003 surveillance season, the US case definition of West Nile Fever continues to require fever, thus potentially under-reporting this presentation.

Figure 2: Epidemic Curve of Human WNv Case Onsets, 2007.

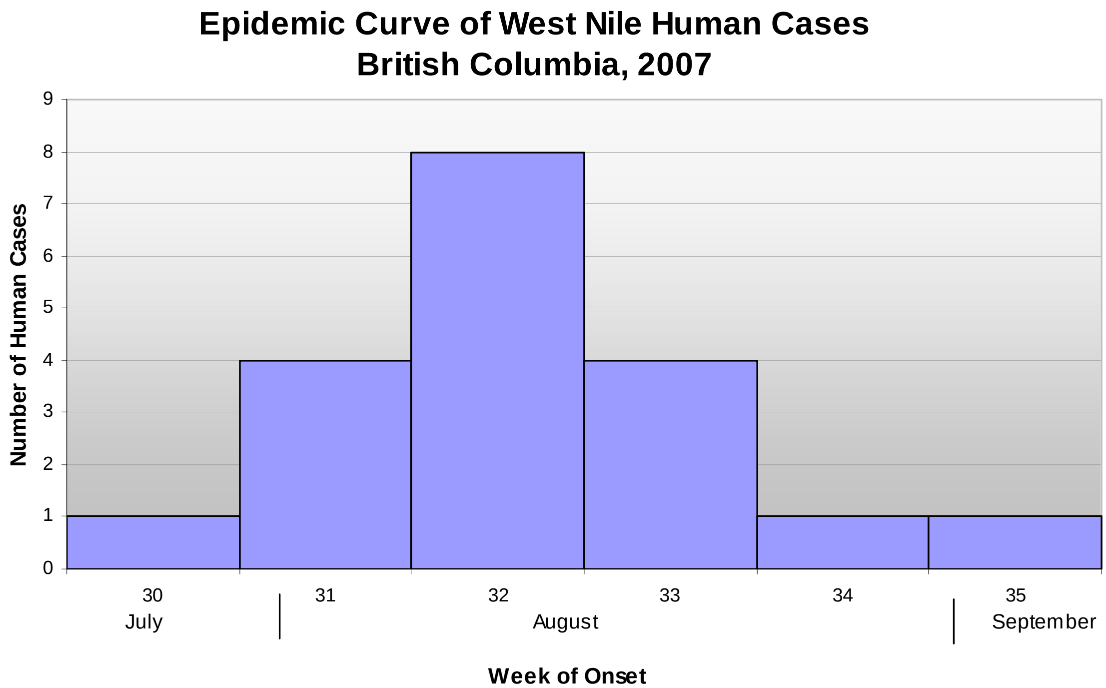
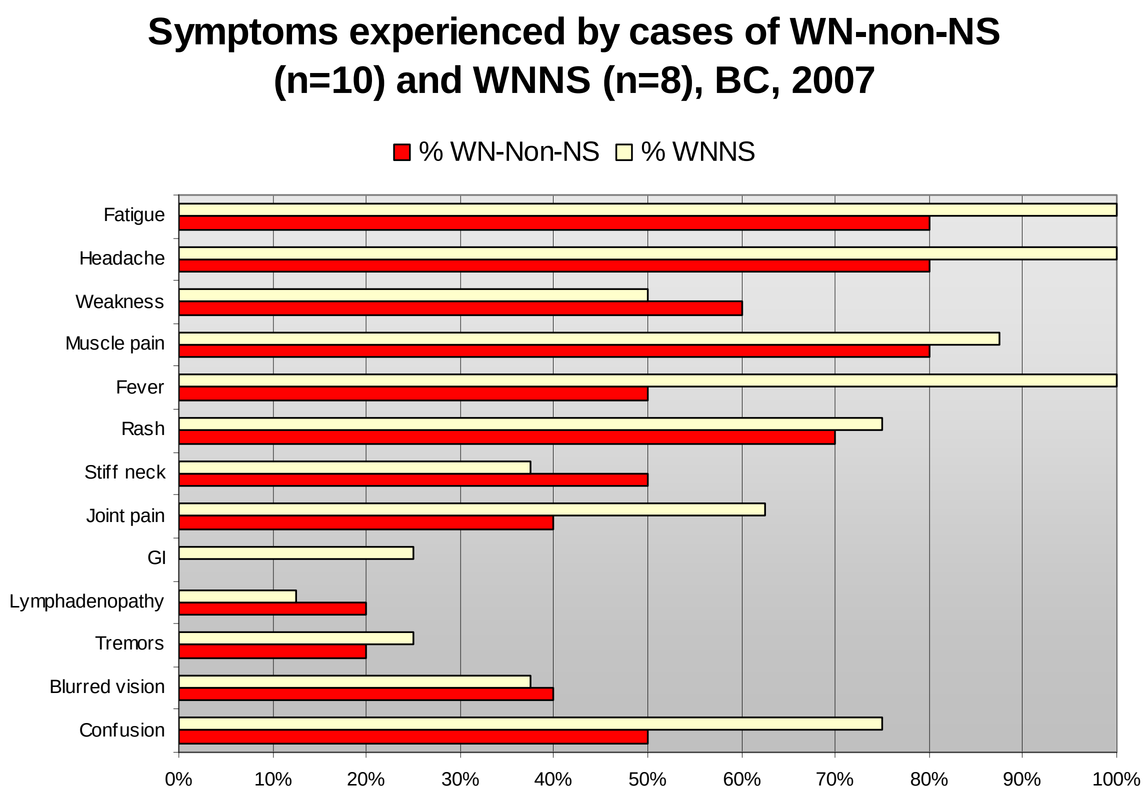


Figure 3: Symptoms Experienced by WNv Cases, BC, 2007



Interpreting Laboratory Results on Human Cases

The testing for WNv is complex, involving multiple types of tests. A case definition is assigned to cases based on a combination of clinical symptoms and laboratory results. Two tables have been developed by BCCDC laboratories to assist in interpretation of human laboratory results. These can be found in Appendix 1. In 2008, it is expected that avidity testing will be performed in-house. The interpretation of this new test in combination with serology and PCR results will be added to these tables in 2008.

Protecting the Blood Supply from West Nile Virus

WNv Testing at CBS

CBS performs year-round WNv nucleic acid testing on every donation. Although routine screening is performed in minipools (MP) of six specimens, more sensitive, single unit (SU) testing[1] is selectively done for blood donations collected from regions of higher WNv risk (Busch et al, 2005). CBS uses two criteria for implementing SU testing: either a positive donor test result or an incidence of public health-reported symptomatic WNv in a health region over a two week period exceeding either 1:1000 in rural areas or 1:2500 in urban settings. SU testing will be implemented for a minimum one week period for all donor clinics in proximity to an affected region; WNv testing reverts to routine MP screening if neither criterion is met over the ensuing one week period.

Blood Donor WNv Screening in British Columbia

There were 2 confirmed positive West Nile virus (WNv) donations in British Columbia in 2007. Both involved asymptomatic infected donors who had recently returned from regions (southern Manitoba and southern Saskatchewan), where high levels of WNv activity were being reported and where they likely were infected. Consequently, SUT was not implemented in BC during the week following these cases. There was also 1 unconfirmed positive WNv donation from southern Vancouver Island, with no epidemiological risk factor identified; this was attributed as a false-positive test result.

Blood Donor WNv Screening Across Canada

Nationally, Canadian Blood Services (CBS) detected WNv in 70 donors during 2007, representing 2.9% of the 2379 symptomatic and asymptomatic human WNv cases reported to the Public Health Agency of Canada (PHAC, 2007). Sixty-five of the 70 WNv-positive blood donations were collected from the Prairie provinces, from where BC routinely imports about 10-15% of its blood supply. The high proportion of blood donors among early season WNv cases reported to PHAC reinforces the public health value of WNv surveillance of blood donors as sentinels of human WNv risk. For example, the first human case detected in Canada this year was from a Winnipeg donation on 19 June, approximately 2 weeks before the first reported cases of clinical WNv disease. As late as 11 Aug, 20% of all WNv cases reported to PHAC were detected through CBS donor testing. As in the previous 4 years, no case of transfusion-transmitted WNv was reported in Canada.

Integrated WNv Surveillance in British Columbia

In BC, CBS, the BC Centre for Disease Control (BCCDC) and BC Ministry of Health (MOH) continued their close co-operation in WNv planning, preparation and surveillance. A comprehensive WNv Action Plan is updated each year; the 2007 edition is available at www.pbco.ca.

From 1 June to 19 October 2007, BCCDC provided daily reports to CBS BC and Yukon Centre on WNv test requests received by BCCDC. This enabled rapid identification of donors who may have recently donated potentially WNv infectious blood, so that a product recall could be carried out as quickly as possible and, to defer donors for a 56 day period to prevent affected donors from donating while potentially infectious. A total of 1017 reports were received by CBS, of which 69 (6.8%) were donors – a proportion similar to previous years. Four product recalls were undertaken as a result.

Anonymized Data Linkage Project

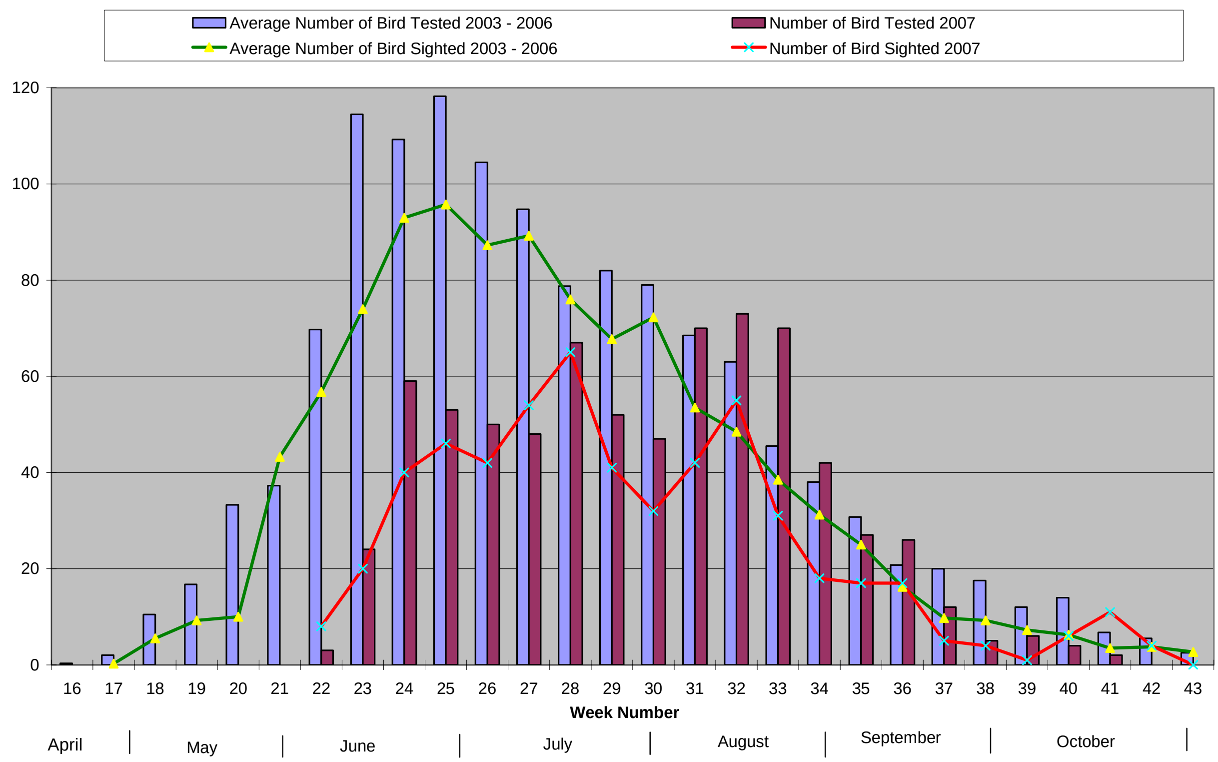
An aim of this project, using WNv as a sentinel blood-borne pathogen, is to demonstrate that timely, accurate, secure data linkage can be performed between the BCCDC laboratory and CBS donor databases to identify potential hazards to blood safety while simultaneously protecting patient confidentiality. This year, further "tuning" of the ADL matching algorithm was carried out to optimize its sensitivity and specificity, by retrospectively matching WNv test data from BCCDC against the national CBS donor database. The ADL algorithm retrospectively identified 2 matches that were not initially made by manual checking, exemplifying the potential benefits of improved timeliness and accuracy of data linkage envisioned in the project. For 2008, ADL matching is planned to be performed in "real time" on a daily basis to further validate the process.

Surveillance of WNv in Corvids

Distribution of Corvid Deaths

Overall, 740 corvids were collected and tested from June 1 to October 31, 2007 (Figure 4). Annual corvid collections have steadily decreased over the last four years; this is due, in large part, to waning public interest in the program as WNv fails to emerge in BC since many regional programs depend on public reporting. Decreases are also partly the result of changes in the start of seasonal surveillance from May 1st to June 1st in 2006. Corvid reporting in 2007 was strong throughout the summer, and actually increased in August, the period of greatest risk, relative to previous years.

Figure 4: Comparison of Birds Sighted and Tested, 2003-2007

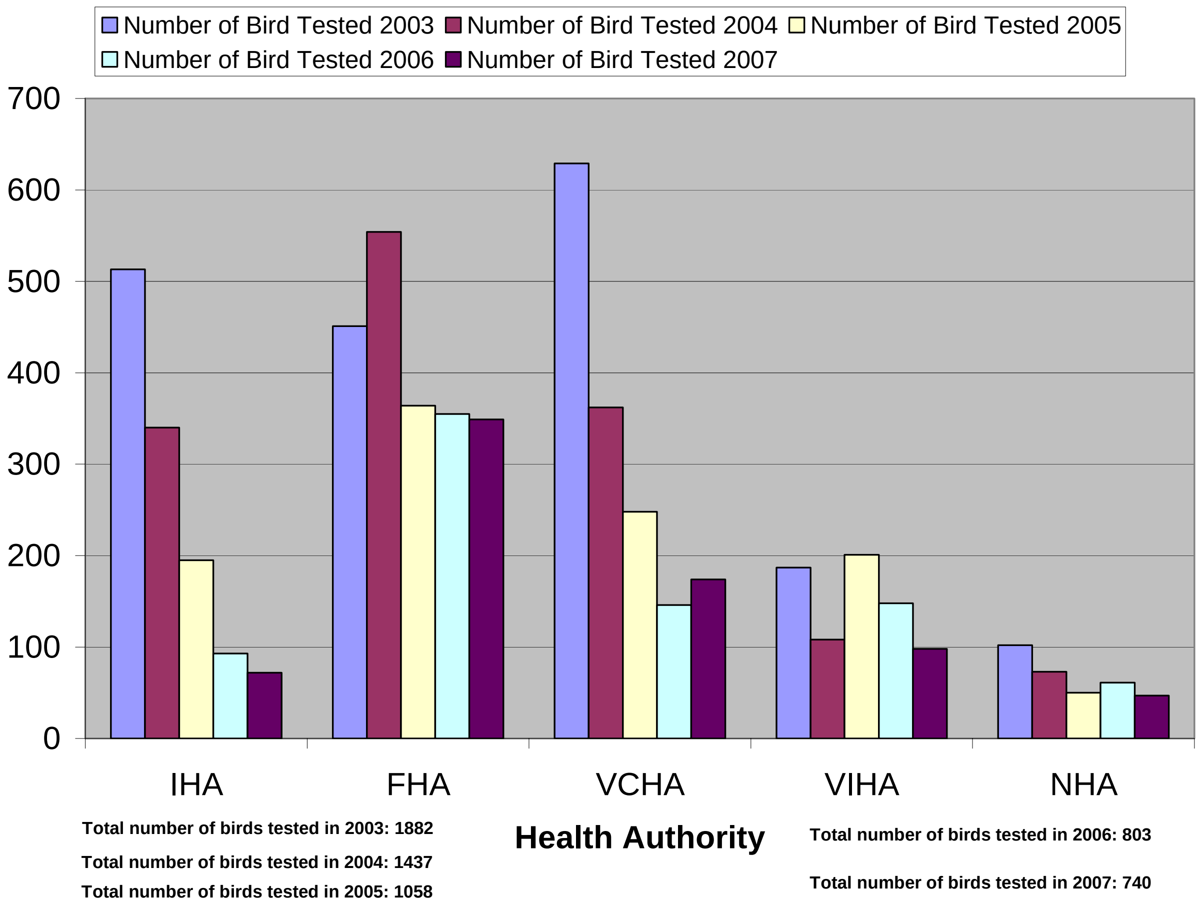


Average number of birds sighted in 2003 - 2006: 1035
Total number of birds sighted in 2007: 562

Average number of birds tested in 2003 - 2006: 1295
Total number of birds tested in 2007: 740

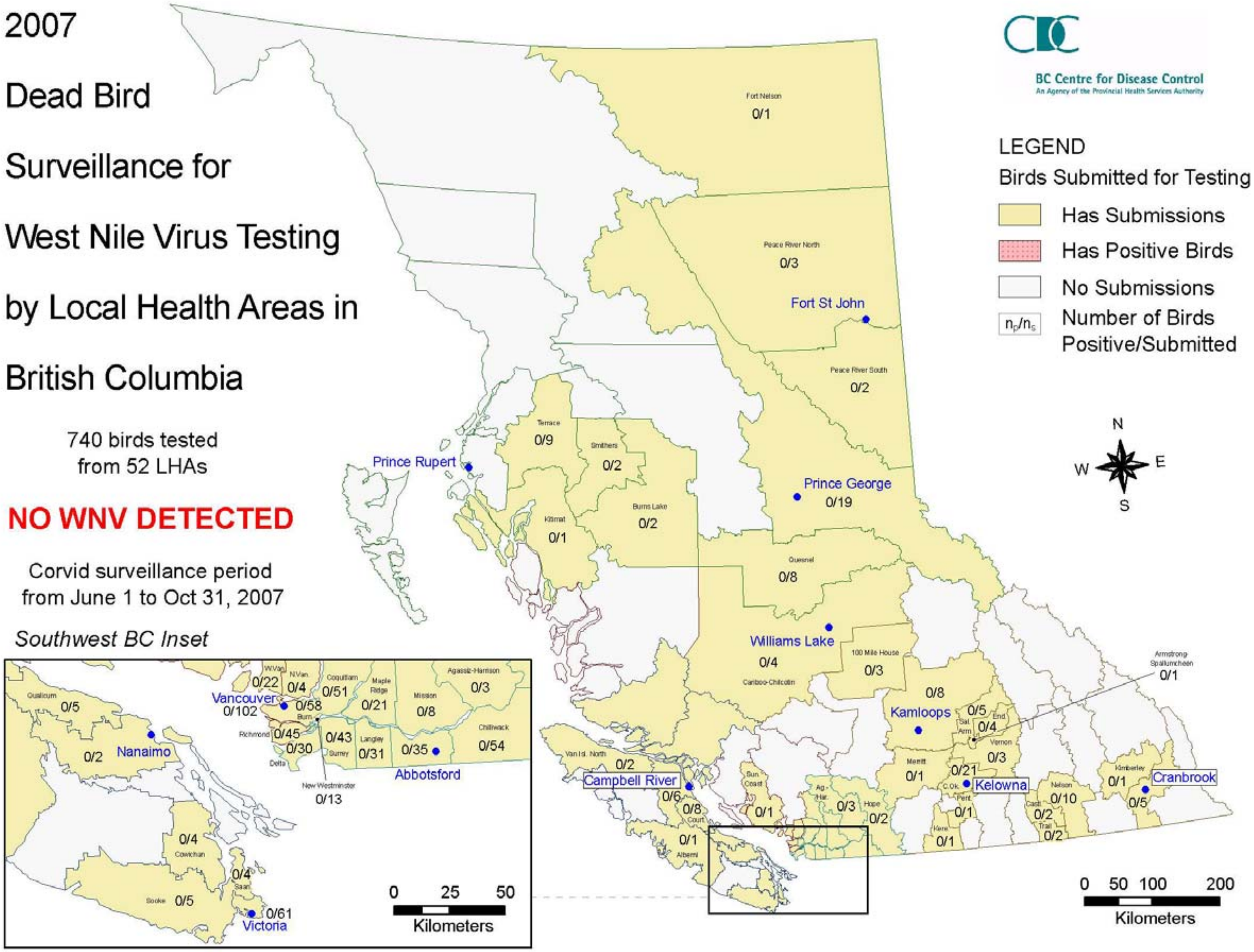
The decline in the number corvids tested from year to year is most notable in Interior Health, an area with sparse population in some areas which makes corvid collections challenging and costly (Figure 5). At the same time, this region has been identified as the highest risk region of the province. Fraser Health has been relatively consistent in their corvid testing practices over time, while a decrease comparable to IHA has occurred in neighbouring VCH (Figure 5).

Figure 5: Comparison of Birds Tested by HA, 2003 - 2007



Spatial representation of dead corvid submissions was patchy in 2007 (Figure 6). The most notable gaps occurred in Southern LHAs along the US border. Given that WNv activity was is typically detected neighbouring states northwestern Montana and Idaho, a concerted effort must be made each year to monitor border areas. It is recognized that these areas have low human and corvid densities therefore other surveillance measures, such as targeted mosquito sampling may be equally effective.

Figure 6: Geographic Distribution of Corvid Test Results, 2007



Appropriateness of Specimens Submitted

Corvid specimens can arrive at the laboratory in a state unsuitable for testing. This can occur for a variety of reasons including desiccation, decomposition and the submission of headless birds (which are unable to be swabbed), among others. High levels of suitability have been achieved in all years of the program and continue in 2007.

Table 3: Appropriateness of Bird Specimens Submitted for Testing by HSDA, 2003 - 2007

HSDA	2003	2004	2005	2006	2007	Ratio Difference (2003 - 2004)	Ratio Difference (2004 - 2005)	Ratio Difference (2005 - 2006)	Ratio Difference (2006 - 2007)
Overall %	98.51	97.76	94.80	96.17	98.40	-0.75	-2.95	1.36	2.24

Lag Times for Corvid Submission and Testing

The timeliness of corvid submissions has been steady over the last 3 years (Table 4), taking an average of 4 days from the date a dead bird is found to receipt at the laboratory.

In half of all corvid samples, results were reported by the animal health centre the same day as samples were received.

When considering median delays in collection/shipping of specimens and time for laboratory processing, on average, three HSDAs (Central/Northern Vancouver Island and North Shore/Coast Garibaldi) received corvid test results more than a week from the date the bird was found. In previous years only 1 HSDA hadn't received their results within a week, on average.

Table 4: Lag Times for Submission of Corvid Specimens, 2003-2007

HSDA	MedianTransit Lag Time					MaxTransitLag				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
EK	14	6	7	9	4	73	31	44	48	**6**
KB	6	7	5	6	4	35	42	14	35	**12**
OK	7	4	5	3	4	38	29	28	12	**14**
TCS	7	6	6	3	6	61	26	39	84	**16**
FRE	5	3	2	3	3	27	13	12	8	**12**
FRN	7	6	4	3	4	72	19	32	33	**12**
FRS	7	6	3	5	3	93	18	10	9	**14**
RICH	7	4	6	7	6	18	27	10	17	**8**
VAN	6	4	5	7	5	29	16	14	23	**40**
NSCG	5	5	4	7	9	32	58	46	17	**16**
SVI	4	6	3	4	6	18	34	32	18	**41**
CVI	5	3	4	6	17	39	31	14	12	**44**
NVI	7	6	5	7	13	22	17	12	29	**53**
NW	2	3	3	2	2	10	10	7	13	**6**
NI	4	4	2	5	3	30	13	33	20	**32**
NE	2	3	6	5	7	6	19	29	50	**10**
Total	**6.0**	**5.0**	**4.0**	**4.0**	**4.0**	**93**	**58**	**46**	**50**	**53**

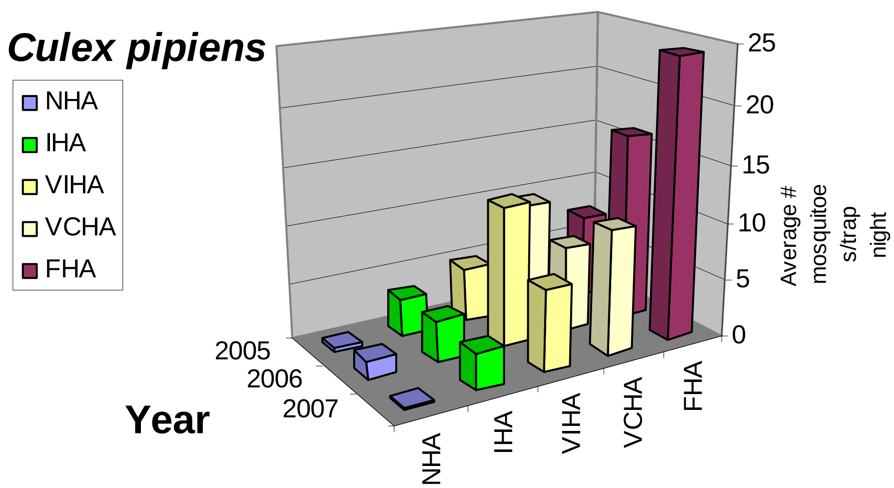
Note:
- All lag times are in days.
- Transit Lag represents the number of days between when a bird is found and when it is received by Animal Health Centre (Abbotsford).

Surveillance of WNv in Mosquitoes

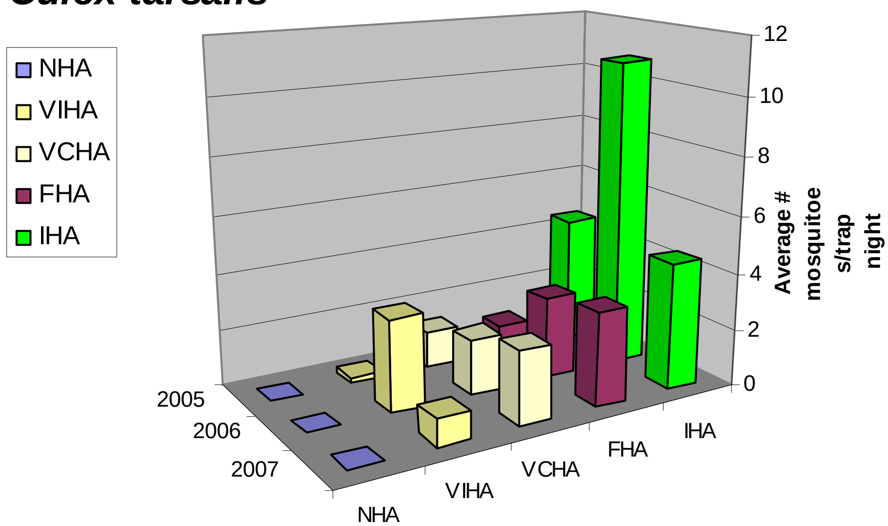
Surveillance efforts in the province have focused on *Culex* species given its prevalence in BC and reports from other North American jurisdictions suggesting it as the major vector of WNv (Farnon**,** E., 2006). *Culex tarsalis* was the primary infected vector reported in Alberta, and Manitoba and Saskatchewan. Three positive pools of *Culex restuans and* 2 of *Culiseta inornata* were also reported in Saskatchewan during 2007.

BC surveillance data now comprises 5 years of adult mosquito surveillance. Each year brings new information about the distribution of species and their relative abundance (Figure 7). In British Columbia, there were a total of 2,184 submissions from mosquito traps in 2007, resulting in 2,568 pools tested. A total of 242,236 mosquitoes were identified from these trap collections. We saw high numbers of nuisance species of *Aedes* along the Fraser and Columbia Rivers and a provincial average of 17.81 *Culex*/trap night (all *Cx*. species, including males). This was slightly higher than, but similar to, last year's average *Culex* count. Both years saw very heavy precipitation which increased available larval habitat, contributing to the larger *Culex* counts. In contrast, 2003 and 2004 were hot dry years with corresponding limited available habitat and reduced *Culex* counts.

Figure 7: Average Number of Culex Mosquitoes/Trap Night in BC Health Authorities, 2005-2007.



Culex tarsalis



Trap Coverage

Figure 8 depicts the locations of adult mosquito traps in 2007. Since adult mosquito surveillance began in 2003, the geographic coverage of traps has increased and the strategic placement of traps in mosquito rich environments has improved, reducing the number of low yield traps and providing better capture of high risk species like *Culex pipiens* (Table 5). This accounts for the increase in the number of pools tested this year over last year. Most major centres have traps located nearby providing a good baseline to assess risk in populated areas.

Table 5: Change in Mosquito Trap Coverage, 2003-2007.

	2003	**2004**	**2005**	**2006**	**2007**
# Traps operated	49	88	139	124	124
# Permanent locations	59	145	189	148	155
# Mosquitoes	6,840	52,657	198,228	394,047	242,215
# Pools tested	2,96	2,980	6,631	2,329*	2,568*
Ave # C. tarsalis^	0.3	0.8	1.9	4.8	3.49
Ave # C. pipiens^	1.5	4.6	5.1	8.6	14.32

* Only *Culex* species tested for WNv.
^ Including male and female mosquitoes during the season. It is calculated by:
Total number of Culex/Total number of trap submissions

Figure 8 Geographic Distribution of Mosquito Traps in BC, 2007

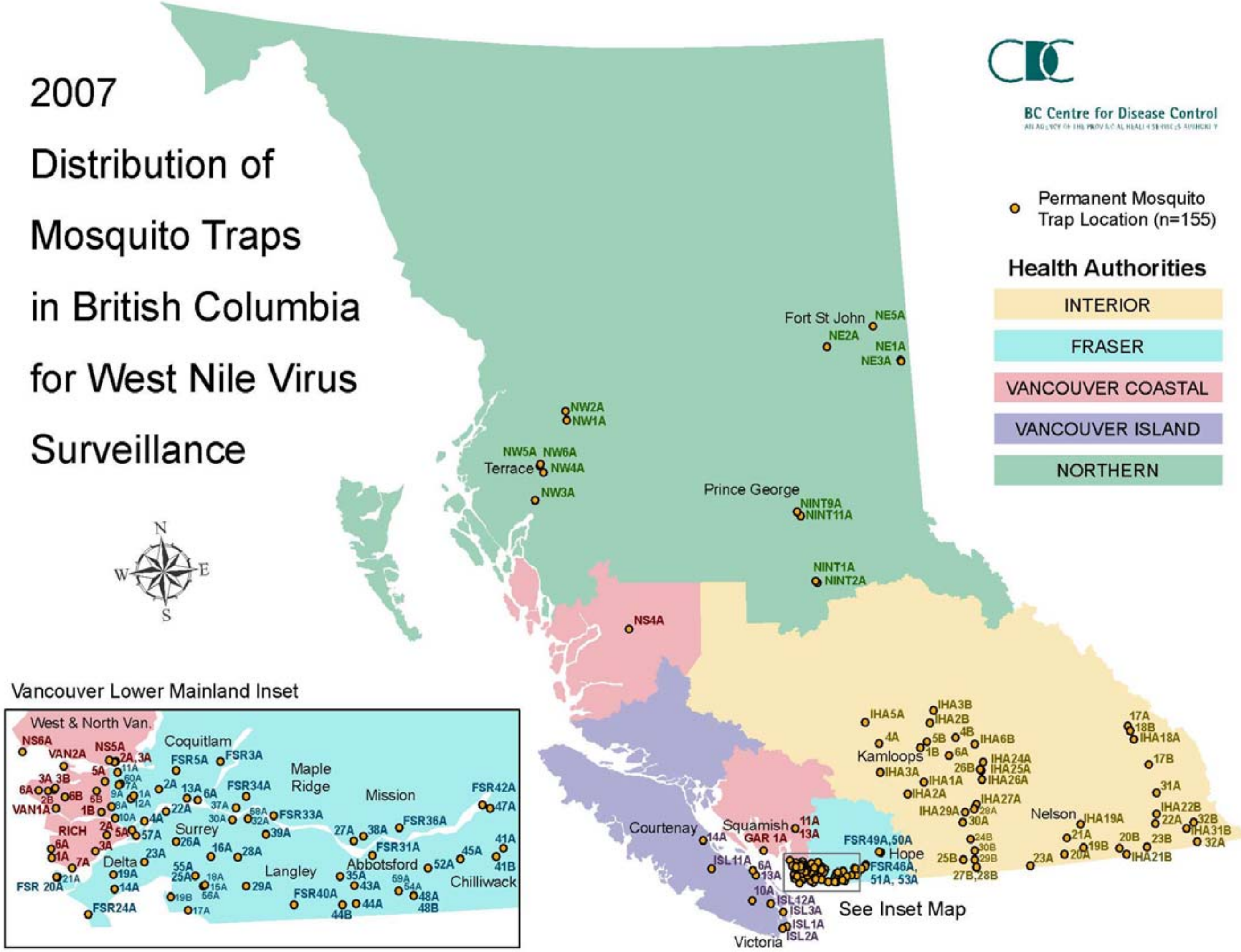
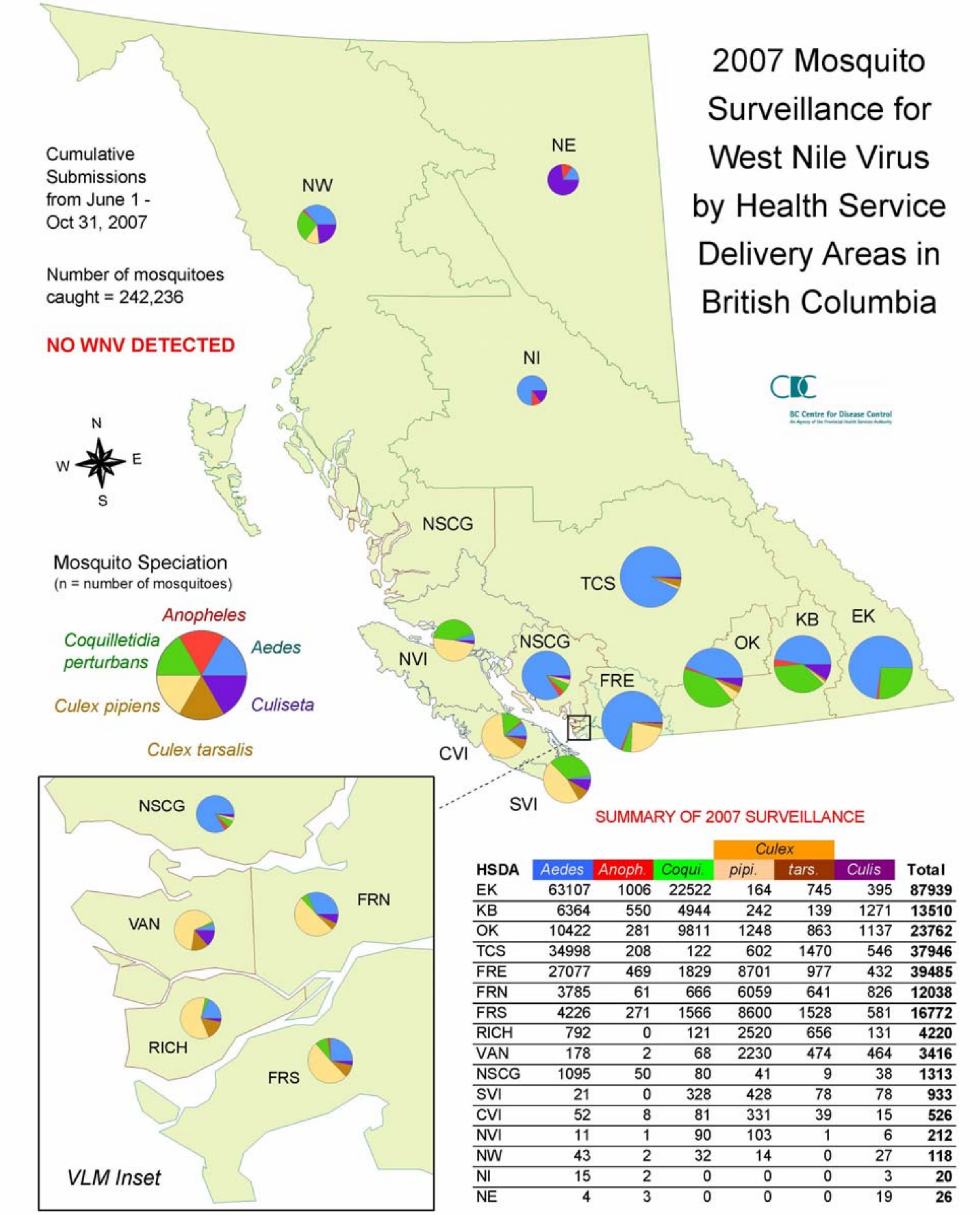


Figure 9: Geographic Distribution of Mosquito Species in BC, 2007



SUMMARY OF 2007 SURVEILLANCE

HSDA	Aedes	Anoph.	Coqui.	Culex pipi.	Culex tars.	Culis	Total
EK	63107	1006	22522	164	745	395	**87939**
KB	6364	550	4944	242	139	1271	**13510**
OK	10422	281	9811	1248	863	1137	**23762**
TCS	34998	208	122	602	1470	546	**37946**
FRE	27077	469	1829	8701	977	432	**39485**
FRN	3785	61	666	6059	641	826	**12038**
FRS	4226	271	1566	8600	1528	581	**16772**
RICH	792	0	121	2520	656	131	**4220**
VAN	178	2	68	2230	474	464	**3416**
NSCG	1095	50	80	41	9	38	**1313**
SVI	21	0	328	428	78	78	**933**
CVI	52	8	81	331	39	15	**526**
NVI	11	1	90	103	1	6	**212**
NW	43	2	32	14	0	27	**118**
NI	15	2	0	0	0	3	**20**
NE	4	3	0	0	0	19	**26**

Geographic Distribution of Species

Figure 9 illustrates the distribution of 242,236 mosquitoes collected in 2007.

Culex pipiens

Generally *Culex pipiens* is only found north of the 39th degree N latitude (Savage and Miller, 1995). Between 36 and 39 degrees N. latitudes, *Cx. pipiens, Cx. quinquefasciatus*, and hybrids are encountered. In 2007 the largest numbers of *Cx. pipiens* were generally found in the highly urbanized areas, particularly the Fraser River Lower Mainland. This species is found throughout the Interior Health Authority but the numbers were not as high in less urbanized EK, and KB (Figure 9). Only a few specimens (n=14) were collected in the north at Terrace.

Culex tarsalis

Culex tarsalis is the primary vector species of WNv in the Prairie Provinces of Canada and the central US, and Montana south of BC, therefore an understanding of where this species is found in BC is of major concern. No specimens were collected in the NHA, 118 in VIHA and only 139 in KB. TCS and FRS collected the most specimens this year.

Culex territans

Culex territans was found in only one location this year (FRS). This species is found more often in surveillance of larvae so baited light traps might not be effective in collecting this mosquito. The females seek a blood meal from cold blooded animals such as amphibians or reptiles, so it is not considered an important vector for West Nile virus.

Coquillettidia perturbans

Unlike other mosquitoes, *Coquillettidia perturbans* over-winter as larvae and live below the surface of the water by extracting oxygen from the stem of emergent littoral plants such as cattails. Traps placed near large stands of cattails catch the greatest number. This species emerged from the littoral zone by the middle of June, for most regions across the province (Figure 11). The adult population peaked in week 29 or 30 for the last 2 years. They are recorded as having one generation per year (Belton, 1983) and adults were collected from the beginning of June up until the middle of August across the province. Crans (2004) noted that adult emergence appears to occur in broods over the course of the summer but this actually represents cohorts of larvae that passed the winter in different instars of larvae and so consequently take different lengths of time to emerge the following year.

Aedes species

Aedes are typically the most abundant mosquitoes in Canada and they have a reputation as nuisance pests, especially when flooding occurs. Mosquito abatement programs found in populated regions along major drainages offer the best surveillance of WNv and mosquitoes. In BC the largest abatement programs are along the Fraser River and its major tributaries (Fraser Valley Regional District, Thompson Nicola Regional District and Prince George). Similar programs exist in Idaho along the Snake River, and in Washington along the Columbia River. This year the mosquitoes were notably higher along Fraser River basin drainages, especially TCS and FRE (Table 6), this sparked several media interviews. Several contractors noted that *Aedes sticticus* was the dominate species resulting from flooding along banks of the river.

Table 6: Changes in Aedes per HSDA Over Last 2 years.

HSDA	2006 *Aedes*	2007 *Aedes*	Status
EK	44901	63107	up
KB	4146	6351	up
OK	216850	10422	down
TCS	13194	34998	up
FRE	15687	27070	up
FRN	2261	4598	up
FRS	2035	3397	up
RICH	2065	787	down
Others	13660	1241	down
Total	314799	151971	down

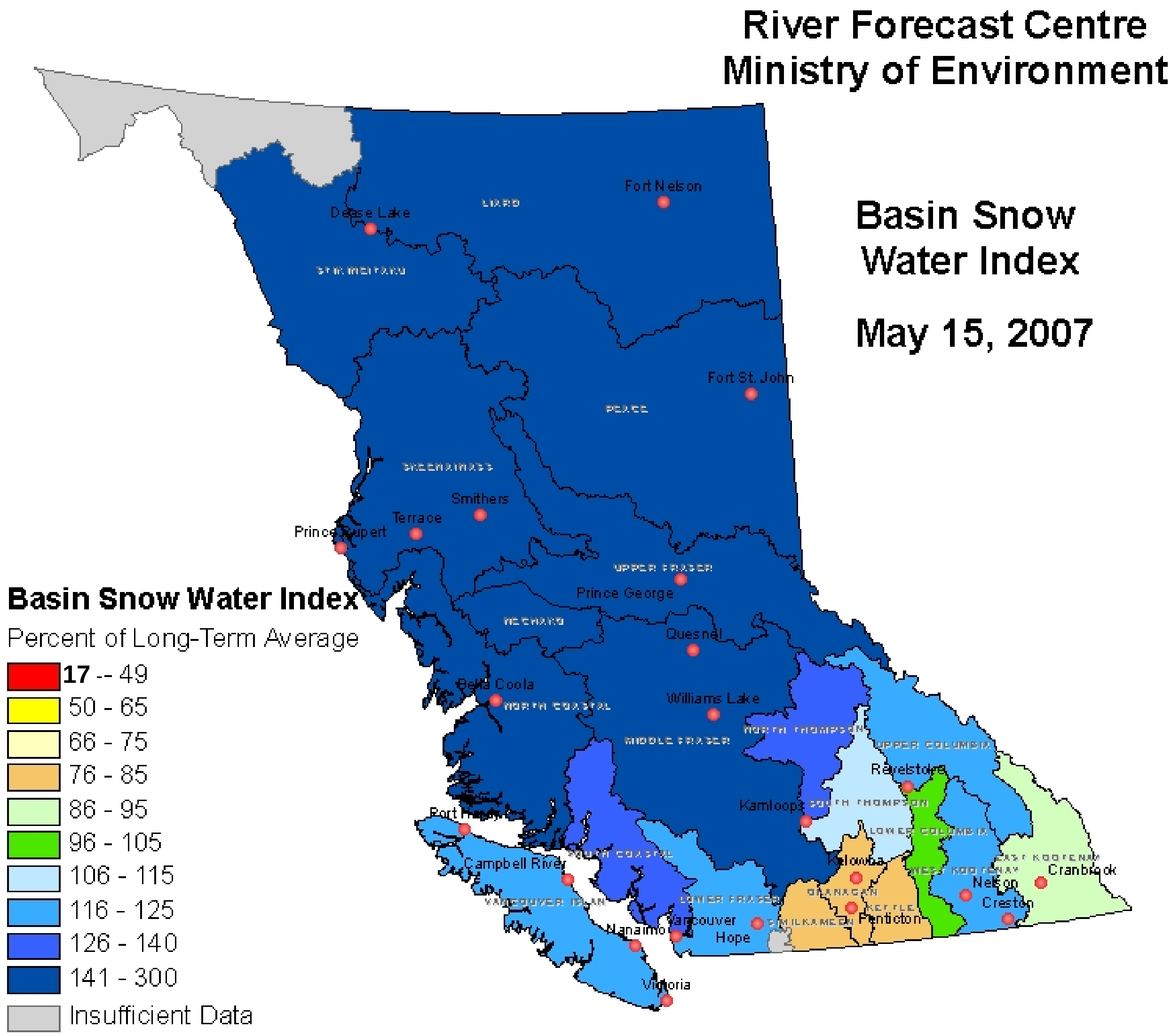
Other Mosquito Species

Anopheles is the primary vector for malaria but can also act as a bridging species for WNv. The largest numbers were collected in KB. Although not abundant across the province this may be important locally where these *Anopheles* species are found. *Culiseta* were most abundant in KB and OK regions, contractors have noted that *Cu. inornata* is collected in all areas of the interior but not usually in large numbers.

The of Effect Rainfall and Snowpack on Mosquito Abundance

Abnormally high accumulation of snow occurred in many parts of BC during the winter of 2006 and this resulted in high spring runoff during this spring in the Fraser River basin (Figure 10). The head waters begin at Mount Robson and drain 236,000 sq km before entering the Pacific Ocean, this is almost ¼ of the province and affects more than ½ of the province's population. The OK and, to a lesser extent, the EK had below normal snow accumulation. Floodwater *Aedes* mosquitoes were up in TCS and FRE and down in OK regions, which may reflect winter moisture accumulation. The significant drop in mosquitoes in OK will also be affected by implementation of a mosquito abatement program this year. In the northern portion of the Fraser basin, according to local authorities, mosquito trapping did not reflect the number of nuisance *Aedes* that appeared after spring runoff. Pine Beetle forest destruction is also being implicated in the issue because dead forests and logged, infested land do not hold as much moisture and this increases the spring runoff.

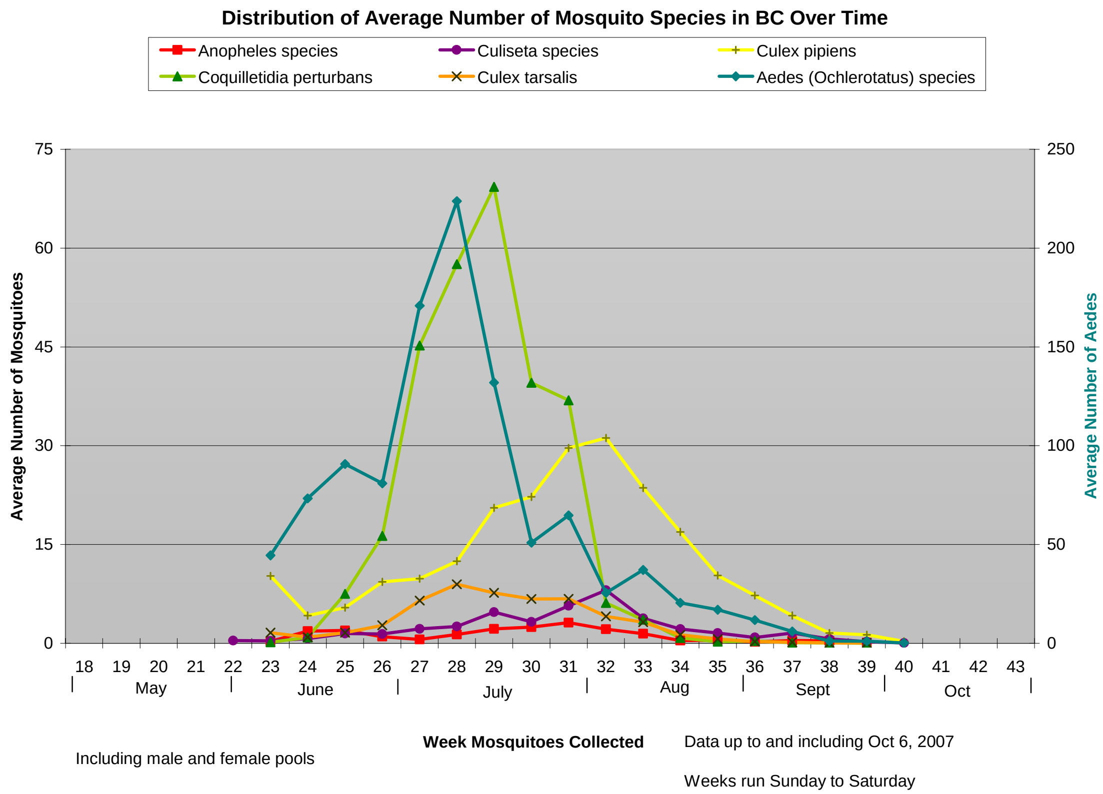
Figure 10: Ministry of Environment Basin Snow Water Index Map 2007



Temporal Distribution of Mosquitoes

This year the window of sampling was from the beginning of June to the end of September. Even though we started a month later than in 2005 and 2006, the major peak in *Aedes* was caught, as was the start of the first generation of both *Culex* species, the primary vectors for WNv (Figure 11). *Coquillettidia perturbans* were the second most abundant species caught for the last 2 years, which is quite different from 2004 when *Culex pipiens* were the second most common group. The use of more light traps since 2005 might account for the difference because the gravid traps seems to be biased towards catching more *Cx. pipiens* than other species.

Figure 11: Average Number of Mosquitoes Species Trapped per Week, 2007



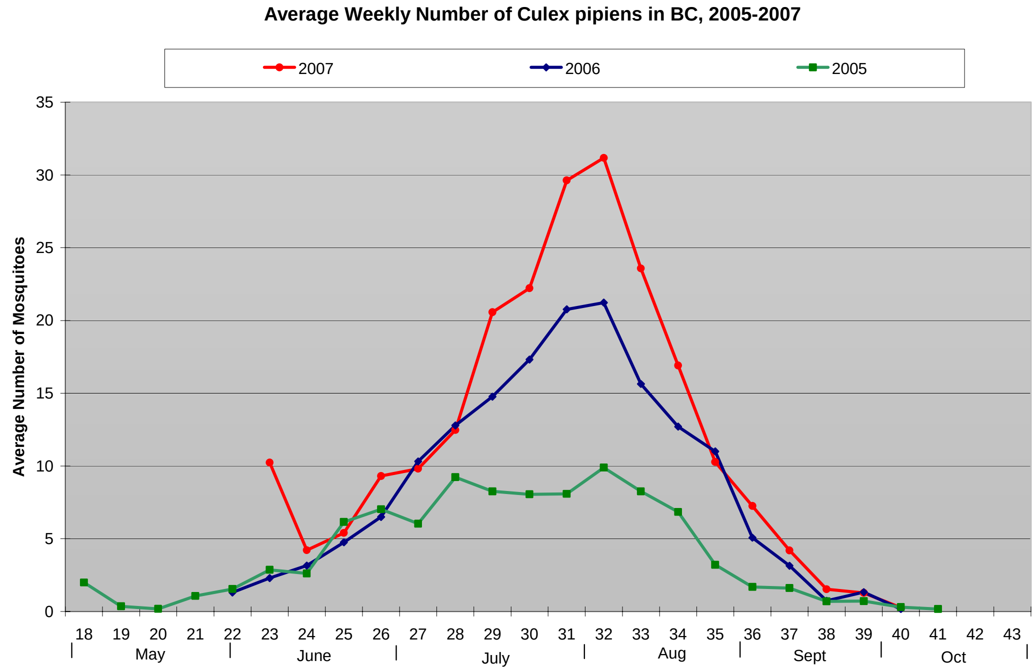
Culex

Culex tarsalis peaked around the middle of July in 2007; we did not see the June peak we experienced in 2006 (Figure 12). *Culex pipiens* numbers built-up to an early August peak in both 2006 and 2007. By mid-August the day length dropped below 14 hours and this seems to signal the switch to an overwintering diapause where the female mosquitoes feed on flower carbohydrates rather than taking a bloodmeal for egg development. The largest population numbers of this mosquito in BC correspond to the period when most human cases would be bitten in Canada, given allowances for incubation period. We can predict that if WNv is present in BC during this period then Culex will be able to play a significant role in transmission.

Aedes

The peak in *Aedes* mosquitoes corresponded with peak discharge of Fraser River in BC which occurred on June 11 at the Mission gauge, June 9 at Spences Bridge and June 8 at South Fort George. The peak adult mosquitoes occurred about 3 weeks later, just in time for the July 1st long weekend. Mosquito control contractors noted that large numbers of adults remained only for a few weeks.

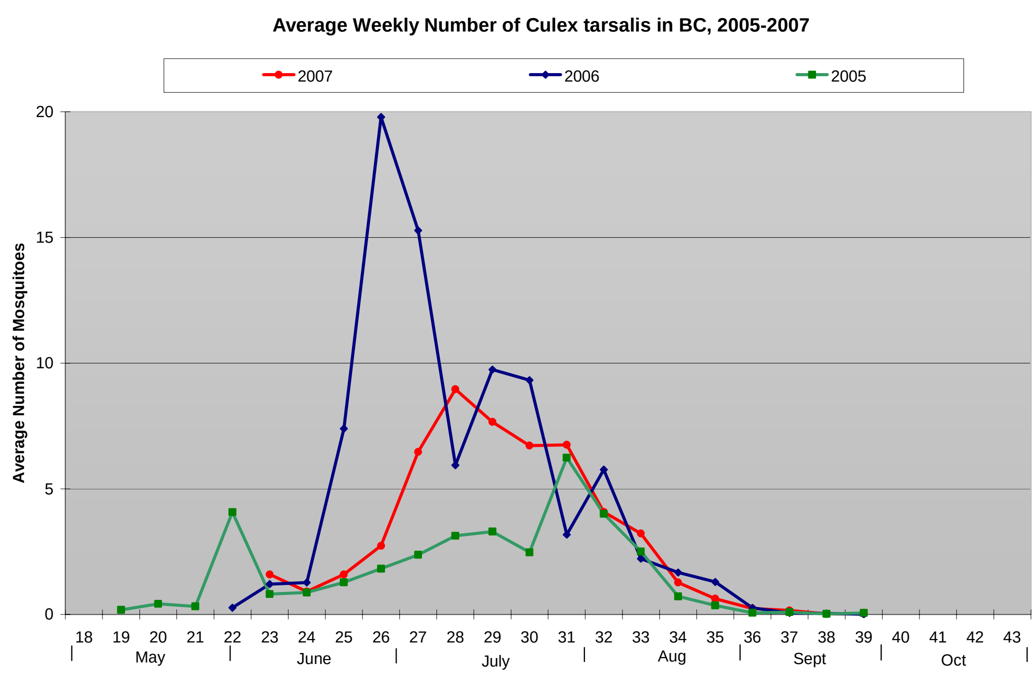
Figure 12: Average Weekly Number of Culex Species in BC, 2005-2007.



Including male and female pools

Data up to and including Oct 6, 2007

Weeks run Sunday to Saturday



Including male and female pools

High Cx. tarsalis numbers in late June 2006 thought to be misclassification of Coquilletidia species

Data up to and including Oct 6, 2007

Weeks run Sunday to Saturday

Timing of Mosquito Mmergence: Canada, BC and the Pacific Northwest

This year the earliest positive mosquito pool occurred in Manitoba (Table 7). In general, mosquitoes have been caught progressively earlier in Prairie Provinces each year. Evidence of viral activity in Oregon was also detected earlier than previous years; Washington state had an early human case in July 2006, however the positive birds appeared about the same time in 2006 and 2007 (Table 8). In endemic areas, some evidence exists that an overwintering female may already be infected before taking her 1st bloodmeal (vertical transmission contributing to an earlier spring transmission cycle; others believe the virus is brought each year with migratory birds before they build resistance to the virus.

Flooding plays a major role in the size of yearly mosquito populations and the Red River is the source of water for Winnipeg. Unlike the Fraser River, it runs south to north before entering Lake Winnipeg and sees peak water at the beginning of May. For Manitoba this is early enough for large *Culex tarsalis* populations to be present by the beginning of June. In contrast, the Fraser rarely floods before the end of May, and typically late in June. The later arrival of vector populations in BC may be a limiting factor to the establishment of efficient viral transmission in the province.

Table 7: First Recorded Dates of Positive West Nile Mosquitoes in Canada.

Year	AB	SK	MN	ON	QC
2007	15-Jul	20-Jun	5-Jun	15-Jul	
2006	18-Jul	17-Jul	4-Jun	5-Jul	10-Aug
2005	7-Aug	28-Jul	15-Jul	26-Jul	3-Aug
2004	10-Aug	13-Aug	28-Jul	3-Aug	19-Aug
2003	23-Jul	12-Aug	25-Jul	23-Jul	29-Jul
2002			15-Aug	16-Jul	16-Aug
2001				22-Oct	

* information extracted from provincial Public Health Agency websites

Table 8: Earliest Positive Surveillance Findings in Washington and Oregon

Year	Washington State	Oregon
2007	Wk 33 (Aug 12-18), horse	Wk 18 (Apr 29-May 5), horse
2006	Wk 29 (July 16-22), human	Wk 25 (Jun 18-24), human
2005	Wk 34 (Aug 21-27), mosquito	Wk 28 (Jul 10-16), human
2004	None	Wk 31, bird/horse
2003	None	None
2002	October, bird	None

NOTE - information extracted from state health department websites

In most regions, mosquitoes were first collected when trapping began at the end of May or 1st week of June. In the North and NVI, specimens did not appear until the beginning of July (Table 9). *Coquillettidia perturbans* usually appears during June for most regions but were not recorded until July in the north.

Table 9: Earliest Date and Location of Different Mosquito Species in BC, 2007

HSDA	*Aedes* and *Ochlerotatus* species	*Anopheles* species	*Coquilletidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species
EK	6/5/2007	6/5/2007	6/7/2007	6/5/2007	6/5/2007		6/12/2007
KB	6/5/2007	6/11/2007	6/20/2007	6/5/2007	6/11/2007		6/5/2007
OK	6/5/2007	6/5/2007	6/5/2007	6/5/2007	6/5/2007		6/5/2007
TCS	6/5/2007	6/7/2007	6/28/2007	6/7/2007	6/5/2007		6/5/2007
FRE	6/5/2007	6/5/2007	6/13/2007	6/5/2007	6/5/2007		6/5/2007
FRN	6/5/2007	6/6/2007	6/19/2007	6/5/2007	6/5/2007		6/5/2007
FRS	6/5/2007	6/5/2007	6/20/2007	6/5/2007	6/5/2007	6/27/2007	6/5/2007
RICH	6/19/2007		6/14/2007	5/29/2007	5/29/2007		6/4/2007
VAN	6/14/2007	6/26/2007	6/28/2007	6/5/2007	6/5/2007		6/6/2007
NSCG	6/27/2007	7/12/2007	7/11/2007	6/24/2007	7/5/2007		6/2/2007
SVI	6/6/2007		6/6/2007	6/6/2007	6/6/2007		6/13/2007
CVI	6/6/2007	6/27/2007	6/20/2007	6/6/2007	6/6/2007		6/27/2007
NVI	7/12/2007	8/1/2007	6/20/2007	6/6/2007	8/1/2007		7/18/2007
NW	7/3/2007	7/23/2007	7/16/2007	7/9/2007			7/3/2007
NE	7/24/2007	7/16/2007					7/16/2007

Note:
Blank cell means that there is no such genus-species found that year.
Yellow background means the earliest date a species was found.

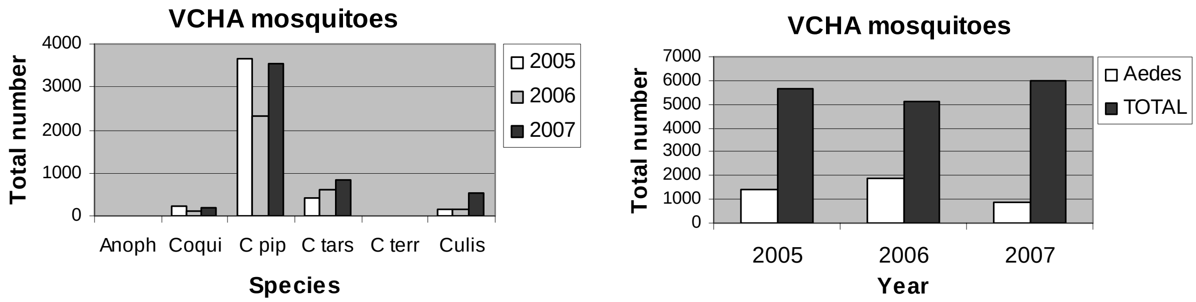
Relative Abundance of Mosquito Species Compared with Previous Years

In order to gauge changing mosquito abundance from year to year, sentinel traps were identified that had been placed in the same location over the last 3 years. Comparison between these traps will reflect true changes in mosquito populations from year to year, independent of changes in the overall number of traps operated or changing environmental conditions associated with different trap locations. Only traps that were not moved more than 2 Km from the general area were included in this analysis.

Vancouver Coastal Health Authority

Traps from this region included 15 located on the North Shore, City of Vancouver and Richmond; the rest of the region had only inconsistent trapping, except for a new traps located in Bella Coola. The civic strike made placement in some sentinel locations difficult because RHA staff would not cross the picket line. To compensate, traps were placed near the original location but off city property.

Figure 13: Species Abundance from 2005-2007 in Representative Light Traps, Vancouver Coastal Health.

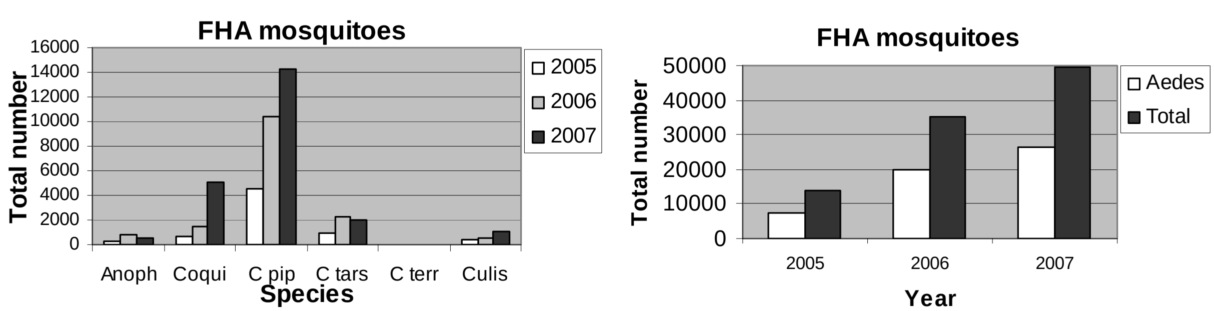


In this region *Culex pipiens* is the dominate mosquito collected in traps (Figure 13), this not unexpected because highly urbanized regions tend to benefit this species. Richmond is known to have a number of salt marsh breeding sites that hatch large numbers of *Aedes dorsalis*, but still *Culex pipiens* is the predominate mosquito collected in our traps over the last three years. The third most common species is *Culex tarsalis*, which has increased over the last 3 years. A possible explanation for the increase this year maybe the use of CO_2 as a bait in the City of Vancouver light traps. This region has the right combination of *Culex* species to potentially amplify and bridge WNv.

Fraser Health Authority

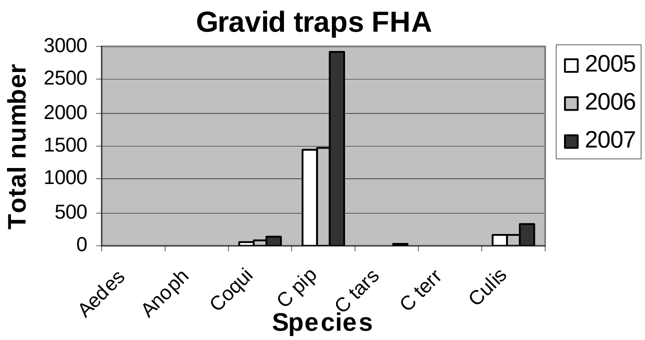
In this region there is a mix of urban and rural habitat for mosquitoes, the Fraser River is a predominate feature that affects their biology. Most of the 26 traps included in this comparison were outside of the dense urban core and situated more in smaller rural centres. *Aedes* make up more than ½ of the total mosquitoes collected. Several *Aedes* species are noted, the most dominate of which is *Aedes vexans* (floodwater mosquito). However, *Aedes sticticus* (woodland mosquito) predominated this year in flooded areas after water levels nearly breached the dykes. With this year's high water, Aedes were over 4 times the number collected in 2005 (Figure 14).

Figure 14: Species Abundance from 2005-2007 in Representative Light Traps, Fraser Health.



Culex pipiens is the second most abundant mosquito and their numbers have increased over the last 3 years. This increase in the adult population was not reflected in 2007 larval surveillance of breeding habitats on public land (including catch basins). It is possible that a significant proportion of artificial containers on private property that are not being monitored are being widely used by this species. Trap yields from gravid traps, which mimic this container environment, caught greater numbers of *Culex pipiens* this year (Figure 15). One could speculate that the high level of property development in Fraser Health could be contributing to the creation of new artificial container environments. Regardless of this difference between monitoring larvae and adults, significant spring precipitation seems to have generated considerably more *Culex pipiens* in 2007.

Figure 15: Species Abundance from 2005-2007 in Representative Gravid Traps

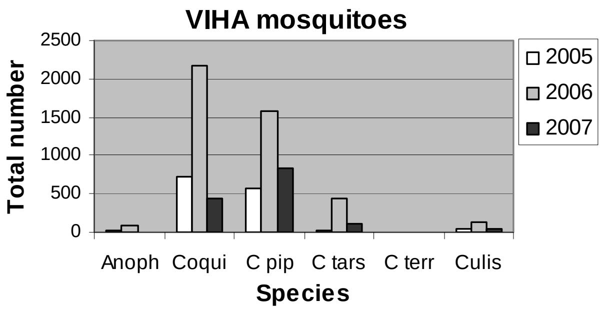


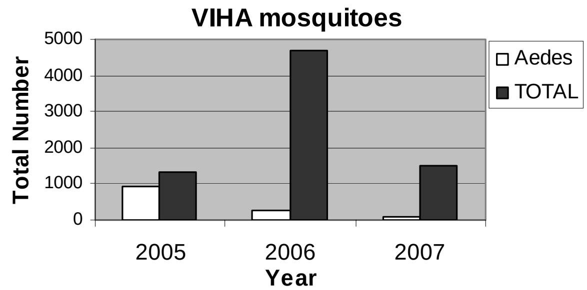
Coquillettidia perturbans increased this year in this region; they often generate complaints about mosquitoes for residents surrounding large freshwater stands of cattail plants. *Culex tarsalis* were collected across the region; we found the greatest number in light traps of the FRS region during 2004 and 2005 but this year more were recorded in FRE and FRN portion of the FHA.

Vancouver Island Health Authority

There were 6 locations which had traps within the same 2 km radius over the last 3 years. Counts for all mosquito species in 2007 were similar to 2005 and considerably less than collected in 2006. In 2007, we collected very few *Aedes*; the most common mosquito group was *Culex pipiens* (Figure 16). This was different from 2006 when *Coquillettidia perturbans* was the most abundant species and in 2005 *Aedes* lead the collections. This shift from year to year might be attributed to the smaller landmass of the island, where microclimate and localized geographical features can swing to the favour of each group of mosquitoes. The extremely high tides during July and August in the northwest during 2005 probably caused a salt marsh at Duncan Bay to produce large numbers of *Aedes dorsalis* which we picked up in that trap.

Figure 16: Species Abundance from 2005-2007 in Representative Light Traps, Vancouver Island Health Authority.

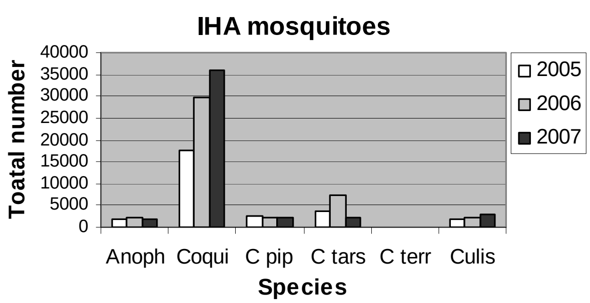




Interior Health Authority

This region of the province is strongly affected by snowmelt and river discharge. In this region the snowmelt *Aedes* and floodwater mosquitoes dominate the catch from 30 sentinel light traps, making up ¾ of the specimens collected (Figure 17). This year Aedes counts were down but this trend can be influenced by outbreaks in some years caused by localized weather events. For example, in last 2 years we have seen record numbers collected from two traps in the Osooyos region. If those traps are removed from the overall count, the *Aedes* actually increased for much of the IHA during 2007, as illustrated in Figure 18.

Figure 17: Species Abundance from 2005-2007 in Representative Light Traps, Interior Health.



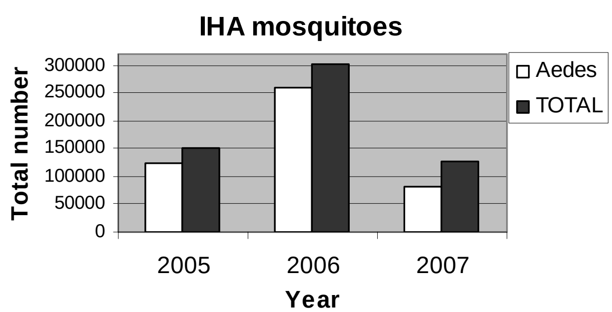
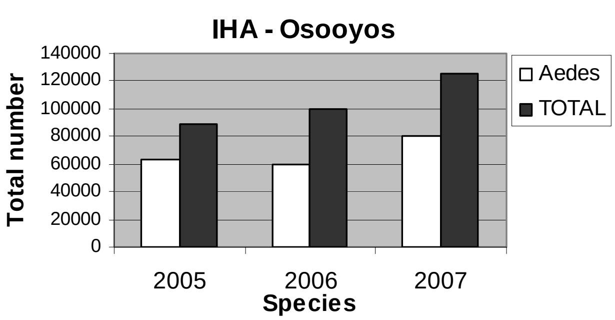


Figure 18: Species Abundance from 2005-2007 in Representative IHA Light Traps with Osooyos traps removed.



Several traps are placed near large cattail stands (Vaseaux Lake and Creston), the sum of these make up ½ of the total *Coquilletitdia perturbans* collected in the Interior Health region. This species increased in numbers in 2007.

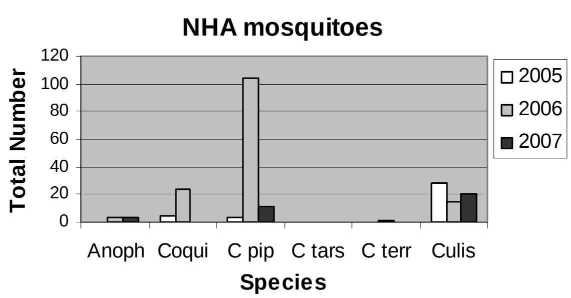
Culex tarsalis numbers doubled from 2005 to 2006 but dropped back to 2005 levels this year. Alberta found that *Culex tarsalis* practically disappeared from samples in 2005 but jumped up in 2006, then to record levels this year (personal communication: Alberta provincial entomologist). *Culex pipiens* dropped slightly this year but generally numbers are small compared to the more urbanized Metro-Vancouver. *Culex pipiens* does best where there are man-made artificial containers to use as habitat.

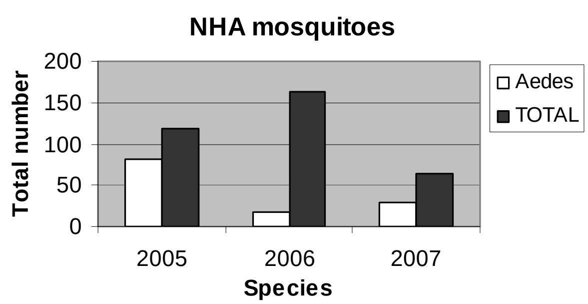
Northern Health Authority

NHA had problems getting any significant catches of mosquitoes this year, however local authorities noted a significant hatch of mosquitoes near Prince George. The greater than average snow pack (Figure 10) in northern areas is partly responsible for the large hatch but some have noted that forest death from the Pine Beetle and subsequent logging is also to blame for the quick excessive spring runoff. Traps were not running early enough to catch the spring hatching of *Aedes* mosquitoes.

Very few *Culex pipiens* were collected in the North West this year, in contrast to 2006 when they managed to collect a fair number: this can probably be attributed to not baiting any of the traps with CO_2 in 2007. No *Culex tarsalis* have ever been caught in these sentinel trap locations (or in any traps in NHA in 2007).

Figure 19: Species Abundance from 2005-2007 in Representative Light Traps, Northern Health.





Lag Times for Mosquito Submissions

The time it takes for a sample to go from the field to the laboratory is important for the timely reporting of WNv results back to the RHA.

The median submission time for mosquitoes in 2007 (1 day), was unchanged from 2005 and 2006 (Table 9). This reflects the strong commitment by RHAs to running this program in a way that ensures that real-time results will be available when the virus arrives. The maximum submission time was 2 weeks in NSCG but this was from a single collection in a remote region of the Health Authority. FHA had one trap stuck behind picket lines and they could not collect specimens for a one month period. If delays occur between collection and submission, HA are encouraged to keep specimens frozen or the quantity of virus in specimens will degrade below detection.

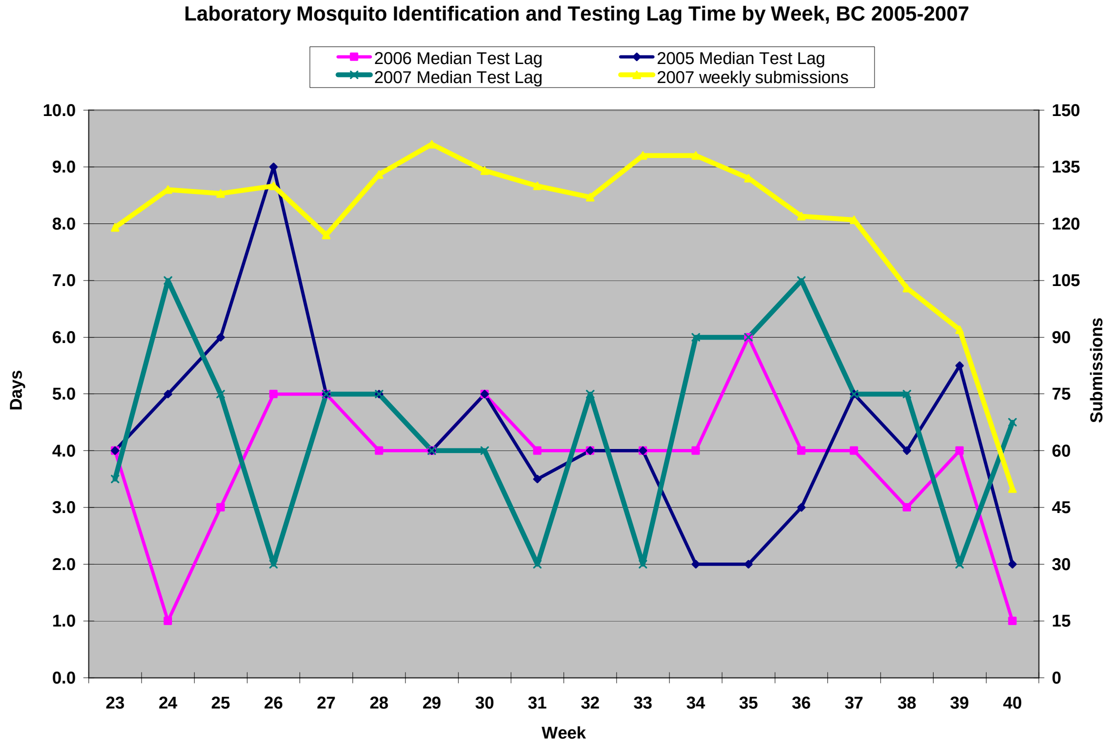
Table 10: Mosquito Lag Time for Sample Submission, 2003-2007

HSDA	Median of Submission					Max Of Submission				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
EK	1.0	3.0	2.0	2.0	3.0	2	7	13	5	13
KB	1.0	1.0	2.0	1.0	2.0	6	5	6	2	4
OK	1.0	2.0	1.0	1.0	1.0	8	7	9	4	3
TCS	1.0	1.0	1.0	2.0	1.0	8	6	5	7	5
FRE	2.0	3.0	2.0	1.0	1.0	5	10	8	4	32
FRN	2.0	1.0	1.0	1.0	1.0	3	7	6	4	1
FRS	1.5	3.0	1.0	1.0	1.0	7	8	16	4	8
RICH	2.0	1.0	1.0	2.0	1.0	17	2	6	8	6
VAN	0.5	0.0	0.0	0.0	0.0	6	5	1	1	2
NSCG	4.0	2.0	1.0	3.0	4.0	7	32	24	16	56
SVI	1.5	1.0	1.0	1.0	1.0	3	7	11	2	6
CVI	1.0	2.0	1.0	1.0	1.0	5	9	6	7	7
NVI	1.5	2.0	2.0	2.0	1.0	2	2	3	3	7
NW	1.0	2.0	2.0	1.0	2.0	1	15	7	10	7
NI	1.0	1.0	3.0	0.0	NA	6	6	14	1	NA
NE	2.0	1.0	2.0	2.0	2.0	2	5	7	12	14
All	**2.0**	**2.0**	**1.0**	**1.0**	**1.0**	**17**	**32**	**24**	**16**	**56**

Note: All numbers are in days.

BCCDC laboratories processed about 120 samples per week in 2007, similar to volumes in 2006. Average turn around time for mosquito identification and testing was 4 to 6 days (Figure 20). Increases in turn around time occurred at the beginning of the summer as large samples of floodwater mosquitoes appeared and again in September when seasonal WNv laboratory staff were lost.

Figure 20: Change in Laboratory Lag Time for Mosquito Identification and Testing



Climate Data – Growing Degree Day Calculations

A growing degree day model based on climate data was developed for *Culex tarsalis* mosquito forecasting. The concept of growing degree days involves the amount of accumulated heat required for mosquitoes to complete their growth and development. Mosquito development occurs more rapidly with warmer temperatures, and consequently multiple generations of mosquitoes may be produced during the growing season enabling WNv to amplify and risk of transmission to humans to increase.

Growing degree days were monitored on a weekly basis for select BC communities from each HSDA. Summer-time temperatures in 2007 were again above the 30 year average for most of the province.

Table 11: Accumulated Growing Degree Days for Select Communities up to August 31st

August 31st	**2007**	**2006**	**2005**	**2004**	**2003**	**30YR**
Cranbrook	442	423	307	360	476	276
Creston	607	554	446	517	620	351
Osoyoos	687	687	680	809	786	540
Kamloops	579	657	575	704	662	475
Abbotsford	295	342	340	430	360	222
Vancouver	221	239	245	329	275	170
Victoria	207	237	239	296	263	153
Prince George	189	237	184	264	196	139

Geographic Information Systems – Applications to WNv

Geographic information systems (GIS) mapping has been an integral tool for WNv surveillance and planning in BC. Data from a variety of sources (health-related events, field sampling, municipal infrastructure, environmental, etc.) and technologies (Global Positioning Systems, remote sensing, databases, etc.) can be integrated in a GIS for visualization and analysis. In addition to the weekly summary maps posted on the WNv website, the BCCDC has developed an interactive web-based GIS mapping system for public health officials and members of the public to view WNv surveillance data in spatial format (http://maps.bccdc.org).

Advanced GIS analysis and modeling have also been performed. A growing degree-day model for *Culex tarsalis* development was used to classify different WNv risk areas in the province (Tachiiri et al., *Int J Health Geogr*, May 2006). The forecasted risk of WNv illness was based on the presence of *Cx. tarsalis* and *Cx. pipiens* mosquitoes, climate and ecosystem type, human population density, and location along bird migration routes. The geographic density of dead corvids submitted for testing or reported by the public has been mapped to identify areas of high observed corvid mortality. In the event of WNv activity, "hotspots" of corvid mortality may indicate localized concentration of the virus in an area. The BCCDC has also examined the feasibility of adult mosquito control in a number of communities in BC to determine which areas can and should be sprayed (in terms of accessibility to mosquito habitat by ground-based approaches, and land-cover type for aerial-based approaches) in the event of an emergency to reduce the risk of WNv (Mak et al., *J Am Mosq Control Assoc*, Dec 2007).

GIS mapping has also been used by other stakeholders of the BC WNv program. For example, Metro Vancouver (formerly the Greater Vancouver Regional District) funded the development of a risk-based model that was used to prioritize the selection of catch basins for larval mosquito control (GDG Environnement, 2006). Mosquito control contractors hired by the Health Authorities and local governments have collected GPS coordinates that are mapped in a GIS and integrated with other surveillance data.

Please refer to http://www.bccdc.org/westnile and http://maps.bccdc.org/ for all WNv mapping related content.

Communications Highlights

BCCDC WNv communications in 2007 followed a pattern similar to previous years without local viral activity.

Communications Planning

The WNv Communications group (chaired by BCCDC with participation from the Ministry of Health, Health Authorities, GVRD/Metro Vancouver, Washington State, Canadian Blood Services) met at monthly teleconferences to provide updates on communications products and media outreach, and to gauge feedback and the level of interest in the WNv story among the media and public at large.

Consultations were held with Health Authorities to discuss a communication protocol in the event of a first positive indicator in 2007. A diagram representing the communications fan-out protocol was developed based on regional feedback (Appendix 2). This was successfully exercised when the first indicator in 2007 was detected - a travel-related human case. No changes to this process were requested by surveillance partners.

The WNv communications matrix was reviewed against an adulticiding "worst case" scenario to ensure its principles were still applicable under these circumstances. This may need to be reviewed in further detail with stakeholders ahead of next year's season, given the high turnover in the WNv Communications group over the past year or two.

Media Activity

BCCDC issued a seasonal press release in tandem with Health Authorities, with the usual reminders and cautionary messages.

A press release was issued when the first imported human infection of the year was confirmed (this caused media interest to spike for a while, before subsiding again). BCCDC Communications received 25 WNv media queries/interview requests this year, mainly on the WNv forecast front along with general precautions the public should take.

GVRD/Metro Vancouver issued a news release discussing larviciding and general WNv precautions/control measures on private land, an issue that had long been a concern from the GVRD perspective. This news release triggered a flurry of media interest and some discussion among the WNv Communications group, although media queries were not directed specifically at BCCDC.

Educational Materials

A new batch of BCCDC WNv brochures were printed and distributed to stakeholders who requested them, including Vancouver Coastal, BC Parks and Canadian Blood Services.

A poster on the appropriate choice of insect repellent for both adults and children was designed for public distribution. It has been placed on the BCCDC website for direct public use or may be printed for further distribution. A copy is available at: http://www.bccdc.org/content.php?item=204

A significant initiative this year was a modest redesign and update of the BCCDC WNv website at http://www.bccdc.org/content.php?item=183. With input and support from PHSA Web Strategies, the BCCDC WNv program made the site more user friendly by way of navigation and content. Feedback from stakeholders was positive.

Surveillance Debrief

A debrief was held with WNv coordinators at the close of the 2007 surveillance season to allow discussion of lessons learned and suggestion of improvements for 2008. In brief, there was some concern over timely receipt of lab reports due to a manual laboratory distribution process. Options for a back-up system were discussed. Initially, connections between WNv coordinators and CD teams performing case interviews were weak but strengthened as more human cases were investigated. Many regions have now developed protocols to foster these internal lines of communication. As two cases this season were detected by CBS, the question of whether serum samples need still be collected from cases with NAT positive results arose. The group determined that in future years, if a case has travelled to a known endemic area and has NAT positive results by both the initial and alternate primer, that no request for acute and convalescent serum is required.

Research Highlights

In British Columbia

Effect of Catch Basin Larvidicing (Mieke Buller, BCCDC)

In anticipation of the arrival of West Nile Virus (WNv) many communities are performing larval mosquito control. The data collected include location coordinates, and attributes about the site including the treatment type and amount. We are currently working on a project with Richmond Health Services to try to determine if the large scale catch basin treatment program that was implemented in 2006 has affected the adult *Culex pipiens* trap catches. The factors that we will be analyzing include temperature, rainfall, catch basin treatment and other larval treatment (in open ditches).

Exposure Protocol (Negar Elmieh, UBC)

The BCCDC human exposure assessment protocol for malathion was revised to include pyrethrins. This protocol can be implemented to test for human pyrethrin exposure in the event of adulticiding using pyrethrin. A review of the literature identified a lack of scientific evidence pertaining to pyrethrin and its synergist piperonyl butoxide. The majority of the literature focused on pyrethroids, the synthetic version of pyrethrin.

Knowledge, Attitudes and Behavior Survey (Negar Elmieh, UBC)

A WNV knowledge, attitudes, and behavior telephone questionnaire was carried out in the summer of 2007 among a random sample of residents in BC (n=350), AB (n=176), and MB (n=177). This questionnaire is a follow-up to the knowledge, attitudes, and behavior survey that was carried out in 2003. Results will be used to investigate WNV perceptions across provinces with varying levels of WNV activity. Results from BC will be compared to that of 2003 to see if perceptions in BC residents have changed in the past 4 years.

Mutli-Criteria Decision Analysis Survey (Negar Elmieh, UBC)

A multi-criteria decision analysis survey was conducted among residents of BC, AB and MB as well as a group of identified WNV health professionals. The goal of the survey is to examine decision-making behaviors between the general public and health professionals around potential WNV programs under varying risk scenarios. This study is the first application of multi-criteria decision analysis to WNV program planning with potential insights for future programmatic decisions.

Catch Basin Mosquito Larvicide Comparison (Pam Mandarino, Royal Rhodes)

This project is sponsored by Vancouver Coastal Health Authority and examines whether limited scale larviciding in storm-sewer, catch basins of a highly urbanized city will affect the adult mosquito population in the treated areas as opposed to other parts of the city which get no larviciding. Field performance data for three mosquito control larvicides (vectolex-wsp®, vectobac-200g®, and altosid-xr briquets®) will be compared.

Geographic Distribution and Rearing Requirements of the Cattail Mosquito, *Coquillettidia perturbans*, in North Central British Columbia (Lisa Porier, UNBC).

This mosquito has unique ability to survive over the winter under the surface of the water as larva. The research will attempt to determine the larval rearing requirements and northern distribution of *C. perturbans*, and will compare various sampling methods.

From the Literature

Surveillance

- Surveillance for the detection of WNv in metropolitan Denver, CO during 2003 found that an environmental indicator preceded almost two thirds of human infections. Dead bird surveillance (51.0%) successfully predicted the highest proportion of human cases, followed by mosquito pools (19.6%) and equines (13.9%). Sentinel chicken surveillance (1.0%) was not a good surveillance method, and it was discontinued in following years (Patnaik et al., *Emerg Infect Dis*, Nov 2007).

- The use of house sparrow nestlings as sentinels for WNv was examined in 2006 and 2007 to augment dead corvid surveillance in rural areas of Saskatchewan. It was determined that house sparrow nestlings as a surveillance tool for WNv was not useful since zero out of 592 samples (0%) collected in 2006 and only four out of 200 samples (2%) collected in 2007 detected WNv using VecTest and RT-PCR (Millins, MSc Thesis, University of Saskatchewan, 2007).

- Squirrels may be a competent amplification host for WNv since they have viremia levels sufficiently high to infect at least a low proportion of mosquitoes (Root et al., *Am J Trop Med Hyg*, 75(4), 2006). The state of California began testing squirrels for WNv in 2004 and found that 64.5% (49/76) tested positive. The added benefit of testing squirrels is that they are extremely localized so a positive squirrel indicates that WNv is present in the immediate area as opposed to corvids which may fly from one place to another (WA State Dept of Health, *Zoonotic Disease Letter*, May 2007).

Clinical Studies

- Results of laboratory experiments suggest that West Nile virus enters the peripheral nervous system and then travels along the axons to infect the CNS, which can cause flaccid paralysis, even in absence of encephalitis or meningitis. They suggest as an early intervention for the disease, use of neutralizing antibodies to block the spread of the virus within the CNS. Proc. Nat. Acad. Sci.104 (43): 17140-17145.

Knowledge, Attitudes and Beliefs

- A multi-method knowledge, attitudes, and behavior survey in urban and rural Kansas residents showed that WNV knowledge was widespread among residents (97% had heard of WNV), with the majority of the information coming from television, newspapers, and word of mouth. Engagement in preventative behaviors was less widespread: 54.1% removed standing water, 36.9% wore long sleeves or pants, 33 % checked screens for holes, and 27.5% used insect repellents. Age, education, area of residence (urban vs. rural), race, and gender appeared to be associated with information sources, removal of standing water, and window screen maintenance. WNV messages should be tailored to the target population using the most appropriate and accessed channels of communication. (Fox, Averett et al., American Journal Of Health Behavior **30**(5): 483-494, 2006)

- Eleven semi-structured focus groups were held in 2 Colorado counties to reflect high WNV areas (Fort Collins, Larimer County) and low WNV areas (Colorado Springs, El Paso County) during the 2003 WNV outbreak. Perception of WNV related risk was attributed to perception of: disease proximity, local ecology, information sources, and local government response. (Zielinski-Gutierrez and Hayden, EcoHealth **3**: 28-34, 2007)

- A knowledge, attitudes, behavior and clinical history survey conducted in Cuyahoga County, Ohio in 2002 revealed that children were more likely to spend time outdoors in comparison to adults. Children were also less likely to avoid going outdoors and to wear long sleeves or pants when compared to adults. The authors conclude that children's behaviors could potentially put them at an increased risk of WNV exposure. Increased WNV education was recommended for this age group. (LaBeaud, Kile et al. Public Health Reports 122(3): 356-361, 2006)

Climate

- The summer of 2007 was the 7th warmest experienced in Canada since nationwide records began in 1948 (Environment Canada, 2007). Temperatures were on average 0.9^{o}C above normal.

- The province of Quebec discontinued funding for larval mosquito control in 2006. This decision was supported by a statistical analysis of 2002 climatic conditions preceding (unusually warm winter) and during (hot summer) the WNv epidemic in the northeast region of North America. The researchers estimated that the return period for the observed 2002 climatic conditions was only once every 40 years for the City of Montreal (El Adlouni et al., *Int J Health Geogr*, Sept 2007).

- Human outbreaks of WNv are most strongly associated with annual precipitation from the preceding year. However, precipitation may affect mosquito populations in vastly different ways depending on the mosquito species and ecological characteristics of an area. In the eastern United States, above average rainfall during the previous year was positively correlated with higher human infection rates of WNv the following summer. Conversely, in the western United States, below average rainfall was correlated with higher human infection rates of WNv the following summer (Landesman et al., *Vector Borne Zoonotic Dis*, 7(3), 2007).

<u>Biology and Transmission</u>

- Co-feeding transmission in mosquitoes, wherein a low proportion of uninfected mosquitoes become infected following feeding in spatial and temporal proximity to infected mosquitoes, has been observed in the laboratory. Recipients became infected when feeding up to 40 mm from the donor and up to 45 minutes after donor feeding. The occurrence of this phenomenon in nature is unknown (McGee et al., *Am J Trop Med Hyg*, 76(3), 2007; Reisen et al., *J Med Entomol*, 44(2), 2007).

- Vertical transmission of WNv from parent to progeny has been demonstrated. Progeny infected vertically during the fall could potentially serve as a mechanism for WNv to overwinter and initiate horizontal transmission the following spring. In situ collections of *Culex pipiens* have documented male and nulliparous females to be infected with West Nile virus showing that mosquitoes in their natural environment can become infected by means other than by blood feeding, possibly by transovarial transmission (Anderson JF et al. J. Med. Entomol. 43(5): 1010-1019 (2006).

- Infection of WNv has been demonstrated in bloodfeeding arthropods other than mosquitoes. This suggests that additional vectors could play a role in enzootic cycle of West Nile virus:
    - Recent research confirms older research that *Ixodes pacificus* ticks could not experimentally transmit WNv and is therefore not involved in the transmission cycle. Reisen et al., 2007. Jour. Med Ent. 44 (2): 320-327.
    - In Louisiana, no-see-ums (*Culicoides*) were found infected with WNv at the same rate as mosquito species. Isidra J. Sabio, Andrew JJ Med. Entomol. 43(5): 1020ð1022 (2006).
    - Stable flies collected from the carcass of dead pelicans tested positive for West Nile virus (Johnston G, University of Montana, NWMVCA meetings, 2007).
    -

- Since 2003, WN02 has completely replaced NY99 as the West Nile Virus strain in circulation in North America (Robin et al, Am. J. Trop. Med. Hyg., 77(2), 2007, pp. 365-370). Although they found no detectable difference in vitro between the genotypes in either replication or fitness, there were significant differences in vivo in *Culex* mosquitoes. EIP (extrinsic incubation period) is shorter by 4 days although after intrathoracic inoculation, there was no difference. Similar species-specific differences in genotype-vector interactions were found with *Culex tarsalis*. Using their findings in a model, they suggested the decrease in the length of the EIP leads to an increase in the probability that a WN02-infected mosquito will survive the EIP to infect new hosts, increasing the vectorial capacity of the WN02 genotype.

- *Culex pipiens* primarily feed on birds but recently it was hypothesized that during the late summer months they may feed indiscriminately on either birds or mammals (Spielman, *Ann N Y Acad Sci*, 951, 2001).

Mosquito Control and WNv Prevention

- Following the four hurricanes making landfall in Florida in 2004, a total of 43 aerial spray missions were conducted in 26 Florida counties to control mosquito populations. Mosquitoes were trapped before and after each spray mission to determine an overall reduction of mosquito populations by 67.7% (Simpson, *J Am Mosq Control Assoc*, Sept 2006).

- After three aerial applications of pyrethrins around the urban center of Sacramento, CA in August 2005 for WNv control, testing of water and sediment samples from nearby creeks did not detect insecticide residues or toxicity. Unexpectedly however, the piperonyl butoxide (PBO) synergist was found in concentrations (2-4 *u*g/L) high enough to enhance toxicity of other pyrethroids already existing in creek sediments from general urban pesticide use (Weston et al., *Environ Sci Technol*, Sept 2006).

- A human health risk assessment for WNv and the insecticides used in mosquito management determined that the risks from infection of WNv greatly exceed the risks from exposure to mosquito insecticides, which are very low and are not likely to exceed levels of concern (Peterson et al., *Environ Health Perspect*, Mar 2006).

- Two adjacent counties in Colorado had severe outbreaks of WNv in 2003. Loveland County residents had a higher neuroinvasive disease rate than Fort Collins County even though Loveland County had a more extensive mosquito control program and fewer mosquitoes. It was determined that personal protective practices such as the use of DEET and avoidance of time spent outdoors during prime mosquito biting hours may directly influence rates of WNv infection even when comprehensive community mosquito control measures are implemented (Gujral et al., *Emerg Infect Dis*, Mar 2007).

- A recombinant bacterial strain expressing the toxins of *Bacillus thuringiensis israelensis* (Bti) and *B. sphaericus* was found to be 20 times more toxic than either of the parental strains and less likely to induce resistance in target populations. It is effective against the larvae of *Culex quinquefasciatus* and *C. tarsalis*. The product is under development by Valent BioSciences (Park et al., *Am J Trop Med Hyg*, 72(6), 2005).

- There are currently four licensed WNv vaccines for horses and one licensed vaccine for domestic geese. Significant process has been made in the development of a WNv vaccine for humans with ongoing clinical trials of four vaccines (Kramer et al., *Annu Rev Entomol*, July 2007).

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Appendix 1: Reference Tables for nterpretation of Human Laboratory Test Results

How to Interpret <u>Acute</u> West Nile Virus Test Results, 2007

Acute WNv IgM EIA	**Acute WNv IgG EIA**	**Acute EDTA blood WNv RT-PCR**	**CSF WNv RT-PCR**	**Interpretation**
any	any	RNA DETECTED		This patient is viremic and is a **confirmed** case of West Nile virus infection. There is no cross-reactivity with other flaviviruses in the BCCDC WNv RT-PCR.
			RNA DETECTED	
			RNA not detected	Viral **RNA not detected** in the CSF. This test has a low sensitivity and does not rule out WNV infection. Please refer to blood tests.
REACTIVE	REACTIVE, Equivocal or Nonreactive	RNA not detected (or not tested)		**Probable** acute West Nile virus infection. Send a convalescent serum taken 10 – 14 days after the acute serum to demonstrate rising titres or titre >= 1:320 by HI.
Equivocal	REACTIVE, Equivocal or Nonreactive	RNA not detected (or not tested)		**Possible*** West Nile virus infection. Send a convalescent serum taken 10 – 14 days after the acute serum to demonstrate rising titres or significant titre >= 1:320
Negative	REACTIVE or Equivocal	RNA not detected (or not tested)		**Possible*** West Nile virus infection. Send a convalescent serum taken 10 – 14 days after the acute serum to demonstrate rising titres or significant titre >= 1:320
Negative	Negative	RNA not detected (or not tested)		Most likely not a WNv case. Send a convalescent serum taken 10 – 14 days after the acute serum for follow-up to rule out infection with Flavivirus other than WNv or very early infection.

* Note: no 'possible' classification exists for WNv cases; if no convalescent serum is collected, these cases will never meet the probable case definition.

EIA: Enzyme Immunoassay
HI: Hemagglutination Inhibition Assay
RT-PCR: Reverse Transcriptase Polymerase Chain Reaction

For consultation call Dr. Morshed at 604-660-6074

Interpretation of Acute and Convalescent West Nile Virus Test Results, 2007

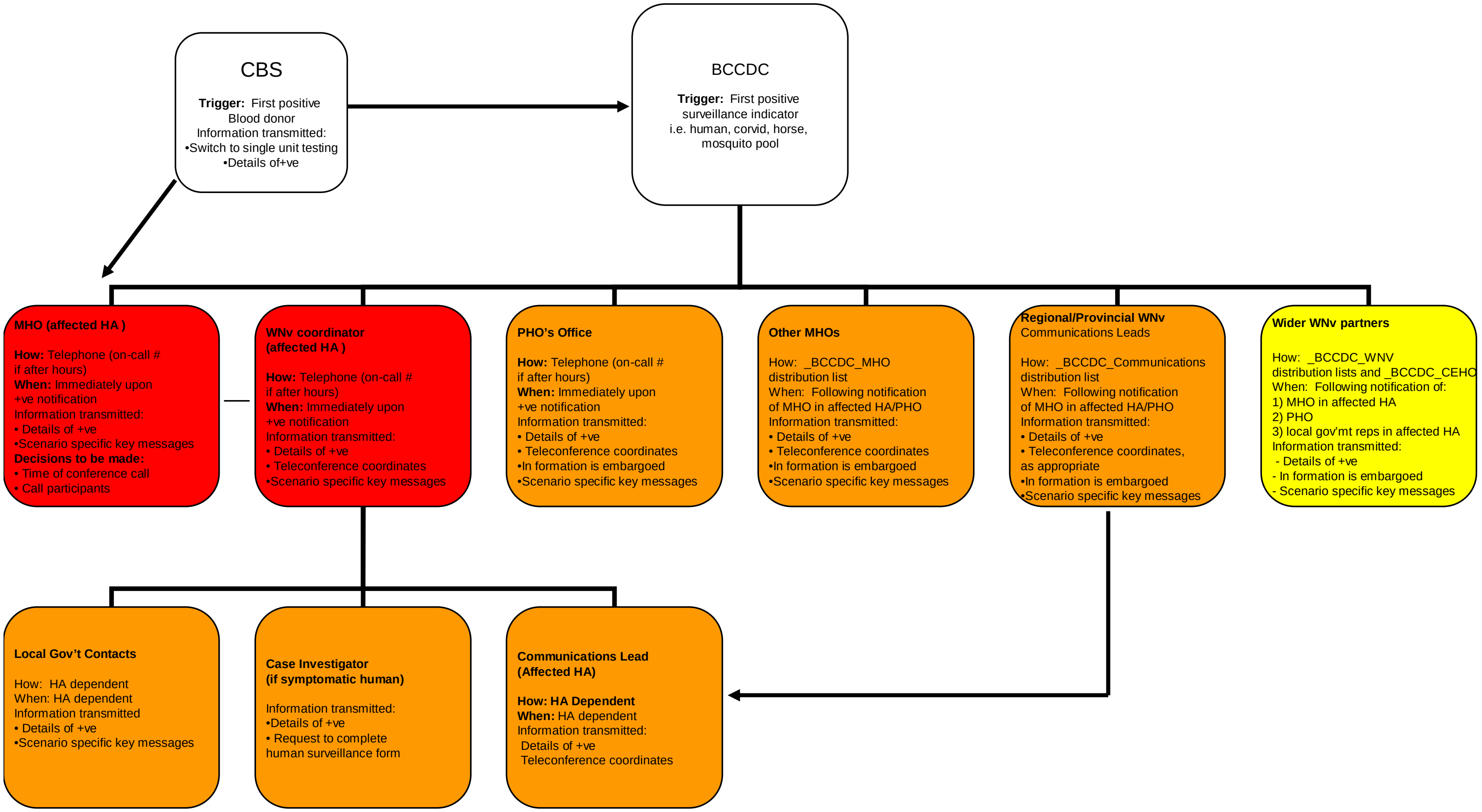
Acute EIA IgM	Acute EIA IgG	Convalescent EIA IgM	Convalescent EIA IgG	Interpretation
Nonreactive	Nonreactive, Equivocal or Reactive	REACTIVE (IgM seroconversion)	Nonreactive, Equivocal or Reactive	**Probable** acute infection with West Nile virus. IgM seroconversion indicates a recent infection. Confirmed with rising or significant HI titres and PRNT**
REACTIVE	Nonreactive	REACTIVE	REACTIVE Significant* rise in IgG level	**Probable** acute infection with West Nile virus. Confirmed with rising or significant HI titres and PRNT**
REACTIVE	REACTIVE	REACTIVE	REACTIVE Significant* rise in IgG level	
Nonreactive	Equivocal or Nonreactive	Nonreactive	REACTIVE Significant* rise in IgG level	**Possible recent flavivirus infection (not WNv)** No IgM is detected in such cases. There is extensive cross-reactivity between flaviviruses (WNV, Dengue, SLE and YF) in EIA IgG and HI tests. Check travel/vaccination history. To be confirmed at the National Microbiology Lab.
REACTIVE	REACTIVE	REACTIVE	REACTIVE Stable non-significant IgG level	**No evidence of recent infection** with West Nile virus. IgM persists for > 1 year in 50% of patients.
Nonreactive	REACTIVE	Nonreactive	REACTIVE Stable non-significant IgG level	**No evidence of recent infection** with West Nile virus. Past infection with a flavivirus. There is extensive cross-reactivity between flaviviruses (WNV, Dengue, SLE and YF) in EIA and HI tests. IgM persists for > 1 year in 50% of patients.
Nonreactive	Nonreactive	Nonreactive	Nonreactive	Not WNv. Lack of antibody by 21 days after onset of illness is extremely unusual.

* Four-fold rise in HI titre, or HI titre >= 1:320
**The first 5 cases in BC will be confirmed at the National Microbiology Lab by PRNT assay.

EIA: Enzyme Immunoassay; **HI:** Hemagglutination Inhibition; **PRNT:** Plaque Reduction Neutralization
For test patterns not included above, please refer to the interpretation included on BCCDC reports.
For consultation call Dr. Morshed at 604-660-6074

Appendix 2: Communications Fan-Out: Notification of First Positive WNv Result in BC

BCCDC Communications Fan-Out: Notification of FIRST POSITIVE



Colour gradient indicates rapidity of notification

Red=fastest; yellow=slowest