# *2005*
# *ENVIRONMENT CANADA*
# *PACIFIC & YUKON REGION*
# *PESTICIDE INFORMATION EXCHANGE*
# *PROCEEDINGS*

## *November 22, 2005*

**at**

**1700 Labatt Hall**
**Simon Fraser University at Harbour Centre**
**515 West Hastings Street**
**Vancouver, British Columbia**

**Regional Program Report 06-01**


Prepared by:

Environment Canada
Environmental Protection Operations
Commercial Chemicals Division & Environmental Emergencies
Pacific and Yukon Region



**December 2005**

# T A B L E  O F  C O N T E N T S

**J. Pasternak** ------------- Commercial Chemicals Division Pesticides Program Update and Residues of Current Use Pesticides in Agricultural Runoff in the Okanagan Valley, BC

**T. Tuominen** ------------- Current-Use Pesticides in Surface Waters, Ground Waters and Precipitation of the Lower Fraser Valley and Okanagan

**P. Ross** ------------------- From the Field to the Lab: Characterizing Current Use Pesticide Impacts on Salmon in British Columbia

**J. Elliott** ----------------- Pesticide Exposure and Reproductive Effects in Native Amphibian Species Using Agricultural Habitat, South Okanagan, British Columbia (2003 – 2005)

POSTER PRESENTATIONS:

**(1) Tracy Hueppelsheuser** (BCMAL) – Research and Innovation in Integrated Pest Management in British Columbia Crops

**(2) Craig Buday and Grant Schroeder** (EC) – 28-Day *Hyalella azteca* Sediment Toxicity Testing with Endosulfan Compounds

**(3) John Elliott** (EC) – Assessing Avian Exposure to Monosodium Methanearsonate (MSMA) as Used for Bark Beetle Control in British Columbia Forests

**(4) John Elliott** (EC) – Raptor & Waterfowl Exposure to Pesticides in Agricultural Ecosystems of Southwestern BC

**(5) Vesna Furtula** (EC) – Pesticides in Nathan Creek, BC (*poster not included in the Proceedings*)

**(6) Brad McPherson** (EC) – Recent Findings for Pesticide Sampling Programs in BC

**(7) Bill Ernst** (EC) – Evaluation of Buffer Zone Effectiveness in the Protection of Aquatic Environments in Prince Edward Island - 2004

HANDOUTS:

**Gevan Mattu** (EC) - Survey of Pesticide Use in British Columbia: 2003
The report can be accessible via the BCMOE Pesticide IPM web site at http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/tech_reports.html or http://www.env.gov.bc.ca/epd/epdpa/ipmp/technical_reports/pesticide_survey2003/survey_2003.html and the English/French abstract will be posted on the PYR GBAP web site: http://www.pyr.ec.gc.ca/georgiabasin/resources/publications_e.htm.

**Mike Wan** (EC) - **Wan MT, Buday C, Schroeder G, Kuo J, & Pasternak J. (2006).** Acute toxicity to *Daphnia magna, Hyalella azteca, Oncorhynchus kisutch, O. mykiss, O. tshawytscha, and*

*Rana catesbeiana* of Atrazine, Metolachlor, Simazine and Their Formulated Products. (MS accepted by *Bull Eenviron Contam Toxicol* - Aug 2005).

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# DISCLAIMER

The presentations in these proceedings represent the views and findings of their authors and do not necessarily reflect the opinions of Environment Canada or their respective agencies.

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# EXECUTIVE SUMMARY

Established in 1995, the Environment Canada (EC) Regional Pesticide Committee of the Pacific and Yukon Region (PYR) is composed of representatives from all operational Branches. The purpose of this committee is to coordinate and communicate the exchange of information on regional pesticide matters pertaining to research, monitoring, effects and risk management approaches between regional and Ottawa-based federal agencies, as well as provincial and municipal governments and academia.

The tenth annual Pesticide Information Exchange was held on November 22, 2005 at the Simon Fraser University Downtown Campus of Vancouver, B.C. This one-day event was convened to exchange information on pesticides work being conducted by various government agencies in the PYR. This year's agenda included a diverse array of presentation topics including government updates on the National Environment Canada Pesticide Program; the National Agri-Environmental Standards Initiative for Pesticides; the Agriculture and Agrifood Canada Minor Use Program, pesticides management under the newly implemented *BC Integrated Pest Management Act*, and West Nile Virus mosquito control. In addition, the scientific findings of various regional research projects were presented on subjects such as the impact of pesticides on forest birds, coho salmon, amphibian habitat and air quality in Prince Edward Island. The results of a surveillance study to determine levels of currently used pesticides in agricultural runoff, surface water, groundwater and precipitation in the Okanagan Valley and/or the Lower Fraser Valley were also presented.

Agencies, departments and academia such as the BC Ministry of Environment (BCMOE), BC Ministry of Agriculture and Lands (BCMAL), EC (Ottawa, Atlantic Region and PYR), Fisheries and Oceans Canada (DFO), PMRA (Ottawa and PYR), Agriculture and Agri-Food Canada, City of Burnaby, Simon Fraser University and AXYS Analytical Laboratory Ltd. were in attendance. A total of 59 people attended the event.

The Information Exchange identified the continued need to explore pesticide issues in a coordinated fashion and the importance of communicating the results of these research initiatives to decision-makers such as those at the PMRA. Much of the information presented resulted from partnerships of various groups within EC and outside agencies, such as the BCMOE, BCMAL, DFO, SFU, PMRA, farmers' associations and private laboratories. It is anticipated that this event will enable participants to enhance and strengthen their working relationships to further pesticide research and program activities.

**John Pasternak**

# AGENDA

## 2005 Pesticide Information Exchange
## Environment Canada, Pacific and Yukon Region

## November 22, 2005

*Labatt Hall*
*(platform; room number: 1700)*
*The Joseph and Rosalie Segal Centre*
*(lunch/posters/discussion/handouts; room numbers: 1420 & 1430)*

*Main Level*
*Simon Fraser University at Harbour Centre*
*515 West Hastings Street, Vancouver, B.C.*

| | | |
|---|---|---|
| **FORMAT:** | **Platform presentations** | **08:30 – 11:55** |
| | **Lunch** (provided) | **11:55 – 12:15** |
| | **Poster session** | **12:15 – 13:30** |
| | **Platform presentations** | **13:30 – 16:25** |
| | **Closing Remark** | **16:25 – 16:30** |
| | **Poster session/Discussion** | **16:30 – 18:00** |

**FACILITATOR: John Pasternak**

**AGENDA:**

***PRESENTATIONS (Platform presentations, Poster session, Handouts)***

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*Platform presentations*

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**08:30** **John Pasternak** (EC) – Opening remarks

**08:40** **Pierre-Yves Caux** (EC) – Environment Canada's Pesticide Program – An Update

**09:10** **Laura MacLean** (EC) – National Agri-Environmental Standards for Pesticides: A Status Report

**09:30** **Robert Adams** (BCMOE) – Transition to the BC *Integrated Pest Management Act*

**09:50** *Break / Discussion* (refreshment provided outside Labatt Hall )

**10:00** **Karen Lloyd** (HC) – Ranking of Pesticides for their Potential to Enter Surface and Ground Water

**10:25** **Victoria Brookes** (AAFC) – Pesticide Reduced Risk & Minor Use Program

**10:45** **Tracy Hueppelsheuser** (BCMAL) – Research and Innovation in Integrated Pest Management in British Columbia Crops

**11:05** **Bob Costello** (BCMAL) – Management of European Chafer and Other Landscape Pests

**11:25** **Dipak Dattani / Yota Hatziantoniou** (City of Burnaby) – City of Burnaby: Ecological/Sustainable Approach in West Nile virus Mosquito Management

**11:45** **Vesna Furtula** (EC) – Pesticides in Nathan Creek, BC

**11:55** *Lunch* (provided in the Joseph and Rosalie Segal Centre)

**12:15** **Poster session** (in the Joseph and Rosalie Segal Centre; Posters are numbered and their titles are listed following the Platform Presentations below)

**13:30** **Bill Ernst** (EC) – Impacts of Pesticide Use on Air Quality in Prince Edward Island

**13:55** **Madeline Waring** (BCMAL) – Pesticide Disposal Issues and Solutions

**14 :20** **Gevan Mattu** (EC) – Survey of Pesticide Sales and Use in BC: 2003

**Gevan Mattu** (EC) – Wood Preservatives

**14 :45** **John Pasternak** (EC) – Commercial Chemicals Division Pesticide Program Update and Residues of Current Use Pesticides in Agricultural Runoff in the Okanagan Valley, BC

**15:00** *Break / Discussion* (refreshment provided outside Labatt Hall )

**15:10** **Taina Tuominen, Mark Sekela, Basil Hii, Melissa Gledhill, Andrea Ryan** (EC) – Current-use pesticides in Surface Waters, Ground Waters and Precipitation of the Lower Fraser Valley and Okanagan

**15:35** **Peter Ross** (DFO) **/ Keith Tierney** (SFU) – From the field to the lab: Characterizing Current Use Pesticide Impacts on Salmon in British Columbia

**16:00** **John Elliott** (EC) – Pesticide Exposure and Reproductive Effects in Native Amphibians Species Using Agricultural Habitat, South Okanagan, British Columbia (2003 – 2005)

**16:25** **Closing remarks**

**16:30 – 18:00** **Poster session / Discussion** (in the Joseph and Rosalie Segal Centre)

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***Poster session*** (in the Joseph and Rosalie Segal Centre; All presenters will be present beside their posters to answer questions from 12:15 to 13:30 but optional from 16:30 to 18:00)

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**(1) Bob Costello** (BCMAL) – Strategies to Mitigate the Impact of WNV Sprays on Organic Farms and Bees (***Cancelled***)

**(2) Tracy Hueppelsheuser** (BCMAL) – Research and Innovation in Integrated Pest Management in British Columbia Crops

**(3) Craig Buday and Grant Schroeder** (EC) – 28-Day *Hyalella azteca* Sediment Toxicity Testing with Endosulfan Compounds

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**(7) Brad McPherson** (EC) – Recent Findings for Pesticide Sampling Programs in BC

**(8) Bill Ernst** (EC) –Evaluation of Buffer Zone Effectiveness in the Protection of Aquatic Environments in Prince Edward Island - 2004

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***Handouts*** (in the Joseph and Rosalie Segal Centre)

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# PLATFORM PRESENTATIONS

## ABSTRACTS AND POWER POINT PRESENTATION SLIDES

(in order of presentation)

## Environment Canada's Pesticide Program – An Update

**Pierre-Yves Caux**, S&T Strategies Directorate, Gatineau Qc.

Abstract

Environment Canada's (EC) Pesticide Program is a young program that has activities taking place in all parts of the nation. The pesticide community at EC is a dedicated group of individuals that contribute to all facets of the Program. The Program's components include science policy, knowledge generation, issue management and enforcement. Most activities and resources reside in knowledge generation. One of the key changes to the program is that activities are beginning to consider agricultural systems as a whole. This life cycle assessment approach is enabling better integration with partners such as Agriculture and Agrifood Canada (AAFC), Fisheries and Oceans and the Pest Management Regulatory Agency of Health Canada. EC does research and surveillance on the impacts of in-use pesticides and uses this information to develop agri-environmental performance standards as indicators of environmental quality. AAFC then develops process standards to achieve these. In several cases, EC is assisting AAFC in research on BMPs to curtail pesticide leaching into first order streams.

The program faces many issues from governance to communicating a consistent message to the public. It has worked with industry over the past year to ensure information is shared and will be seeking their participation in areas where common objectives can be obtained. Other management issues include the Board of Review for lindane, re-evaluations for endosufan, strychnine and atrazine, MeBr under the Montreal Protocol and the use of cosmetic pesticides all of which we contribute expert advice to PMRA (& others) for action and regulatory decision-making. These efforts are an attestation that the federal government is collaborating, integrating and increasing efficiencies in pesticide management in Canada thereby building public confidence.

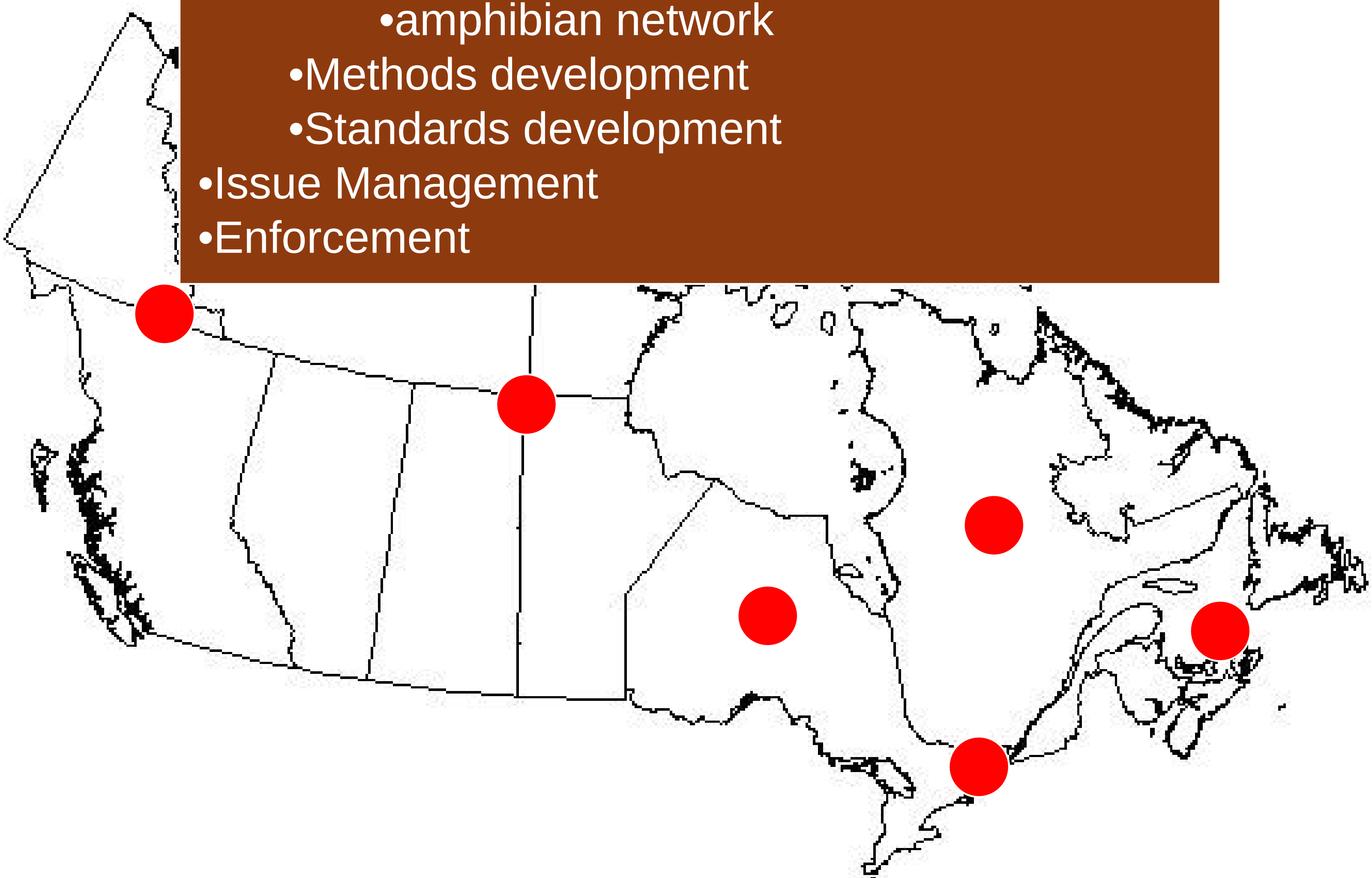
# Environment Canada's Pesticide Program

**2005, Pesticide Information Exchange**
**November 22, 2005**

**Pierre-Yves Caux**
**Conservation Strategies Directorate**

Environment Canada Environnement Canada

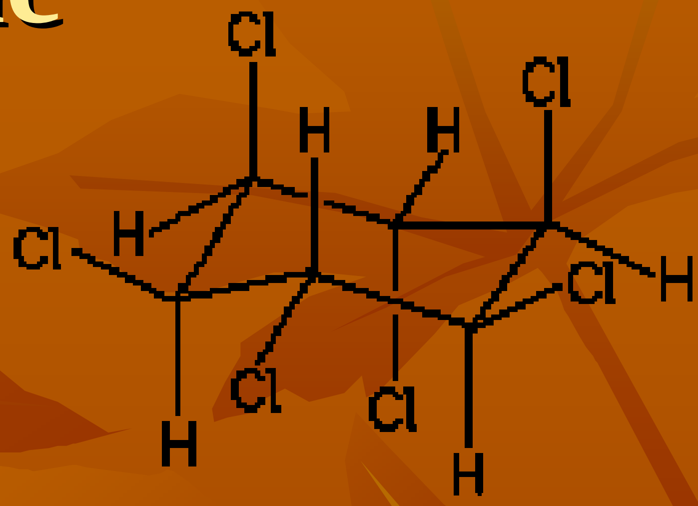
- Science policy
- Knowledge generation
  - Canadian Pesticide Air Sampling Campaign
  - National Water Survey of Pesticides
  - Toxicity testing & impacts research all media
    - amphibian network
  - Methods development
  - Standards development
- Issue Management
- Enforcement



# Science / Policy Issues

- Capacity, funding
- Data access
- Data assessment/interpretation & regulatory use
- Science to contribute to competitivity of sector
- Governance
- Integration / collaboration
- Communication
- TB reporting, Departmental reporting (A-base)
- Issue management

# Lindane




- Gamma-HCH, $C_6H_6Cl_6$
- Insecticide – seed treatment
- V.p. 4.4 mPa, $LogK_{ow}$ 3.5
- PMRA Regulatory decision 2002
- Unacceptable risks through occupational exposure
- Recognized POPs internationally

# Lindane

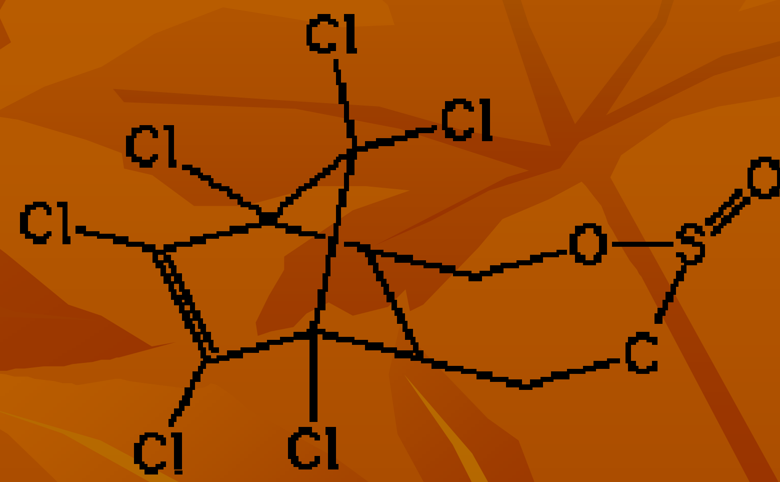
- Crompton Co. contested
- Health Minister set up independent board to examine decision
- International implications
- Media & ENGOs involved
- Board decision known but not public, Minister getting prepared

# Lindane

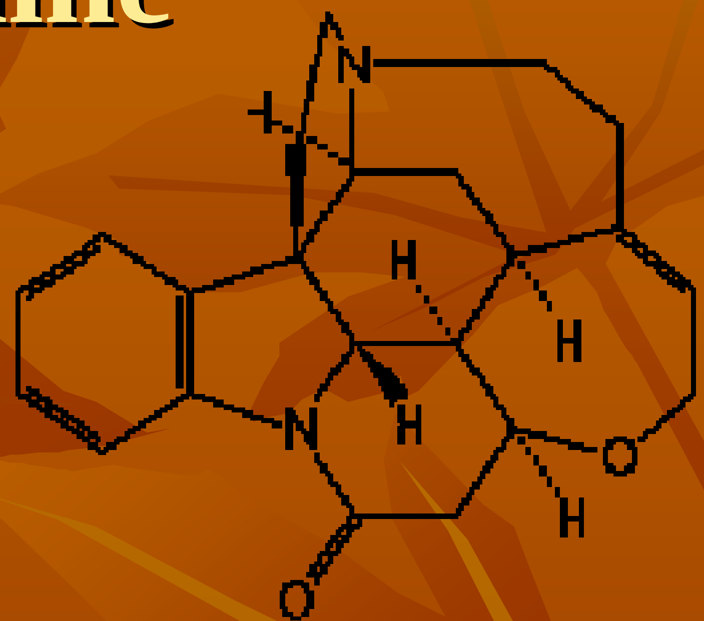
- EC's objectives:
  - Provide PMRA with advice vis-à-vis the environmental impacts assessment and identify data sources not mined.
  - Work on an collaborative approach to updating their assessment
    - environmental monitoring data
    - atmospheric modelling

# Endosulfan

- $C_9H_6Cl_6O_3S$
- Insecticide
- V.P. 0.8 mPa, $K_{ow}$ 4.74
- Regulatory reevaluation
- Ubiquitous environmentally
- EC provided comments
- Collaborative report – Non POPs

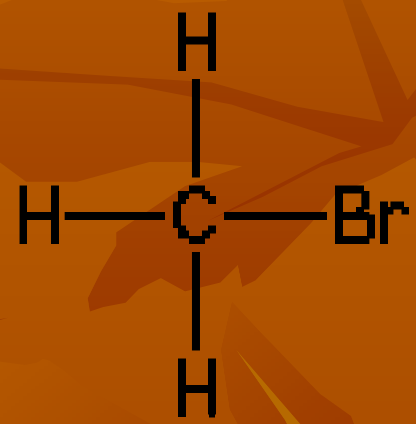


# Strychnine




- $C_{21}H_{22}N_2O_2$
- Avicide, rodenticide
- Regulatory reevaluation
- SARA implications
- EC provided comments

# Methyl Bromide




- $CH_3Br$
- V.P. 2.3 X $10^8$ mPa
- Fumigant insecticide
- Ozone depletion
- ODS Regulations on imports, exports & use (CEPA 99)
- Phase out & elimination by 2005

# Methyl Bromide

- Used worldwide on wood pallets
- Alternative is heat treatment
- Dilemma: ODS *vs.* invasive species
- Fumigation standards being revised (ISPM 15)

# Others

- Gage Town – Agent Orange
- West Nile Virus
  - pesticides of choice
- Cosmetic pesticides
  - Pollution Prevention to reduce & eliminate
  - *vs*. responsible use, strive to reduce risk
- Chlorothalonil in air
  - Need for air standard

# Summary

- National activities
  - Science policy, knowledge generation, issue management, enforcement
- Linking/integrating & partnering – efficiency
- Contributing to regulations
- Contributing to competitivity
- Communication / education
  - Risk reduction
- Challenges ahead


Thank You for Your Time.

# Media

news

**Farmers can no longer use Lindane on their crops - but that could change if our pesticide agency wilts under threat of NAFTA suit.**

**Photo By Laurence Acland**

The second coming

Did feds stack a review board to get lethal pesticide back on fields?

# Pacific and Yukon

- Mixed farms, cash crops - cranberries, vineyards, orchards
- Forest sector – wood preservatives
- High regional loads
- Surveillance water & air, bird, amphibians
- Tox. tests – Birds, amphibians
- Standard Development
  - Demonstration

Back

# Prairie and Northern

- Large farms – Wheat, canola
- Highest pesticide use – ubiquitously found
- Surveillance water, sediments, biota & air
  - Wetlands
- Tox. tests – algae, bacteria, birds, amphibians, fish
- Standard Development
  - Cummulative standard
  - Demonstration?

# Prairies

**Dirty Seven**

- 2,4-D
- MCPA
- Clopyralid
- Dichlorprop
- Dicamba
- Mecoprop
- Bromoxynil

- Lindane
- Triallate
- Trifluralin
- Picloram
- Sulphonylureas

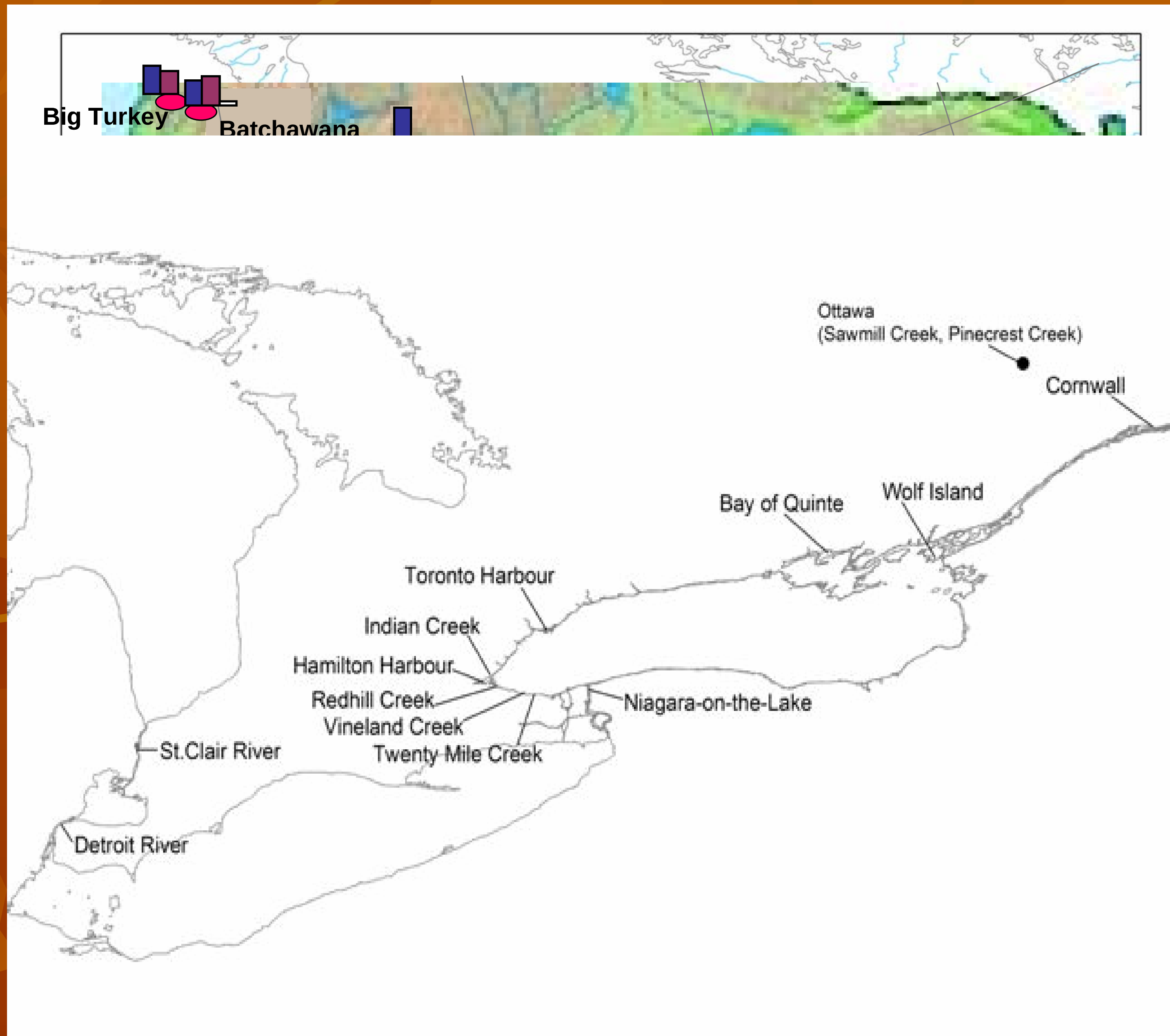
Back

# Ontario

- Mixed farms, cash crops, vineyards
- High load – agricultural and urban (conc. low)
- Surveillance water, sediments, phyto-zooplankton, amphibians & air
  - Great lakes, northern Ont., tribs
- Air campaign coordination
- Standard Development
  - Demonstration?

# Ontario

- Triazines
- Metolachlor
- Bromoxynil
- Dyfonate
- Chlorothalonil
- Dimethenamid
- Linuron
- Dacthal
- Tebuconazole
- Pyrethroids



# National Capital Region

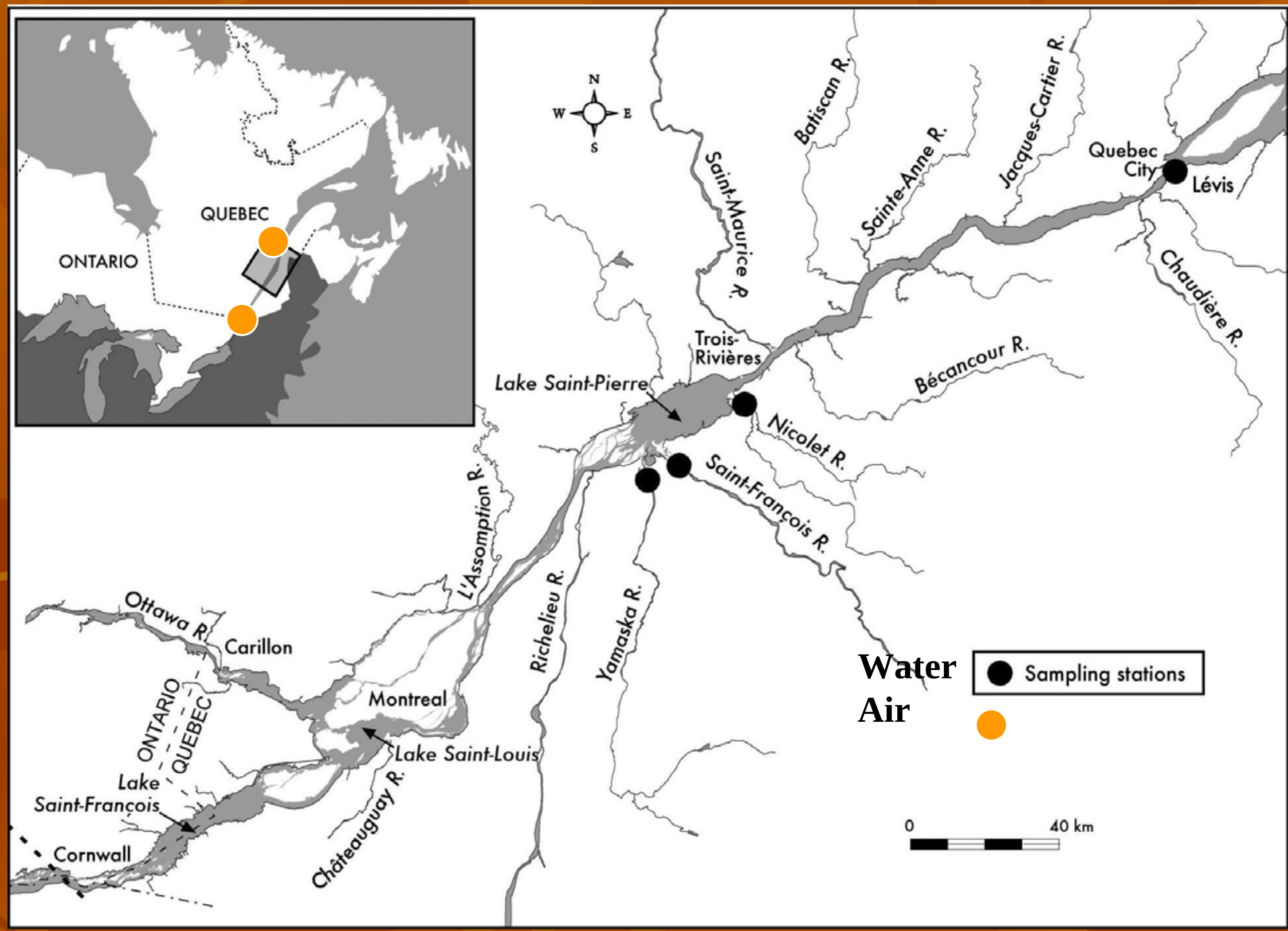
- **Impacts research: amphibians, birds, mammals**
  - **amphibian network coordination**
- Methodology development
- Water surveillance coordination
- Guideline development
- **Standard development**
  - NAESI-Pesticide coordination
  - development of Ideal National Agri-environmental Performance and Achievable Performance Standards
- National Pesticide Program coordination

# Quebec

- Mixed farms – Corn & soybean, cash crops
- High loads in aquatic systems
- Surveillance water & air
- Amphibian tox. tests
  - resistance to parasitism
- Standard Development
  - tools and techniques – modelling
  - Demonstration

# Quebec

- Triazines
- Metolachlor
- 2,4-D
- Dicamba
- Bromoxynil
- Clopyralid
- Dimethenamid
- MCPA
- Mecoprop
- Chlorpyrifos
- Dimethoate






Back

# Atlantic

- Smaller farms – Potato
- Forestry, blueberries
- 26 Fish kills
- Surveillance water, sediments, biota & air
  - Finfish, shellfish
- Tox. tests - fish & inverts, benthos, amphibians, algae
  - mesocosms
- Standard Development
  - Commodity-based standard
  - Development of Ambient Air Quality and Meteorological Standards for pesticide use in agriculture
  - Demonstration
- IPM

# Atlantic

- Imidacloprid
- Metribuzin
- Chlorothalonil
- Carbofuran
- Dithiocarbamates
- Endosulfan
- Azinphos-methyl
- Pyrethroids

# National Agri-Environmental Standards for Pesticides: A Status Report

**Laura Maclean, Environmental Conservation Branch, Environment Canada, Pacific and Yukon Region**

Abstract

The National Agri-Environmental Standards Initiative (NAESI) is one of 13 program elements under the Environment chapter of the Agricultural Policy Framework. NAESI is a four-year program (2004-2008) with a budget of $25M. Under this initiative, Environment Canada is developing agri-environmental standards in four key areas: Pesticides, Water, Air and Biodiversity. Standards are not intended to be used as regulatory instruments, but as practical and consistent science-based advice to help guide the design of farm practices in achieving desired environmental outcomes.

The work plan for developing Pesticides standards has, to date, resulted in technical protocols for generating both Ideal and Achievable standards, as required by Agriculture and Agri-Food Canada. Ideal Performance Standards (IPS's) will be based on a species-sensitivity distribution approach for protecting aquatic and terrestrial organisms from pesticide toxicity. Environment Canada already has significant experience in generating Water Quality Guidelines based on this type of approach. Achievable Performance Standards (APS's) will be based on the expected ability of Beneficial Management Practices (BMP's) to reduce pesticide losses to the receiving environment under specific conditions.

A science-based ranking exercise was completed in close collaboration with the PMRA to identify ten priority pesticides for IPS development this fiscal year. In parallel with this effort, tools and techniques are being developed to translate ecosystem-scale standards to the farm scale, recognizing that it is the farm scale where BMP's are applied. This effort will involve a modeling component as well as a demonstration phase in several watersheds across Canada, to be completed over the next two years. Several additional projects are exploring innovative approaches to defining Pesticide standards, including commodity-based standards and standards for pesticide mixtures.

The NAESI Pesticides Theme will continue to work closely with Agriculture and Agri-Food Canada, Health Canada, the PMRA and other partners over the remaining two years of NAESI to ensure that Pesticide standards are robust and defensible. Linkages and information sharing between NAESI Pesticide Theme activities and other agri-environmental initiatives (Watershed Evaluation of BMP's, Pesticide Science Fund, Environmental Farm Planning etc.) will continue.




# National Agri-Environmental Standards for Pesticides: A Status Report

Pesticide Information Exchange
November 22, 2005

Laura Maclean
NAESI Regional Coordinator, PYR

# APF Context:
# Environment Chapter Elements

reduce agricultural risk and provide environmental benefits to:
**Air, Biodiversity, Soil and Water**

## Delivery Mechanisms

### Knowledge & Information Tools

- Watershed Evaluation of BMPs (WEBs)
- National Land and Water Information Service (NLWIS)
- Provincial Scans
- Pesticide Risk Reduction Program (PRRP)

### On-Farm Action

- Environmental Farm Planning
- Greencover Canada
- National Farm Stewardship Program
- National Water Supply Expansion Program
- Farm Certification…?

### Performance Measurement

- National Agri-Environmental Health Analysis and Reporting Program (NAHARP): *indicators*
- National Agri-Environmental Standards Initiative (NAESI): *standards*

# Priority Standards

**Air**

- particulate matter/ammonia and odour

**Biodiversity**

- habitat conservation - wetlands, riparian areas and connective corridors

**Pesticides**

- top priority agricultural pesticides in air and water and commodity-based pesticides

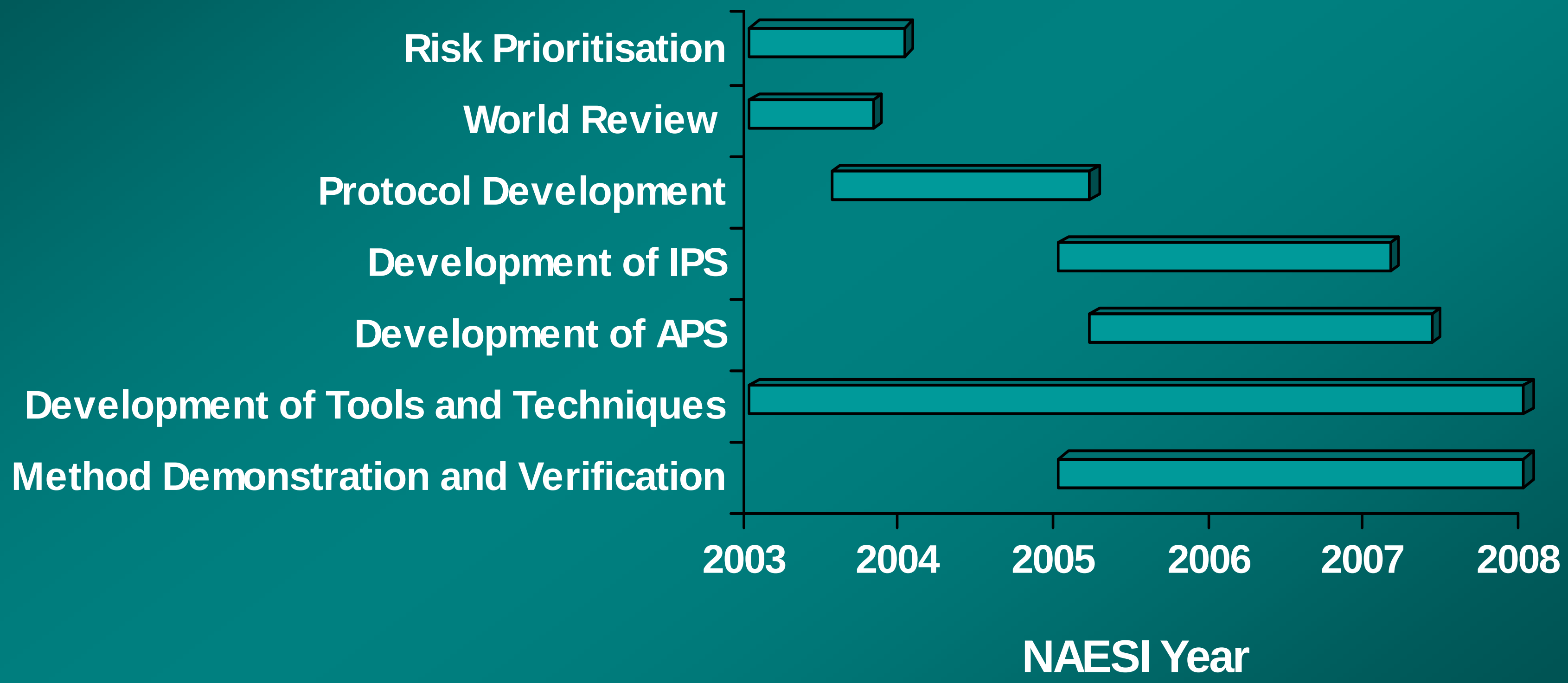
**Water**

- nutrients, sediments, pathogens and instream flow

# Products

- 20 IPS - individual Pesticides
- 6 APS - classes
- IPS terrestrial
- IPS commodities
- IPS air
- IPS mixtures
- Tools and techniques
  - Ecosystem to farm scale

# Gantt Chart for Pesticide Activities 2003-2008

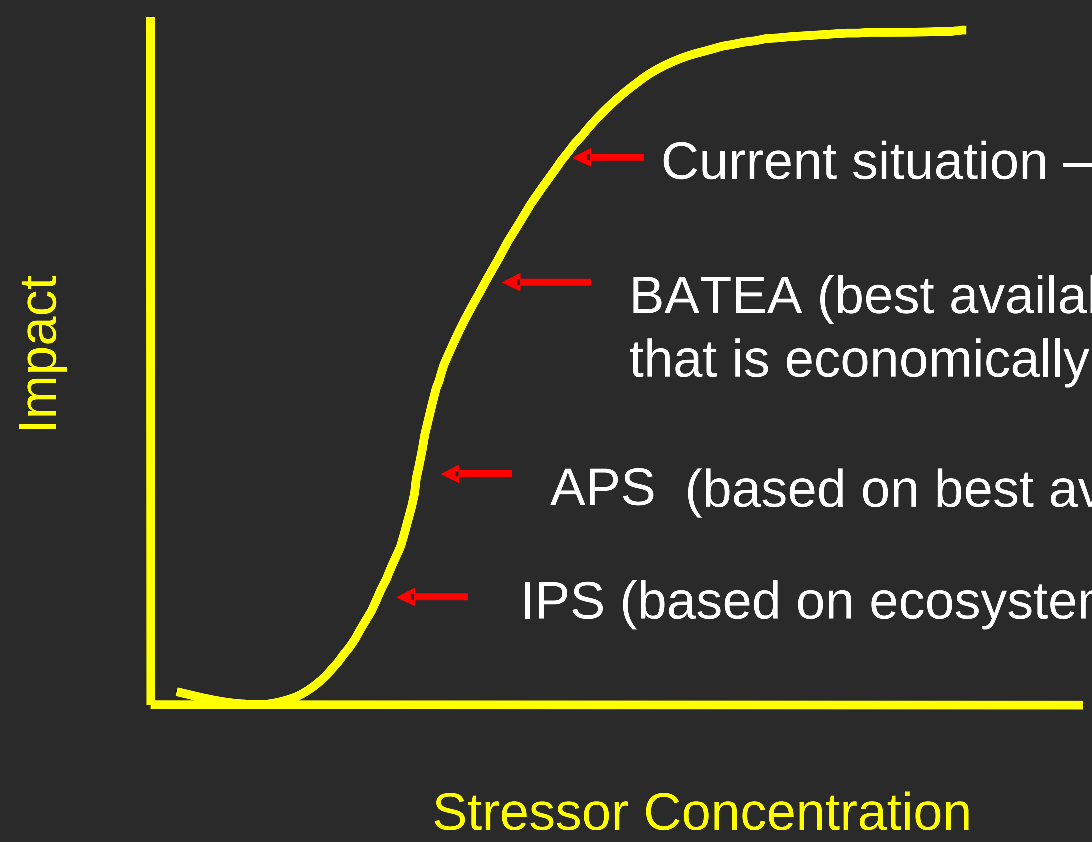


# Approach

1. Build on the trued and tested
2. Use opportunity to innovate
3. Remain pragmatic

- Guiding principles & Team strategy

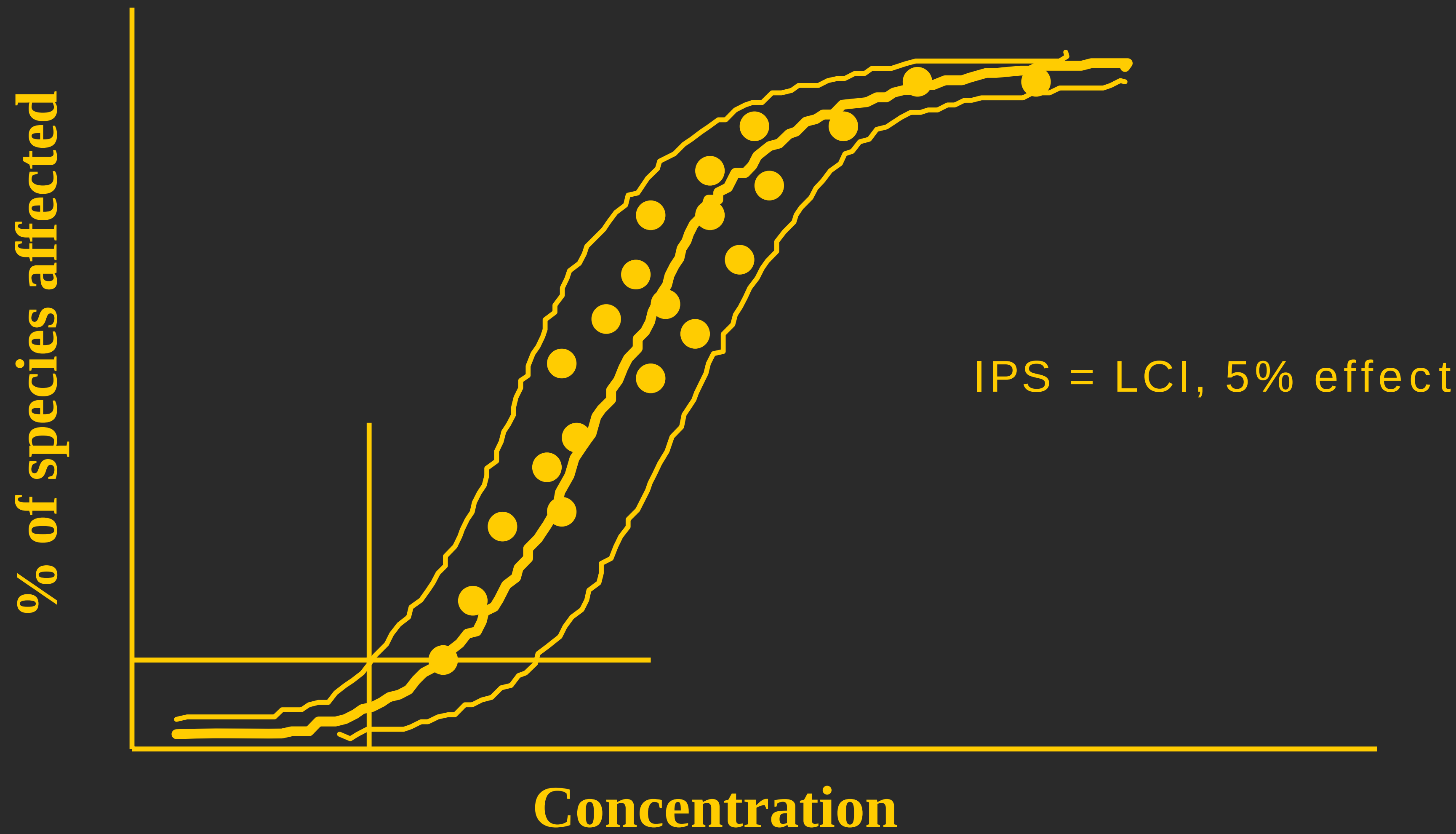
# Two Types of Standards Called For: Ideal *vs*. Achievable Performance Standards – IPS *vs*. APS



# Projects

1. IPS – P. Jiapizian
2. APS – P. Jiapizian, M. Amrani
3. IPS air – B. Ernst
4. IPS commodity – C. Murphy
5. IPS mixtures – D. Donald
6. IPS terrestrial – P. Mineau
7. Modeling – M. Amrani
8. Demonstration – R. Kent
9. Scenarios – P. Delorme

# Preferred Approach to IPS Development: Species Sensitivity Distribution



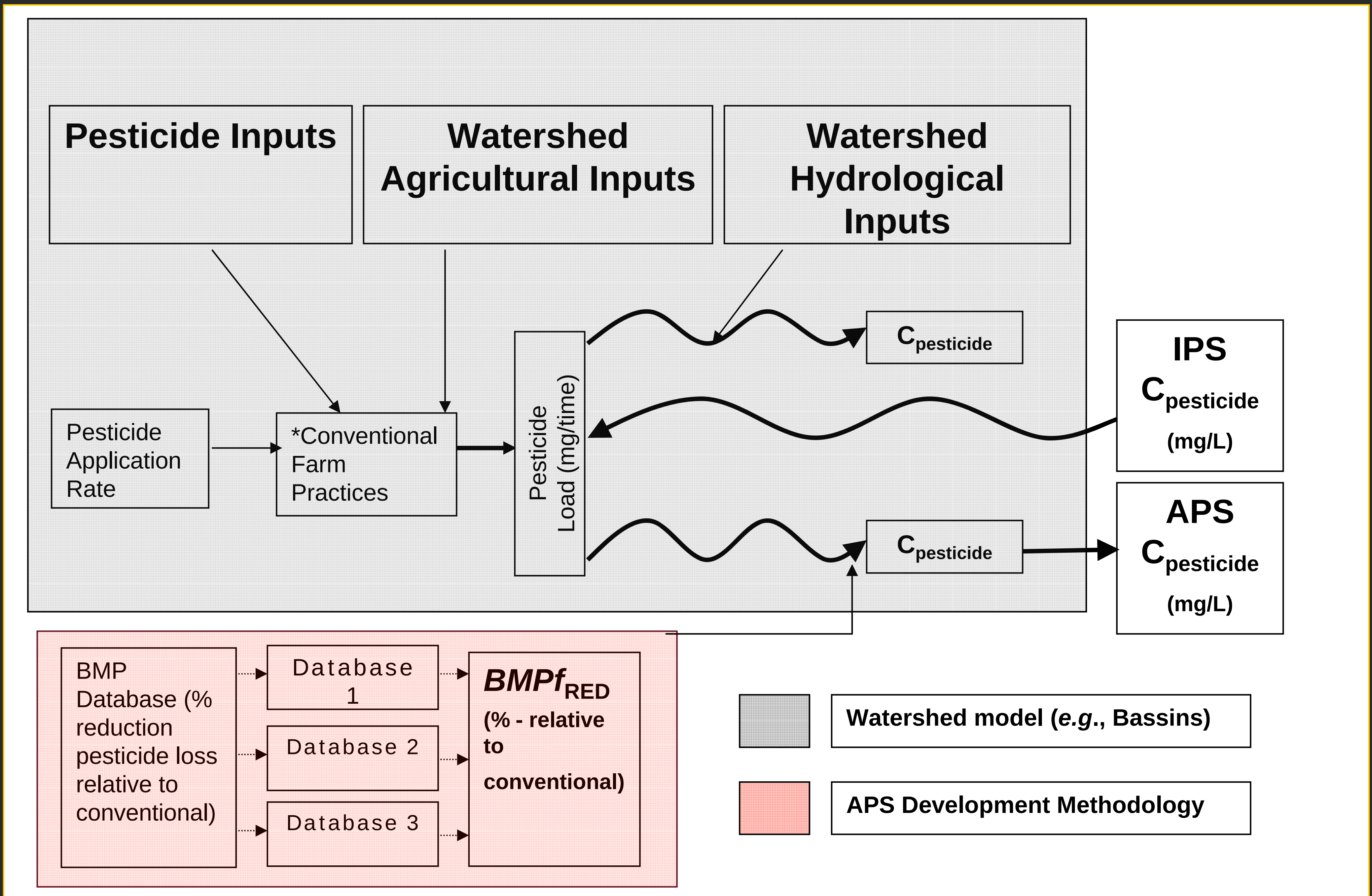
# Priority Agricultural Pesticides for IPS Development

1. Chlorpyrifos
2. Atrazine
3. Trichlorfon
4. Pendimethalin
5. Tefluthrin
6. Methomyl
7. Quintozene
8. Malathion
9. Diquat
10. Fluroxpyr

# APS Development

- Novel
- Technology-based
- Uses a BMP reduction function – ***F*** red
- APS – IPS gap
- Need for Watershed Modelling

# Proposed Methodology for APS Development




Environment Canada Environnement Canada

# Novel Approaches: Commodity-Based IPS, IPS for Pesticide Mixtures

- Commodity-based approach
  - pilot on potato production
- Mixtures-based approach
  - pilot on prairie potholes

# Novel Approaches Cont'd: Terrestrial IPS

- A greater than 15% mortality of songbirds due to Bromacil exposure in this ecoregion is unacceptable
- Birds, mammals, bees & other beneficial arthropods, earthworms, non-target plants
- Work with PMRA
  - databases – risk determination

# Demonstrating, Evaluating and Verifying Standards

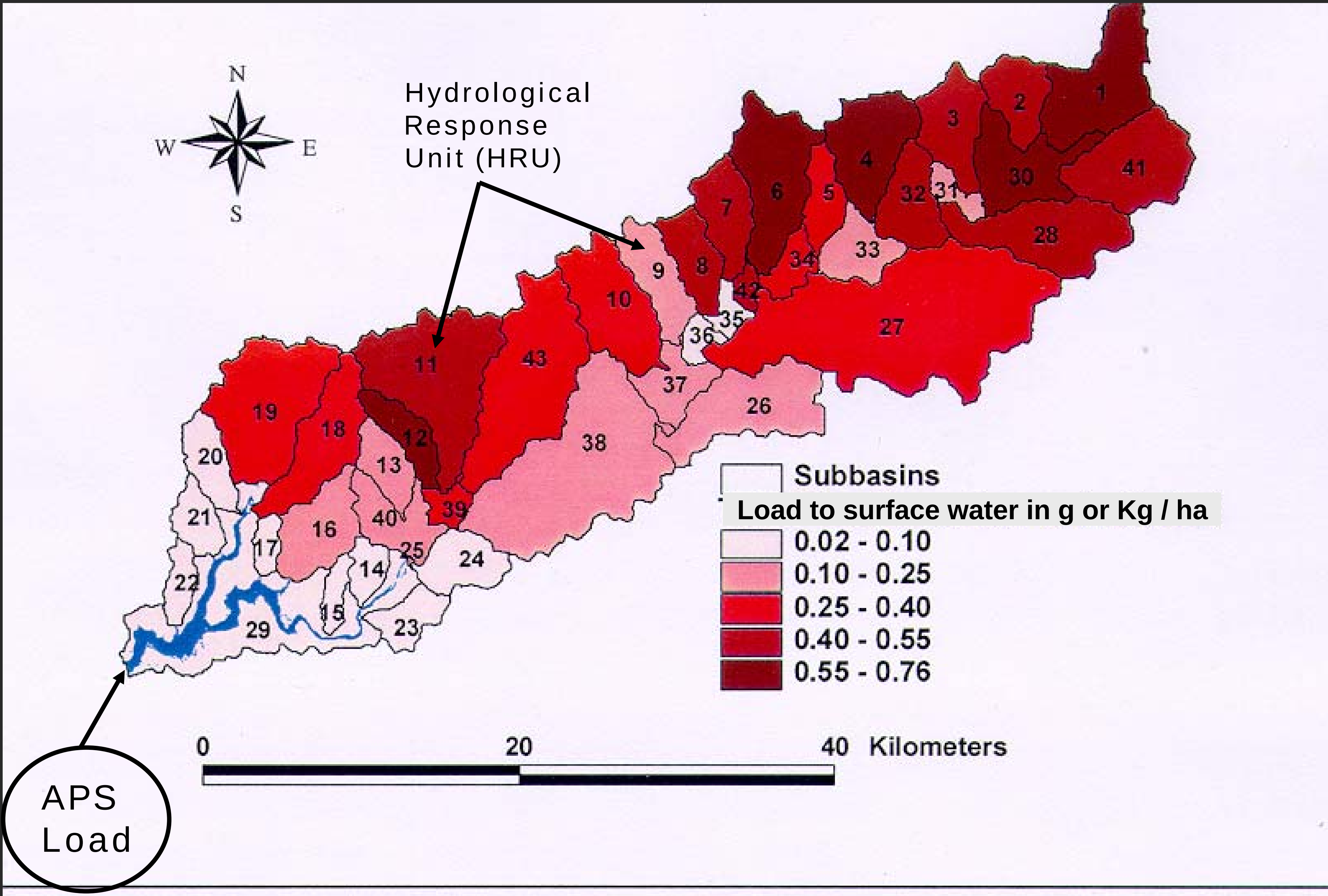
- Translate ecosystem standards to the farm scale
- Focus attention on priority areas
  - IPS & APS comparison
- Use site-specific data
- Use models – need to populate these
- Link to AAFC 'WEBs' & other watersheds
- Ensure coherence with other NAESI standards – nutrients, sediments

# Multicriteria Analysis of 20 Watershed Models

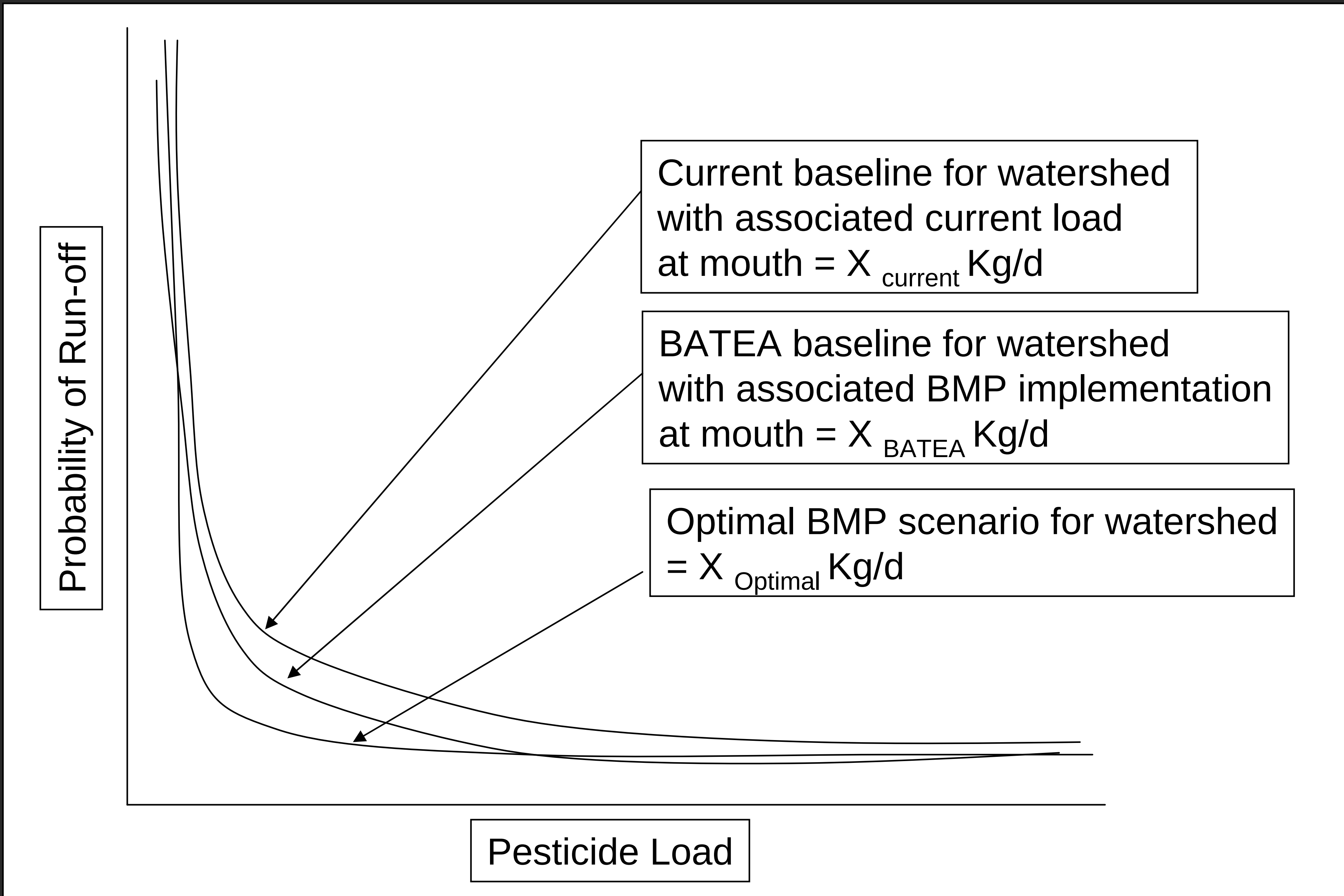
## CSL & INRS-ETE

| Modèle | Score ( /87) |
|---|---|
| BASINS | 80 |
| SWAT | 74 |
| MIKE SHE | 71 |
| HSPF | 70 |
| GIBSI | 66 |
| WARMF | 63 |
| AnnAGNPS | 59 |
| NELUP | 59 |
| WATERWARE | 59 |
| CatchIS | 58 |
| DRIPS | 56 |
| SHETRAN | 54 |
| UP | 51 |
| GeoPEARL | 50 |
| GERIQEAU | 42 |
| Regression Model | 42 |
| SURFACE | 40 |
| SoilFug | 37 |
| POLA | 35 |
| CHEMCAN | 33 |

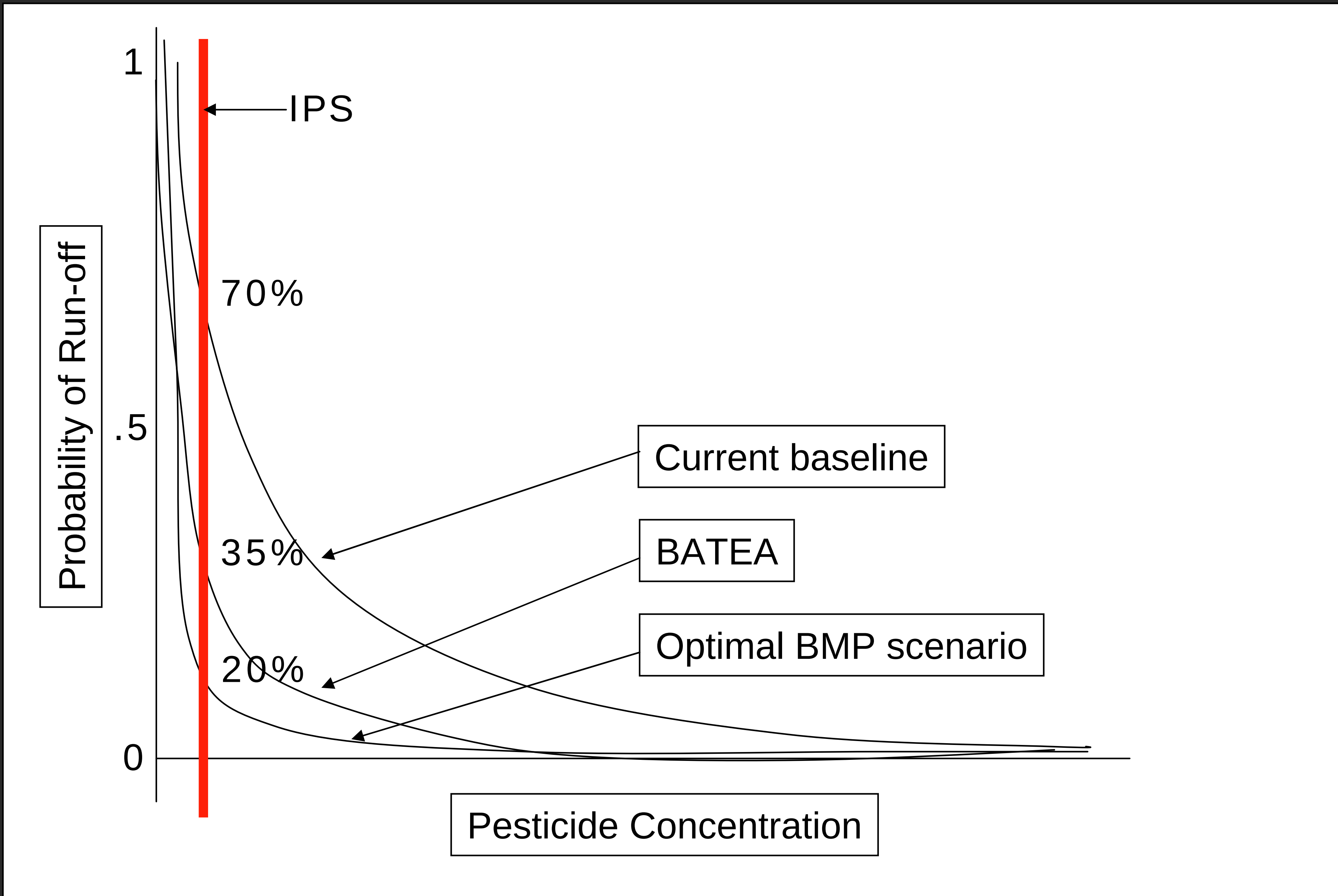
# Watershed Parameterization



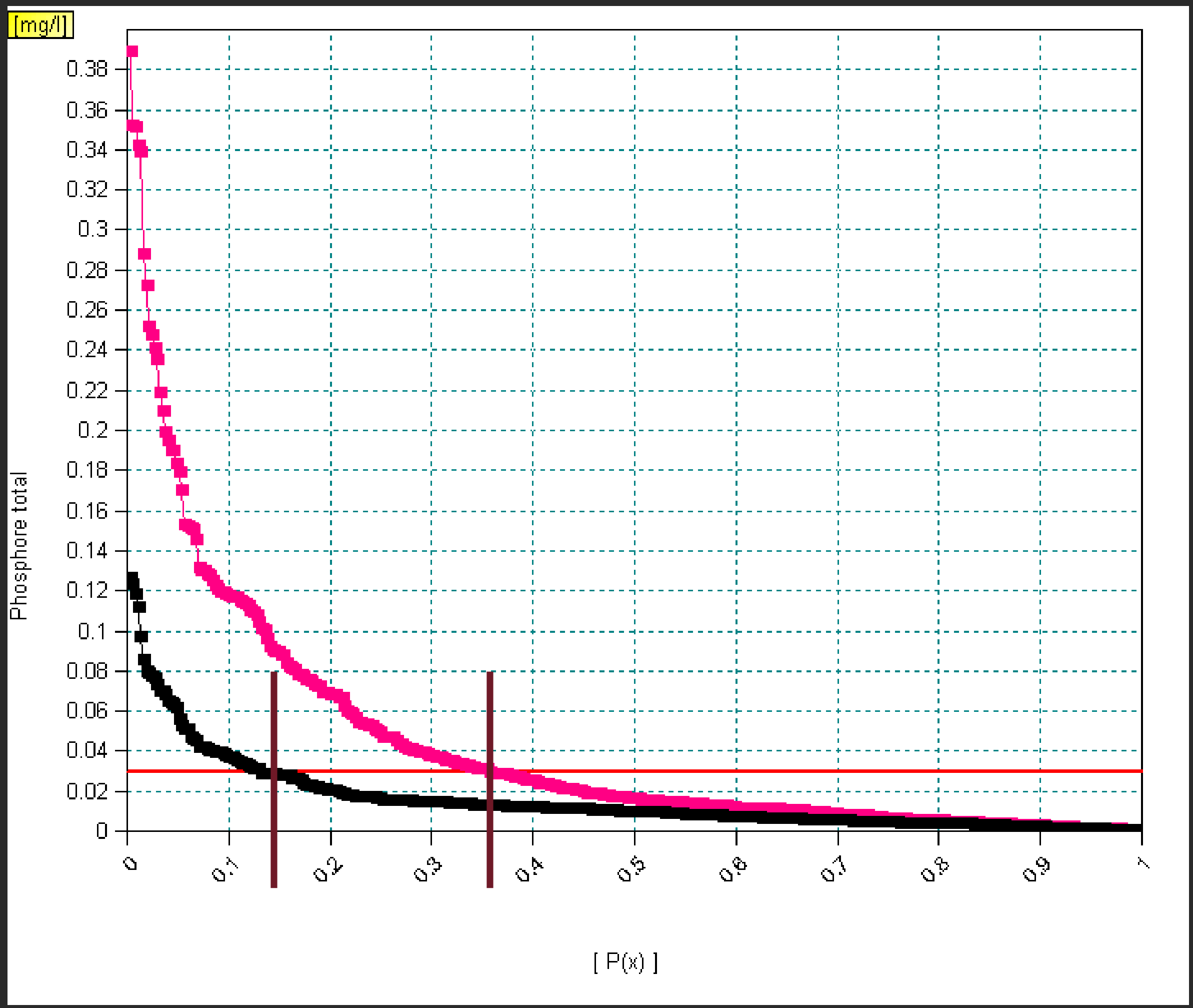
# Probability Density Function of pesticide runoff



# Probability Density Function of pesticide runoff



# Probability of Exceeding a Water Quality Standard (ex. 0,03 mg-P/l or IPS)




a) BMP Scenario

b) Base Case Scenario

IPS

Environment Canada Environnement Canada

# Demonstration watershed: Chaudière River, QC (WEB)

Nicosulfuron
Dicamba
Atrazine

# Proposed Watersheds

*Criteria*

- Watershed Evaluation of BMPs (WEB) watersheds
- Commodity-based
- Representative
- Readily available streamflow & pesticide data

*Watersheds*

- Yamaska, Chaudière (WEBs watershed) – QC
- South Nation – ON
- Wilmot / Dunk – PEI
- Salmon – BC
- Little Bow, wetlands – Prairies

# Yamaska River, QC

- Corn producing region
- Not a WEBs
- Provincial sampling/data
- problems with pesticides, nutrients and erosion
- atrazine, dicamba, dimethenamid, metholachlor

# Wilmot/Dunk, PEI

- Potatoes
- Not a WEB
- EC and PEI data
- Issue with pesticide, nutrient and erosion
- Intensive pesticide use

# Salmon River, BC (tbd...)

- WEBs watershed
- Cattle overwintering
- Water quality and hydrometric monitoring stations
- Pathogens, nutrients, pesticides data

# Summary

- Projects on track
- Will build on "trued & tested" approaches but will also employ novel approaches
- Challenges range from technical to political
- Integration/collaboration ongoing
- Tools and techniques
  - Providing meaning at the farm scale

## Transition to the BC *Integrated Pest Management Act*

**Rob Adams,** Integrated Pest Management Program, BC Ministry of Environment

Abstract

The Integrated Pest Management Program of the BC Ministry of Environment administers legislation for the management of pesticides in BC. A new Act and Regulation were brought into force in December, 2004. The major objectives were to shift to results based regulations and increase regulatory efficiency. The most significant change was to eliminate the requirement for project specific authorizations for specified pesticide uses and instead to incorporate standards for these uses directly in the regulation. These standards are for the use of Integrated Pest Management, consultation, notification and protection of human health and the environment.

Implementation activities underway during 2005/06 include:

- Communication and explanation of the new requirements
- Development of guidelines and training methods
- Making minor amendments to the regulation
- Development of policies for exempting pesticides and evaluating requests to amend standards
- Development of plans to monitor effectiveness,
- Special Projects including:
  - Assessment of content of registered pest management plans
  - Investigation of pesticide use for bed bugs
  - Investigation of use of fumigant gases
  - Survey of apartment, hotel and strata managers regarding licencing requirement that comes into effect in 2007
  - Survey of agricultural pesticide storage in the Okanagan area

Summaries of the new *Integrated Pest Management Act* and Regulation and other information are posted on the ministry web site at http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/index.html or go to the main BC Government web page at www.gov.bc.ca and in the search function type " IPM program".

# Transition to the BC *Integrated Pest Management Act*

Pesticide Information Exchange

November 22, 2005


Rob Adams

Integrated Pest Management Program

BC Ministry of Environment

# *Integrated Pest Management Act* and Regulation

Brought into force December 31, 2004

Replaced BC *Pesticide Control Act*

Major Objectives:

- Protect human health and the environment
- Shift toward results-based regulations
- Increase regulatory efficiency
- Provide provincial consistency
- Flexibility to amend standards

# IPMA - Major changes

- No ministry approval for standard pesticide uses for forestry, industrial vegetation/noxious weed management and mosquito control
- Pest Management Plan/Pesticide Use Notice System for large scale pesticide uses
- Standards incorporated in regulation for:
  - Use of IPM
  - Consultation and Notification
  - Environmental Protection
- Increased penalties

# Pesticide Use Permits Still Required For:

- **Permit-Restricted Class pesticides**
- **Aerial application, except for bacterial pesticides and glyphosate**
- **Pesticide application to public land or a body of water other than when a licence or PMP is required**

# Pest Management Plan Registration Required For:

Public Land

- Forestry and Veg. Managem’t on Industrial Sites >20 ha/year
- Noxious and Invasive Weeds >50 ha/year
- Mosquito Management > 1ha/year

Public and Private Land

- Veg. Managem’t on Rights-of- Way >20ha/year

# PMP Process for Proponents

- Develop Draft Pest Management Plan (PMP)
- Advertise Draft PMP and Request Comments
- Finalize PMP and Send Notice to MoE
- Prepare Detailed Maps of Treatment Area with No Treatment Zones
- Submit Annual Notice of Intent to Treat to MoE
- Conduct Treatment, Following IPM Standards
- Keep Records, Submit Annual Report

# Protection Standards for All Users During Pesticide Application

- Prevent Unprotected Human Exposure
- Protect Domestic Water Sources for their Intended Use
- Maintain a 30 m NTZ around wells and intakes
- Prevent Release onto Adjacent Property
- Prevent Release into a Body of Water

# Additional Standards for PMP Registrants

- Maintain a 10 m PFZ around water bodies, specified dry streams and classified wetlands. Can be 5 m PFZ for glyphosate except:
  - 2 m PFZ for railway ballast
  - 2 m PFZ for non-fish and selective methods (Forestry)
  - 2 m NTZ for non-fish bearing (Ind. Veg.)
  - HW for temporary free-standing water, not draining directly into fish bearing water
- No treatment of *Rubus* species >3 m from rails (Railway)

# Communicating New Requirements

- Sector Review Papers
- Presentations and Field Visits

Clarification Required for:

- Notification requirements
- Level of detail in PMPs
- Mapping Requirements
- Terms: selective treatments, water body, self contained, directly flowing

# Regulation Amendments

- Fix Small Errors
- Will Post for Public Review on web with notice to web list server subscribers – minimum 30 days posting

# Development of Explanatory Notes (Guidelines)

- Ensure there is agreement on standard methods to achieve compliance
  - Clarify Terms
  - Give Examples of accepted methods
  - Recommend sources of Information
- Involve industry
- Avoid being prescriptive

# Development Steps for Explanatory Notes

- Identify Issues and Who Wants to be Consulted
- Hold Workshops/Develop Drafts/Consult
- Provide Training Venues

# Development of Policies/Plans

- Criteria for Exempted Pesticides
- Evaluation of Requests for Amendment of Standards
- Frequency of General Review of Standards
- Monitoring to Evaluate Effectiveness

# Inspection/Investigations/ Special Projects

- Ensure Pesticide Users obtain appropriate Licences and PMP Registrations
- Assess Content of Pest Management Plans
- Investigate Pesticide Use for Bed Bugs
- Investigate Use of Fumigant Gases
- Survey Apartment/Hotel and Strata Managers
- Survey of Agricultural Pesticide Storage in the Okanagan

## Ranking of Pesticides for their Potential to Enter Surface Water and Ground Water

**Karen Lloyd and Peter Delorme.** Environmental Assessment Division, PMRA, Health Canada.

Abstract

Drinking water guidelines, environmental quality guidelines and monitoring pesticide residues in water are important for protecting and safeguarding water resources. The Pest Management Regulatory Agency (PMRA) has developed a comprehensive ranking of 274 pesticides to assist priority setting of several federal departments by identifying pesticides with the greatest potential to contaminate surface and ground waters.

Rankings were developed using data on physical/chemical properties, environmental fate and ecotoxicological data. For surface water, we used a modified version of APPLES (A Pesticide Priority List Evaluation Scheme) rating system originally developed by Environment Canada. For groundwater, we used three models: Groundwater Ubiquity Score (GUS) (Gustafson 1989). Data were primarily derived from studies submitted by pesticide registrants.

A total of 274 active ingredients with uses likely to result in releases into the environment had sufficient information to run the ranking models. Overall rankings were determined. Rankings can also be sorted for major categories (e.g. insecticides, fungicides, herbicides) of pesticides.

Results of the ranking are being shared with Health Canada, Environment Canada, Department of Fisheries and Oceans and Agriculture/Agri- Food Canada. Healthy Environment and Consumer Safety (HECS) used our preliminary results to prioritize re-evaluation of existing pesticides drinking water guidelines. It is hoped that rankings will be used to help prioritize the development of future for drinking water and water quality guidelines for the protection of aquatic life. Other departments will consider ranking results for pesticide monitoring programs and pesticide research.

# Ranking of Pesticides for their Potential to Enter Surface Water and Ground Water

Karen Lloyd, PMRA

Presented to Environment Canada

Pacific & Yukon Pesticide Information Exchange

November 22nd, 2005

Vancouver, B.C.

# Background

- Project a response to recommendation from CESD
- Results to help prioritization of guideline development and water monitoring activities
- This is initial step – more work remains

# Methods - Models

- Models for initial ranking chosen as readily available with relatively simple inputs
- Inputs consist of phys/chem, fate and environmental toxicity properties
- Models use criteria to determine scores or classification based on input values
- Ranking based on scores – NOT RISK BASED

# Methods - Models

## Ground Water

- Groundwater Ubiquity Score (GUS) (Gustafson, 1989)
- Empirical regression-based model to determine a "score"
- Score used to Rank
- Score also classified with criteria derived from field data
- Data inputs:
  – soil sorption (Koc)
  – soil persistence (t½)

## Surface Water

- Modified version of APPLES (CCME 2004)
- Modular - criteria based scoring method
- Three Modules:
  - Fate Score
  - Ecotox Score
  - Presence in Environment Score
- ScoreECO = Fate + Ecotox
- ScoreDW = Fate Score

# Data Sources

Decreasing Preference

1. PMRA internal reviews or publications
2. US EPA Public Documents and Databases
3. Public Documents from Other Countries/ Jurisdictions (e.g. EU, Australia, etc.)
4. Other Published Sources:
   - **USDA ARS pesticide properties database**
   - **Syracuse Research Corporation PhysProp database**
   - **Pesticide Action Network database**
   - **Extoxnet**
   - **ePesticide Manual 13$^{th}$ ed., v.3.1.**
   - **Journal Articles**

→ **Fate and Ecotox Database**

# Data Selection

- maximum values of log Octanol:Water Partition coefficient (Kow), soil half-life (in days) and solubility (@~pH 7, 20 – 25 °C)
- lowest toxicity endpoints (e.g. fish $LC_{50}$)
- minimum values of Soil Organic Carbon partition coefficient (Koc)

| AI = Prometryn | |
|---|---|
| Soil $t_{1/2}$ (days) | 270 |
| Koc | 116.8 |
| *Solubility | 33 |
| Log Kow | 3.51 |
| *Fish 96h $LC_{50}$ | 2.9 |
| *Invert 48h $EC_{50}$ | 18.59 |
| *Algae $EC_{50}$ | 0.0012 |

* mg ai/L

# Ground Water Score - Example

| Parameter | Value |
|---|---|
| Soil $t_{½}$ | 270 d |
| Koc | 116.8 |

$$GUS = \log_{10}(t_{½}\ soil) \times (4 - \log_{10}(Koc))$$

**GUS = 4.70**

## Classify

| | |
|---|---|
| > 2.8 | Leacher |
| 1.8 – 2.8 | Borderline Leacher |
| < 1.8 | Non-Leacher |

## Rank

| Active Ingredient | GUS | Class | Rank |
|---|---|---|---|
| Triticonazole | 4.76 | Leacher | 46 |
| Ethofumesate | 4.72 | Leacher | 47 |
| Prometryne | 4.70 | Leacher | 48 |
| Azaconazole | 4.63 | Leacher | 49 |
| Pirimicarb | 4.59 | Leacher | 50 |

# Surface Water – Criteria/Scoring Example

| Prometryn Fate Scores | | | | | | | |
|---|---|---|---|---|---|---|---|
| Soil $t_{½}$ (days) | | Log Kow | | Koc (L/kg) | | Solubility (mg ai/L) | |
| Criteria | Score | Criteria | Score | Criteria | Score | Criteria | Score |
| > 100 | 6 | >5 | 5 | <100 | 5 | > 3000 | 6 |
| | | | | | | 300 – 3000 | 5 |
| 30 – 100 | 4 | 4 – 5 | 4 | 100 – 300 | 4 | 30 – 300 | 4 |
| | | 3 – 4 | 3 | 300 – 500 | 3 | 2 – 30 | 3 |
| < 30 | 2 | 2 – 3 | 2 | 500 – 1000 | 2 | 0.5 – 2 | 2 |
| | | < 2 | 1 | > 1000 | 1 | < 0.5 | 1 |

| Prometryn Ecotoxicity Criteria/Scores | | | |
|---|---|---|---|
| Acute Toxicity ($LC_{50}$ mg ai/L) | Score | | |
| | Fish | Invert | Algae |
| < 0.01 | 8 | 5 | 3 |
| < 0.1 | 6.5 | 4 | 2.5 |
| < 1 | 5 | 3 | 1.8 |
| < 10 | 3.5 | 2 | 1.3 |
| < 100 | 2 | 1.25 | 0.75 |
| ≥ 100 | 0.5 | 0.3 | 0.2 |

# Surface Water – ECO & DW Example

$$ScoreECO = \left[ \left( \frac{\sum InputScores(Fate + Tox)}{\sum MaxInputScores(Fate + Tox)} \right) * 100 \right]$$

$$ScoreDW = \left[ \left( \frac{\sum Input\,Scores(Fate)}{\sum Max\,Input\,Scores(Fate)} \right) * 100 \right]$$

$$ScoreECO = \left[ \left( \frac{6+3+4+4+3.5+2+2.5}{6+5+5+6+8+5+3} \right) * 100 \right]$$

$$ScoreDW = \left[ \left( \frac{6+3+4+4}{6+5+5+6} \right) * 100 \right]$$

**Prometryn ScoreECO = 65.8**

**Prometryn ScoreDW = 77.27**

| Active Ingredient | Type | Score | Rank |
|---|---|---|---|
| Diazinon | INS | 66.6 | 25 |
| Propyzamide | HER | 66.0 | 26 |
| Atrazine | HER | 65.8 | 27 |
| Famoxadone | FUN | 65.8 | 27 |
| Oxadiazon | HER | 65.8 | 27 |
| Prometryn | HER | 65.8 | 27 |
| Fenamidone | FUN | 65.3 | 31 |
| Methyl bromide | FUM | 64.3 | 32 |

| Active Ingredient | Type | Score | Rank |
|---|---|---|---|
| Paclobutrazol | HER | 77.27 | 13 |
| Picloram | HER | 77.27 | 13 |
| Prometryn | HER | 77.27 | 13 |
| Propoxur | INS | 77.27 | 13 |
| Triflusulfuron methyl | HER | 77.27 | 13 |
| Sodium dimethyldithiocarbamate | FUN | 75.00 | 34 |
| 2,4-D present as acid | HER | 72.73 | 35 |

# Results

PMRA Water Ranking 2005.xls

# Caveats

- The rankings generated only reflect the potential of the pesticides to move to ground or surface waters.
- This is a good initial step.  Provides indication of the <u>relative</u> potential for movement.
- Additional work is needed to update, refine and expand the ranking.
- Not all pesticides are  included – these represent pesticides with use pattern having major outdoor uses which can result in exposure of water.

# Caveats

- For ECO & DW Scores there are many ties – reflects the models used.
- Many factors which influence actual entry to water are not included (e.g. application rate, app method, landscape, formulation type).
- Groundwater & DWScore do not include consideration of mammalian toxicity
- These can be considered by refining the models used (e.g. include presence in environment module, use risk based approach).

# Summary

- Initial steps on the refinement have already been taken. In cooperation with EC, Scores for presence in the environment were generated based on PSF monitoring data and Sales information compiled by EC.
- Results of this refinement exercise were used to guide initial choice of actives for standards development under NAESI
- This project resulted in creation of fate and ecotox database
- This generated substantial interest within PMRA, from EC, HC-HECS, and from other government departments.
- Preliminary results have already been considered by HECS and EC in prioritization of pesticides for on going work.

# Next Steps

- Finalize document and distribute to federal partners.
- Look at sharing beyond Federal Departments.
- Update to include more recently registered pesticides (on going already).
- Examine ways to refine models
  - EC currently working on risk-based approach,
  - Work to include mammalian/human toxicity component.
- Start to Compare rankings with available monitoring data to assess performance.

# Ranking of Pesticides for their Potential to Enter Surface Water and Ground Water

P. Delorme, PhD, L. Pepin, MSc, B. Gauthier, BA, G. Malis, MSc, I. Nicholson, PhD and F. Wandelmaier, MSc

Environmental Assessment Division, Pest Management Regulatory Agency, Health Canada, Ottawa, Canada

## INTRODUCTION

Drinking water guidelines, environmental quality guidelines and monitoring pesticide residues in water are important for protecting and safeguarding water resources. In response to a recommendation from the Commissioner of the Environment and Sustainable Development (CESD), Health Canada (HC) and Environment Canada (EC) agreed to develop a ranking of pesticides for their potential to contaminate surface water and groundwater.

The Pest Management Regulatory Agency (PMRA) in consultation with scientists in EC and Healthy Environment and Consumer Safety (HC-HECS) undertook an initial ranking of 274 pesticides to assist priority setting of several federal departments by identifying pesticides with the greatest potential to contaminate surface water and groundwater.

## METHODS

**Models** - To do this initial ranking PMRA used established models for which inputs were generally available and which offered some flexibility when not all data are available. Rankings were developed using laboratory-derived data on physical/chemical properties, environmental fate and ecotoxicological data.

**Surface Water** - PMRA chose to use a modified version of APPLES (A Pesticide Priority List Evaluation Scheme). This model was recently developed by EC for the Canadian Council of Ministers of the Environment (CCME). It draws upon methods and approaches that have been used in other ranking and scoring schemes (CCME 2004).

**Groundwater -** Three models were considered for ranking the leaching potential of pesticides to groundwater, the Groundwater Ubiquity Score (GUS) (Gustafson 1989), the Leaching Potential (LP) of Laskowski et al. (1982), and Leaching Index (LI) of Laskowski et al. (1982). Of these GUS was chosen as the primary model for ranking. While values for LP/LI were determined, the results are not presented here.

**Pesticides** - From an initial list of 534 active ingredients (AIs) registered in Canada as of December 2004, 274 active ingredients were ranked. These all had uses which could result in potential entry into surface and/or groundwater and met data needs for ranking. These included 135 herbicides, 68 fungicides, 65 insecticides and 6 soil fumigants.

**Data Sources -** Data were primarily compiled from studies submitted by pesticide registrants.

**RESULTS** (See Table 1)

## OUTCOMES

Results of the ranking are being shared with various federal departments including Health Canada (HC), Environment Canada (EC), Department of Fisheries and Oceans (DFO) and Agriculture and Agri-Food Canada (AAFC).

Preliminary results were used by HC-HECS to help prioritize re-evaluation of existing pesticides drinking water guidelines. Final ranking will be used to help prioritize the development of future drinking water and water quality guidelines. We anticipate that other departments will consider ranking results for identification and prioritization of pesticides examined in pesticide research and monitoring programs.


## Summary

- This is an initial step. Additional work is needed to update, refine and expand the ranking.
- This project resulted in the creation of a number of databases which will be used beyond this project and have generated substantial interest within PMRA, from HC-HECS and from other government departments.
- The rankings generated only reflect the potential of the pesticides to move to ground or surface waters. Many factors which influence actual entry to water are not included (e.g. application rate, method, etc.), but can be considered by refining the models used (e.g. use risk based approach).
- Not all pesticides are included – these represent active ingredients which based on use pattern have major outdoor uses which can result in exposure of water.
- Preliminary results have already been considered by HECS and EC in prioritization of pesticides for on going work.


## Next Steps

- Finalize document and distribute to interested federal partners.
- Update to include more recently registered pesticides.
- Examine ways to refine models – e.g. EC currently working on risk-based approach, need to include mammalian/human toxicity component.
- Compare rankings with available monitoring data to assess performance.

**Data Sources**

Decreasing Preference

- PMRA internal reviews or publications
- US EPA Public Documents and Databases
- Public Documents from Other Countries/ Jurisdictions (e.g. EU, Australia, etc.)
- Other Published Sources:
  - USDA ARS pesticide properties database
  - Syracuse Research Corporation PhysProp database
  - Pesticide Action Network database
  - Extoxnet
  - ePesticide Manual 13th ed., v.3.1.
  - Journal Articles

**Data Choice**

- maximum values of log Octanol:Water Partition coefficient (Kow), soil half-life (in days) and solubility (@~pH 7, 20 – 25 °C)
- lowest toxicity endpoints (e.g. fish $LC_{50}$)
- minimum values of Soil Organic Carbon partition coefficient (Koc)

| AI = Prometryn | |
|---|---|
| Soil $t_{1/2}$ (days) | 270 |
| Koc | 116.8 |
| *Solubility | 33 |
| Log Kow | 3.51 |
| *Fish 96h $LC_{50}$ | 2.9 |
| *Invert 48h $EC_{50}$ | 18.59 |
| *Algae $EC_{50}$ | 0.0012 |

* mg ai/L

## Groundwater

**Groundwater - GUS** uses an empirical regression-based model to determine a "score", which is then classified with criteria derived from field data. The method combines lab measures of soil sorption (Koc) and soil persistence ($t_{1/2}$) to assess the likelihood that pesticides will leach to groundwater.

**CALCULATE**

$$GUS = \log_{10}(t_{1/2}\ soil) \times (4 - \log_{10}(Koc))$$

| Parameter | Value |
|---|---|
| Soil $t_{1/2}$ | 270 d |
| Koc | 116.8 |

GUS = 4.70

**CLASSIFY**

| | |
|---|---|
| > 2.8 | Leacher |
| 1.8 – 2.8 | Borderline Leacher |
| < 1.8 | Non-Leacher |

**RANK FOR LEACHING POTENTIAL**

| Active Ingredient | GUS | Class | Rank |
|---|---|---|---|
| Triflusulfuron methyl | 5.23 | Leacher | 38 |
| Methoxyfenozide | 5.17 | Leacher | 39 |
| Arsenic | 5.17 | Leacher | 40 |
| Metalaxyl-m (mefenoxam) | 5.04 | Leacher | 41 |
| Chlorimuron-ethyl | 5.02 | Leacher | 42 |
| Tepraloxydim | 4.97 | Leacher | 43 |
| Cyanazine | 4.77 | Leacher | 44 |
| Metalaxyl | 4.77 | Leacher | 45 |
| Triticonazole | 4.76 | Leacher | 46 |
| Ethofumesate | 4.72 | Leacher | 47 |
| Prometryne (+ related active triazines) | 4.70 | Leacher | 48 |
| Azaconazole | 4.63 | Leacher | 49 |
| Pirimicarb | 4.59 | Leacher | 50 |

## Surface Water

**Surface Water - APPLES** uses a criteria-based scoring system with four modules: presence of the active ingredient in the Canadian environment, environmental fate, aquatic toxicity and number of interested jurisdictions. For the current ranking APPLES was modified and scores were generated using only the environmental fate and the aquatic toxicity modules. Surface water scores for prioritization of drinking water (DW) guidelines used only the fate module, whereas scores for prioritization of environmental water quality guidelines included both fate and aquatic toxicity. Scores can easily be modified to include presence in the Canadian environment once sufficient use and monitoring data are available.

**CLASSIFY INPUTS**

| Prometryn Ecotoxicity | | | |
|---|---|---|---|
| Acute Toxicity ($LC_{50}$ mg ai/L) | Score | | |
| | Fish | Invert | Algae |
| < 0.01 | 8 | 5 | 3 |
| < 0.1 | 6.5 | 4 | 2.5 |
| < 1 | 5 | 3 | 1.8 |
| < 10 | 3.5 | 2 | 1.3 |
| < 100 | 2 | 1.25 | 0.75 |
| ≥ 100 | 0.5 | 0.3 | 0.2 |

| Prometryn Fate | | | | | | | |
|---|---|---|---|---|---|---|---|
| Soil $t_{1/2}$ (days) | | Log Kow | | Koc (L/kg) | | Solubility (mg ai/L) | |
| Value | Score | Value | Score | Value | Score | Value | Score |
| > 100 | 6 | >5 | 5 | <100 | 5 | > 3000 | 6 |
| | | | | | | 300 – 3000 | 5 |
| 30 – 100 | 4 | 4 – 5 | 4 | 100 – 300 | 4 | 30 – 300 | 4 |
| | | 3 – 4 | 3 | 300 – 500 | 3 | 2 – 30 | 3 |
| < 30 | 2 | 2 – 3 | 2 | 500 – 1000 | 2 | 0.5 – 2 | 2 |
| | | < 2 | 1 | > 1000 | 1 | < 0.5 | 1 |

**CALCULATE SCORE**

$$ScoreECO = \left[\left(\frac{\sum Input\ Scores(Fate + Tox)}{\sum Max\ Input\ Scores(Fate + Tox)}\right) * 100\right]$$

$$ScoreDW = \left[\left(\frac{\sum Input\ Scores(Fate)}{\sum Max\ Input\ Scores(Fate)}\right) * 100\right]$$

$$ScoreECO = \left[\left(\frac{6+3+4+4+3.5+2+2.5}{6+5+5+6+8+5+3}\right) * 100\right]$$

$$ScoreDW = \left[\left(\frac{6+3+4+4}{6+5+5+6}\right) * 100\right]$$

Prometryn ScoreECO = 65.8

Prometryn ScoreDW = 77.27

**RANK FOR RUNOFF POTENTIAL**

| Active Ingredient | Type | Score | Rank |
|---|---|---|---|
| Diazinon | INS | 66.6 | 25 |
| Propyzamide | HER | 66.0 | 26 |
| Atrazine | HER | 65.8 | 27 |
| Famoxadone | FUN | 65.8 | 27 |
| Oxadiazon | HER | 65.8 | 27 |
| Prometryne (+ related active triazines) | HER | 65.8 | 27 |
| Fenamidone | FUN | 65.3 | 31 |
| Methyl bromide | FUM | 64.3 | 32 |
| d-trans Allethrin | INS | 64.3 | 33 |
| Dinoseb in free form | HER | 64.3 | 33 |
| Methoxychlor | INS | 64.3 | 33 |

| Active Ingredient | Type | Score | Rank |
|---|---|---|---|
| Paclobutrazol | HER | 77.27 | 13 |
| Picloram | HER | 77.27 | 13 |
| Prometryne plus related active triazines | HER | 77.27 | 13 |
| Propoxur | INS | 77.27 | 13 |
| Triflusulfuron methyl | HER | 77.27 | 13 |
| Sodium dimethyldithiocarbamate | FUN | 75.00 | 34 |
| 2,4-D present as acid | HER | 72.73 | 35 |
| Chlorimuron-ethyl | HER | 72.73 | 35 |

# Table 1. Ranking of Pesticides for their Potential to Enter Surface Water and Groundwater – Alphabetical Listing

| Active Ingredient Common Name | Type | GUS | GUS Class | GUS Rank | Drinking Water Score | Drinking Water Rank | ECO Water Score | ECO Water Rank |
|---|---|---|---|---|---|---|---|---|
| 1,3-Dichloropropene | Fumigant | 3.27 | Leacher | 88 | 68.18 | 62 | 55.90 | 117 |
| 1-MCP | Herbicide | | Borderline Leacher | | 54.55 | 181 | | |
| 2-(Thiocyanomethylthio)benzothiazole | Fungicide | 0.29 | Non-leacher | 213 | | | 58.70 | 88 |
| 2,4-D present as acid | Herbicide | 3.32 | Leacher | 85 | 72.73 | 35 | 48.70 | 182 |
| 2,4-D present as amine salts | Herbicide | 0.29 | Non-leacher | 211 | 63.64 | 83 | 43.70 | 218 |
| 2,4-D present as low volatile esters | Herbicide | 1.37 | Non-leacher | 175 | 40.91 | 250 | 36.20 | 249 |
| 2,4-D present as sodium salt | Herbicide | 3.32 | Leacher | 85 | 68.18 | 62 | 46.10 | 202 |
| 2,4-DB present as mixed butyl esters or as isooctyl esters | Herbicide | 3.51 | Leacher | 77 | 63.64 | 83 | 51.30 | 163 |
| 6-Benzylaminopurine | Herbicide | | | | 58.82 | 180 | 44.20 | 217 |
| Abamectin | Insecticide | 0.54 | Non-leacher | 196 | 40.91 | 250 | 58.40 | 96 |
| AC 900001 | Herbicide | -0.30 | Non-leacher | 230 | 50.00 | 210 | 57.90 | 98 |
| Acephate | Insecticide | 1.07 | Non-leacher | 182 | 63.64 | 83 | 47.10 | 191 |
| Acetamiprid | Insecticide | 1.63 | Non-leacher | 160 | 54.55 | 181 | 39.60 | 238 |
| **Acifluorfen** | Herbicide | 5.42 | Leacher | 32 | 81.82 | 1 | | |
| Aluminum phosphide | Insecticide | | | | 68.75 | 58 | 60.40 | 72 |
| Aminoethoxyvinylglycine | Herbicide | 1.79 | Non-leacher | 153 | 50.00 | 210 | 37.60 | 246 |
| Amitraz | Insecticide | 0.36 | Non-leacher | 206 | 40.91 | 250 | 49.30 | 177 |
| Amitrole | Herbicide | 4.15 | Leacher | 58 | 63.64 | 83 | 44.90 | 210 |
| Anilazine | Fungicide | -0.16 | Non-leacher | 228 | 40.91 | 250 | 48.60 | 185 |
| Arsenic as elemental, present as monosodium methane arsonate | Herbicide | 5.17 | Leacher | 40 | 77.27 | 13 | 56.10 | 112 |
| Atrazine | Herbicide | 5.76 | Leacher | 26 | 77.27 | 13 | 65.80 | 27 |
| Azaconazole | Fungicide | 4.63 | Leacher | 49 | 77.27 | 13 | 63.30 | 44 |
| Azinphos-methyl | Insecticide | 2.86 | Leacher | 106 | 63.64 | 83 | 68.60 | 12 |
| Azoxystrobin | Fungicide | 3.24 | Leacher | 89 | 59.09 | 145 | 60.00 | 75 |
| BAS 510 F | Fungicide | 3.58 | Leacher | 74 | 59.09 | 145 | 52.10 | 150 |
| Bendiocarb | Insecticide | 0.92 | Non-leacher | 187 | 50.00 | 210 | 52.90 | 145 |
| Bensulide | Herbicide | 2.32 | Borderline leacher | 131 | 63.64 | 83 | 61.30 | 60 |
| Bentazon | Herbicide | 2.56 | Borderline leacher | 123 | 59.09 | 145 | 42.10 | 227 |
| Bis(trichloromethyl)sulfone | Fungicide | | | | 50.00 | 210 | 55.20 | 126 |
| Boracic acid | Insecticide | | | | 63.64 | 83 | 32.50 | 254 |
| Borax | Insecticide | | | | | | 35.80 | 250 |
| **Bromacil** | Herbicide | 8.87 | Leacher | 2 | 77.27 | 13 | 58.70 | 88 |
| Bromoxynil | Herbicide | 0.30 | Non-leacher | 210 | 36.36 | 265 | 51.30 | 163 |
| Captan | Fungicide | 1.45 | Non-leacher | 172 | 45.45 | 234 | 54.70 | 128 |
| Carbaryl | Insecticide | 2.86 | Leacher | 107 | 54.55 | 181 | 57.40 | 99 |
| Carbathiin | Fungicide | 0.00 | Non-leacher | 219 | 54.55 | 181 | 48.80 | 179 |
| Carbendazim | Fungicide | 4.28 | Leacher | 55 | 63.64 | 83 | 58.40 | 96 |
| Carbofuran | Insecticide | 3.14 | Leacher | 92 | 59.09 | 145 | 62.90 | 46 |
| Chinomethionat | Fungicide | 1.18 | Non-leacher | 178 | 54.55 | 181 | 57.40 | 99 |
| Chloridazon | Herbicide | 1.94 | Borderline leacher | 150 | 50.00 | 210 | 39.70 | 237 |
| Chlorimuron-ethyl | Herbicide | 5.02 | Leacher | 42 | 72.73 | 35 | 52.10 | 150 |
| Chlormequat chloride | Herbicide | 2.45 | Borderline leacher | 127 | 68.18 | 62 | 51.70 | 156 |
| Chloroneb | Fungicide | 2.59 | Borderline leacher | 121 | 63.64 | 83 | 55.70 | 118 |
| Chloropicrin | Fumigant | -0.88 | Non-leacher | 237 | 59.09 | 145 | 39.40 | 239 |
| Chlorothalonil | Fungicide | 3.34 | Leacher | 84 | 59.09 | 145 | 63.90 | 38 |
| Chlorpropham | Herbicide | 2.27 | Borderline leacher | 137 | 59.09 | 145 | 52.10 | 150 |
| **Chlorpyrifos** | Insecticide | 0.98 | Non-leacher | 186 | 63.64 | 83 | 75.80 | 2 |
| Chlorsulfuron | Herbicide | 3.00 | Leacher | 100 | 63.64 | 83 | 45.50 | 203 |
| Chlorthal | Herbicide | 0.24 | Non-leacher | 215 | 40.91 | 250 | 35.70 | 251 |
| Chromic acid | Fungicide | | | | 63.64 | 83 | 55.10 | 127 |
| Clethodim | Herbicide | 1.58 | Non-leacher | 165 | 77.27 | 13 | | |
| Clodinafop-propargyl | Herbicide | 0.29 | Non-leacher | 214 | 54.55 | 181 | 53.40 | 138 |
| Clofentezine | Insecticide | -1.15 | Non-leacher | 240 | 54.55 | 181 | 53.90 | 135 |
| Clomazone | Herbicide | 3.98 | Leacher | 60 | 77.27 | 13 | 58.70 | 88 |
| Clopyralid | Herbicide | 6.25 | Leacher | 21 | 68.18 | 62 | 45.00 | 207 |
| Cloransulam-methyl | Herbicide | 3.76 | Leacher | 64 | 54.55 | 181 | 48.00 | 189 |
| Clothianidin | Insecticide | 6.38 | Leacher | 19 | 77.27 | 13 | 48.80 | 179 |
| Cyanazine | Herbicide | 4.77 | Leacher | 44 | 68.18 | 62 | 64.20 | 36 |
| Cyfluthrin | Insecticide | -1.38 | Non-leacher | 246 | 50.00 | 210 | 68.60 | 12 |
| Cyhalothrin-lambda | Insecticide | -1.48 | Non-leacher | 247 | 50.00 | 210 | 67.90 | 20 |
| Cymoxanil | Fungicide | 3.08 | Leacher | 94 | 59.09 | 145 | 46.20 | 200 |
| Cypermethrin | Insecticide | 0.42 | Non-leacher | 200 | 36.36 | 265 | 60.00 | 75 |
| Cyprodinil | Fungicide | 2.13 | Borderline leacher | 142 | 59.09 | 145 | 57.40 | 99 |
| **Cyromazine** | Insecticide | 4.52 | Leacher | 53 | 81.82 | 1 | 56.40 | 111 |
| Daminozide | Herbicide | -1.37 | Non-leacher | 245 | 63.64 | 83 | 45.00 | 207 |
| Dazomet | Fumigant | -3.98 | Non-leacher | 251 | 63.64 | 83 | 62.60 | 50 |
| Deltamethrin | Insecticide | -0.85 | Non-leacher | 236 | 22.73 | 269 | 50.80 | 167 |
| Denatonium benzoate | Insecticide | | | | 63.64 | 83 | | |
| Desmedipham | Herbicide | 1.79 | Non-leacher | 152 | 59.09 | 145 | 53.40 | 138 |
| Diazinon | Insecticide | 2.58 | Borderline leacher | 122 | 63.64 | 83 | 66.60 | 25 |
| Dicamba | Herbicide | 4.57 | Leacher | 51 | 63.64 | 83 | 42.40 | 223 |
| Dichlobenil | Herbicide | 4.53 | Leacher | 52 | 63.64 | 83 | 54.70 | 128 |
| Dichloran | Fungicide | 2.87 | Leacher | 105 | 59.09 | 145 | 52.90 | 145 |
| Dichlorprop present as esters | Herbicide | 1.00 | Non-leacher | 184 | 50.00 | 210 | 52.10 | 150 |
| Dichlorprop present as dimethylamine salt | Herbicide | 1.77 | Non-leacher | 154 | 59.09 | 145 | 52.30 | 148 |
| **Dichlorvos** | Insecticide | 2.93 | Leacher | 103 | 63.64 | 83 | 73.00 | 5 |
| Diclofop-methyl | Herbicide | -0.17 | Non-leacher | 229 | 50.00 | 210 | 54.30 | 131 |
| Dicofol | Insecticide | 0.38 | Non-leacher | 203 | 54.55 | 181 | 59.20 | 83 |
| Didecyl dimethyl ammonium chloride | Fungicide | -4.96 | Non-leacher | 252 | 68.75 | 58 | 63.80 | 43 |
| Dieldrin | Insecticide | 0.23 | Non-leacher | 216 | 59.09 | 145 | 68.60 | 12 |
| Difenoconazole | Fungicide | 1.47 | Non-leacher | 170 | 63.64 | 83 | 62.90 | 46 |
| Difenzoquat | Herbicide | -0.99 | Non-leacher | 238 | 77.27 | 13 | 55.70 | 118 |
| Diflubenzuron | Insecticide | 0.20 | Non-leacher | 218 | 31.82 | 267 | 37.60 | 246 |
| Diflufenzopyr | Herbicide | 2.76 | Borderline leacher | 113 | 63.64 | 83 | 46.20 | 200 |
| Dimethenamid | Herbicide | 3.38 | Leacher | 82 | 72.73 | 35 | 61.20 | 64 |
| Dimethoate | Insecticide | 1.12 | Non-leacher | 180 | 63.64 | 83 | 55.70 | 118 |
| Dimethomorph | Fungicide | 3.37 | Leacher | 83 | 68.18 | 62 | 53.90 | 135 |
| Dinocap | Fungicide | 0.99 | Non-leacher | 185 | 40.91 | 250 | 58.60 | 93 |
| Dinoseb | Herbicide | 2.84 | Leacher | 110 | 59.09 | 145 | 64.30 | 33 |
| Diphenylamine | Herbicide | 0.00 | Non-leacher | 219 | 45.45 | 234 | 44.30 | 216 |
| Diquat | Herbicide | -3.00 | Non-leacher | 249 | 63.64 | 83 | 59.30 | 82 |
| Disodium octaborate tetrahydrate | Fungicide | | | | | | 49.20 | 178 |
| Disulfoton | Insecticide | 2.06 | Borderline leacher | 147 | 54.55 | 181 | 55.70 | 118 |
| Dithiopyr | Herbicide | 2.61 | Borderline leacher | 120 | 59.09 | 145 | 59.20 | 83 |
| Diuron | Herbicide | 3.42 | Leacher | 81 | 68.18 | 62 | 61.80 | 57 |
| Dodemorph-acetate | Fungicide | 0.70 | Non-leacher | 194 | 50.00 | 210 | | |
| Dodine | Fungicide | -1.26 | Non-leacher | 242 | 40.91 | 250 | 43.40 | 220 |
| d-trans Allethrin | Insecticide | 1.54 | Non-leacher | 166 | 54.55 | 181 | 64.30 | 33 |
| Endosulfan | Insecticide | 0.30 | Non-leacher | 209 | 45.45 | 234 | 60.00 | 75 |
| Endothall | Herbicide | 2.97 | Leacher | 102 | 63.64 | 83 | 59.00 | 87 |
| **Endrin** | Insecticide | 0.33 | Non-leacher | 207 | 59.09 | 145 | 74.30 | 4 |
| EPTC | Herbicide | 2.93 | Leacher | 104 | 72.73 | 35 | 56.10 | 112 |

| Active Ingredient Common Name | Type | GUS | GUS Class | GUS Rank | Drinking Water Score | Drinking Water Rank | ECO Water Score | ECO Water Rank |
|---|---|---|---|---|---|---|---|---|
| Ethalfluralin | Herbicide | 0.80 | Non-leacher | 188 | 50.00 | 210 | 51.30 | 163 |
| Ethametsulfuron-methyl | Herbicide | 5.26 | Leacher | 37 | 63.64 | 83 | 44.90 | 210 |
| Ethephon | Herbicide | 1.06 | Non-leacher | 183 | 50.00 | 210 | 37.00 | 248 |
| Ethofumesate | Herbicide | 4.72 | Leacher | 47 | 72.73 | 35 | 62.00 | 56 |
| Ethoxyquin | Herbicide | | | | 54.55 | 181 | 41.70 | 228 |
| Ethylene oxide | Insecticide | 3.64 | Leacher | 67 | 63.64 | 83 | | |
| Etridiazole | Fungicide | 1.58 | Non-leacher | 164 | 59.09 | 145 | 60.50 | 68 |
| Famoxadone | Fungicide | 0.50 | Non-leacher | 197 | 54.55 | 181 | 65.80 | 27 |
| Fenamidone | Fungicide | 3.27 | Leacher | 87 | 68.18 | 62 | 65.30 | 31 |
| Fenbuconazole | Fungicide | 1.69 | Non-leacher | 158 | 59.09 | 145 | 53.40 | 138 |
| **Fenbutatin oxide** | Insecticide | 1.71 | Non-leacher | 157 | 59.09 | 145 | 71.40 | 7 |
| Fenhexamid | Fungicide | 0.00 | Non-leacher | 219 | 50.00 | 210 | 44.90 | 210 |
| Fenitrothion | Insecticide | 2.48 | Borderline leacher | 126 | 63.64 | 83 | 62.60 | 50 |
| Fenoxaprop-p-ethyl | Herbicide | 0.71 | Non-leacher | 193 | 40.91 | 250 | 46.80 | 192 |
| Ferbam | Fungicide | 2.66 | Borderline leacher | 117 | 54.55 | 181 | | |
| Flamprop-m-methyl | Herbicide | | | | 45.45 | 234 | | |
| Florasulam | Herbicide | 3.12 | Leacher | 93 | 63.64 | 83 | 46.80 | 192 |
| Fluazifop-p-butyl | Herbicide | 0.36 | Non-leacher | 205 | 50.00 | 210 | 45.40 | 206 |
| Fluazinam | Fungicide | 1.77 | Non-leacher | 155 | 54.55 | 181 | 61.30 | 60 |
| Flucarbazone | Herbicide | 5.56 | Leacher | 29 | 72.73 | 35 | 58.50 | 95 |
| Fludioxonil | Fungicide | -0.16 | Non-leacher | 227 | 59.09 | 145 | 58.70 | 88 |
| Flufenacet | Herbicide | 2.85 | Leacher | 109 | 59.09 | 145 | 56.60 | 109 |
| **Flumetsulam** | Herbicide | 5.67 | Leacher | 27 | 81.82 | 1 | 57.40 | 99 |
| Fluroxypyr 1-methylheptyl ester | Herbicide | 6.69 | Leacher | 14 | 72.73 | 35 | 63.90 | 38 |
| Flusilazole | Fungicide | 2.44 | Borderline leacher | 128 | 68.18 | 62 | | |
| Folpet | Fungicide | 5.87 | Leacher | 24 | 63.64 | 83 | 62.10 | 54 |
| Fomesafen | Herbicide | 5.39 | Leacher | 33 | 77.27 | 13 | 64.10 | 37 |
| Foramsulfuron | Herbicide | 2.37 | Borderline leacher | 129 | 63.64 | 83 | 46.80 | 192 |
| Formaldehyde | Fungicide | 2.06 | Borderline leacher | 146 | 63.64 | 83 | | |
| Formetanate | Insecticide | 1.90 | Borderline leacher | 151 | 59.10 | 144 | 58.60 | 92 |
| Fosamine ammonium | Herbicide | 2.86 | Leacher | 108 | 63.64 | 83 | 40.90 | 230 |
| Fosetyl-al | Fungicide | -3.25 | Non-leacher | 250 | 63.64 | 83 | 46.30 | 197 |
| Gibberellic acid A3 | Herbicide | | | | 54.55 | 181 | 34.20 | 252 |
| Gibberellins A4A7 | Herbicide | | | | 63.64 | 83 | 52.10 | 155 |
| Glufosinate ammonium | Herbicide | 3.19 | Leacher | 91 | 63.64 | 83 | 40.90 | 230 |
| Glyphosate (present as isopropylamine salt) | Herbicide | 2.29 | Borderline leacher | 132 | 68.18 | 62 | 51.70 | 156 |
| Glyphosate (present as mono-ammonium salt) | Herbicide | 2.29 | Borderline leacher | 132 | 68.18 | 62 | 51.70 | 156 |
| Glyphosate (present as potassium salt) | Herbicide | 2.29 | Borderline leacher | 132 | 68.18 | 62 | 51.70 | 156 |
| Glyphosate (present as trimethylsulfonium salt) | Herbicide | 2.29 | Borderline leacher | 132 | 68.18 | 62 | 45.00 | 207 |
| Glyphosate acid | Herbicide | 2.29 | Borderline leacher | 132 | 68.18 | 62 | 43.60 | 219 |
| Hexaconazole | Fungicide | 2.78 | Borderline leacher | 112 | 63.64 | 83 | 54.70 | 128 |
| **Hexazinone** | Herbicide | 6.06 | Leacher | 23 | 81.82 | 1 | 52.90 | 144 |
| Imazamethabenz | Herbicide | 6.72 | Leacher | 13 | 77.27 | 13 | 50.90 | 166 |
| Imazamox | Herbicide | 6.27 | Leacher | 20 | 72.73 | 35 | 50.80 | 167 |
| **Imazapyr** | Herbicide | 6.96 | Leacher | 12 | 81.82 | 1 | 51.40 | 160 |
| **Imazethapyr** | Herbicide | 8.25 | Leacher | 4 | 77.27 | 13 | 48.80 | 179 |
| Imidacloprid | Insecticide | 5.64 | Leacher | 28 | 72.73 | 35 | 50.70 | 170 |
| Iodocarb | Fungicide | | | | 47.06 | 233 | 53.90 | 137 |
| Iodosulfuron-methyl-sodium | Herbicide | 3.76 | Leacher | 63 | 63.64 | 83 | 53.30 | 143 |
| Iprodione | Fungicide | 2.11 | Borderline leacher | 144 | 50.00 | 210 | 49.50 | 174 |
| Isoxaben | Herbicide | 2.14 | Borderline leacher | 141 | 50.00 | 210 | 46.80 | 192 |
| Isoxaflutole | Herbicide | 0.77 | Non-leacher | 190 | 54.55 | 181 | 50.80 | 167 |
| Kresoxim-methyl | Fungicide | 1.08 | Non-leacher | 181 | 54.55 | 181 | 59.20 | 83 |
| Linuron | Herbicide | 3.43 | Leacher | 80 | 68.18 | 62 | 60.50 | 68 |
| Magnesium phosphide | Insecticide | | | | 68.75 | 58 | 60.40 | 72 |
| **Malathion** | Insecticide | 1.54 | Non-leacher | 167 | 54.55 | 181 | 71.40 | 7 |
| Maleic hydrazide | Herbicide | 0.00 | Non-leacher | 219 | 63.64 | 83 | 42.40 | 223 |
| Mancozeb | Fungicide | 0.21 | Non-leacher | 217 | 31.82 | 267 | 40.00 | 236 |
| Maneb | Fungicide | 2.26 | Borderline leacher | 138 | 45.45 | 234 | 48.10 | 188 |
| MCPA present as acid | Herbicide | 3.58 | Leacher | 70 | 63.64 | 83 | 44.90 | 210 |
| MCPA present as amine salts | Herbicide | 3.58 | Leacher | 70 | 63.64 | 83 | 44.90 | 210 |
| MCPA present as esters | Herbicide | 3.58 | Leacher | 70 | 40.91 | 250 | 45.50 | 203 |
| MCPA present as potassium salt or as sodium salt | Herbicide | 3.58 | Leacher | 70 | 63.64 | 83 | 46.30 | 197 |
| MCPB present as sodium salt | Herbicide | 1.45 | Non-leacher | 171 | 45.45 | 234 | | |
| Mecoprop present as potassium salt | Herbicide | 3.03 | Leacher | 95 | 59.09 | 145 | 39.30 | 240 |
| Mecoprop d-isomer present as amine salt | Herbicide | 3.03 | Leacher | 95 | 59.09 | 145 | 39.30 | 240 |
| Mecoprop d-isomer present as potassium salt | Herbicide | 3.03 | Leacher | 95 | 59.09 | 145 | 39.30 | 240 |
| Mecoprop present as acid | Herbicide | 3.03 | Leacher | 95 | 59.09 | 145 | 39.30 | 240 |
| Mecoprop present as amine salts | Herbicide | 3.03 | Leacher | 95 | 59.09 | 145 | 39.30 | 240 |
| Mesotrione | Herbicide | 4.23 | Leacher | 57 | 63.64 | 83 | 42.40 | 223 |
| Metalaxyl | Fungicide | 4.77 | Leacher | 45 | 72.73 | 35 | 47.20 | 190 |
| Metalaxyl-m (mefenoxam) | Fungicide | 5.04 | Leacher | 41 | 72.73 | 35 | 48.70 | 182 |
| Metam | Fumigant | 2.72 | Borderline leacher | 114 | 63.64 | 83 | 68.30 | 19 |
| Methamidophos | Insecticide | -1.22 | Non-leacher | 241 | 63.64 | 83 | 57.10 | 104 |
| Methomyl | Insecticide | 5.46 | Leacher | 30 | 72.73 | 35 | 63.80 | 42 |
| Methoprene | Insecticide | -0.36 | Non-leacher | 231 | 45.45 | 234 | 55.70 | 118 |
| Methoxychlor | Insecticide | -0.71 | Non-leacher | 234 | 50.00 | 210 | 64.30 | 33 |
| Methoxyfenozide | Insecticide | 5.17 | Leacher | 39 | 72.73 | 35 | 60.00 | 75 |
| Methyl bromide | Fumigant | 5.30 | Leacher | 36 | 72.73 | 35 | 64.30 | 32 |
| Methyl isothiocyanate | Fumigant | 2.72 | Borderline leacher | 114 | 63.64 | 83 | 62.60 | 50 |
| Metiram | Fungicide | -1.30 | Non-leacher | 243 | 22.73 | 269 | 18.30 | 255 |
| Metobromuron | Herbicide | 1.96 | Borderline leacher | 149 | 54.55 | 181 | | |
| Metolachlor | Herbicide | 5.33 | Leacher | 34 | 72.73 | 35 | 61.20 | 64 |
| Metribuzin | Herbicide | 7.13 | Leacher | 11 | 77.27 | 13 | 61.80 | 57 |
| **Metsulfuron-methyl** | Herbicide | 7.96 | Leacher | 6 | 81.82 | 1 | 54.20 | 133 |
| Myclobutanil | Fungicide | 3.54 | Leacher | 75 | 68.18 | 62 | 61.30 | 60 |
| Naled | Insecticide | 0.00 | Non-leacher | 219 | 45.45 | 234 | 59.20 | 83 |
| N-alkyl (40% C12, 50% C14, 10% C16) dimethyl benzyl ammonium chloride | Fungicide | | | | | | 61.10 | 66 |
| N-alkyl (67% C12, 25% C14, 7% C16, 1% C18) dimethyl benzyl ammonium chloride | Fungicide | | | | | | 61.10 | 66 |
| Naphthalene acetic acid | Herbicide | 1.41 | Non-leacher | 173 | 54.55 | 181 | 40.90 | 233 |
| Naphthaleneacetamide | Herbicide | 2.00 | Borderline leacher | 148 | 50.00 | 210 | | |
| Napropamide | Herbicide | 4.42 | Leacher | 54 | 77.27 | 13 | 62.10 | 54 |
| Naptalam | Herbicide | 2.34 | Borderline leacher | 130 | 54.55 | 181 | 40.90 | 233 |
| N-Decanol | Herbicide | 1.20 | Non-leacher | 177 | 63.64 | 83 | 55.70 | 118 |
| Nicosulfuron | Herbicide | 3.76 | Leacher | 65 | 63.64 | 83 | 46.80 | 192 |
| N-Octanol | Herbicide | -0.09 | Non-leacher | 226 | 59.09 | 145 | | |
| Octylbicyclo heptene dicarboximide | Insecticide | | | | 43.75 | 249 | 48.30 | 186 |

| Active Ingredient Common Name | Type | GUS | GUS Class | GUS Rank | Drinking Water Score | Drinking Water Rank | ECO Water Score | ECO Water Rank |
|---|---|---|---|---|---|---|---|---|
| Oxadiazon | Herbicide | 2.65 | Borderline leacher | 118 | 63.64 | 83 | 65.80 | 27 |
| Oxamyl | Insecticide | 5.78 | Leacher | 25 | 63.64 | 83 | 58.60 | 93 |
| Oxine benzoate | Fungicide | | | | 50.00 | 210 | | |
| Oxycarboxin | Fungicide | 3.51 | Leacher | 78 | 68.18 | 62 | | |
| Oxyfluorfen | Herbicide | 1.50 | Non-leacher | 168 | 59.09 | 145 | 60.50 | 68 |
| Paclobutrazol | Herbicide | 5.44 | Leacher | 31 | 77.27 | 13 | 67.10 | 23 |
| Paraquat | Herbicide | -0.57 | Non-leacher | 233 | 63.64 | 83 | 51.40 | 162 |
| Parathion | Insecticide | 0.38 | Non-leacher | 204 | 40.91 | 250 | 54.30 | 131 |
| Pendimethalin | Herbicide | 0.41 | Non-leacher | 201 | 63.64 | 83 | 68.40 | 17 |
| Pentachlorophenol | Fungicide | 0.50 | Non-leacher | 198 | 59.09 | 145 | 63.90 | 38 |
| Permethrin | Insecticide | -0.42 | Non-leacher | 232 | 40.91 | 250 | 62.90 | 46 |
| Phenmedipham | Herbicide | 0.29 | Non-leacher | 212 | 40.91 | 250 | 41.40 | 229 |
| Phorate | Insecticide | 0.60 | Non-leacher | 195 | 50.00 | 210 | 61.40 | 59 |
| Phosalone | Insecticide | 0.79 | Non-leacher | 189 | 63.64 | 83 | 67.90 | 20 |
| Phosine | Insecticide | | | | 68.75 | 58 | 60.40 | 72 |
| Phosmet | Insecticide | 1.49 | Non-leacher | 169 | 45.45 | 234 | 57.10 | 104 |
| Picloram present as acid or as isooctyl esters or as potassium salt | Herbicide | 6.47 | Leacher | 17 | 77.27 | 13 | 56.70 | 108 |
| **Picloram present as amine salts** | Herbicide | 7.58 | Leacher | 9 | 81.82 | 1 | 63.30 | 45 |
| Piperonyl butoxide | Insecticide | 1.60 | Non-leacher | 162 | 54.55 | 181 | 52.90 | 145 |
| Pirimicarb | Insecticide | 4.59 | Leacher | 50 | 68.18 | 62 | 62.90 | 46 |
| Potassium n-methyldithiocarbamate | Fungicide | | | | 60.00 | 143 | | |
| **Primisulfuron-methyl** | Herbicide | 10.80 | Leacher | 1 | 68.18 | 62 | 52.10 | 150 |
| Prometryne | Herbicide | 4.70 | Leacher | 48 | 77.27 | 13 | 65.80 | 27 |
| Propamocarb hydrochloride | Fungicide | 3.92 | Leacher | 61 | 72.73 | 35 | 52.30 | 148 |
| Propanil | Herbicide | 0.72 | Non-leacher | 192 | 50.00 | 210 | 50.00 | 171 |
| Propiconazole | Fungicide | 2.62 | Borderline leacher | 119 | 63.64 | 83 | 63.90 | 38 |
| **Propoxur** | Insecticide | 8.05 | Leacher | 5 | 77.27 | 13 | 67.90 | 20 |
| Propyzamide | Herbicide | 3.62 | Leacher | 68 | 72.73 | 35 | 66.00 | 26 |
| **Prosulfuron** | Herbicide | 6.42 | Leacher | 18 | 81.82 | 1 | 56.10 | 112 |
| Pymetrozine | Insecticide | 2.23 | Borderline leacher | 139 | 54.55 | 181 | 38.20 | 245 |
| **Pyraclostrobin** | Fungicide | 0.73 | Non-leacher | 191 | 59.09 | 145 | 70.50 | 10 |
| Pyrethrins | Insecticide | 0.31 | Non-leacher | 208 | 45.45 | 234 | | |
| **Pyridaben** | Insecticide | -1.09 | Non-leacher | 239 | 59.09 | 145 | 75.00 | 3 |
| Pyridate | Herbicide | 0.00 | Non-leacher | 219 | 50.00 | 210 | 43.40 | 220 |
| **Quinclorac** | Herbicide | 7.48 | Leacher | 10 | 81.82 | 1 | 54.20 | 133 |
| Quintozene | Fungicide | -0.74 | Non-leacher | 235 | 54.55 | 181 | 57.10 | 104 |
| Quizalofop p-ethyl | Herbicide | 2.72 | Borderline leacher | 116 | 63.64 | 83 | 61.30 | 60 |
| **Resmethrin** | Insecticide | 3.51 | Leacher | 76 | 72.73 | 35 | 82.90 | 1 |
| RH-117281 technical fungicide | Fungicide | 1.25 | Non-leacher | 176 | 40.91 | 250 | 48.70 | 182 |
| Rimsulfuron | Herbicide | 3.62 | Leacher | 69 | 63.64 | 83 | 42.40 | 223 |
| Sethoxydim | Herbicide | 2.80 | Borderline leacher | 111 | 72.73 | 35 | 51.40 | 160 |
| Simazine | Herbicide | 4.23 | Leacher | 56 | 72.73 | 35 | 57.40 | 99 |
| S-Metolachlor and r-enantiomer | Herbicide | 5.33 | Leacher | 34 | 72.73 | 35 | 62.50 | 53 |
| **Sodium dimethyldithiocarbamate** | Fungicide | | | | 75.00 | 34 | 71.40 | 7 |
| Spinosad | Insecticide | 1.68 | Non-leacher | 159 | 68.18 | 62 | 50.00 | 171 |
| **Sulfosulfuron** | Herbicide | 7.71 | Leacher | 8 | 77.27 | 13 | 55.50 | 124 |
| **TCA** | Herbicide | 8.31 | Leacher | 3 | 81.82 | 1 | | |
| **Tebuconazole** | Fungicide | 7.82 | Leacher | 7 | 81.82 | 1 | 69.10 | 11 |
| Tebufenozide | Insecticide | 4.14 | Leacher | 59 | 68.18 | 62 | 67.10 | 23 |
| **Tefluthrin** | Insecticide | -2.17 | Non-leacher | 248 | 59.09 | 145 | 71.80 | 6 |
| Tepraloxydim | Herbicide | 4.97 | Leacher | 43 | 63.64 | 83 | 40.90 | 230 |
| Terbacil | Herbicide | 6.68 | Leacher | 15 | 77.27 | 13 | 59.90 | 81 |
| Terbufos | Insecticide | 1.61 | Non-leacher | 161 | 50.00 | 210 | 68.60 | 12 |
| Tetrachlorvinphos | Insecticide | 1.16 | Non-leacher | 179 | 45.45 | 234 | 57.10 | 104 |
| Thiabendazole | Fungicide | 2.49 | Borderline leacher | 125 | 59.09 | 145 | 60.00 | 75 |
| **Thiamethoxam** | Insecticide | 6.21 | Leacher | 22 | 81.82 | 1 | 50.00 | 171 |
| Thifensulfuron methyl | Herbicide | 2.18 | Borderline leacher | 140 | 59.09 | 145 | 42.90 | 222 |
| Thiophanate-methyl | Fungicide | 0.00 | Non-leacher | 219 | 45.45 | 234 | 45.50 | 203 |
| Thiram | Fungicide | 1.39 | Non-leacher | 174 | 40.91 | 250 | 49.50 | 174 |
| Tralkoxydim | Herbicide | 1.76 | Non-leacher | 156 | 54.55 | 181 | 49.50 | 174 |
| Triadimenol | Fungicide | 3.45 | Leacher | 79 | 72.73 | 35 | 56.10 | 112 |
| Triallate | Herbicide | 1.59 | Non-leacher | 163 | 54.55 | 181 | 56.10 | 112 |
| Triasulfuron | Herbicide | 6.49 | Leacher | 16 | 77.27 | 13 | 53.40 | 138 |
| Tribenuron methyl | Herbicide | 2.99 | Leacher | 101 | 54.55 | 181 | 40.20 | 235 |
| Trichlorfon | Insecticide | 3.90 | Leacher | 62 | 63.64 | 83 | 68.60 | 12 |
| Triclopyr butoxyethyl ester | Herbicide | 3.22 | Leacher | 90 | 63.64 | 83 | 55.50 | 124 |
| Trifloxystrobin | Fungicide | 0.39 | Non-leacher | 202 | 45.45 | 234 | 60.50 | 68 |
| Trifluralin | Herbicide | 0.45 | Non-leacher | 199 | 63.64 | 83 | 68.40 | 17 |
| Triflusulfuron methyl | Herbicide | 5.23 | Leacher | 38 | 77.27 | 13 | 53.40 | 138 |
| Triforine | Fungicide | 2.56 | Borderline leacher | 124 | 54.55 | 181 | 34.20 | 252 |
| Trinexapac-etyl | Herbicide | -1.34 | Non-leacher | 244 | 63.64 | 83 | 46.30 | 197 |
| Triticonazole | Fungicide | 4.76 | Leacher | 46 | 72.73 | 35 | 60.00 | 75 |
| Vinclozolin | Fungicide | 3.69 | Leacher | 66 | 59.09 | 145 | 48.20 | 187 |
| Zineb | Fungicide | 2.06 | Borderline leacher | 145 | 40.91 | 250 | 44.40 | 215 |
| Ziram | Fungicide | 2.11 | Borderline leacher | 143 | 45.45 | 234 | 56.60 | 109 |

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## Acknowledgments


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PMRA ARLA

## Pesticide Reduced Risk & Minor Use Program

**Victoria R. Brookes**, Agriculture and Agri-Food Canada

Abstract

The Pesticide Reduced Risk and Minor Use Program was created in 2002 when funding was announced for both Agriculture and Agri-Food Canada and the Pest Management Regulatory Agency of Health Canada.

The success of this program involves working with both provincial and federal governments, growers, stakeholders and specialists. The goals of the program are to:
- reduce risks from the use of pesticides
- improve access to reduced-risk pesticides and more pest specific solutions
- support transition from pesticides under re-evaluation
- support development and adoption of Integrated Pest Management
- develop better ways to manage pesticide resistance
- support farm profitability, public safety and agro-industry competitiveness.

The headquarters of the program are located in Ottawa at the Pest Management Centre (PMC) and there are 9 AAFC site across Canada. The sites are located at Agassiz, BC, Summerland, BC, Scott, SK, Harrow, ON, Delhi, ON, Vineland, ON, St-Jean, QC, Kentville, NS and Bouctouche, NB. An annual Prioritization Workshop is held in March to set the trial work for the following year. Thirty-six main projects are chosen as follows; 10 weed science (including growth regulators), 10 entomology, 10 pathology, 5 regional upgrades (any discipline) and 1 organic.

The pre-submission process involves getting company support, data mining, sending pre-submission consultation to PMRA and obtaining the data requirements from PMRA. Data is required for product efficacy, crop tolerance and pesticide residues on the crop.

The projects to date include:

2003 projects:57 projects
350 residue, efficacy and crop tolerance trials
50 active ingredients

2004 projects:68 projects
400 residue, efficacy and crop tolerance trials
20 pesticides and 1 biological on 39 crops

2005 projects:52 projects
400 residue, efficacy and tolerance trials

So far 26 completed submissions have been sent to PMRA and 6 registrations have been granted. Collaboration with the U.S. minor use program, IR-4, has resulted in more efficient use of resources and therefore allows more submissions to be developed.

# Pesticide Reduced Risk and Minor Use Program

2005 Pesticide Information Exchange
November 22, 2005

Victoria Brookes
AAFC

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canada

# Ministerial Announcements

- May 23, 2002 Pesticide Risk Reduction (jointly affects AAFC & HC-PMRA)
- June 24, 2002 Bridge Financing to create the new Minor Use Program
- New Pest Control Products Act, C-53 passed December 2002

# Goals of the program

**Working with governments and producers to:**

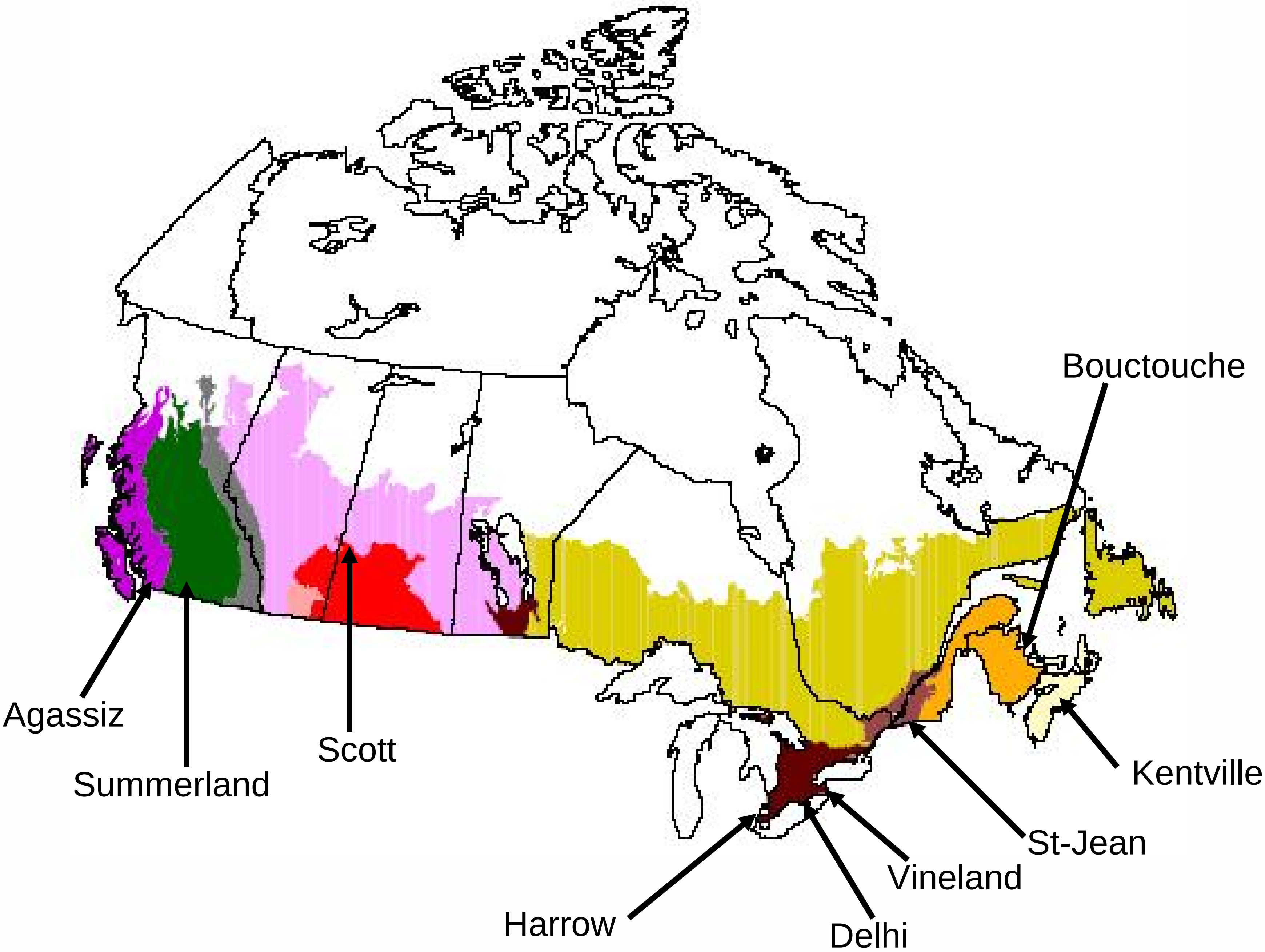
- Reduce risks from the use of pesticides
- Improve access to reduced-risk pesticides and more pest specific solutions
- Support transition from pesticides under re-evaluation
- Support development and adoption of IPM
- Develop better ways to manage pesticide resistance
- Support farm profitability, public safety and agro-industry competitiveness

# Overview of the Program

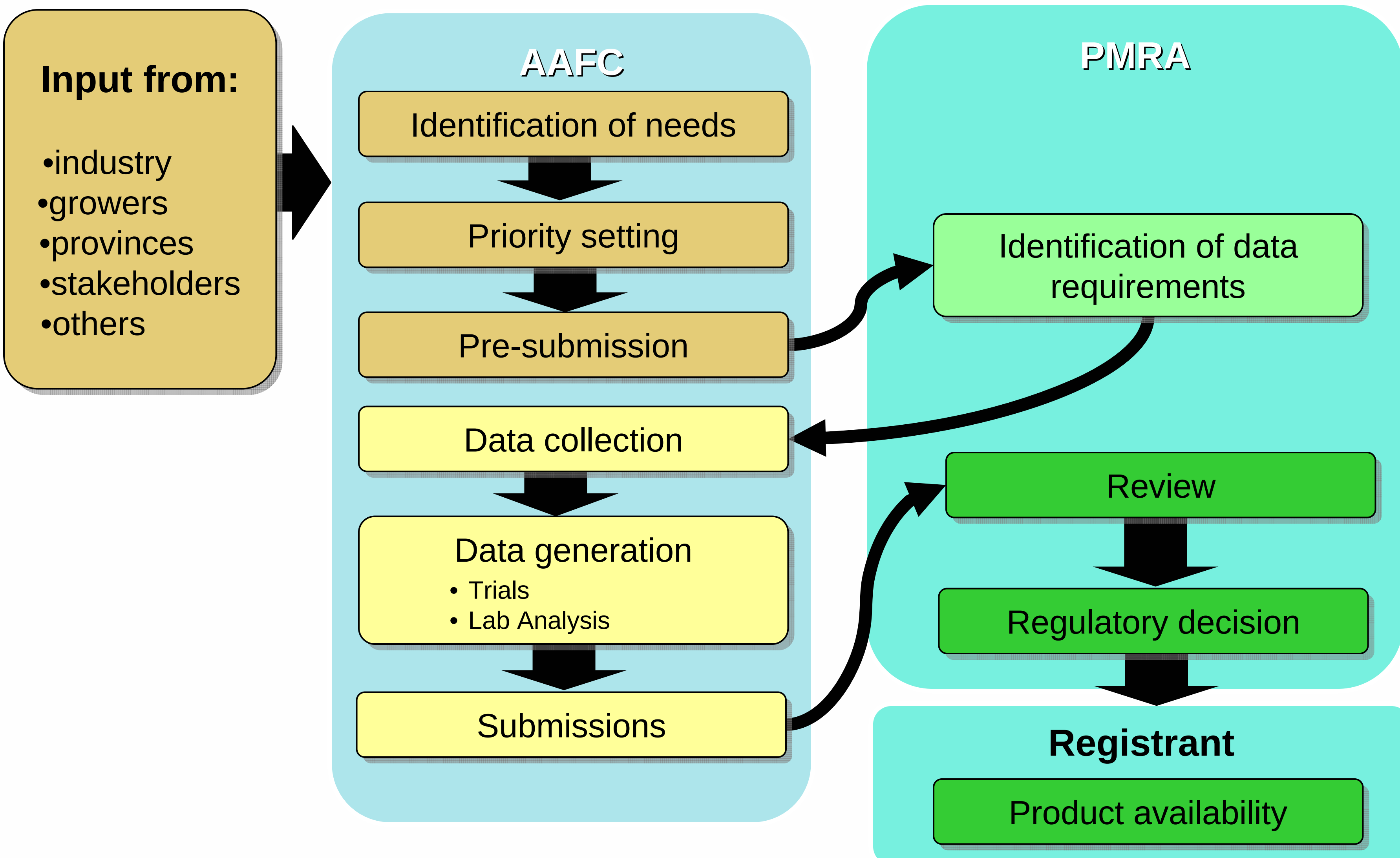
- Pest Management Centre
- Canadian Prioritization Workshop
- Data Generation
- Areas of collaboration between Canada and the US
- Status update

# Pest Management Centre

- 9 AAFC Sites across Canada
  - ➢ Agassiz – BC
  - ➢ Summerland – BC
  - ➢ Scott – SK
  - ➢ Harrow, – ON
  - ➢ Delhi – ON
  - ➢ Vineland – ON
  - ➢ St-Jean – QC
  - ➢ Kentville – NS
  - ➢ Bouctouche – NB


Bouctouche
Agassiz
Summerland
Scott
Kentville
St-Jean
Vineland
Harrow
Delhi

# Minor Use Program - Overview



# Main Minor Use Program Elements

- Priority setting
- Pre-submission
- Data generation
- Submissions
- Review by PMRA

# Canadian Prioritization Workshop

- Growers, Provincial Minor Use Coordinators, PMRA, IR-4, EPA, Pesticide Industry, Specialists
- On a crop-specific basis, determine key pest problems for insects, diseases, weeds
- Determine national priorities for the following year:
  - 10 weed science (includes growth regulators)
  - 10 entomology
  - 10 pathology
  - 5 regional priorities (any discipline)
  - 1 organic (new addition in 2005)

# Pre-submission Process

- **Company support**
- **Data mining**
- **Submit Pre-submission consultation document (PSC)**
- **Obtain data requirements from PMRA (DACO)**

# Data generation

- **Conduct field trials to assess:**
  - ➢ **Product efficacy**
  - ➢ **Crop Tolerance**
  - ➢ **Pesticide residue on crop**

# Data Generation

- AAFC
  - 9 GLP Research Centers
    - Agassiz, BC
    - Summerland, BC
    - Scott, SK
    - Harrow, ON
    - Delhi, ON
    - Vineland, ON
    - Saint-Jean, QC
    - Kentville, NS
    - Bouctouche, NB
  - Universities
  - Private Contractors

- IR-4
  - 4 Regions
    - Northeast (NY)
    - North Central (MI)
    - Western (CA)
    - Southern (FL)
  - Field Research Centers (Land Grant Universities)
  - USDA-ARS Sites
  - Regional Labs and Satellite Labs
  - Private contractors

Differences: no labs, little University capacities

# Submissions

- Generation of final reports
- Preparation of submission package
- Delivery to the PMRA

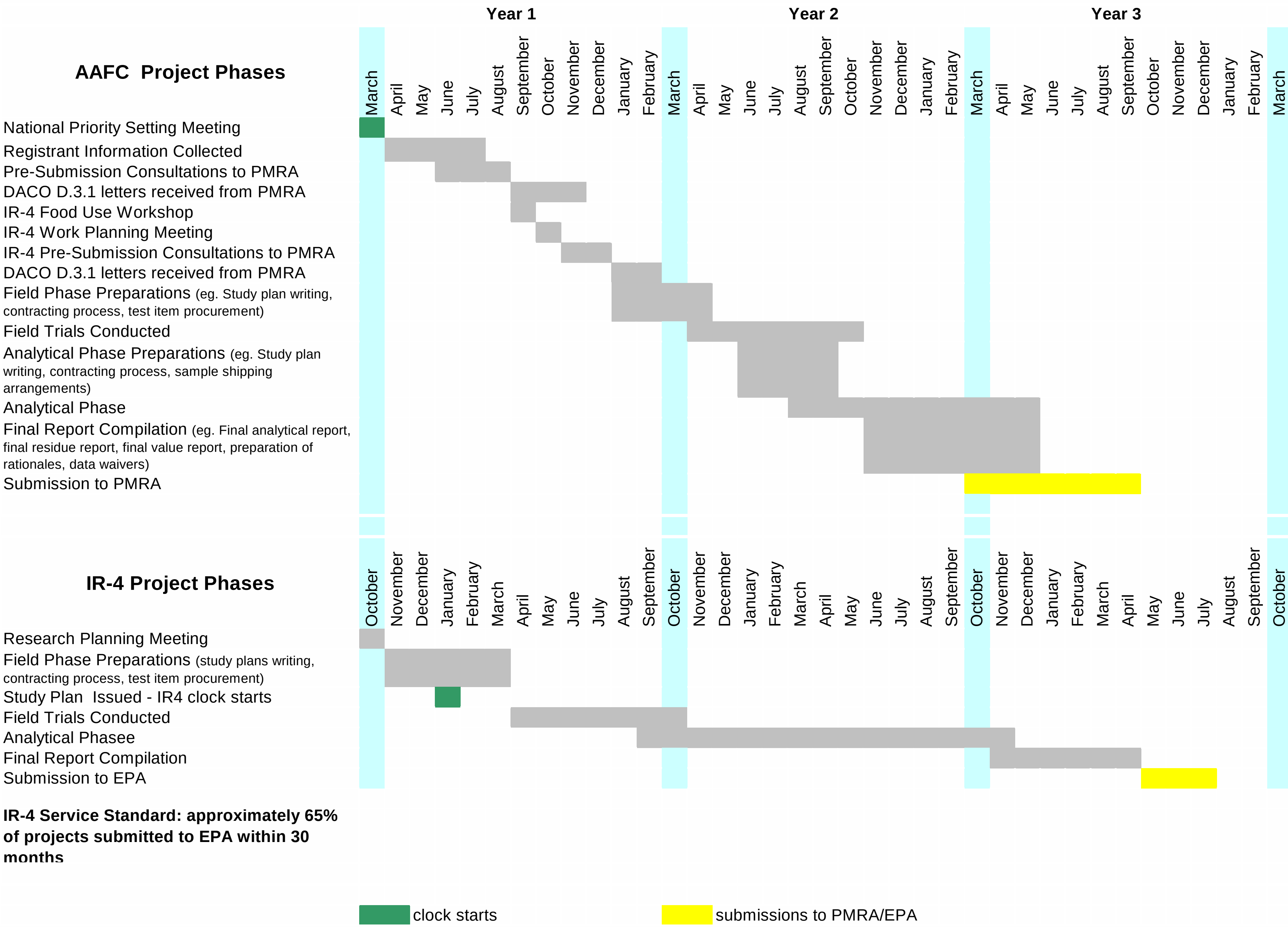
# AAFC Projects

- 2003 projects
  - 57 projects
  - 350 residue, efficacy and tolerance trials
  - 50 active ingredients
- 2004 projects
  - 68 projects
  - 400 residue, efficacy and tolerance trials
  - 20 pesticides and 1 biological on 39 crops
- 2005 projects
  - 52 projects
  - 400 residue, efficacy and tolerance trials

# Timelines

## 30 months

- **First year – priority setting, pre-submission**
- **Second year – data generation**
- **Third year – submission**


Year 1
Year 2
Year 3
AAFC Project Phases
March
April
May
June
July
August
September
October
November
December
January
February
National Priority Setting Meeting
Registrant Information Collected
Pre-Submission Consultations to PMRA
DACO D.3.1 letters received from PMRA
IR-4 Food Use Workshop
IR-4 Work Planning Meeting
IR-4 Pre-Submission Consultations to PMRA
DACO D.3.1 letters received from PMRA
Field Phase Preparations (eg. Study plan writing, contracting process, test item procurement)
Field Trials Conducted
Analytical Phase Preparations (eg. Study plan writing, contracting process, sample shipping arrangements)
Analytical Phase
Final Report Compilation (eg. Final analytical report, final residue report, final value report, preparation of rationales, data waivers)
Submission to PMRA
IR-4 Project Phases
Research Planning Meeting
Field Phase Preparations (study plans writing, contracting process, test item procurement)
Study Plan Issued - IR4 clock starts
Field Trials Conducted
Analytical Phasee
Final Report Compilation
Submission to EPA
IR-4 Service Standard: approximately 65% of projects submitted to EPA within 30 months
clock starts
submissions to PMRA/EPA

# Submissions to PMRA

- 26 submissions have gone to PMRA
- 6 registrations have now been granted

# Collaboration between AAFC and IR-4

- Participation in the Food Use Workshop in September in the U.S.
- Participation in the Research Planning Meeting in October in the U.S.
- Participation in the Ornamental Workshop in November in the U.S.
- Participation in EPA / IR-4 / PMRA / AAFC Conference calls
- Meetings with Canadian and US registrants

# Collaboration between AAFC and IR-4

- 2003 AAFC/IR-4 projects
  - 23 joint projects (including 20 joint residue and 3 joint efficacy)
  - 58 residue and 98 efficacy and tolerance trials
- 2004 AAFC/ IR-4 projects
  - 13 joint projects (11 joint residue & 2 joint efficacy)
  - In addition, 5 “Canadian” projects to complete crop grouping and a joint efficacy project
  - 3 joint projects carry forward from 2003
  - 62 residue and 57 efficacy and tolerance trials
- 2005 AAFC/ IR-4 projects
  - 11 joint projects
  - Including two projects on a compound which is under development
  - 44 residue and approximately 40 efficacy and tolerance trials

# Joint Pilot Projects

- Fenhexamid on ginseng:
  - submitted to both Agencies
- Fenhexamid on pome fruit:
  - Submitted to both Agencies
- Acetamiprid on GH tomato:
  - The company has requested more efficacy data and AAFC is working with them on this issue
- S-metolachlor on winter squash:
  - IR-4 Residue report and AAFC value report ready soon

# 2005 Priority Meeting Results

- Due to existing data and scientific rationales over 50% of data requirements are available for the 36 priorities
- Will facilitate completion of existing trial work
- Facilitates long term goal of increasing priorities that can be set at future sessions

# Meetings with Canadian and U.S. Registrants

- Valuable exercise
- Development of a partnership with companies
- Privileged information on new product developments

# Prestop

- 3 efficacy and tolerance trials being carried out on tomatoes and peppers

# THANK YOU!

**FOR MORE INFO...**

Visit our website: www.agr.gc.ca/prrmup

## Research and Innovation in Integrated Pest Management in British Columbia Crops

**Tracy Hueppelsheuser**, British Columbia Ministry of Agriculture and Lands

Abstract

British Columbia Ministry of Agriculture and Lands had a one-time budget to address plant health issues that are negatively impacting British Columbia crops, from 2004 to March 31, 2006. This program was part of the Agriculture Policy Framework, and considered part of a transition program to help industries move to newer tools and practices. A committee was struck to decide how to spend the money, made up of Plant Health, Industry Competitiveness, and Resource Management staff. We referred to our BC Crop Profiles for guidance as well as our collective knowledge of the pest management needs in the industry.

For growing season 2005, the Committee identified 8 projects across 7 commodities. Additionally, 7 projects will be run over the winter 2005/06 across 5+ crops. Weed, insect, disease, and mite problems were addressed. The first 8 projects are summarized below, while the second group of projects are presented in my poster, also presented at PIE 2005.

1. Herbicide Screening for Ginseng
    - Problem: Lack of herbicides for post-emergent broadleaf weeds in ginseng. Weeds compete with newly planted ginseng, and hand weeding is currently the only option, which is not economical.
    - Objective: to screen new herbicides in hopes of finding candidate products for minor use registration
    - Cooperators: The Associated Ginseng Growers of BC, Agriculture and Agri-Food Canada (AAFC), private contractor
    - Location: Summerland
    - Methods: 5 herbicides were tested on young established ginseng plants for efficacy on present weeds and crop tolerance.
    - Results: Phenoxy herbicides (2,4-D and MCPA) were the safest on the crop, and controlled the weeds present. Some herbicides significantly damaged ginseng.
    - Next Steps: Screening needs to continue with pre-emergent products as well as other post-emergent products.

2. Raspberry Integrated Pest Management
    - Problem: insects contaminate machine harvested fruit. There are limited tools to control them. BC's main competitor, USA growers, have adequate tools and their fruit is clean.

- Objective: to develop non-chemical strategies to reduce the problem of contaminants during machine harvesting.

- Raspberry Integrated Pest Management
- Cooperators: B.C. Raspberry Council, BCMAL, AAFC, private consultant, growers, processors
- Location : Fraser Valley
- Methods: Evaluate and demonstrate Integrated Pest Management techniques to improve control of raspberry fruit contaminants (caterpillars, weevils), through: improved pest monitoring practices, use of 'soft' pesticides (ie. spinosad), and use of Bio-control agents (ie. Trichogramma).
- Results: Improved monitoring allowed better timing of application of control tools, spinosad did not adequately control caterpillars, and Trichogramma performed better than conventional insecticides for caterpillar control.
- Next Steps: IPM vs. Clean up sprays
    i. IPM: Year round approach, several tools targeting various life stages of pests, no tool is completely effective used alone.
    ii. Clean-up spray: Broad spectrum insecticide application shortly before harvest, high risk timing; only one chance to control several pests, our competitors rely on this approach, which is still very effective.

3. Biological Control of Cabbage Root Maggot
    - Problem: Cabbage root maggot is the most significant pest of rutabagas and other brassicae crops; the larvae tunnel into the roots and stems damaging and killing plants. There is resistance to commonly used insecticides.
    - Objective: To evaluate a fungus (Metarhizium anisopliae) and a nematode (Steinernema feltiae) as infective agents against the larval stages of Delia radicum and D. pratura.
    - Cooperators: AAFC, BCMAL, Lower Mainland Horticulture Improvement Association (LMHIA)
    - Location: Agassiz, Abbotsford/Sumas
    - Methods: In the field, radish plants were treated with the bios at different rates and the numbers of maggots and root damage were collected.
    - Results: Neither damage nor number of maggots were reduced by use of the bio-control agents.

- Next Steps: Is bio-control worth pursuing further for this pest? Maybe with different agents or a different approach with these ones; the results were not promising. This project was part of a larger project that looked at time of planting, trap crops, and pesticide screening (‘hard’ and ‘soft’ chemistries tried).

4. Impact and Management of Aphids on Sweet and Forage Corn
    - Problem: Aphids feed on corn during pollination and potentially impact yield and cob quality. The only insecticide available will be gone by 2006/07.
    - Objective: To determine the impact of aphids on corn yields and to identify potential management products.
    - Location: Fraser Valley
    - Cooperators: SnowCrest Packers, Corn Growers Assn., LMHIA, private consultant, AAFC
    - Methods: Forage and Sweet corn fields were monitored for aphid and bio-control populations throughout the season. Six insecticides were applied and evaluated for efficacy (‘hard’ and ‘soft’ chemistry). Yield and cob quality data were gathered.
    - Results: Sweet corn had more aphids than forage corn, sweeter varieties had more aphids, aphids population peaked at tassling. While pesticides controlled the aphids, yield may not have been significantly affected, but quality may have been; analyses are underway.
    - Next Steps: Continue with pursuit of registration of replacement aphicides. Determine if action thresholds from elsewhere are useful for BC.

5. Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides
    - Problem: Limited knowledge of IPM, pest identification, and pesticide safety in this relatively small and somewhat isolated group of growers.
    - Objective: Identify pest species, determine and increase the level of IPM awareness and uptake, determine pesticide use and knowledge, pest control needs, develop a multilingual pesticide guide.
    - Cooperators: BCMAL, UCFV, growers, private consultant.
    - Location: Fraser Valley

- Methods: Write pesticide guide, one-on-one farm visits to meet the growers, discuss IPM and learn about current pest control practices, monitor fields for pests and bio-control agents.
- Results: Pesticide guide produced, one-on-one farm visits was best approach for education and awareness of IPM approach, compliance related to pesticide was best enforced by retail sales reps and buyers/marketing agencies.
- Next Steps: Continue one-on-one farm visits, develop pictoral guides for pest identification, register new low/reduced toxicity pesticides for Asian vegetables where needed, and teach effective use of the ones already registered.

6. Varroa Mite Control in Honey Bees
   - Problem: Varroa mites feed on bee brood and adults and cause colony weakening and death particularly over the winter. Insecticides are limited and resistance exists to a key product in some regions.
   - Objective: To evaluate acetic acid as a varroa mite control product for honey bees, compared to oxalic acid, a newly registered tool. Acetic acid is easier to handle and apply than oxalic acid, so would be a preferred tool.
   - Cooperators: BCMAL, beekeepers, private contractor.
   - Location: Fraser Valley
   - Methods: Side by side, 20 colonies each of acetic acid and oxalic acid treatments. Applications done this fall, during non-brood period. Colonies will be assessed for mite levels in January.

7. Varroa Mite Eradication Project, Sunshine Coast
   - Problem: Varroa mite is present in this area. Due to the isolated location, small number of growers, and nearly non-existent feral bee population, eradication attempts were initiated in fall 2004.
   - Objective: Survey to determine levels of Varroa mite on the Sunshine Coast after winter chemical treatments and provide information towards an eradication strategy.
   - Cooperators: Sunshine Coast Beekeepers Assn, private contractor, BCMAL
   - Methods & Results: Survey for mites in January, mites were present, so spring pesticide treatments were made, surveyed again, mites still present.
   - Next Steps: Eradication does not appear possible, and a coordinated management approach may be the best path forward.

8. Eastern Filbert Blight Area Wide Management

- Problem: EFB is an industry-limiting disease recently found in BC.
- Objective: Assess the extent of this new disease and evaluate tree removal as a management strategy; attempt to slow the spread of EFB
- Cooperators: Hazelnut Growers Assn., BCMAL, contractor
- Location: Abbotsford area
- Methods: Survey trees for infection. Discussed threat to hazelnut industry with landowners who were receptive and supportive of the project. Infected trees were removed, chipped and composted.
- Results: Disease found in south Abbotsford in 15 out of 115 sites. One commercial orchard in Central Fraser Valley is infected.
- Next Steps: Survey and evaluate sites in 2006

# Research and Innovation in Integrated Pest Management in British Columbia Crops

Tracy Hueppelsheuser

British Columbia Ministry of Agriculture and Lands

# Plant Health Protection

- One-time budget to address plant health issues that are negatively impacting British Columbia crops
- Committee struck to decide how to spend the $$
- Made up of Plant Health, Industry Competitiveness, and Resource Management staff

# Plant health "gaps"

- For growing season 2005, the Committee identified 8 projects across 7 commodities
- Additionally, 6 projects will be run over the winter across 5+ crops
- Weed, insect, disease, and mite problems were addressed

# Plant health “gaps”

- Our BC Crop Profiles and Gaps Analyses were useful documents for helping steer the Committee to areas of need

# Herbicide Screening for Ginseng

- Problem: Lack of herbicides for post-emergent broadleaf weeds in ginseng. Weeds compete with newly planted ginseng, and hand weeding is currently the only option, which is not economical.

- Objective: to screen new herbicides in hopes of finding candidate products for minor use registration

# Herbicide Screening for Ginseng

- Cooperators: The Associated Ginseng Growers of BC, Agriculture and Agri-Food Canada (AAFC), private contractor
- Location: Summerland

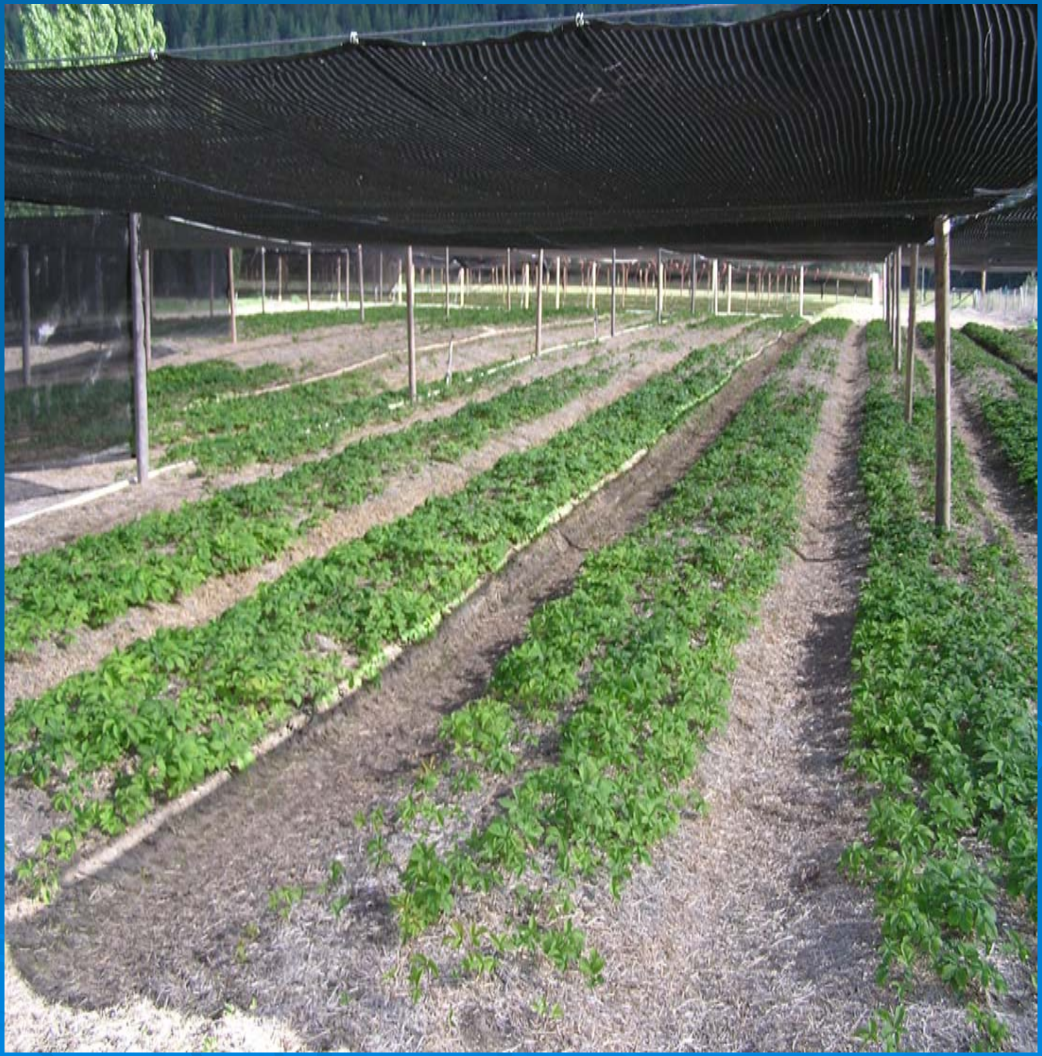
# Herbicide Screening for Ginseng

- Methods: 5 herbicides were tested on young established ginseng plants for efficacy on present weeds and crop tolerance.

- Results: Phenoxy herbicides were the safest on the crop, and controlled the weeds present. Some herbicides significantly damaged ginseng.

# Herbicide Screening for Ginseng

- Next Steps: Screening needs to continue with pre-emergent products as well as other post-emergent products.



# Raspberry Integrated Pest Management

- Problem: insects contaminate machine harvested fruit. There are limited tools to control them. BC's main competitor, USA growers, have adequate tools and their fruit is clean.

- Objective: to develop non-chemical strategies to reduce the problem of contaminants during machine harvesting.

# Raspberry Integrated Pest Management

- Cooperators: B.C. Raspberry Council, BCMAL, AAFC, private consultant, growers, processors

- Location : Fraser Valley

# Raspberry Integrated Pest Management

- Methods: Evaluate and demonstrate Integrated Pest Management techniques to improve control of raspberry fruit contaminants (caterpillars, weevils)

  - Improved pest monitoring practices
  - Use of 'soft' pesticides (ie. spinosad)
  - Use of Bio-control agents (ie. *Trichogramma*)

# Raspberry Integrated Pest Management

- Results:
  - Improved monitoring allowed better timing of application of control tools
  - Spinosad did not adequately control caterpillars
  - *Trichogramma* performed better than conventional insecticides for caterpillar control

# Raspberry Integrated Pest Management

- Next Steps: IPM vs. pre-harvest clean-up sprays

- IPM
  - Year round approach
  - Several tools targeting various life stages of pests
  - No tool is completely effective used alone

- Clean-up spray
  - Broad spectrum insecticide application shortly before harvest
  - High risk timing; only one chance to control several pests
  - Competitors rely on this approach, which is still very effective……

- Raspberry harvester

- Fruit cleaning line

# Biological Control of Cabbage Root Maggot

- Problem: Cabbage root maggot is the most significant pest of rutabagas and other brassicae crops; the larvae tunnel into the roots and stems damaging and killing plants. There is resistance to commonly used insecticides.

- Objective: To evaluate a fungus *(Metarhizium anisopliae)* and a nematode (*Steinernema feltiae*) as infective agents against the larval stages of *Delia radicum* and *D. pratura.*

# Biological Control of Cabbage Root Maggot

- Cooperators: AAFC, BCMAL, Lower Mainland Horticulture Improvement Association (LMHIA)
- Location: Agassiz, Abbotsford/Sumas

# Biological Control of Cabbage Root Maggot

- Methods: In the field, radish plants were treated with the bios at different rates and the numbers of maggots and root damage were collected.

- Results: Neither damage nor number of maggots were reduced by use of the bio-control agents.

# Biological Control of Cabbage Root Maggot

- <u>Next Steps:</u> Is bio-control worth pursuing further for this pest? Maybe with different agents or a different approach with these ones…..

# Biological Control of Cabbage Root Maggot

- Next Steps: This project was part of a larger project that looked at
  - time of planting,
  - trap crops, and
  - pesticide screening, ‘hard’ and ‘soft’ chemistries tried

# Impact and Management of Aphids on Sweet and Forage Corn

- Problem: Aphids feed on corn during pollination and potentially impact yield and cob quality. The only insecticide available will be gone by 2006/07.
- Objective: To determine the impact of aphids on corn yields and to identify potential management products

# Impact and Management of Aphids on Sweet and Forage Corn

- Location: Fraser Valley

- Cooperators: SnowCrest Packers, Corn Growers Assn., LMHIA, private consultant, AAFC

# Impact and Management of Aphids on Sweet and Forage Corn

- Methods:
  - Forage and Sweet corn fields were monitored for aphid and bio-control populations throughout the season,
  - 6 insecticides were applied and evaluated for efficacy (‘hard’ and ‘soft’ chemistry).
  - Yield and cob quality data were gathered

# Impact and Management of Aphids on Sweet and Forage Corn

- Results:
  - Sweet corn had more aphids than forage corn,
  - sweeter varieties had more aphids,
  - aphids population peaked at tassling.
  - While pesticides controlled the aphids, yield may not have been significantly affected, but quality may have been; analyses are underway.

# Impact and Management of Aphids on Sweet and Forage Corn

# Impact and Management of Aphids on Sweet and Forage Corn

- Next Steps:
  - Continue with pursuit of registration of replacement aphicides
  - Determine if action thresholds from elsewhere are useful for BC

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Problem:
  - Limited knowledge of IPM, pest identification, and pesticide safety in this relatively small and somewhat isolated group of growers

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Objective:
  - Identify pest species,
  - Determine and increase the level of IPM awareness and uptake,
  - Determine pesticide use and knowledge,
  - Pest control needs,
  - Develop a multilingual pesticide guide

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Cooperators: BCMAL, UCFV, growers, private consultant.
- Location: Fraser Valley

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Methods:
  - Write pesticide guide
  - one on one farm visits to meet the growers, discuss IPM and learn about current pest control practices
  - Monitor fields for pests and bio-control agents

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Results:
  - guide produced,
  - one on one farm visits was best approach for education and awareness of IPM approach,
  - compliance related to pesticide was best enforced by retail sales reps and buyers/marketing agencies

# Chinese Vegetables: Grower Pest Management Knowledge and Safe Use of Pesticides

- Next Steps:
  - Continue one on one farm visits
  - Develop pictoral guides for pest identification
  - Register new low/reduced toxicity pesticides for Asian vegetables

# Varroa Mite Control in Honey Bees

- Problem:
  - Varroa mites feed on bee brood and adults and cause colony weakening and death particularly over the winter.
  - Insecticides are limited and resistance exists to a key product in some regions.

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Objective:

- To evaluate acetic acid as a  varroa mite control product for honey bees, compared to oxalic acid, a newly registered tool.
- Acetic acid is easier to handle and apply than oxalic acid, so would be a  preferred tool.

# Varroa Mite Control

- Cooperators: BCMAL, beekeepers, private contractor.
- Location: Fraser Valley

# Varroa Mite Control

- Methods:
  - Side by side, 20 colonies each of acetic acid and oxalic acid treatments.
  - Applications done this fall, during non-brood period.
  - Colonies will be assessed for mite levels in January.

# Varroa Mite Eradication Project, Sunshine Coast

- Problem: Varroa mite is present in this area. Due to the isolated location, small number of growers, and nearly non-existent feral bee population, eradication attempts were initiated in fall 2004.

- Objective: Survey to determine levels of Varroa mite on the Sunshine Coast after winter chemical treatments and provide information towards an eradication strategy.

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# Eastern Filbert Blight Area Wide Management

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- Location: Abbotsford area

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- Methods:
  - Survey trees for infection,
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  - Infected trees were removed, chipped and composted.

# Eastern Filbert Blight Area Wide Management

- Results:
  - disease found in south Abbotsford in 15 out of 115 sites
  - One commercial orchard in Central Fraser Valley is infected.
- Next Steps:
  - Survey and evaluate sites in 2006

## Management of European Chafer and Other Landscape Pests

**Bob Costello**, BC Ministry of Agriculture and Lands

Abstract

European Chafer, Rhizotrogus majalis, a pest of turf, was first found in New Westminister but has now spread to Burnaby, Vancouver, and possibly Coquitlam. Both primary damage, caused by the grubs, and secondary damage caused by animals and birds feeding on the grubs, is important.

Management of European Chafer combines cultural, biological, and chemical controls. Healthy turf can tolerate higher grub populations than poorly maintained turf. Nematodes can be used under certain conditions to control European chafers. Chemical control can be achieved with a systemic product (imidicloprid) or a contact insecticide (carbaryl).

Other pests discussed briefly are leatherjackets, European cutworm, and viburnum leaf beetle.

# Management of European Chafer and Other Landscape Pests

Presented to the

2005 EC PYR Pesticide Information Exchange

Bob Costello

B.C. Ministry of Agriculture and Lands

# European Chafer
## Rhizotrogus majalis

- This pest has been established in Ontario and Quebec for several years but was first found in B.C. in 2001, in New Westminster.
- European Chafer quickly spread into Burnaby, and in 2004 it was found in Vancouver. In 2005 it was reported in Coquitlam.

# Life stages and identification


# European Chafer damage

# My lawn

# Management

- Regulatory Control
- Cultural control
- Biological control
- Chemical control

# Regulatory control

- Federal quarantines discontinued.
- There are no provincial regulations.
- Some municipalities have developed policies regarding movement of sod and soil.

# Cultural control

- Keep turf healthy and vigorous by aeration, de-thatching, fertilizing, deep watering, and high mowing.
- This will help lawns tolerate infestations and show less damage symptoms.
- Consider grass replacement such as mulch or paving stones, or use alternate ground covers.
- Chafer survival is lower in regularly irrigated turf.

# Biological Control

- Birds and animals reduce grub numbers.
- There does not seem to be significant predation or parasitism by other insects.
- Commercially available insect-parasitic nematodes have been found to provide some chafer control.

# Nematodes for European Chafer control

- *Heterorhabditis bacteriophora*
- Applied against 1st and 2nd instar grubs, ideally during the 3rd week of July.
- Water lawn for 3 hours before and 3 hours after application. Apply in the evening or on a cloudy day.
- Apply at a rate of 100 million/140 $m^2$ of turf.
- Cost:  $140.00 retail for 100,000,000 nematodes.

## WHITE GRUBS IN YOUR LAWN?

PROTECT YOUR GRASS FROM ATTACK WITH

# TERRANEM™

BENEFICIAL NEMATODES

**EFFECTIVE, ALL NATURAL!**
Beneficial nematodes are nature's way of effectively controlling the larvae stage (white grubs) of the Common Chafer, European Chafer, Japanese Beetle plus May and June beetles.

**SAFE FOR PEOPLE and PETS!**
Beneficial nematodes are a safe and sensible way to reduce white grub infestations and eliminate damage to your lawn. TERRANEM™ does not contain any chemical pesticides.

**HARMLESS TO PLANTS AND OTHER BENEFICIAL INSECTS!**
TERRANEM™ controls many soil dwelling pest insects without harming valuable plants, beneficial insects and earthworms.

**EASY TO APPLY!**
You can apply beneficial nematodes with a hose end sprayer, tank sprayer or even a watering can. Complete application instructions are included in every package.

**EXCELLENT COVERAGE!**
TERRANEM™ is available in packages of 6, 50, and 500 million nematodes. The 50 million size is adequate for areas of up to 3000 square feet (300 square meters), depending on the level of infestation.

TERRANEM™ is a product of Koppert Biological Systems, the world leader in biological control of insect pests in horticulture. TERRANEM™ is available at better garden centres. Read the instructions on the package insert before using.

Koppert Canada Limited, Scarborough, ON M1X1G4

Web: www.koppertonline.ca

# Chemical Control
## Directed against the grubs

- Commercial applicators use imidicloprid (Merit granular and Merit liquid).
- Imidicloprid is applied and soaked into the turf during the egg laying period (last 2 weeks of July). It is systemic and is taken up by the roots. The newly hatched 1$^{st}$ instar grubs feed on the roots and are killed.
- Imidicloprid is restricted by the label to be applied during July.

# Chemical Control

<u>Home Owner do-it-yourself;</u>

- GrubOut: contains carbaryl, acts as a contact insecticide.
- GrubOut can be used effectively from late July until late October.
- GrubOut must be applied with a high volume of water and then watered in.
- Cost: $40.00 for 140 $m^2$ of turf.

# Carbaryl for do-it-yourself control by home owners

# Leatherjacket life stages


# *European Marsh Cranefly*

## *Tipula paludosa*

- Leatherjacket problems have lessened in recent years, probably due to the effect of natural enemies. However there are still localized out-breaks requiring control measures.
- There are no registered Domestic products for leatherjacket control. Commercial applicators can use a carbaryl-based product.
- Nematodes have been found to be unreliable.

# European cutworm
## *Noctua pronuba*

# European cutworm
## (large yellow underwing)

- Native to Europe, first found in North America in Halifax in 1979, and has spread throughout eastern North America
- Identified in B.C. in 2004.
- Feeds mainly on grasses, but also a variety of herbacious plants.
- Pest potential of this insect is unknown, but could be troublesome as it has few natural enemies in B.C.

# Viburnum leaf beetle

- 

# Viburnum Leaf Beetle management

- Success (spinosad) will control both larvae and adults, but has little residual activity.
- Sprays applied to control other insect pests (aphids, weevils) will usually control VLB.
- Removal of overwintering eggs by pruning will reduce pest numbers for the next year.
- When planting viburnum, try to select the less susceptible species (*V. dentatum*, *V. lantana*, *V. trilobum*).

# Other Common Landscape Pests

- Mites
- Weevils
- Aphids
- Borers
- Caterpillars
- Whitefly
- Scales




# City of Burnaby: Ecological/Sustainable Approach to West Nile Virus Mosquito Management

**Dipak Dattani and Yota Hatziantoniou**, Engineering Department, City of Burnaby, 4949 Canada Way, Burnaby, BC V5G 1M2

Abstract

Since 2003, the City of Burnaby has undertaken an integrated pest management approach to reduce the production of West Nile virus (WNv) vector mosquitoes on City of Burnaby public lands, including surface waters and catch basins (CBs) located in parks and on road right-of-ways.

The City has been particularly active in identifying and mapping mosquito producing areas, and in developing partnerships that have facilitated the mapping of such areas in adjacent jurisdictions. The identification and mapping of mosquito producing areas is necessary in order to ensure due diligence, accountability, data-sharing and informed decision-making by local jurisdictions.

The City of Burnaby has been involved in the following activities to-date:

- 2003
  - Surface water monitoring and mapping
- 2004
  - Public education and awareness
  - Continued surface water monitoring & mapping
  - Surface water treatment
  - Catch basin monitoring
  - Burnaby & GVRD mapping system development
- 2005
  - Expanded surface water and CB monitoring
  - Surface water and CB treatment
  - Burnaby and GVRD mapping systems implementation
  - Partnership with Burnaby School District for CB mapping
  - Strategic use of ecological treatment methods

Since 2004, the City has undertaken the treatment of vector mosquitoes in advance of WNv being detected the region, as per the recommendations of the Fraser Health Authority. To this end, the City has made selective use of the most ecological mosquito control methods, including application of the biological control agents *Bacillus thuringiensis israelensis* and *Bacillus sphaericus* in surface waters and catch basins, respectively. In 2005, the City has also undertaken the use of native fish in an enclosed pond, and the planting of willow stakes along a major roadside ditch. In 2006, additional surveillance and mapping of mosquito producing areas will continue to inform the City's sustainable approach to WNv mosquito control.

# City of Burnaby:

## Ecological/Sustainable Approach to WNv Mosquito Management

2005 Pesticide Information Exchange

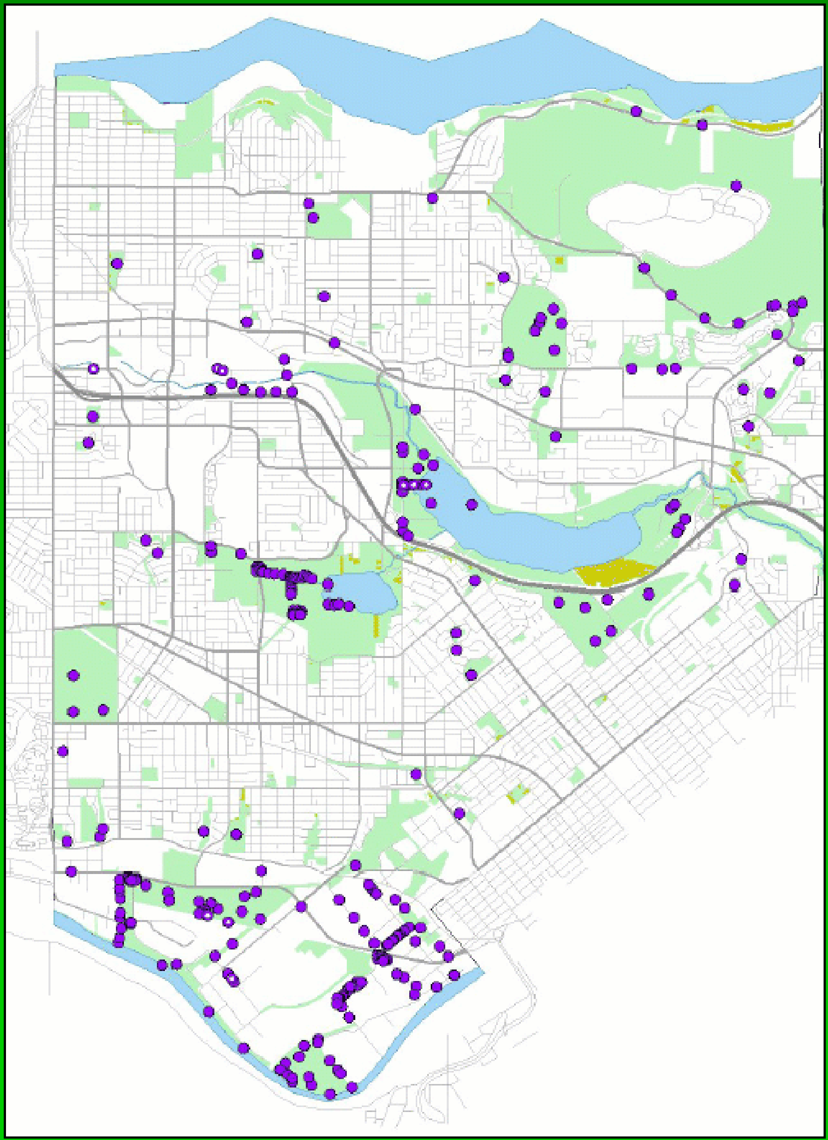
November 22, 2005

# Overview

- 2003:
  - Surface water monitoring & mapping
- 2004:
  - Education and awareness
  - Surface water treatment
  - Catch basin monitoring
  - Burnaby & GVRD mapping system creation
- 2005:
  - Expanded surface water & CB monitoring
  - Surface water & CB treatment
  - Mapping systems on-line
  - Partnership with Burnaby School District
  - Strategic use of ecological approaches

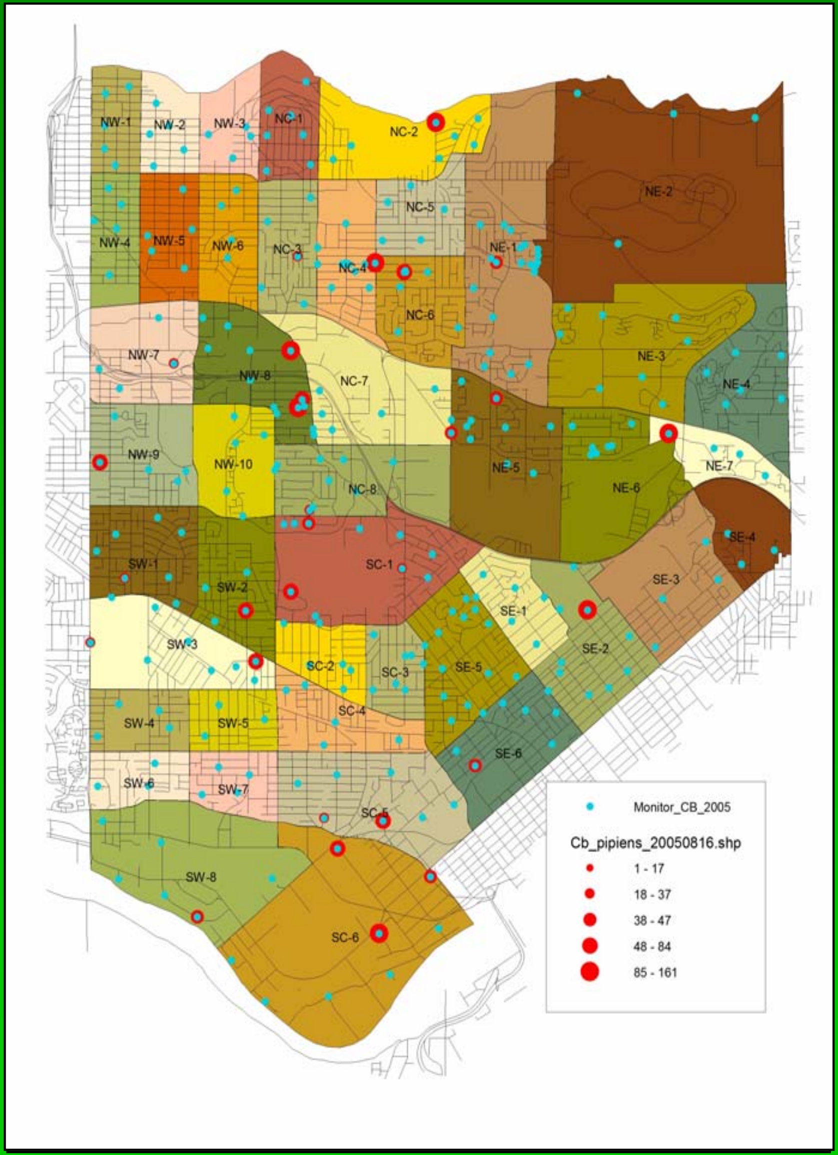
# Surface Waters Monitored for WNv Mosquitoes (2005)

- Total # SW sites: 289
- Method: Dip method
- Schedule: Every 2 weeks
- Jun 26 – Sep 18
- Peak Activity: Jul 24 (30)
- Main species: *Cx pipiens*
- Treatment start: Jul 13 (28)
- Treatment type: *Bti*
- Total area treated: 3.5 ha



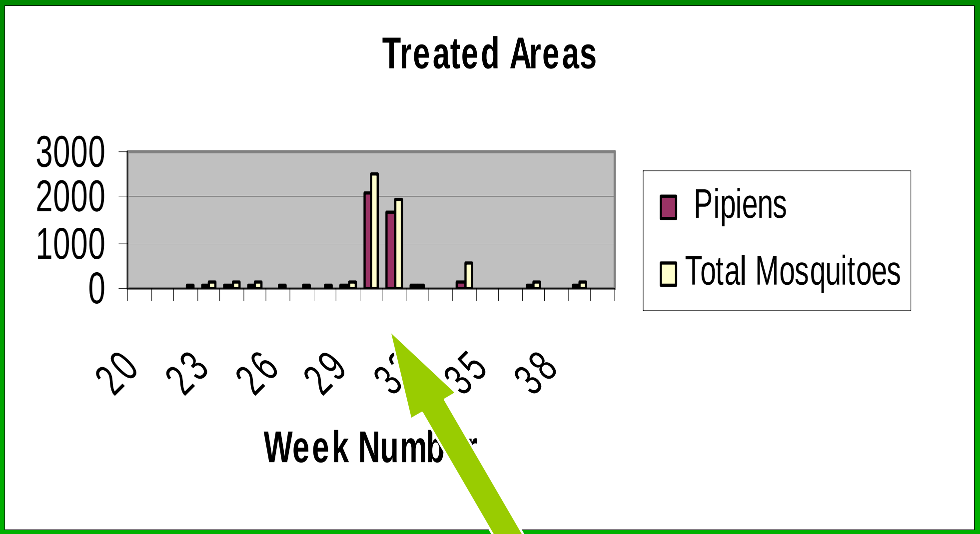
# CBs Monitored for WNv Mosquitoes (2005)

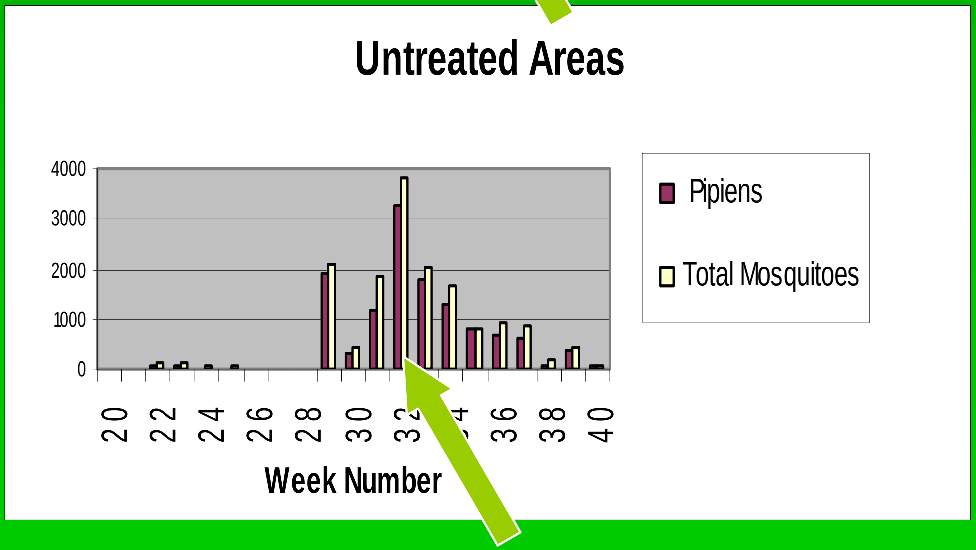
- Total # CB sites: 90/302
- Method: 20 sec sweep
- Schedule: Every 2 weeks
- Jul 17 - Oct 2
- Peak Activity: Aug 7 (32)
- Main species: *Cx pipiens*
- Treatment start: Aug 7 (32)
- Treatment type: *Bsp*
- Total # treated: 959 CBs



# Treated vs Untreated CBs

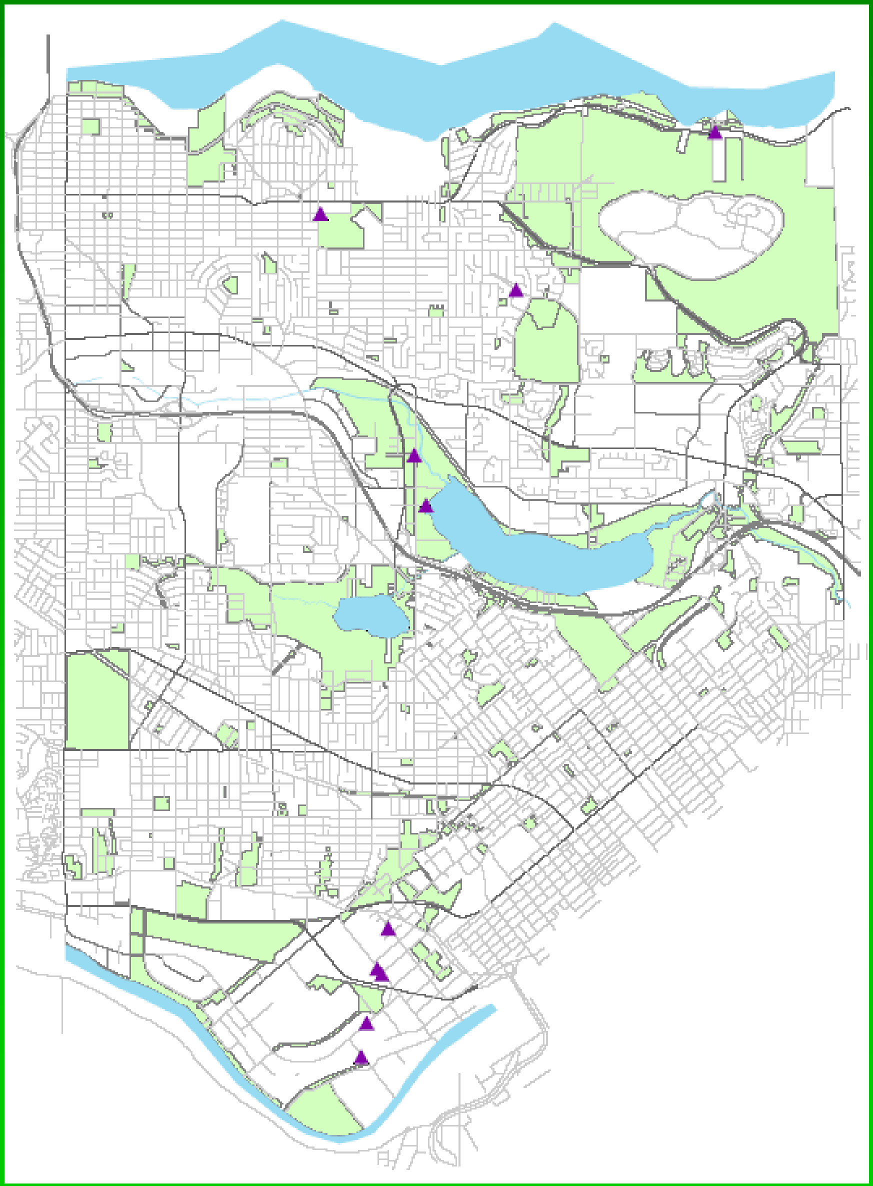
- All treatments conducted during weeks 31-33
- Treatments effective until week 40 +



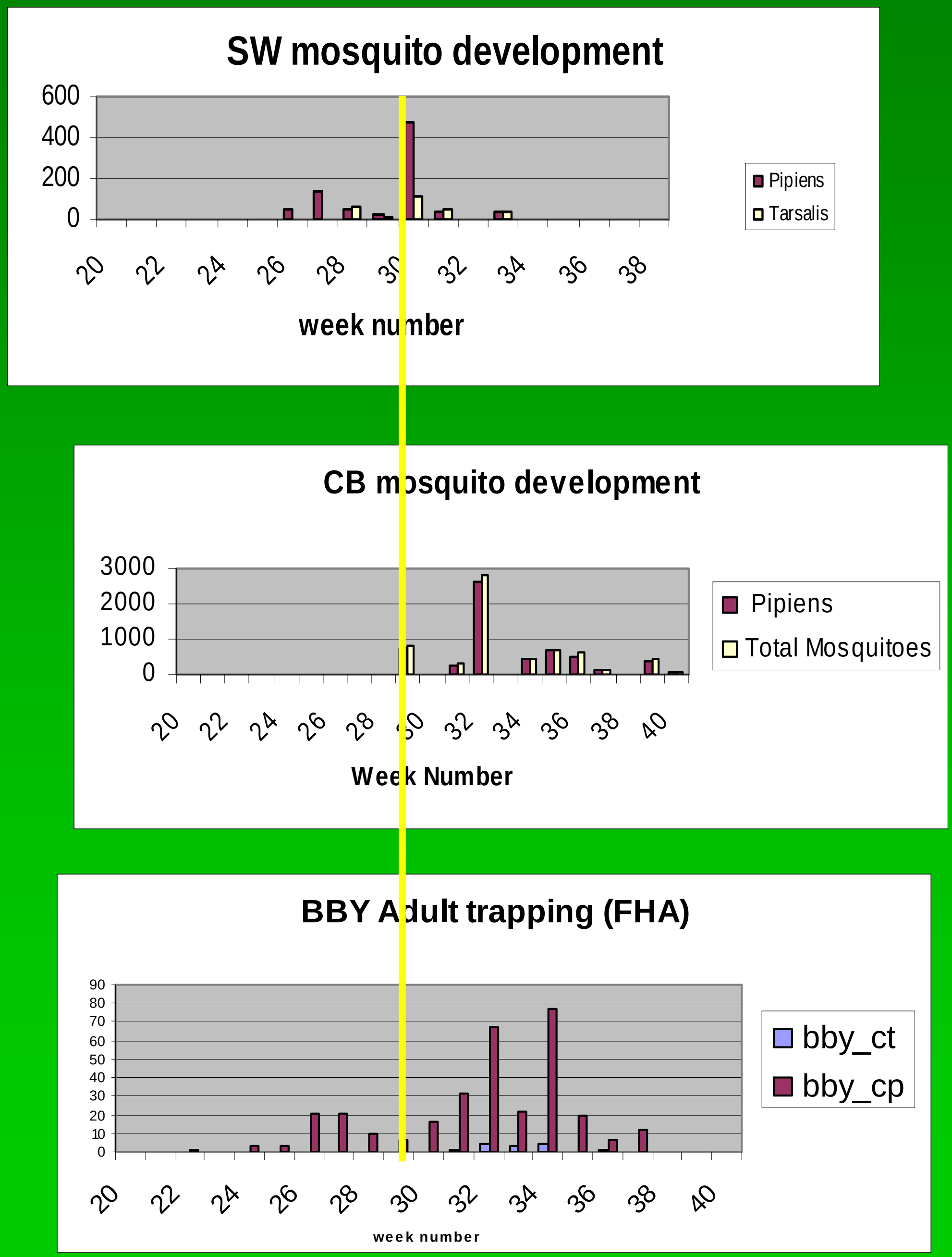
# Adult Traps Monitored for WNv Mosquitoes (2005)

- CDC light traps with $CO_2$
- FHA – 4 traps
- MBL – 10 traps
- 2 week lag b/w timing of adult and larval pop'ns
- Rapid decline in catches end of Aug (35)
- Higher numbers of *Cx pip* relative to *Cx tarsalis*



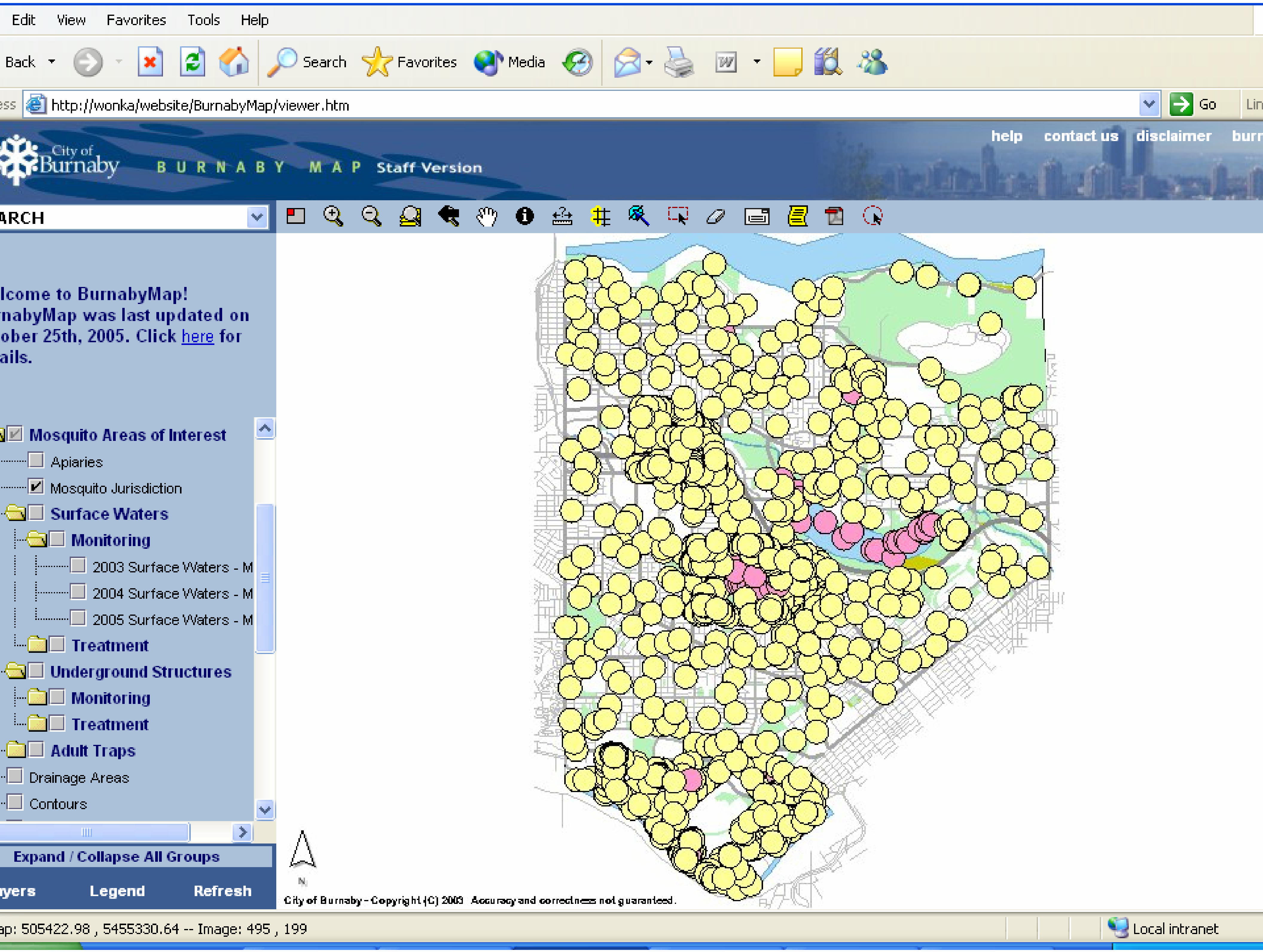
# Predictive Peaks?

- Continued increase in *Cx. pipiens* after surface water treatments began.
- CB activity remained high relative to surface water



# Data Collection & Mapping

- Burnaby Web Map
  - Intranet (staff)
  - Extranet (public)
- Partnerships for enhanced mapping
  - Burnaby School District CB mapping
  - GVRD WNv Mapping System



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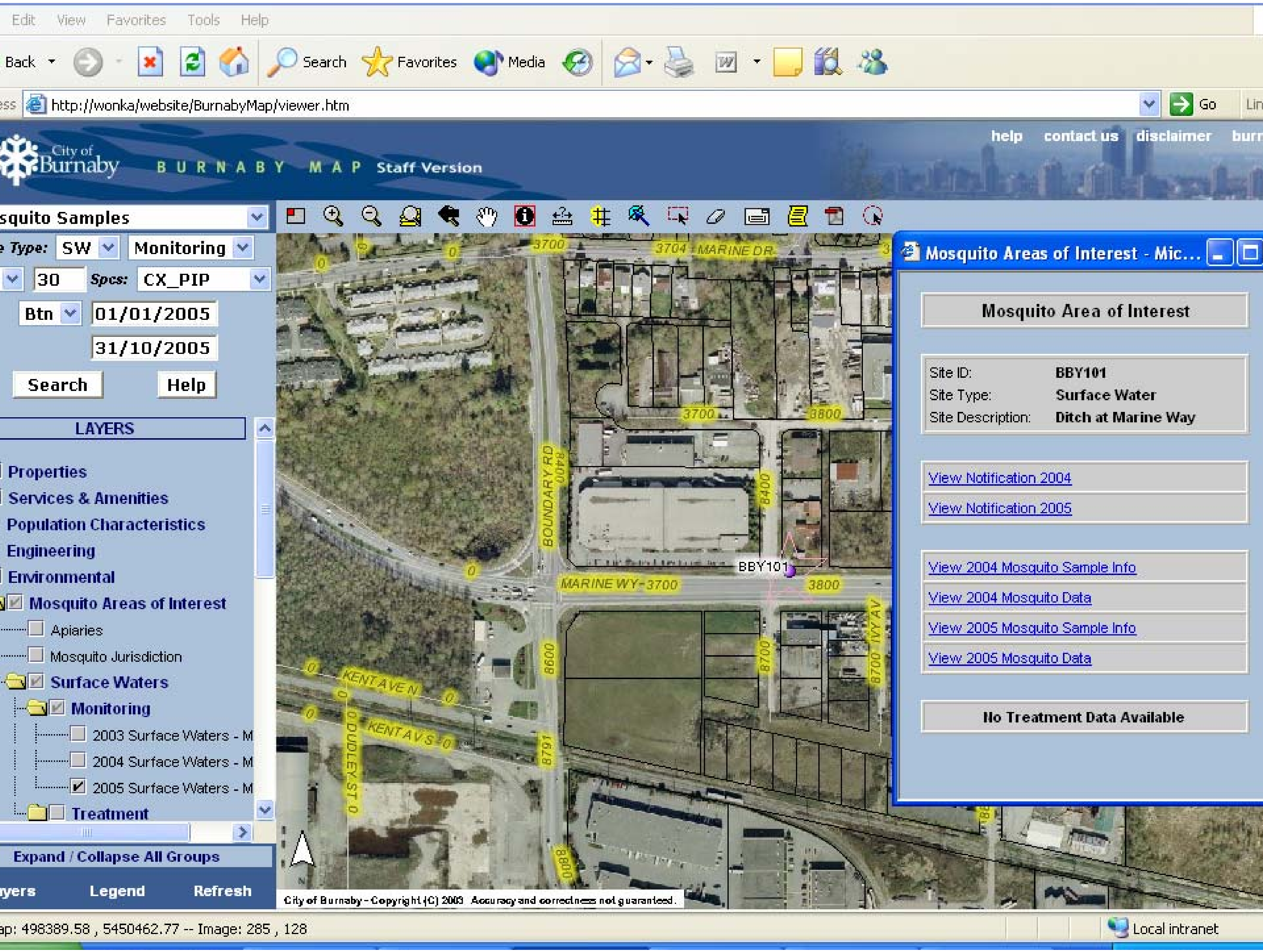

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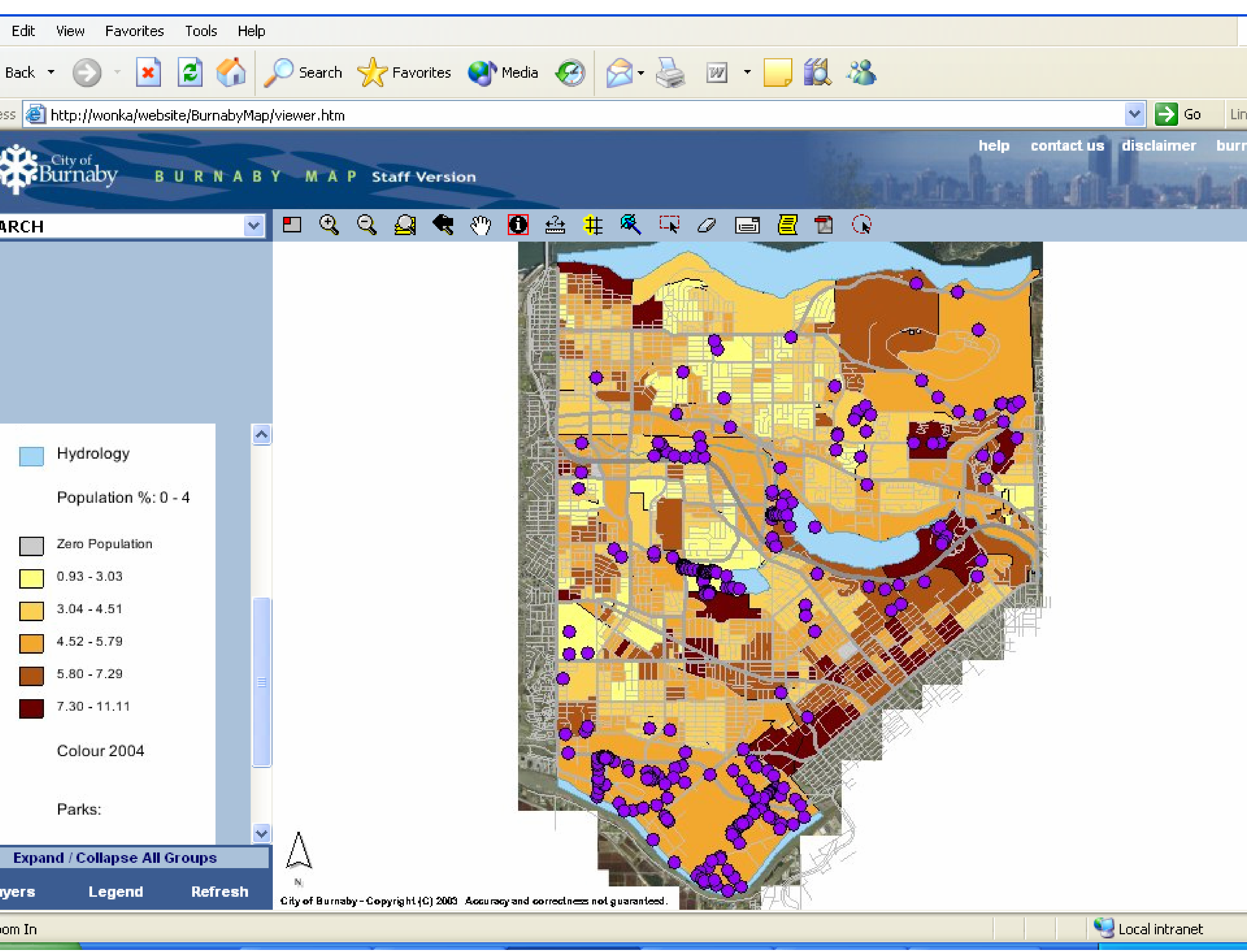
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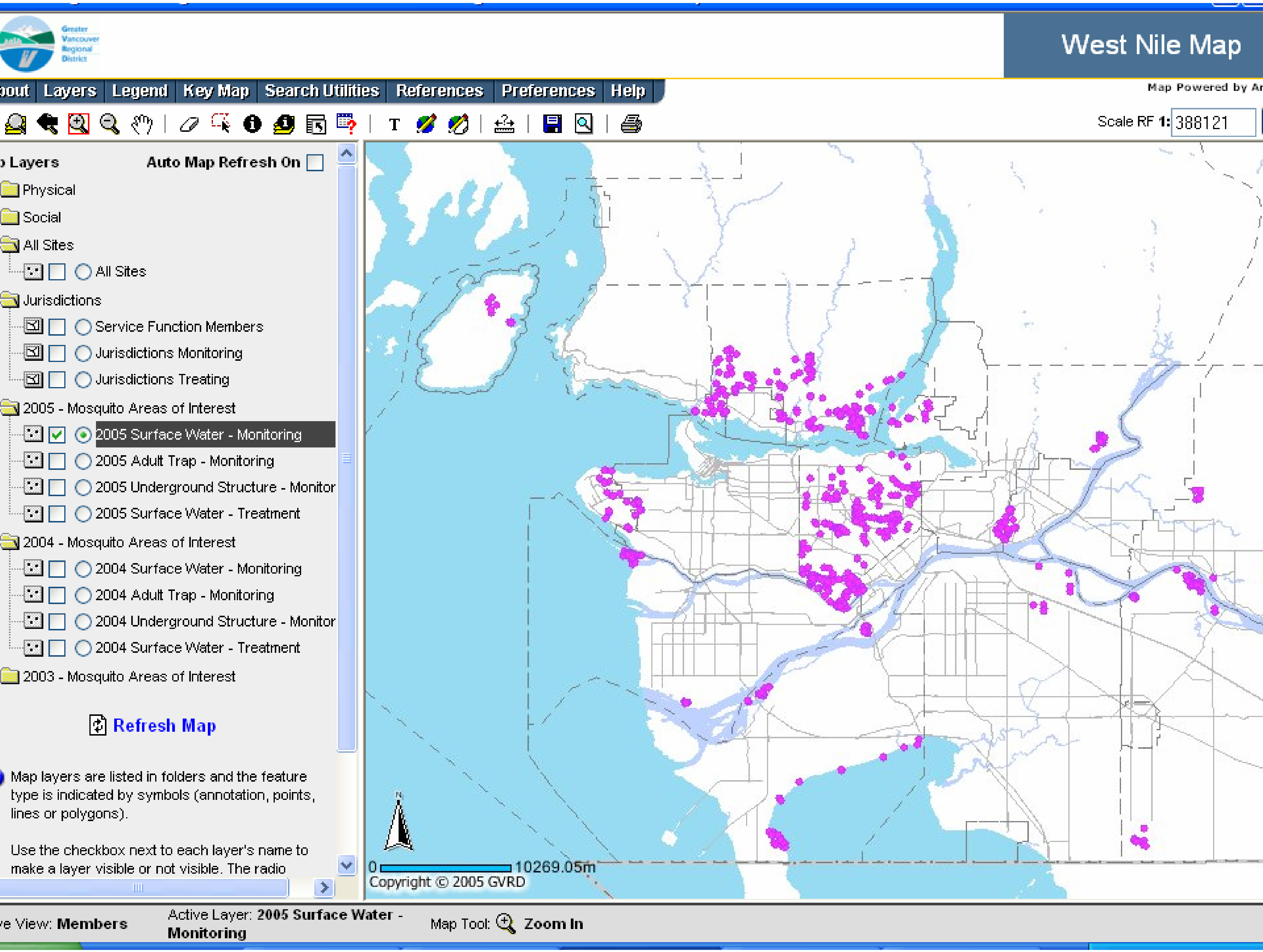

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2003 - Mosquito Areas of Interest
Refresh Map
Map layers are listed in folders and the feature type is indicated by symbols (annotation, points, lines or polygons).
Use the checkbox next to each layer's name to make a layer visible or not visible. The radio
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ve View: Members
Active Layer: 2005 Surface Water - Monitoring
Map Tool: Zoom In

# Ecological Approaches

- Fish stocking of enclosed pond
  - Stickleback in Glenlyon Pond east
- Planting along exposed ditch
  - Willow stakes along Thomas St ditch
- Efficacy may become apparent over 1+ seasons

# Glenlyon Pkwy East Pond

# Thomas St. Ditch Planting

# Questions?

## Pesticides in Nathan Creek, British Columbia

**Vesna Furtula, George Derksen*, Randy Englar**, Pacific Environmental Science Centre, Science and Technology Branch, Environment Canada

* Environmental Stewardship Branch, Environment Canada

Abstract

Nathan Creek Watershed is located in the City of Abbotsford within the Fraser Valley, BC. It is the dominant watershed (3400 hectares) of theWest Matsqui region and drains approximately 60% of the area. The agricultural landuse in the West Matsqui region is quite diverse and includes pasture and forage grass, blue berries, raspberries, strawberries, nursery and other crops. Nathan Creek is prime salmon (coho, chum) and trout (cutthroat) habitat so water quality is of a great importance.

Based on Agriculture Census data, there was an estimated nutrient surplus of 174 kg-N per cropped hectare for small and large farms combined in the West Matsqui region, using the Brisbin model. The number of poultry (chickens) has increased form ~1,.6 million in 1991 to ~2.0 million in 2001. This project originated as an assessment of stream nutrient levels to determine whether they reflected the high nutrient surplus estimated by the model for the watershed.

For locations with high nutrient levels screening of organic contaminants was conducted using gas chromatography/mass spectrometry identification methodology (GCMSId). Acquired data were than processed using Automated Mass Spectrometry Deconvolution Software (AMDIS) capable of screening 567 pesticides. Conformation and quantification of detected pesticides was done by OP/NP GC/MS SIM method. The pesticides profile detected correlates with pesticides used on crops covered in the West Matsqui Region.

## Pesticides in Nathan Creek, British Columbia

**Vesna Furtula, George Derksen*, Randy Englar**, Pacific Environmental Science Centre, Science and Technology Branch, Environment Canada

* Environmental Stewardship Branch, Environment Canada

**Power Point presentation slides are not available.**

## Impacts of Pesticide Use on Air Quality in Prince Edward Island

**Bill Ernst, Christine Garron, and Clair Murphy**, Environment Canada, Atlantic Region

Abstract

Potato agriculture is heavily dependant upon the use of pesticides, with up to 18 applications occurring on a single crop within one growing season. Concerns are raised by the public each year on the potential for impact on air quality by this intensive pesticide use and data on which to make good risk assessments for wildlife and humans are not generally available. For the past three years, Environment Canada has measured pesticides in air in order to quantify exposure levels. The air studies have two components: long duration (1 week) measurement of a suite of commonly used pesticides in ambient air and precipitation of agricultural communities; and short duration (1 hr) measurements in the immediate vicinity of potato fields during spraying. The one week sampling of ambient air indicates low concentrations of a range of pesticides, with the highest levels being for those pesticides (chlorothalonil and endosulfan) used locally. The short duration sampling near fields during spraying indicates higher concentrations of chlorothalonil than previously reported in the literature however they are less than available guidelines from other jurisdictions. The pesticide concentrations in air diminish rapidly with time and distance from the field.

Because Canada currently does not have acceptable human health or wildlife benchmarks for pesticides in ambient air, as part of the National Agri-Environmental Standards Initiative, efforts are underway by Environment Canada to establish a method for setting such standards. In addition, in an effort to assist the agricultural community in reducing the amounts of pesticides released to air, standards are being developed for meteorological conditions that should guide spray application decisions. The results of those efforts to date are presented.

# IMPACTS OF PESTICIDE USE ON AIR QUALITY IN PRINCE EDWARD ISLAND

B. Ernst, C. Garron, C. Murphy

ENVIRONMENT CANADA
ATLANTIC REGION

# Context

- Application of pesticides in the potato agriculture sector represents the most intensive use of pesticides (in terms of kg active ingredient per ha) in Canada
- Pesticides are used to prevent disease; increase production; increase shelf lifeand to meet crop insurance requirements
- Potential for impact of pesticide use on air quality in PEI has been has subject of public interest for several years
- Need for better understanding of potential air quality impacts on environmental and human health due to pesticide use

# Background

- Numerous potato pesticide drift & deposit studies conducted in PEI during 1980's and 1990's
- Pesticides measured in precipitation since 1980's in the Atlantic Region
- Near field air pesticides studies initiated in 1998
- Pesticide spray advisory pilot project conducted in 2000 and 2001
- Increased Federal and Provincial long-term funding for research and monitoring obtained in 2003

# Commonly used pesticides in PEI

- Chlorothalonil
- Endosulfan
- Metalaxyl
- Carbofuran
- Mancozeb
- Metribuzin
- Methamidophos

# Current Pesticides in Air Projects

**PESTICIDE SCIENCE FUND (PSF) RESEARCH AND MONITIORING ACTIVITIES**

1. Long duration (1 week) sampling of commonly used pesticides in air and precipitation in agricultural areas
2. Short duration (1 hour) sampling in immediate vicinity of spray applications

**NATIONAL AGRI-ENVIRONMENTAL STANDARDS INITIATIVE (NAESI) ACTIVITIES**

1. Method development for ambient air quality standards
2. Development of meteorological standards for pesticide application

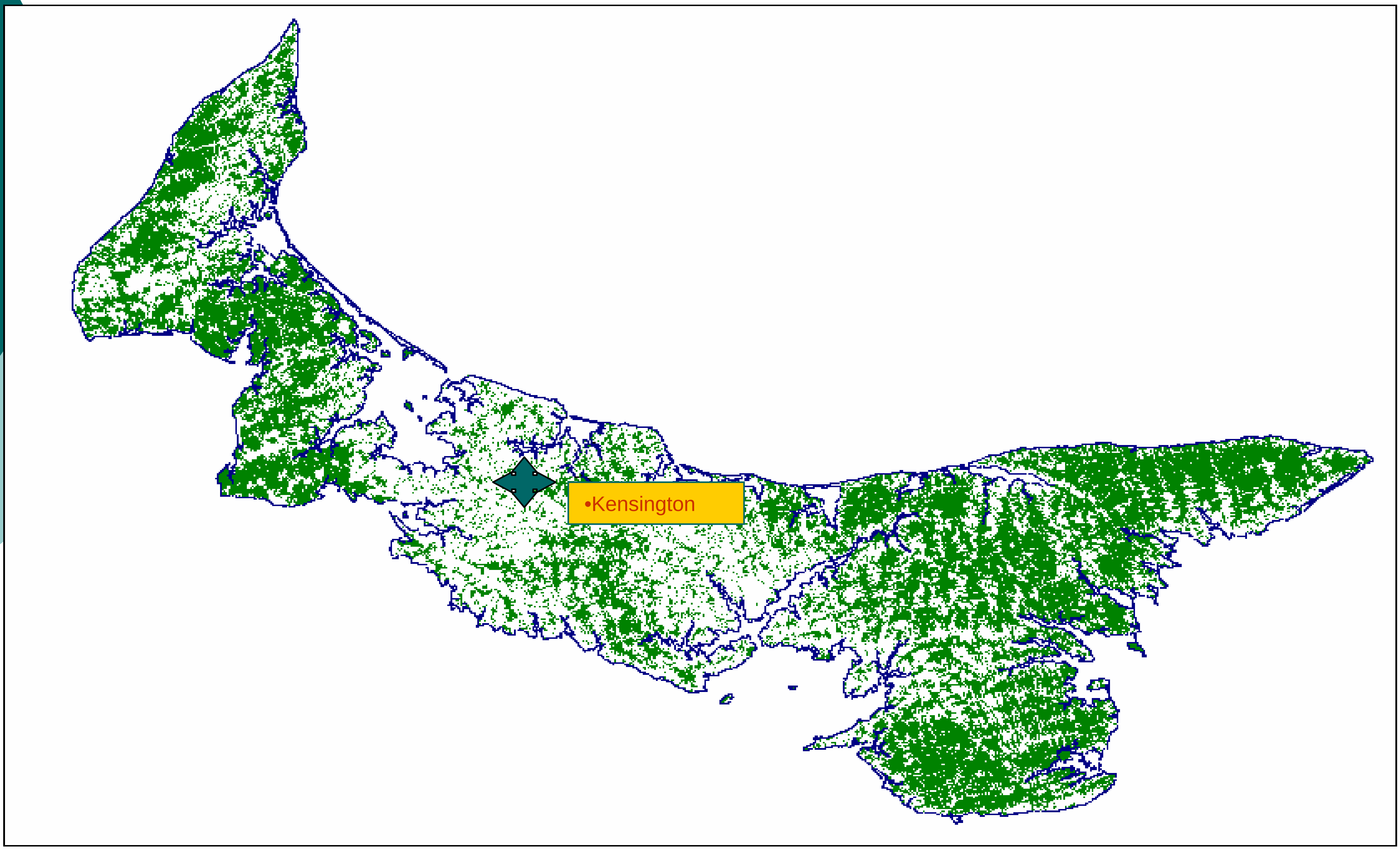
# 1. Long duration sampling

- National program measuring commonly used pesticides (CUP) in ambient air of agricultural areas
- Sites established in Quebec, Ontario, Saskatchewan, British Columbia and PEI (Kensington)
- Three year program began in 2003
- Generates information on ambient exposure for risk assessments

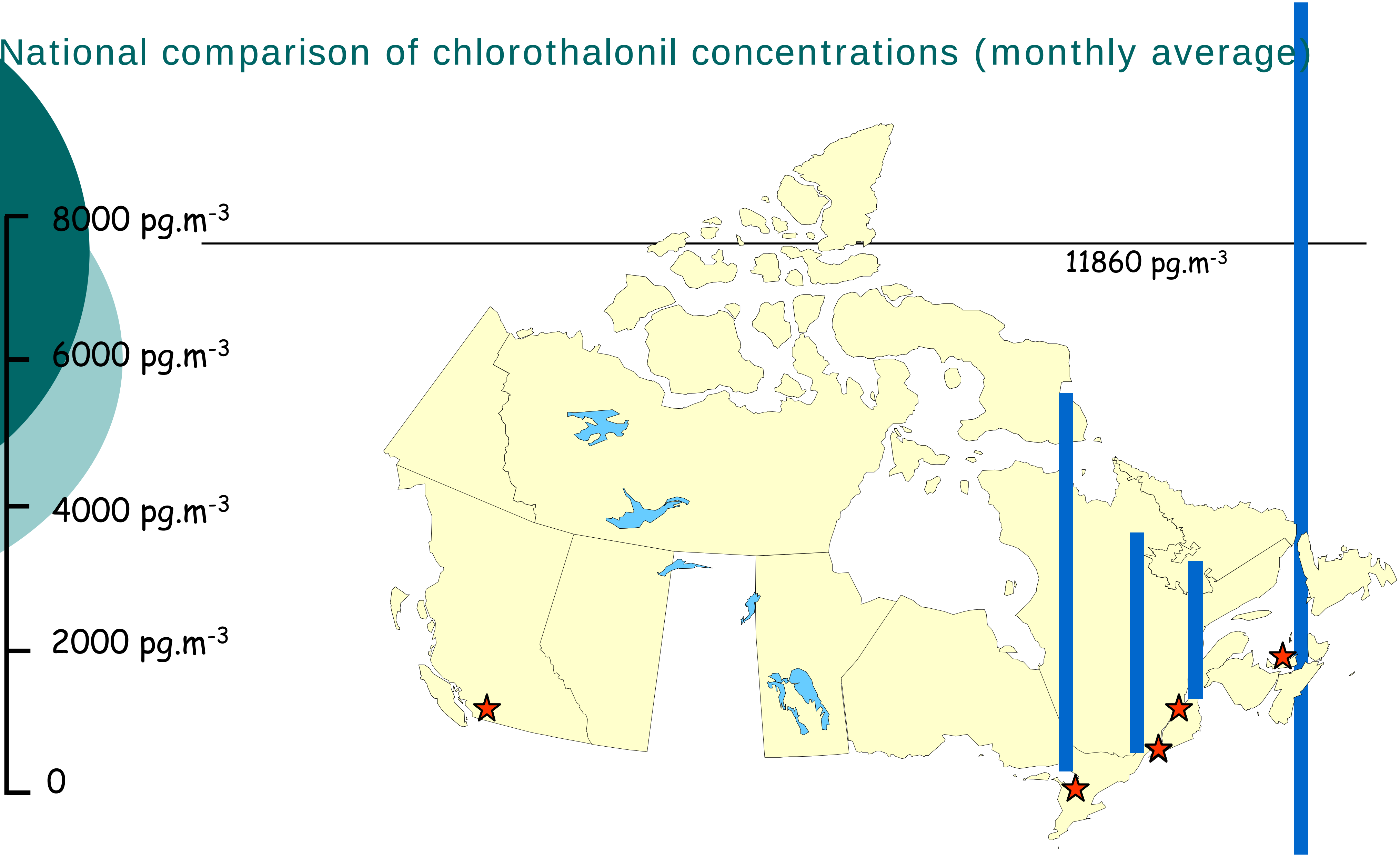
# Study design

- Weekly sampling during potato growing season
- High Volume samplers (Hi-vols); passive samplers and precipitation samplers
- Suite of pesticides analyzed at each site varies, but reflects those commonly used in respective areas

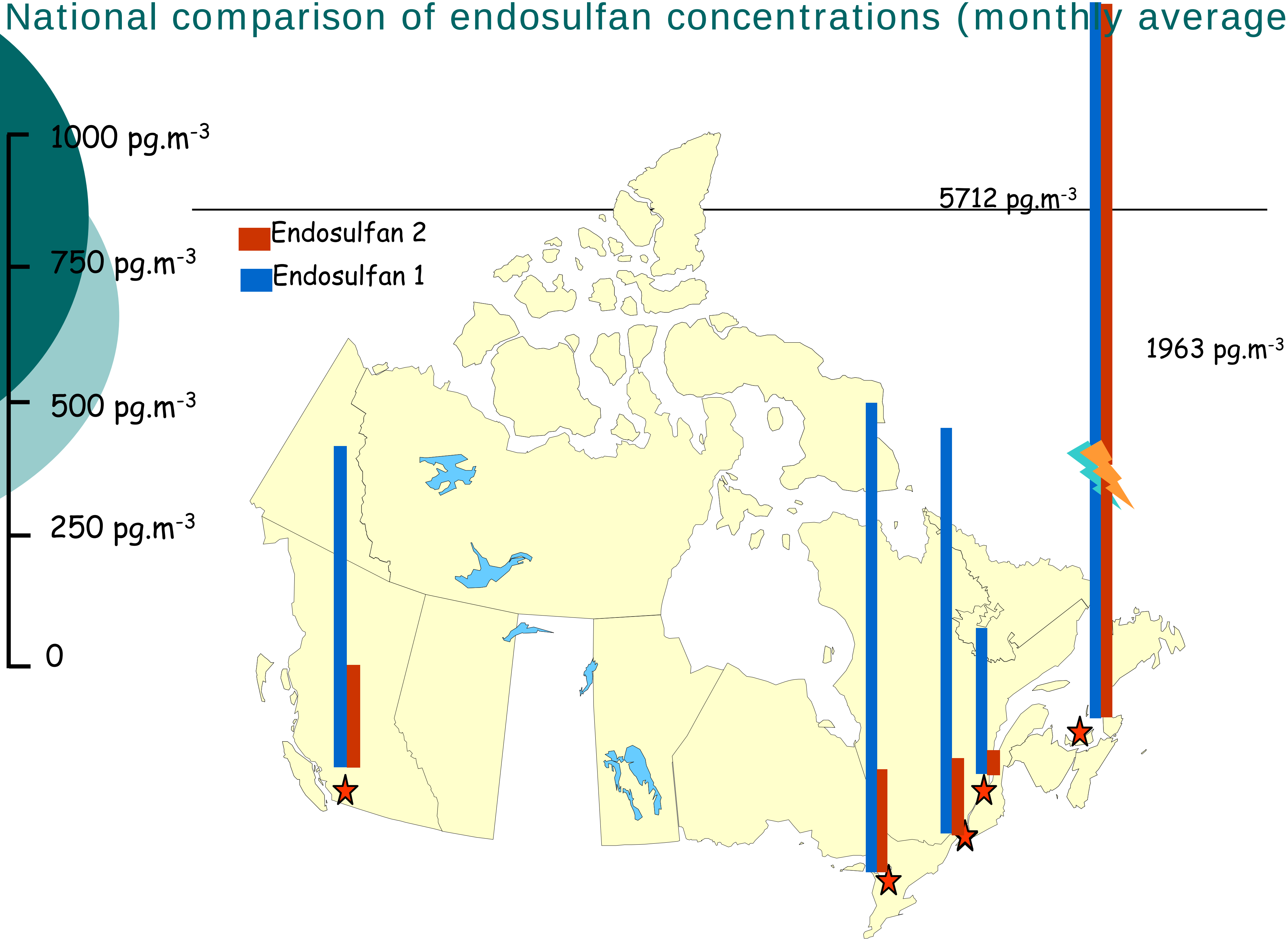
# PEI sampling location



# National comparison of chlorothalonil concentrations (monthly average)



# National comparison of endosulfan concentrations (monthly average)



# Summary

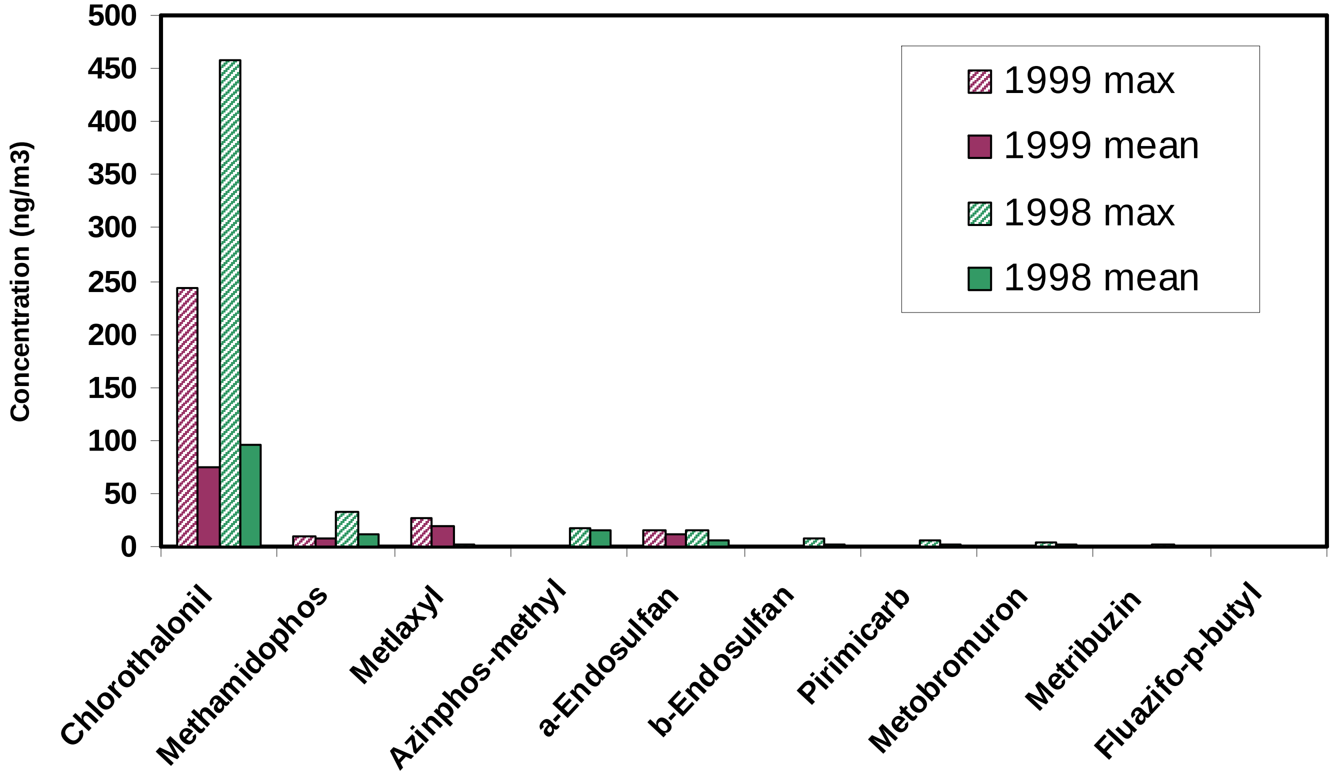
- Measurable concentrations of several CUPs detected in Hi-vol samples in both 2003 and 2004 – all below available guidelines
- No pesticides detected in passive sampler in 2003, but five CUPs detected in 2004
- Chlorothalonil detected in rainwater in 2003, but not in 2004

# 2. Short duration sampling

- Conducted at various PEI potato-growing locations
- Measurement of near field concentrations of specific pesticides in air during and immediately after spraying
- To determine near real time exposures for wildlife and human health risk assessments

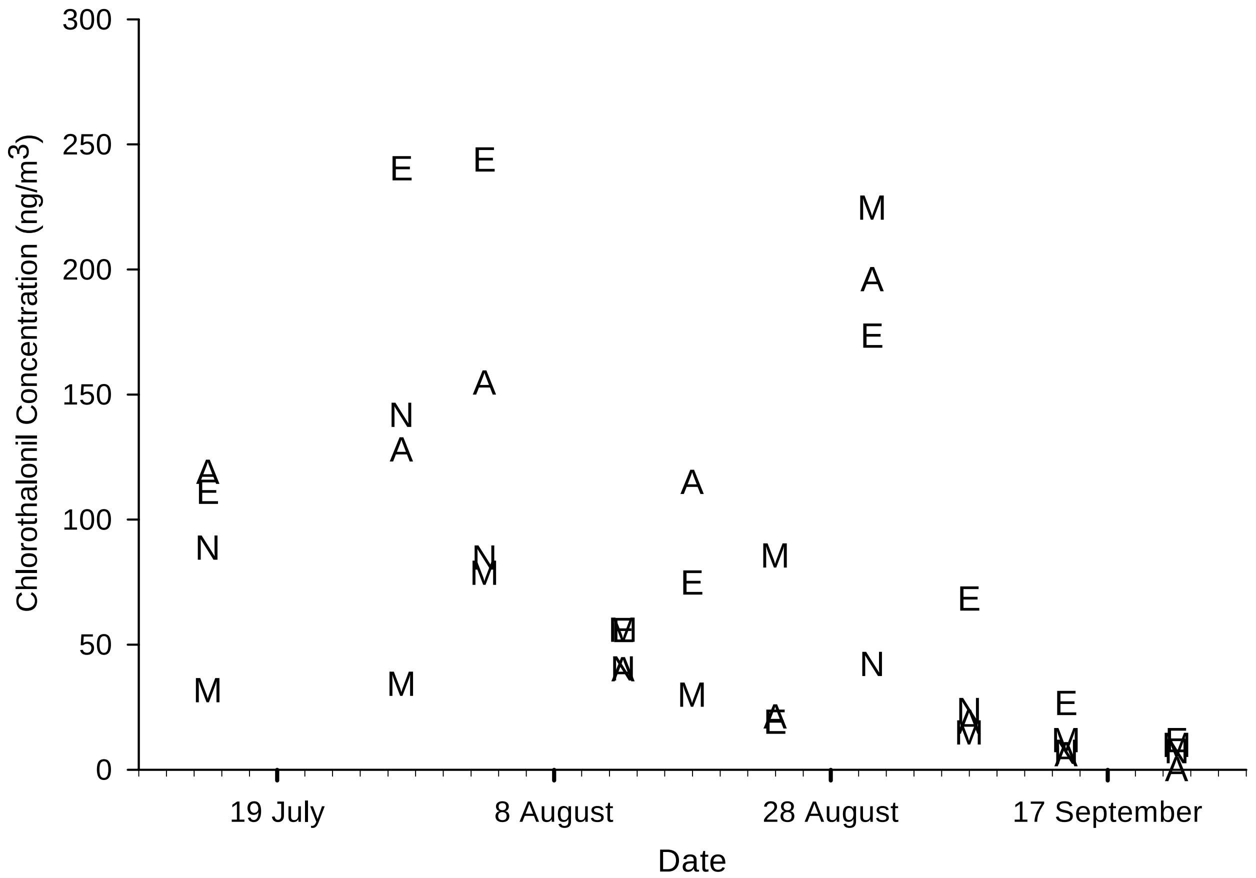
# Previous PEIStudies

**Concentrations (max and means) of pesticides detected in agricultural areas (1998 and 1999)**



# Previous PEI Studies

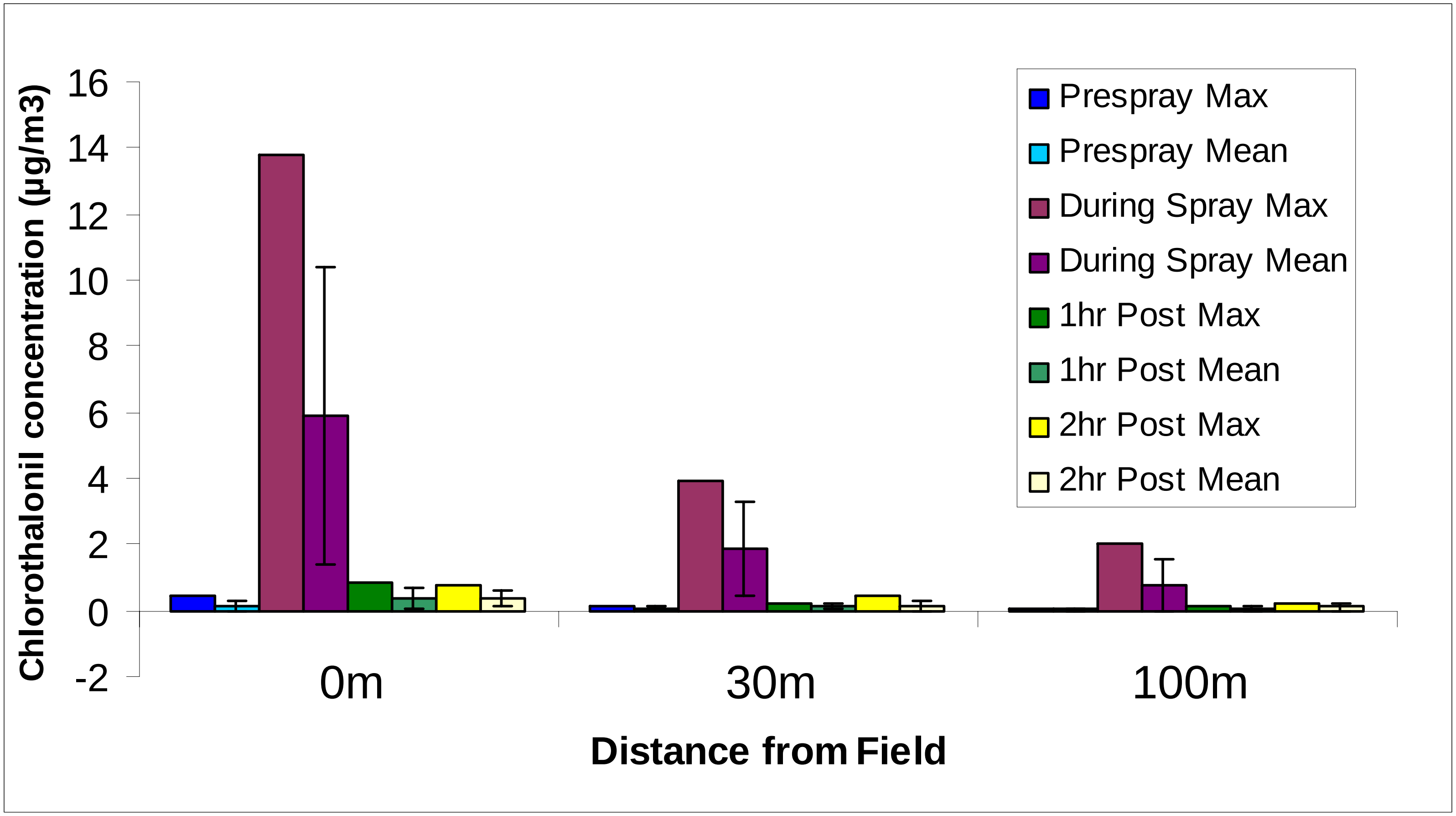
## Chlorothalonil air concentrations (1999) at different times of day (M = morning; A = afternoon; E = evening; and N = overnight)



# Current Study design

- Samples collected using Hi-vols at various distances and times post-spray downwind of potato fields
- Coarse particles (>2.5µm and >10µm) separated from finer aerosols

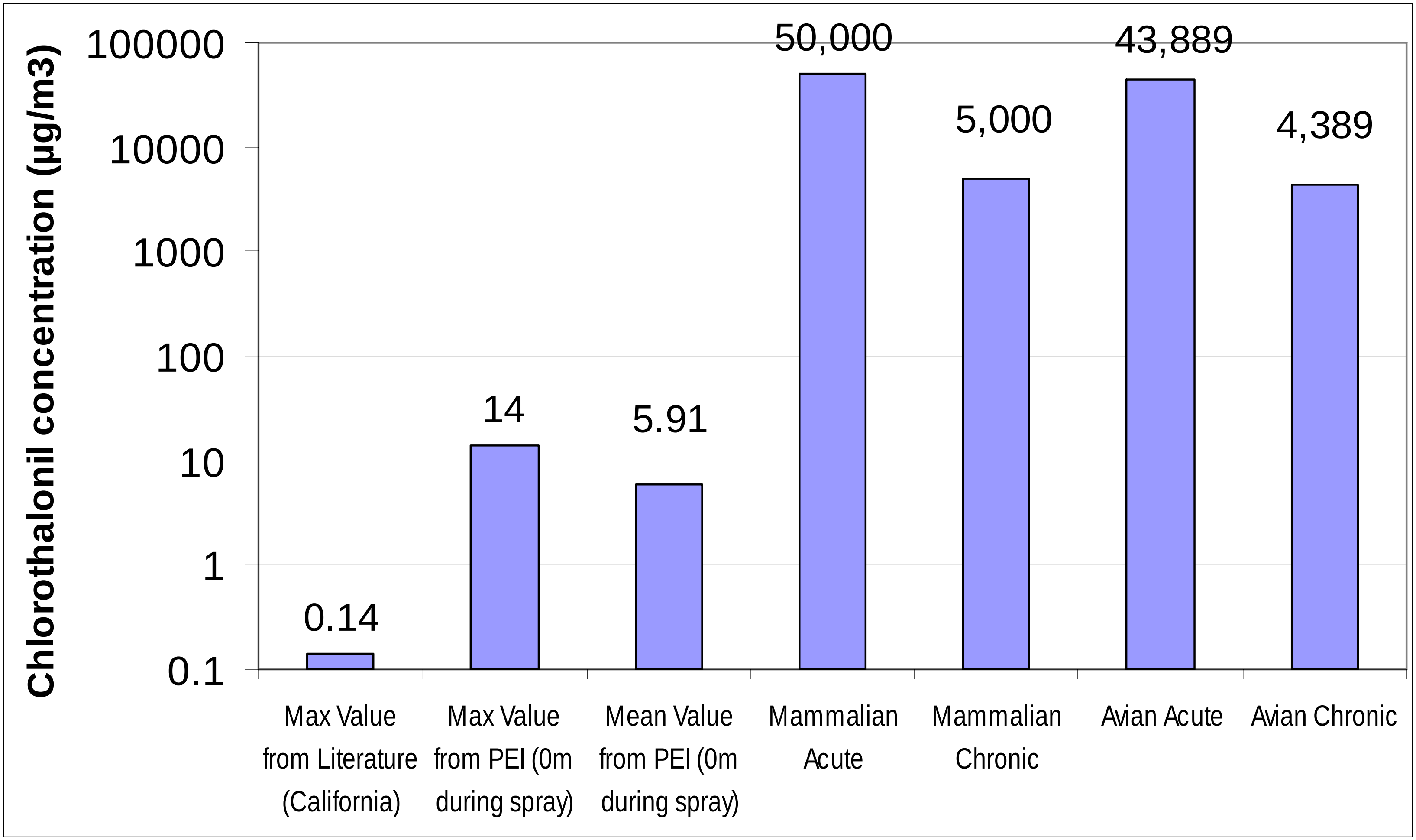
# Chlorothalonil air concentrations (max and mean) pre and post spray near potato fields



# Comparison with concentrations measured in other studies

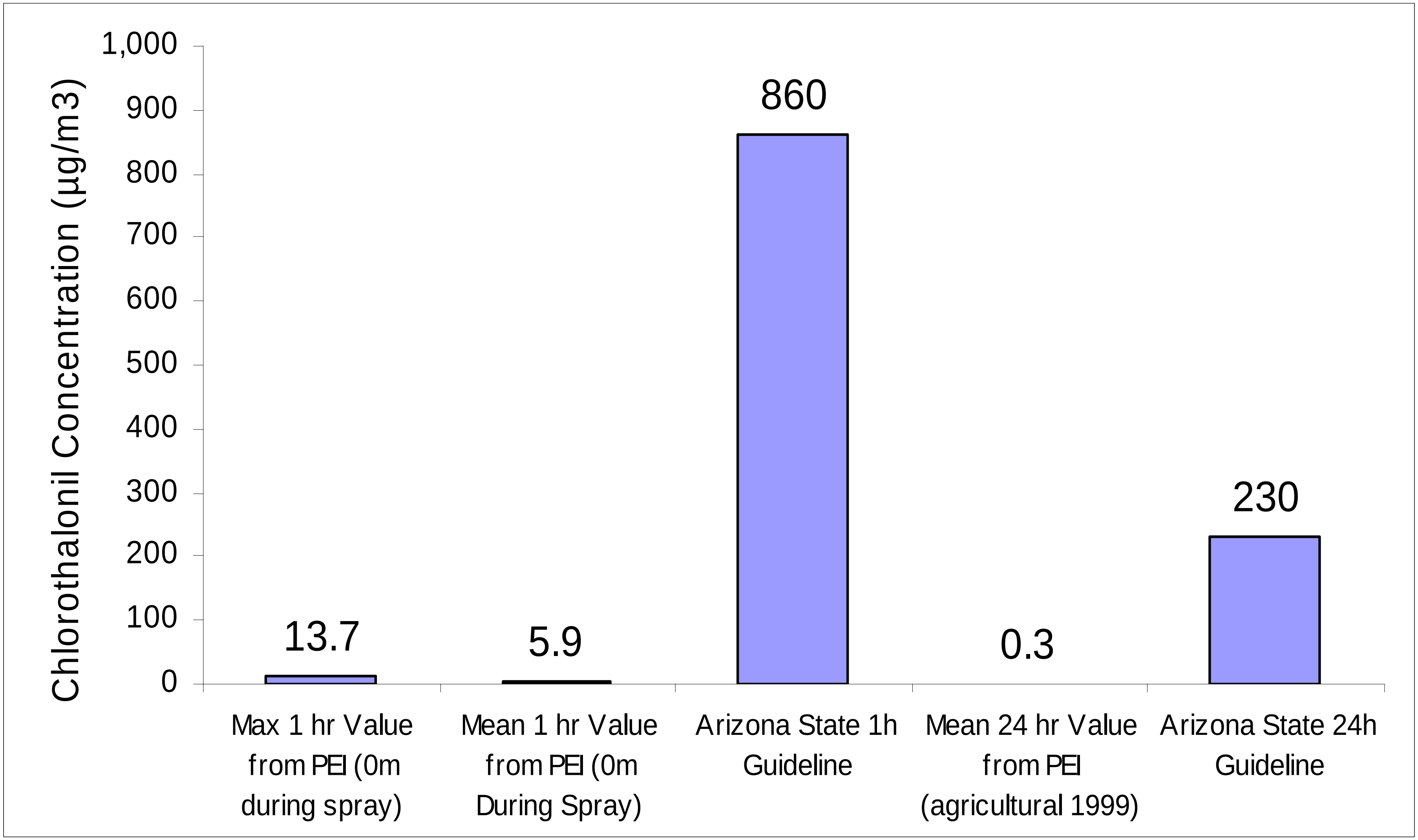
| Type of Sample | Location | Maximum (ng/m$^3$) | Mean (ng/m$^3$) | Land Use | Sampling Details | Reference |
|---|---|---|---|---|---|---|
| Background (remote) | Siberian Coast | -- | 0.005 (gas phase) | 1000's miles from nearest agriculture (at sea) | fog vapour; Aug to mid Sept | Rice and Chernyak, 1997 |
| | | -- | 0.0001 (particle) | 1000's miles from nearest agriculture (at sea) | fog vapour; Aug to mid Sept | Rice and Chernyak, 1997 |
| Background (non-agricultural) | Great Lakes | 0.24n=7 | 0.084(mean of detected) | Urban/Non-agricultural | (gaseous; 24 hours at 12 day intervals) | James and Hites, 1999 |
| | North Dakota | 7.8 | -- | "Island" of non-farmed land in intensely farmed area | mid May-Oct | Hawthorne *et. al*., 1996 |
| | California | -- | <3.9 | Urban | 15 day integrated | Lee *et. al*., 2002 |
| Ambient (agricultural) | California | 4.6 | 4.4 | Fresno (tomato crop) and Ventura (celery crop) | 15 day integrated | |
| | Kensington, PEI | -- | 12 | Heart of potato growing country | Composite of 5 weekly samples (July – Aug) | Harner and Blanchard, 2005 |
| | Baie St. Francois, QC | -- | 1.9 | Wetland with mixed vegetation. Receptor site. | Composite of 5 weekly samples (July – Aug) | Harner and Blanchard, 2005 |
| | St. Anicet, Quebec | -- | 3 | Rural and agricultural (corn, pasture). | Composite of 5 weekly samples (July – Aug) | Harner and Blanchard, 2005 |
| | Egbert, Ontario | -- | 5.2 | Rural and suburban, surrounded by fields and mixed forest | Composite of 5 weekly samples (July – Aug) | Harner and Blanchard, 2005 |
| | Chesapeake Bay | 6.8 | 0.99 | Agricultural, urban, forested rural | approximately 2 months | Harmon-Fetcho *et. al.*, 2000 |
| Adjacent to sprayed | California | 140 | -- | Agricultural, during spray | Downwind | Baker *et al.*, 1996 |
| | PEI 2003 | 14,000 | 5,700 | Agricultural, during spray | Downwind | Garron *et al.* 2005 |

# Comparison of measured chlorothalonil air concentrations with toxicity thresholds




Thresholds based on extrapolation of oral to inhalation exposure

# Air concentrations of chlorothalonil near potato fields compared with short term guidelines



# 2005 Field season

- Measurement of DNA damage in blood of mice and meadow voles (Comet Assay)
- Measurement of <PM2.5 fraction
- Comparison of air concentrations at 1m height and at ground level

# General conclusions

- Chlorothalonil measured most frequently and at higher concentrations than other pesticides
- Lower concentrations of endosulfan, methamidophos, metalaxyl, azinphos-methyl, metribuzin measured
- Pesticides measured in agricultural air at all times of the day and night
- Concentrations of chlorothalonil measured in PEI substantially higher than comparable studies in other jurisdictions.
- Concentrations in air decrease rapidly with time and with distance from the sprayed field
- Concentrations measured adjacent to sprayed fields are two orders of magnitude less than only available US guideline. No Canadian guidelines exist.
- Concentrations measured are lower than acute toxicity thresholds, which are based on ingestion studies

# **1. NAESI** - Method Development for Pesticide Ambient Air Quality Standards

- Objective to establish method for setting risk-based national environmental quality standards for pesticides in ambient air.
- Cantox Environmental Inc.
- Examined current standards and methods worldwide

# Key Results and Findings

- 14 jurisdictions in Canada and the US identified ambient air quality benchmarks for a variety of pesticides
- U.S. EPA and California EPA most often adopted by other jurisdictions
- Often extrapolated from the oral route of exposure
- All existing pesticide AAQB are based entirely on protection of human health.
- Paucity of toxicity information related to inhalation routes of exposure for pesticides in mammalian and wildlife species

## Key Results and Findings (con't)

- Most common approaches:
  1. Occupational exposure limit (OEL) divided by safety or uncertainty factor(s), and amortizing for continuous exposure;
  2. No observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) divided by a series of uncertainty factors;
  3. Non-threshold procedures (e.g., carcinogens): based on acceptable levels of incremental lifetime cancer risk, such as one in 100,000.

# Key Results and Findings (con't)

- Proposed human IPS methodology based on elements of the EC/HC (1996) NAAQO Protocol, as well as approaches currently used within Ontario and Alberta to develop ambient air quality objectives or criteria.
- A scientifically defensible standard wildlife ambient air IPS methodology for pesticides cannot be developed at this time.
- Propose a screening level site-specific ecological risk assessment (ERA) methodology for wildlife.
- Demonstrated methods using carbofuran, chlorothalonil and trifluralin

# Recommendations and path forward

- Proposed approaches should be tested on a range of priority pesticides
- Assumption that human health AAQB is protective of ecological health should be tested
- Verification of oral to inhalation factors
- Stakeholder consultation

## **2. NAESI** - Establishing Meteorological Standards for Pesticide Applications

- Objective to develop a method by which meteorological standards can be set to prevent aerial drift and run-off of pesticides.
- Atlantic Agritech Inc/DACOM Plant Services was awarded the contract in 2004
- Survey of current world methods

# Key findings

- Most jurisdictions have upper wind speeds  (8-25 km/hr) and some have lower
- Some jurisdictions have temperature/RH limits
- Some jurisdictions have rain advisories (generally within 2-4h)
- Some labels have met restrictions
- Australia has a range of categories for winds   (issues meteorological advisories)
- Run-off minimization virtually non-existent

# Key findings

- Developed categories for wind speed, spray droplets, boom height and rainfall amount
- User-specific advisories most effective
- A general wind speed only advisory could be issued
- A rainfall advisory would be of limited use

## Path forward

- PSF work:
  - Both the long and short term sampling projects will conclude this fiscal year. Summary reports will be prepared.
- NAESI work:
  - Wider stakeholder involvement
  - Increase range of ambient demonstration standards
  - Pilot meteorological advisories
- In terms of stakeholder consultations

# Pesticide Disposal Issues and Solutions

**Madeline Waring**, Pesticide Specialist, BC Ministry of Agriculture and Lands

Abstract

There are issues regarding the disposal of both Domestic and Agricultural pesticides in BC. Nevertheless, there are also solutions!

Domestic Pesticides

The Consumer Product Stewardship Program (CPSP) was established as a means of disposing of unwanted domestic pesticides and other products. A levy placed on the purchase of certain pesticides is used to manage this CPSP. Homeowners can take domestic pesticides that have a skull and cross bones on the label to the CPSP sites for disposal. However, many domestic pesticides are not labeled with these symbols due to the low toxicity of the products. Homeowners are told to dispose of domestic pesticides without skull and cross-bone symbols in their household garbage. This triggers confusion among the population as they often hear pesticides are dangerous. Another limitation of the CPSP is that it will only accept domestic pesticides with a PCP # on the label. Homeowners that have historical pesticides or products lacking intact labels or obtained from the US or other countries will not be accepted for disposal. There is no easy economical way for homeowners to dispose of these products. There are CPSP locations in the urban areas, but not in all rural areas. The municipalities without disposal locations can request a temporary collection in their area to collect waste products. However, the disposal options are limited in many areas. The CPSP should be reassessed and modified to address these issues. Homeowners should also have more access to information on pesticides so they understand the variations between pesticide products and associated hazards.

Agricultural Pesticides

Agricultural pesticides in the context of this presentation include those federally classed as commercial (agricultural, industrial, etc.) and restricted. BC producers use a range of these pesticides to help manage a variety of pest problems. There are multiple reasons why pesticides could become obsolete and need to be disposed. Over time, some of pesticides may be replaced with more effective or less toxic products. Farmers may also change the type of crops they produce or use different production techniques, making certain pesticides obsolete. Other farmers inherit pesticides with the purchase of farms and ranches. Or, the government may restrict or eliminate pesticides as is the case with the recent federal re-evaluation program. These unwanted pesticides can collect on farms or in pesticide storages where the integrity of the containers is eventually compromised. Some containers may become “leakers”, contaminating the environment or posing risks to humans. Pesticide disposal is costly. This is a deterrent to proper disposal and can contribute to the accumulation of unwanted agricultural pesticides.

Solutions to help avoid the accumulation of pesticides include enhancing the agricultural communities' awareness about good purchasing habits, safe storage, and disposal options. The increasing adoption of integrated pest management reduces the use of some pesticides and helps farmers move towards using lower risk pesticides. This reduces the potential risks associated with the accumulation of pesticides. However, the agricultural community will continue to accumulate unwanted pesticides and needs convenient economical solutions to avoid the potential risks associated with unwanted pesticides. A very affective approach is hosting pesticide disposal programs where the agricultural community can return pesticides at no or minimal cost to properly managed sites that will safely dispose of the pesticides. BC collections between 2000 and 2002 were very successful. Over 740 farmers brought pesticides to one of several collection locations. Four hundred and sixty five (465) lab packed drums (205 Litre) and 125 cubic yard boxes were filled with obsolete pesticides and safely disposed. The program was a result of a partnership between government and industry.

Another collection program is being planned for 2006. Two collection locations will be in the Fraser Valley spring 2006 and several sites will be in the Okanagan fall of 2006. The program organizers continue to welcome financial contributions, help advertising, or volunteers at the collections. If you want to contribute or would like more information on the 2006 program contact Madeline Waring at 604 556-3027.

# Pesticide Disposal Issues and Solutions

Madeline Waring
Pesticide Specialist
BC Ministry of Agriculture and Lands

- Domestic Pesticides
- Agricultural Pesticides

# Domestic Pesticides

(Consumer Product Stewardship Program)

**Issues**

- Labels need skull and X-Bones
- Labels need a PCP#
- Not all products accepted
- Select locations only
- Others put in domestic garbage or ?

**Solutions**

- Review and modify Consumer Product Stewardship Program

# Agricultural Pesticides
# - Issues -


- POP's, OP's, & others
- Container integrity
- Storage
- Re-evaluation
- Costs
- Locations
- Unknown quantities
- Creative solutions

# Solutions

- Education
- IPM Programs
- Reduced or Low Risk Pesticides
- Pesticide Collections
- Other ideas?

# Pesticide Collections

- Remove the potential hazard from unwanted & obsolete agricultural pesticides
- Depend on funding & partnerships

# BC Pesticide Return 2000 - 2002

(Fraser Valley, Vancouver Island, Okanagan, Kootenays, Grand Forks, Interior)

- 465 lab packed drums (205 Litre)
- 125 cubic yards of solid pesticides
- Over 740 farmers participated


# 2006 Collection Plans

- **$260,000**
- **Fraser Valley**
  - Feb 27th – March 3rd
  - Abbotsford 2 days
  - Delta 2 days
- **Okanagan**
  - Fall 2006

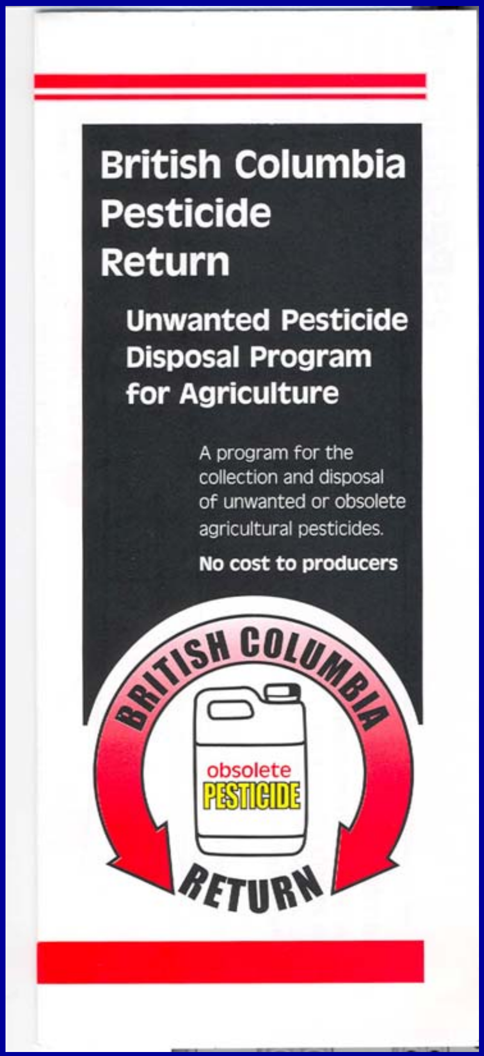
# 2006 Collection

Partnership with:

- BC Agriculture Council
- CropLife Canada
- BC Ministry of Environment
- BC Ministry of Agriculture & Lands
- Environment Canada

# How can you help?

- Contribute funds
- Advertise the program
- Volunteer at a collection site



# Questions or Comments?

## Survey of Pesticide Sales and Use in British Columbia: 2003

**Gevan Mattu**, Environment Canada, Pacific and Yukon Region

**Abstract is not available but the Power Point presentation slides are available after this page.**

# Survey of Pesticide Sales and Use in British Columbia: 2003

**Gevan Mattu**
**Environment Canada**
**November 22**

# Study Objectives

- Obtain BC pesticide sales records for 2003
- Obtain pesticide use records:
  - for the Lower Mainland (pest control services in agriculture, landscape and forestry use categories)
  - for Anti-sapstain chemicals and wood preservatives
  - from golf courses (Lower Mainland)
  - for aquaculture (if available)

# Study Objectives – cont'd

- Estimate the quantities of 'inert' (e.g. solvents, surfactants, adjuvants) ingredients used in BC
- Identify data related to minor use permits, research permits and emergency registration of pesticides (if available)
- **Identify changes in pesticide active ingredients used over time**

# Total Quantities (kg) of Pesticide Active Ingredients Sold or Used in BC from 1991 to 2003

| Year | Totals (kg) |
|---|---|
| 1991 | 5,039,977 |
| 1995 | 8,674,920 |
| 1999 | 8,102,384 |
| **2003** | **4,666,709** |

# Summary of Changes in Pesticide Sales or Use in British Columbia, 1991 to 2003

| Survey Category | 1991 (kg) | 1995 (kg) | 1999 (kg) | 2003 (kg) | Change from 1991 (kg) |
|---|---|---|---|---|---|
| Wood Preservative Use | 3,685,955 | 6,905,728 | 6,529,878 | 3,236,267 | -449,688 |
| Anti-Sapstain Chemical Use | 838,319 | 754,314 | 479,251 | 206,041 | **-632,278** |
| Reportable Pesticide Sales | 923,275 | 1,010,372 | 1,093,195 | 1,146,263 | **+222,988** |
| Use by Landscape Services | 15,154 | 14,802 | 9,071 | 7,541 | **-7,613** |
| Use by Agriculture Services | 42,083 | No data | 86,565 | 11,338 | -30,745 |

Changes shown in **bold** represent significant trends and/or product replacements

# 2003 Survey Results

## Overall Pesticide Sales and Use

- 4,666,709 kg of pesticide active ingredients were purchased or used (excluding most Domestic label products)
  - 73% were anti-microbial pesticides
  - 9% were insecticides
  - 7% were fungicides
  - 6% were herbicides
  - the remaining 5% included biological control products/biological insecticides, fumigants, plant growth regulators, insect growth regulators, molluscicides, vertebrate control products, adjuvants and surfactants

# Reportable Pesticides Results

- 1,146,263 kg of Reportable pesticides sold account to 25% of the total quantity of the top 20 pesticide active ingredients

# Quantities of Top 20 Pesticides Sold or Used in BC, 2003

| Active Ingredient | Quantity (kg) | Percent of Total |
|---|---|---|
| Creosote | 2,163,142 | 47.1% |
| CCA | 824,100 | 18.0% |
| Mineral Oil (Insecticidal or Adjuvant) | 317,108 | 6.9% |
| Didecyl Dimethyl Ammonium Chloride | 174,606 | 3.8% |
| Pentachlorophenol | 147,684 | 3.2% |
| Glyphosate | 120,724 | 2.6% |
| *Bacillus thuringiensis* Berliner *ssp. kurstaki* | 85,765 | 1.9% |
| ACQ | 74,448 | 1.6% |
| Sulphur | 73,408 | 1.6% |
| *Bacillus thuringiensis, Serotype H-14* | 39,153 | 0.9% |
| Mancozeb | 34,888 | 0.8% |
| Chlorothalonil | 33,505 | 0.7% |
| Metam | 28,582 | 0.6% |
| Diazinon | 27,074 | 0.6% |
| Captan | 25,500 | 0.6% |
| Disodium Octaborate Tetrahydrate | 24,679 | 0.5% |

# Regional Summary

- Okanagan – insecticidal or adjuvant mineral oil accounted for over 56% of the pesticide active ingredient sales (major crops = fruit trees)
- Vancouver Island and Lower Mainland – insecticidal or adjuvant mineral oil also accounted for much of the sales
- Lower Mainland – formaldehyde accounted for 4.2% of sales (used as a fungicide/disinfectant in mushroom-growing and poultry operations)
- Peace River region – herbicides glyphosate and MCPA ester accounted for 48% of sales (major crops = grains). Some herbicides were sold only in the Peace River region.
- Skeena region – no Reportable pesticides were sold in 2003

# Wood Preservatives

- Two plants did not report their wood preservative use for 2003
- Five heavy-duty wood preservatives used in BC:  creosote, CCA, pentachlorophenol, ACQ, disodium octaborate tetrahydrate and ACZA
- Majority of facilities used only CCA (824,100 kg)
- Three plants applied creosote; quantities were high enough to make creosote the most-used wood preservative in BC (2.16 million kg or 67%).  This translated into creosote accounting for 47% of total pesticide use in BC
- Three plants used ACQ (74,448); new for 2003
- 147,684 kg of pentachlorophenol used
- 24,679 kg of disodium octaborate tetrahydrate used
- 2,214 kg of ACZA used

# Anti-Sapstain

- 51 mills used or had used anti-sapstain (35 mills continue to use anti-sapstain)
- DDAC accounted for 85% of total anti-sapstain usage

| **Active Ingredient** | **Total (kg)** |
|---|---|
| Didecyl dimethyl ammonium chloride (DDAC) | 174,606 |
| Disodium octaborate tetrahydrate | 14,908 |
| Iodocarb (IPBC) | 11,822 |
| Propiconazole | 4,705 |
| Total | 206,041 |

# Pesticide Use by Lower Mainland Service Licensees

Landscape services:

- applied 7,541 kg of pesticides
- Used 77 different active ingredients of which 10 accounted for 86% of pesticides applied
- Largest volume of active ingredients were insecticidal mineral oil (1,171 kg), glyphosate (969 kg) and 2,4-D amine (899 kg)

# Pesticide Use by Lower Mainland Service Licensees

Agricultural services:

- Applied 11,338 kg of pesticides
- Used 83 different active ingredients of which five accounted for 60% of all pesticides applied

| **Active Ingredient** | **Total (kg)** |
|---|---|
| Methyl bromide (fumigant) | 2,026 |
| Atrazine (herbicide) | 1,810 |
| Chlorothalonil (fungicide) | 1,096 |
| Mancozeb (fungicide) | 941 |
| Chloropicrin (fungicide/ insecticide) | 998 |

# Pesticide Use by Lower Mainland Service Licensees

Forestry:

- Applied 102,804 kg of pesticides
- 85,765 kg of BTK used applied and comprised of 84% of the total active ingredients applied

| **Active Ingredient** | **Amount Applied (kg)** |
|---|---|
| *Bacillus thuringiensis* Berliner ssp. *kurstaki* | 85,765 |
| Glyphosate | 14,790 |
| Triclopyr | 2,249 |
| Dried blood | 0.12 |
| Denatonium benzoate | 0.00024 |
| Total | 102,804 |

# Golf Courses

- 53 golf courses responded to the survey
- Estimated that golf courses used about 14,000 kg of pesticide active ingredients in 2003
- Ten active ingredients accounted for 94% of all pesticides applied

| **Active Ingredient** | **Total (kg)** |
|---|---|
| Quintozene | 3,149 |
| Chlorothalonil | 1,877 |
| Iprodione | 373 |
| Carbryl | 331 |
| Mancozeb | 321 |

# Other Pesticide Results

- No permits or sales of pesticides relating to aquaculture reported for 2003
- 122 kg of flea control pesticide active ingredients sold by veterinarians
  - Imidaclorprid accounted for 84% of sales (102.8 kg)
- 11 emergency registrations of pesticide in 2003
- Research permits quantities were very small
- Pesticide purchases outside of BC were difficult to quantify

# Georgia Basin Pesticide Sales/Use

- Three sources of lists for pesticides of potential concern in the Georgia Basin and Puget Sound (1998 Nominating List, NOAA Puget Sound List, Killer Whale List)
- Eight reportable pesticide active ingredients appears on two or more of these three lists
- Sales of these eight have all decreased since 1991 except for Lindane which increased by 17 kg to 152 kg

# Conclusions

- From 1991 to 2003 the quantity of Reportable pesticides sold increased by about 24% of which 92% of this increase is attributable to increased sales of mineral oil
- Sales of federally-labeled Restricted pesticides decreased by 63%
- Anti-sapstain chemical use by lumber mills declined by 79%
- Use of pesticides by landscape services in the Lower Mainland decreased by 50%

## Wood Preservatives

**Gevan Mattu**, Environment Canada, Pacific and Yukon Region

**Abstract is not available but the Power Point presentation slides are available after this page.**

# Wood Preservatives

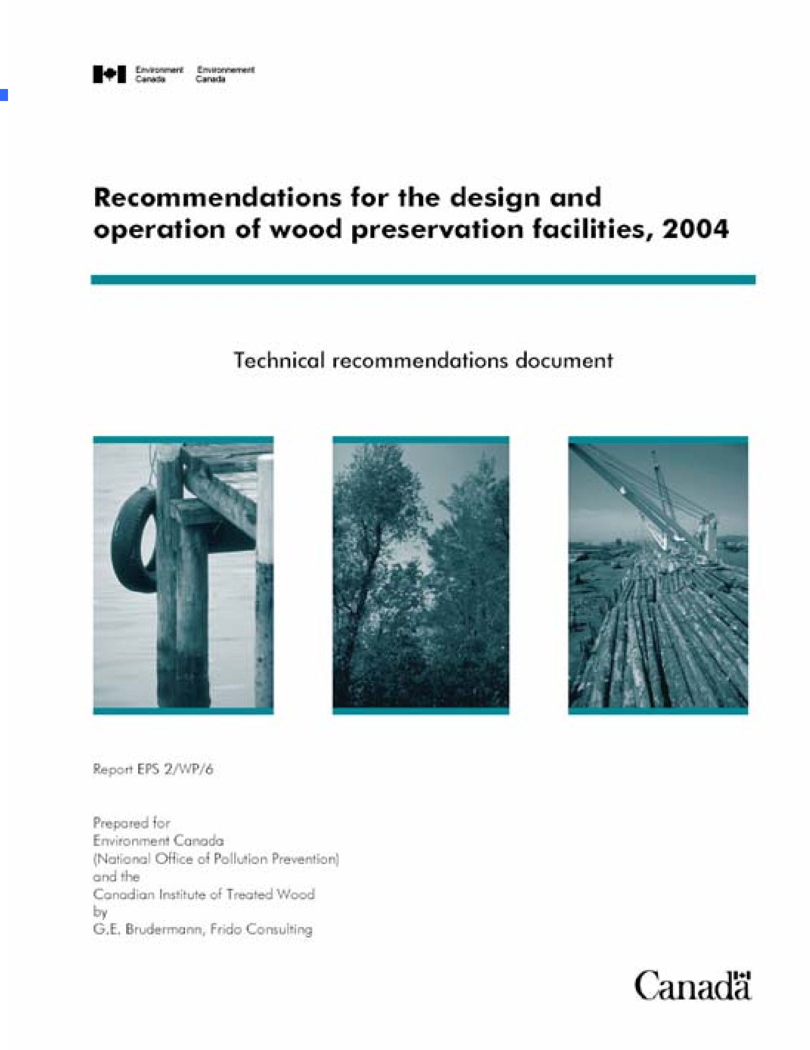
November 22, 2005

# Background

- 1984 Environment Canada's Technical Steering Committee to develop TRDs for the wood preservation industry
- Objectives:
  - Reduce/eliminate release of wood preservative chemicals to the environment
  - Minimize exposure of workers to chemicals
- Resulted in 5 technical recommendations documents (TRDs) in 1988
  - CCA, ACA, PCPP, PCPT, and creosote

# Background – continued

- Updates in 1995, 1999 and 2004
- Resulted in
  - 8 TRDs (CCA, ACZA, Creosote, PCPP, PCPT, ACQ, CA-B, Borate
  - Industrial Treated Wood Users Guidance Document


Environment Canada Environnement Canada

**Recommendations for the design and operation of wood preservation facilities, 2004**

Technical recommendations document

Report EPS 2/WP/6

Prepared for
Environment Canada
(National Office of Pollution Prevention)
and the
Canadian Institute of Treated Wood
by
G.E. Brudermann, Frido Consulting

Canada

# The New TRDs

- The same format as 1999 TRDs.
- Made a few, relatively minor changes to existing sections.
- Added ACQ, CA-B and Borates.
- Have now provided CD with electronic version and “Technical Guidance Documents”.
- Included sections for pesticide labels/other information.

# Wood Preservative Products Regulated by:

- Pest Management Regulatory Agency (PMRA), part of Health Canada, under the Pest Control Products Act (PCPA)

- U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

# Regulatory Position (Oct 2003)

- Re-Evaluation of Heavy Duty Wood Preservatives Commenced 1992
- February 12, 2002 – CCA manufacturers voluntarily commit to withdraw CCA from residential market (U.S.)
  - New products treated with ACQ or CA-B are available.
- April 3, 2002 – Commitment made by Canadian manufacturers (December 31, 2003 deadline)
- Re-Evaluation is ongoing

# What is Environment Canada’s Role?

Chromium and Arsenic:

- Both declared “CEPA Toxics”
- Risk Management program underway

| **CEPA-Toxic Substance** | **Wood Preservative** |
|---|---|
| Chromium VI, Inorganic arsenic | Chromated Copper Arsenate |
| Inorganic arsenic | Ammoniacal Copper Arsenate |
| Creosote-impregnated waste materials, Polycyclic Aromatic Hydrocarbons | Creosote |
| Polychlorinated dibenzodioxins, Polychlorinated dibenzofurans, Hexachlorobenzene (micro-contaminants) | Pentachlorophenol |

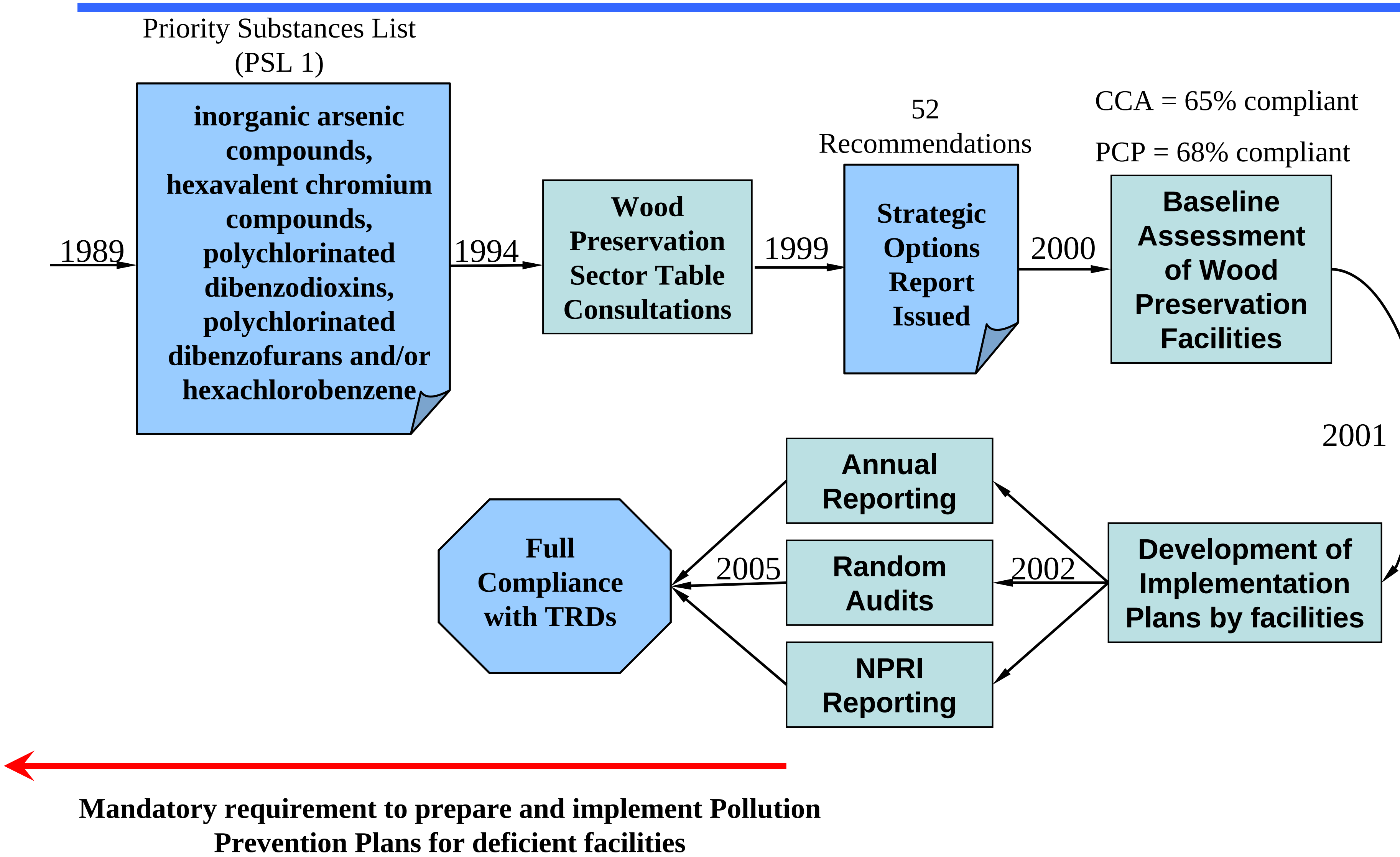
# Environmental Effects

- CEPA toxics are released to the environment via leaching, gravitational migration from the wood to the soil, biodegradation and/or photo degradation, and volatilization.

- Health effects from exposure to treated wood can occur from inhalation of vapours, inhalation and/or ingestion of contaminated dust particles, contact to skin, and ingestion of surface dislodged materials or contaminated soil.

- Depending on factors such as time, quantity, and substance characteristics, contaminants leached from rain and/or water from melted snow may affect the immediately surrounding biota and ecosystems.

# Strategic Options Process (SOP)



# Pollution Prevention Notice

- Issued May 14, 2005;
- Proposed Notice covers 3 facilities;
- Final Notice published in October 2005;
- Can name additional facilities in the final notice.

# The Future

- Final audits to be conducted through 2005-2006
- Will roll into certification program

# For More Information

- Wood preservation website
  - http://www.ec.gc.ca/toxics/wood-bois/
- Inorganic Arsenic Compounds:
  - http://www.ec.gc.ca/sop/wood-bois/over/iac_e.htm
- Chromium
  - http://www.ec/gc.ca/sop/wood-bois/over/chrom_e.htm
- Alkaline Copper Quaternary
  - http://www.osmose.com/wood/usa/preserved/naturewood/characteristics/
  - http://www.treatedwood.com/products/preserve/
- Copper Azole
  - http://www.naturalselect.com/

# Commercial Chemicals Division Pesticides Program Update and Residues of Current Use Pesticides in Agricultural Runoff in the Okanagan Valley, BC

**J.P. Pasternak, J. Kuo, C. Garrett and A. Soon,** Commercial Chemicals Division and Environmental Emergencies, Environmental Stewardship Branch, Environment Canada, (604-666-8077; john.pasternak@ec.gc.ca)

Abstract
This presentation consisted of two components. The first component highlighted pesticide program activities in the Chemicals Evaluation Section, Commercial Chemicals Division and Environmental Emergencies (CCDEE). The second component provided details on a currently ongoing project which determines levels of pesticides in runoff water in the Okanagan Valley, BC.

A. Commercial Chemicals Division Pesticides Program Update

In PYR, CCDEE continues to function as a co-ordinator on issues relating to pesticides in relation to Environment Canada's mandate pursuant to the *Fisheries Act* (FA, Section 36), *Migratory Birds Convention Act* (MBCA) and the *Species at Risk Act* (SARA). CCDEE actively influences the decisions made by two key agencies with regulatory authorities on pesticides, the Pest Management Regulatory Agency (PMRA) of Health Canada, and the British Columbia Ministry of Environment (BCMOE). Over the past year, our activities have included:

- provision of scientific and technical advice relevant to the FA, MBCA and SARA on BCMOE Pesticide Use Permits (PUPs) and Pest Management Plans (PMPs) on behalf of PYR (including the Canadian Wildlife Service) and Fisheries and Oceans Canada.
- participation as an appointed member on the BC Integrated Pest Management Committee, and acting as the liaison between Environment Canada/Fisheries and Oceans Canada and BC on provincially relevant pesticide issues (e.g., participation as a stakeholder in the development of the *BC Integrated Pest Management Act* (BCIPMA) and its regulations).
- development and update of guidelines and conditions on pesticide use to protect non-target organisms and sensitive habitat areas.
- coordination and support in relation to regional pesticide activities and work groups (e.g., coordinator of the Pesticide Information Exchange and the BC Wireworm Task Force, and supporter of the BC Lower Mainland Horticultural Growers Association IPM courses for horticultural growers).
- scientific assessment of regionally important pesticides to inform PRMA pesticide re-evaluation efforts and provincial decision-making respecting pesticide use (e.g., an assessment of triazine pesticide levels in the Lower Fraser Valley, and the surveillance of currently used agricultural pesticides in runoff water, sediments and soils in the Okanagan Valley, BC).

B. Residues of Current Use Pesticides in Agricultural Runoff in the Okanagan Valley, BC

In 2005, sampling was conducted to determine concentrations of selected currently used pesticides and some transformations products in agricultural runoff in the Okanagan Valley, BC. A total of 13 sites were sampled in early June and late September, 2005 following rainfall events and/or extended periods of irrigation. Undisturbed reference sites were also sampled. Water, sediment and soil samples were collected from drainage ditches and/or from small streams. Water samples were analyzed by AXYS Analytical Limited. The sediment and soil samples were analyzed by the Pacific Environmental Science Centre of Environment Canada. The selection of the sampling sites and the analytical laboratory for the analysis of water samples was done in conjunction with others at Environment Canada who were sampling larger surface waters, precipitation and groundwater in the area (i.e., see presentation by Tuominen et al. which is also included in these proceedings). By mid-November 2005, approximately 50% of samples had been analyzed. Various organochlorine (e.g., endosulfan, endosulfan-sulphate, endosulfan-alpha, endosulphan-beta, lindane, heptachlor, dieldrin, quintozene andtrifluralin), nitrile (atrazine, atrazine-desethyl, simazine, heazinone, pentimehalin and metribuzin) and organophosphate (diazinon, diazinon-oxon, metolachlor, azinphos-methyl, phosmet, captan and chlorpyiphos-methyl) pesticides were detected in runoff and small stream water (detection limits ranged from 0.01 – 12.5 ng/L). No currently used pesticides were detected in the soils and sediments samples analyzed to date (detection limits ranged from 0.01 to 1.0 µg/kg dw); however, DDT (dichlorodiphenyltrichloroethane) and/or its transformation products, DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane) were detected at eight sites. The next steps for this project will include the completion of data evaluation upon the receipt of the remaining analytical results, reporting on study findings to the Water Surveillance Pesticide Science Fund (PSF) Team this winter followed by the preparation of a study for publication in a peer reviewed journal. Pending the availability of PSF funding in 2006/2007, we plan to sample runoff and small streams on Vancouver Island in the next fiscal year.

# Commercial Chemicals Division Pesticides Program Update

Presentation by:
John Pasternak
Commercial Chemicals and Environmental Emergencies
Environmental Protection Branch
Pacific and Yukon Region

2005 EC PYR Pesticide Information Exchange

22 November 2005

# Presentation Outline

1. Current Program and Science Activities

2. Okanagan Valley Runoff Surveillance Study Update

# Current Program Activities

- Regional advisor to the Pest Management Regulatory Agency (PMRA) and BC Ministry of Environment (BCMOE) on regional concerns relating to registered pesticides and requests for emergency registrations.
- Fisheries Act (Subsection 36(3)), Migratory Birds Convention Act, Species at Risk Act.
- Stakeholder/advisor to the BCMOE process on the administration of Pest Management Plans, Pesticide Use Permits (PUPs).
  - BC PUP for pesticide application to control mosquito West Nile Virus.
  - Stakeholder in development of the BC Integrated Pest Management Regulations under the *BC Integrated Pest Management Act*, and their supporting information and Guidelines.

# Current Program Activities

- Appointed membership to BC Integrated Pest Management Committee.
- BC Wireworm Taskforce, Pesticide Program Coordinating Committee, BC Centre for Disease Control Committees on Mosquito Control and Emergency Contingency, Pesticide Program Coordinating Committee
- Support to the Lower Mainland Horticultural Growers Association IPM courses for horticultural growers, and BC Agriculture Council Pesticide Return Program.

# Current Science Initiatives

- Assessment of triazine and metalochlor pesticide levels in soils, ditch/stream sediments and runoff water the of Lower Fraser Valley
  - Field sampling
  - Toxicity research on amphibian tadpole, scud (*Hyallella azteca*) and a representative salmonid (coho salmon). Conducted at PESC.
  - For publication in *Journal of Environmental Quality*.
  - See hand out.
- Pesticide Science Fund (PSF) Study in the Okanagan Valley.

# Residues of current use pesticides in agricultural runoff in the Okanagan Valley, BC

John Pasternak, Jen-ni Kuo, Chris Garrett, Alicia Soon

Commercial Chemicals and Environmental Emergencies
Pacific and Yukon Region

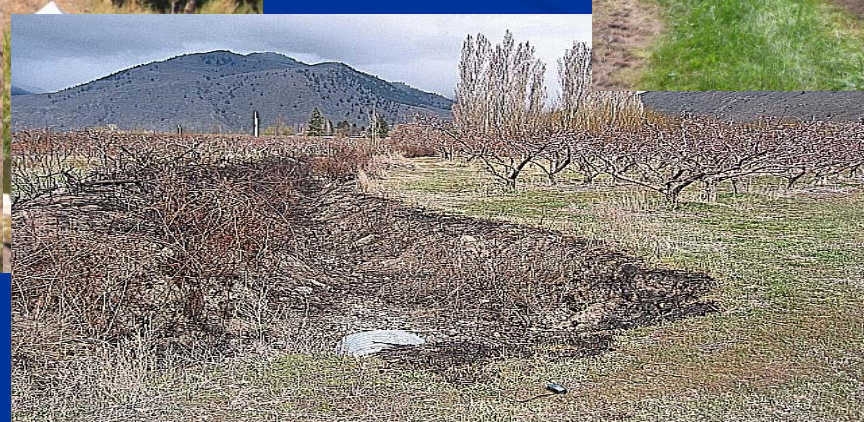
**2005 EC PYR Pesticide Information Exchange**
**November 22, 2005**

# Contents

- Objectives
- Background
- Sampling locations
- Sampling methodology
- Target pesticides
- Results to date
- Next steps

# Objectives

To determine the residues of selected priority currently used pesticides and some transformation products from agricultural runoff in the Okanagan Valley, British Columbia.



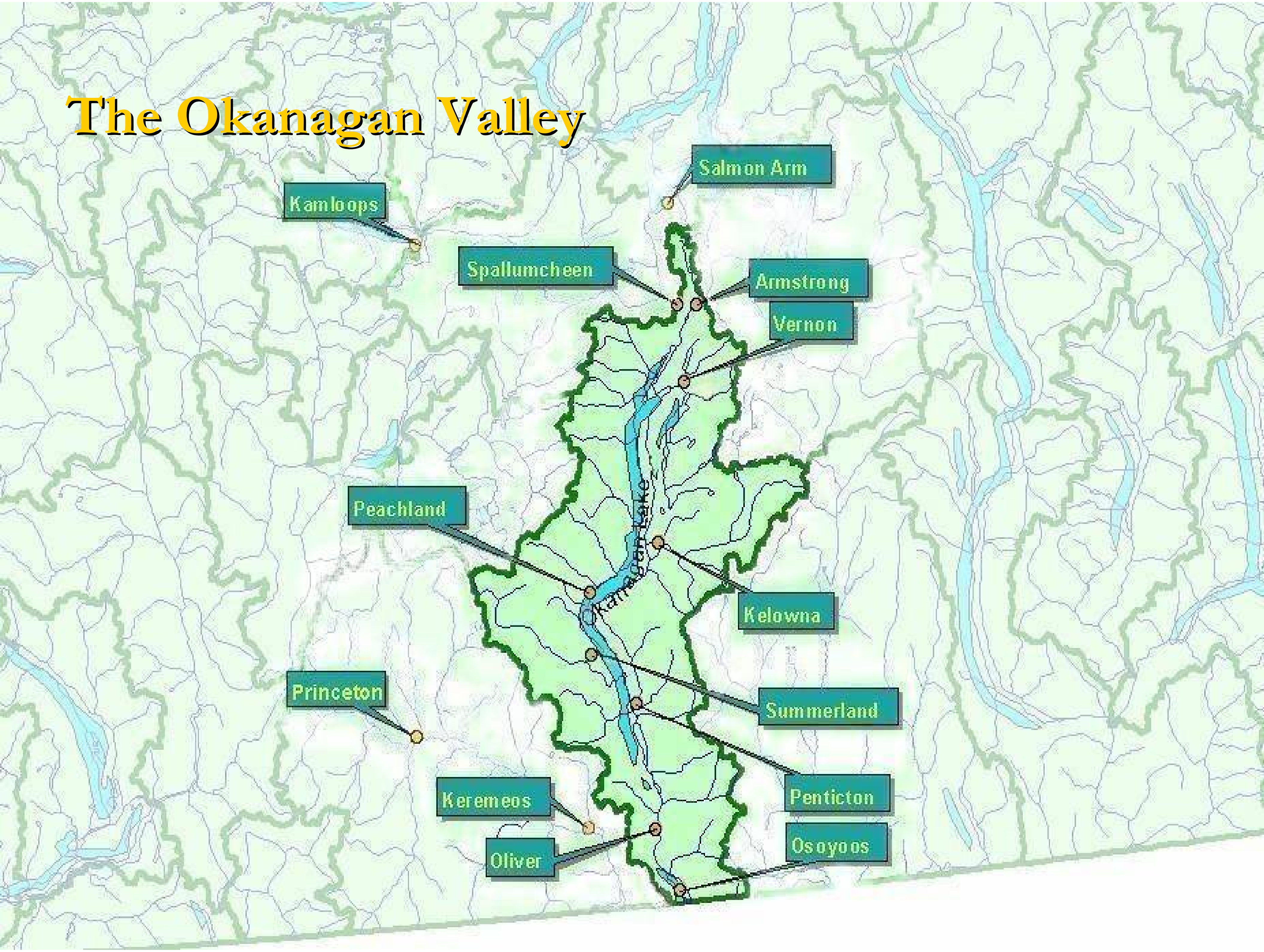
# Background

- Funding from the Environment Canada Pesticide Science Fund
- Part of a National and Regional Surface Water Surveillance Study.
- This is a continuation of surveillance study determining levels of pesticides in runoff water conducted in the Lower Mainland, BC between 2003 and 2004.

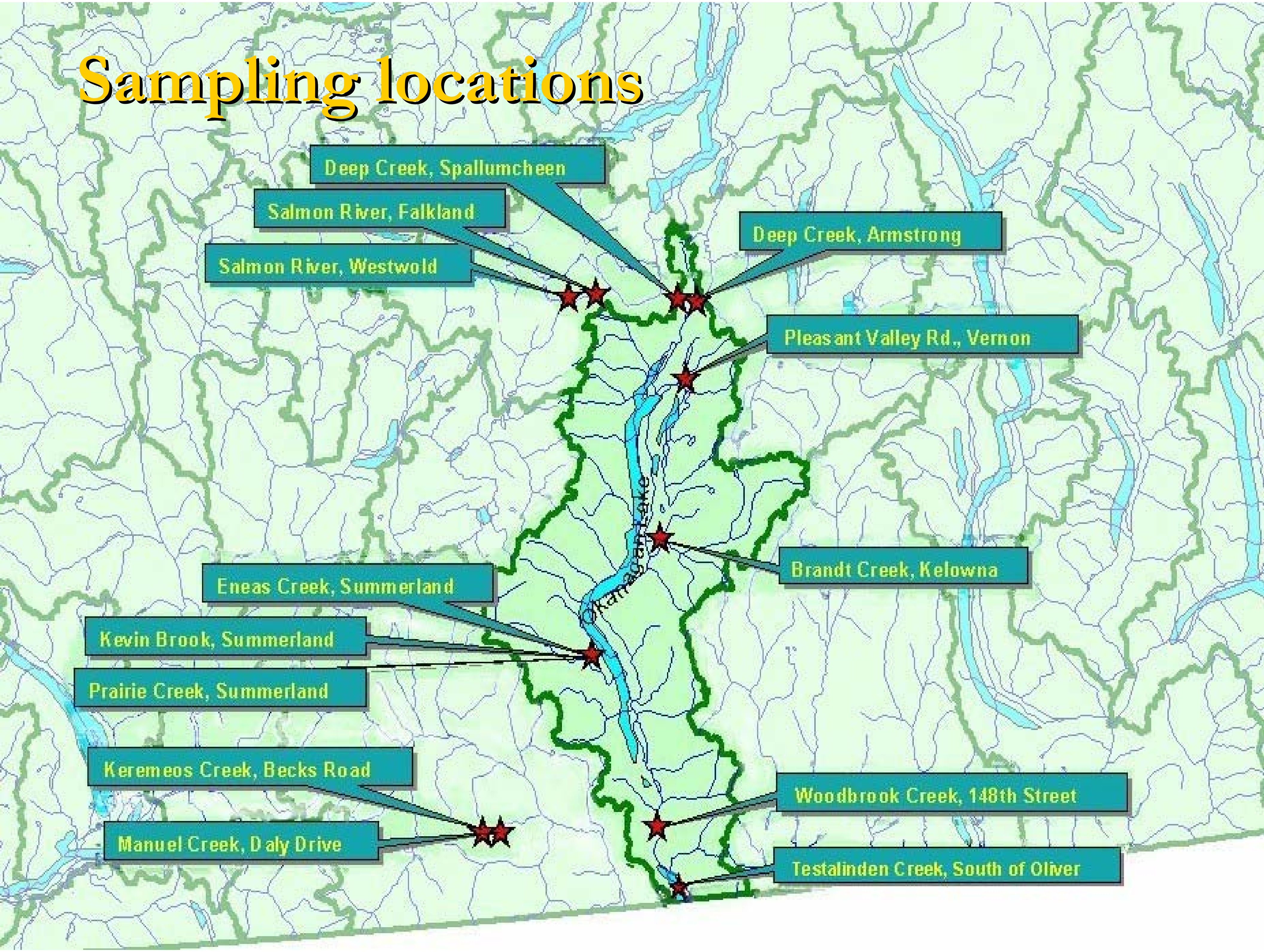
# Study Location

# Study Location

# The Okanagan Valley



# Sampling locations



# Sampling Methodology

- A total of 13 sites sampled.
- Runoff ditches and small streams in coordination with surface water surveillance (by Environmental Conservation Branch).
  - Shared reference sites.
  - Adjacent to farms (e.g., adjacent to orchards, vineyards, vegetables, ginseng, forage crops and sod farms)
- Sampled in early June and late September 2005.
- Following rainfall events, also irrigation.

# Sampling Methodology *(cont.)*

- Water sampling:
  - 2 x 1L unfiltered water samples.
  - Composite grab.
- Soil and sediment samples from farmland and adjacent ditches/small streams:
  - 250 g soil/sediment samples.
  - Composite grab.
- QA/QC included blind spiked samples, lab spikes.

# Pesticide Analytes

- Target analytes based on:
  - Pesticide sales and use patterns (ENKON Environmental Ltd., 2001).
  - Evaluation of local crop types.
  - Published information on environmental toxicity.
  - Persistence in the environment.
  - Analytical capabilities.

ENKON Environmental Ltd., 2001. *Survey of Pesticide Use in British Columbia: 1999*. Prepared for Environment Canada and BC Ministry of Water, Land and Air Protection. EC/GB-01-032.

# Target Pesticides for PSF Okanagan Valley Project

- 2,4-D
- 2,4,5-T
- 2,4,5-TP
- Alachlor
- Ametryn
- Anilazine
- Atrazine
- Atrazine, desethyl
- Azinphos, methyl
- Bromoxynil
- Butralin
- Butylate
- Captan
- Carbaryl
- Chlorothalonil
- Chlorpyriphos
- Chlorpyriphos, methyl
- Chlorpyriphos, oxon
- Cyanazine
- Cypermethrins
- Dacthal
- Diazinon
- Diazinon, oxon
- Dicmba
- Dichlorvos
- Dimethenamid
- Dimethoate
- Disulfoton
- Disulfoton, sulfone
- Endosulphan, alpha
- Endosulphan, beta
- Endosulphan, sulphate
- Ethalfluralin
- Ethion
- Fenitrothion
- Fluazifop, butyl
- Flufenacet
- Flutriafol
- Fonofos
- HCH, alpha
- HCH, beta
- HCH, delta
- HCH, gamma (lindane)
- Hexachlorobenzene
- Hexazinone
- Linuron
- Malathion
- MCPA
- Mecoprop
- Metalaxyl
- Methamidophos
- Methoprene
- Methoxychlor
- Metolachlor
- Metribuzin
- Mirex
- Naled
- Octachlorostyrene
- Parathion, ethyl
- Parathion, methyl
- Pendimethalin
- Permethrins
- Phorate
- Phosmet
- Pirimiphos, mehtyl
- Quintozene
- Simazine
- Tebuconazol
- Tecnazene
- Terbufos
- Triallate
- Triclopyr
- Trifluralin

*Note: Total number of target pesticides = 73.*

# Pesticide Analyses of Runoff Water

**Acid Extractable Herbicides**

2,4-D
Bromoxynil
Dicamba
Fluazifop
MCPA
MCPP
Triclopyr

**Nitrile Pesticides**

Alachlor
Ametryn
Atraxine
Atrazine, desethyl
Butraline
Butylate
Cyanazine
Cypermethrins
Dimethenamid
Ethalfluralin
Flutriafol
Hexazinone
Metribuzin
Permethrins
Pendimethalin
Simazine
Tebuconazol
Triallate
Trifluralin

**Organochlorine Pesticides**

Aldrin
Captan
Chlordane, alpha (cis)
Chlordane, gamma (trans)
Chlorothalonil
Decthal
Dieldrin
Endosulphan, alpha
Endosulphan, beta
Endosulphan, sulphate
Endrin
Endrin, aldehyde
Endrin, ketone
HCH, alpha
HCH, beta
HCH, delta
HCH, gamma
Heptachlor
Heptachlor, epoxide
Hexachlorobenzene
Methoxychlor
Mirex
Nonachlor, cis
Nonachlor, trans
Octachlorostyrene
Oxychlordane
Tecnazene
Quintozene

**Organophosphate Pesticides**

Azinphos-methyl
Chlorpyriphos
Chlorpyriphos, methyl
Chlorpyriphos, oxon
Diazinon
Diazinon, oxon
Dichlorvos
Dimethoate
Disulfoton sulfone
Disulfoton
Ethion
Fenitrothion
Fonofos
Malathion
Methamidophos
Metolachlor
Naled
Parathion, ethyl
Parathioin, methyl
Phorate
Phosmet
Pirimiphos, methyl
Terbufos

**Miscellaneous Pesticides**

Flufenacet
Linuron
Methoprene

*Note: Total number of pesticides = 80.*

# Pesticide Analyses of Soils and Sediments

**AEH**

2,4,5-T
2,4,5-TP (silvex)
2,4-D
Dicamba
Dichlorprop
Dinoseb
MCPA
Mecoprop
Picloram
triclopyr

**OC**

Aldrin
BHC, alpha
BHC, beta
BHC, delta
BHC, gamma (lindane)
Captan
Chlordane, alpha
Chlordane, gamma
Chlorothalonil
Dieldrin
Endosulfan, alpha
Endosulfan, beta
Endosulfan, sulphate
Endrin
Endrin aldehyde
Heptachlor
Heptachlor, epoxide
Methoxychlor
p,p'-DDD
p,p'-DDE
p,p'-DDT
Quintozine

**OP**

Azinphos-methyl
Chlorpyrifos
Demeton-O
Demeton-S
Diazinon
Dimethoate
Ethion
Malathion
Methamidaphos
Methidathion
Metolachlor
Mevinphos
Naled
Parathion
Phosalone
Phosmet
Terbufos

**Misc.**

Methoprene
Glyphosate
AMPA

**NP**

Anilazine
Atrazine
Atrazine, desethyl
Carbaryl
Dichlobenil
Hexazinone
Myclobutanil
Metalaxyl
Napropamide
Propazine
Simazine
Trifluralin

*Note: Total number of pesticides = 64.*

# Target Pesticides for PSF Okanagan Valley Project

- Of the top 9 insecticides, fungicides or herbicides sold in the Okanagan Valley between 1991 – 2001 (BCMOE 2005):
  - 18 pesticides analyzed in sediment and soil samples.
  - 9 pesticides analyzed in water samples.

## Analyses of Predominant Pesticides Used in the Okanagan Valley in Sediments, Soil and Runoff

| Insecticides | Fungicides | Herbicides |
|---|---|---|
| Dormant oil | Lime sulphur (ss) | Glyphosate (ss) |
| Guthion (ss, **w**)* | Sulphur (ss) | 2,4-D products (ss, **w**) |
| Diazinon (ss, **w**) | Metiram | Paraquat |
| Carbaryl (ss) | Mancozeb | Casoron (ss) |
| B.t. | Metam | Ureabor |
| Endosulfan (ss, **w**) | Captan (ss, **w**) | Simazine (ss, **w**) |
| Phosmet (ss, **w**) | Ziram | Devrinol (ss) |
| Phosalone (ss) | Metalaxyl (ss) | Atrazine (ss, **w**) |
| Dimethoate (ss,**w**) | Myclobutanil (ss) | Amitrole |

*Note: **ss = residues determined in sediments and soils**; **w = residues determined in runoff water.**

# Results to Date

- Analytical results for all June soil and sediment samples received.
- Analytical results for approximately 50% of runoff water samples received (June 2005 samples).

## Sediment and Soils

- Detection limits were approximately 0.01 – 0.1 ug/g dw for acid extractable herbicides, 0.02 – 0.2 ug/g dw for nitrile pesticides, 0.01 – 1.0 for organophosphate pesticides, and 0.2 ug/g dw for organochlorine pesticides.
- Only DDT, DDE & DDD detected. Total concentration to 2.95 ug/g dw.
- all DDT, DDE, DDD detected at sampling sites in the = Pleasant Valley in Vernon
- no DDT products detected at:
  - ✓ Deep Creek in Armstrong
  - ✓ Deep Creek in Spallumcheen
  - ✓ Salmon River at Falkland
  - ✓ Salmon River at Westwold

next slide


Aquifer water from the top of the hill

**Pleasant Valley near Vernon**

back


Deep Creek in
Armstrong
back


Deep Creek in Spallumcheen
back

# Salmon River at Falkland

back


Salmon River at Westwold
back

# Results to Date

## Pesticides Detected in Runoff Water

| Number of sites | Which Pesticides were Detected |
| --- | --- |
| 6 | chlorothalonil, dacthal, endosulfan-sulphate, hexachlorobenzene, hexachlorohexane (HCH) alpha, MCPA |
| 5 | HCH-alpha, flutriafol |
| 4 | diazinon, diazinon-oxon, endosulfan-alpha, metolachlor, MCPP |
| 3 | 2,4-D, atrazine, atrazine-desethyl, dicamba, endosulfan-beta, linuron |
| 2 | azinphos-methyl, heptachlor, hexazinone, nonachlor-trans, simazine, pendimethalin, phosmet |
| 1 | bromoxynil, captan, chlorpyriphos-methyl, dieldrin, metribuzin, quintozene, trifluralin |

- A total of 47 pesticides were not detected at any site.
- Detection limits from 0.01-12.5 ng/L

# Next Steps

- Data analyses and reporting of all late spring and fall samples
- 2006 and beyond, sampling in Vancouver Island, Peace Region pending on PSF funding availability

# Acknowledgements


- Environment Canada's Pesticide Science Fund for funding the sampling of runoff water.
- Environmental Protection Branch for funding sediment and soil sampling.
- Yvonne Herbison (PMRA, HC) for crop and spray information and schedule, site information and field sampling.
- Dennis Einarson (BCMOE) for sampling site information.
- Lori Suffredine (CCD, EC) for transporting samples to AXYS (AXYS) Analytical Laboratory Ltd.
- Pacific Environmental Science Centre (PESC) for sediment and soil sample analyses.
- AXYS for water sample analyses.

# For More Information

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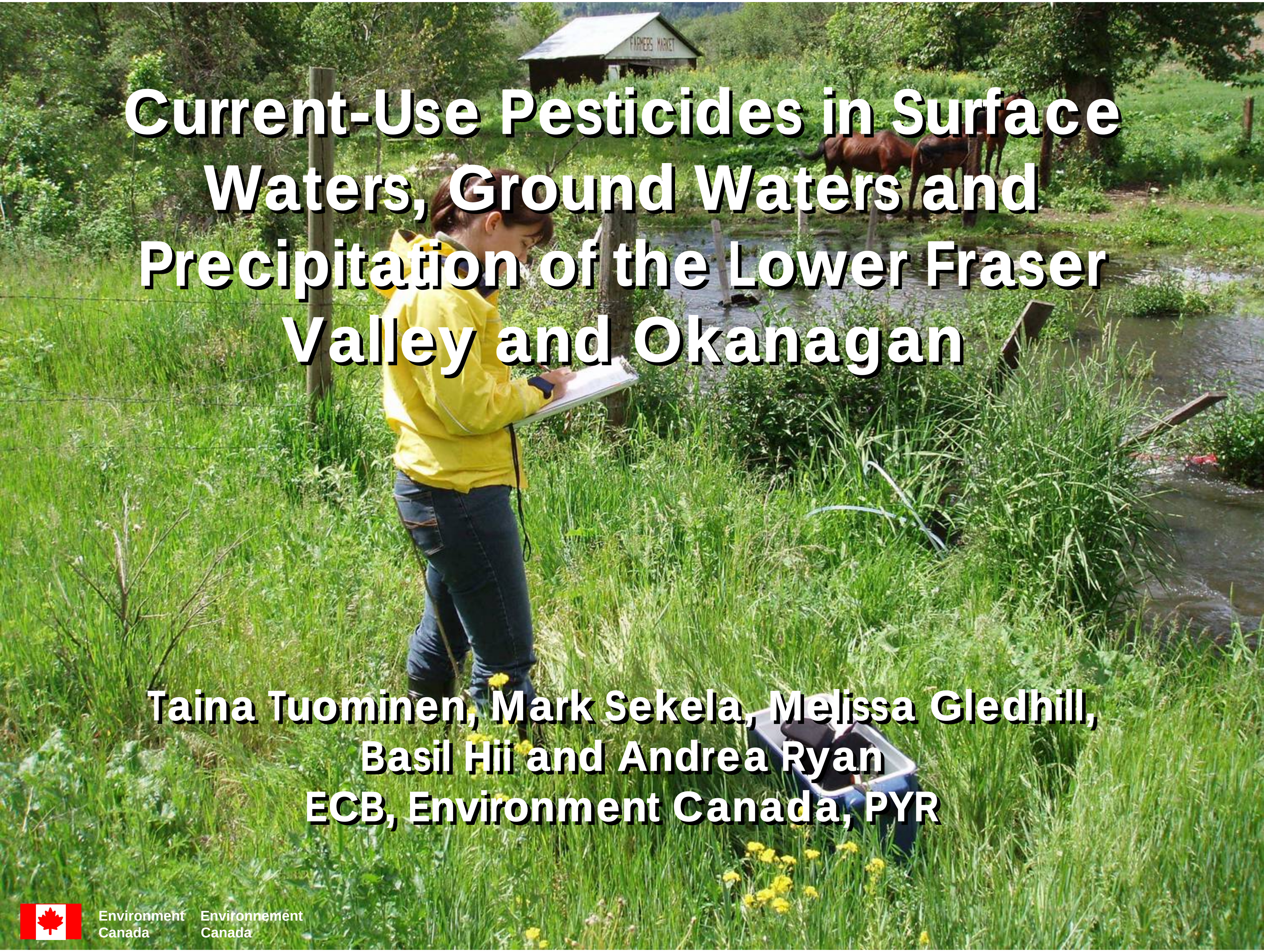
***Thank you for your time!***

Environment Canada Environnement Canada

# Current-Use Pesticides in Surface Waters, Ground Waters and Precipitation of the Lower Fraser Valley and Okanagan

**Taina Tuominen, Mark Sekela, Melissa Gledhill, Basil Hii and Andrea Ryan**
ECB, Environment Canada, PYR

Abstract
The presence of current-use pesticides in BC waters and precipitation is being investigated as part of a national water surveillance project to improve the understanding of these pesticides in the Canadian aquatic environment. Surface waters, groundwaters and precipitation were sampled in the fall and spring of 2003, 2004 and 2005 after rain events in the two high pesticide use areas of British Columbia—the Lower Fraser Valley and the Okanagan Basin. Reference sites that were removed from significant human activity, and sites exposed to urban activity, agricultural activity, or to both urban and agricultural activity were sampled. One litre samples were analysed for surface- and ground waters. Precipitation samples were collected using an automated rain sampler and XAD resin, deployed for 60 days. Current-use pesticides were detected at all sites and in all three media. The reference sites had the fewest number of pesticides detected and the lowest total pesticide concentrations. Generally sites with agricultural activity had the greatest number of pesticide detections and higher total pesticide concentration. The Lower Fraser Valley had the greatest diversity in pesticides detected and some of the higher total pesticide concentrations per site. In each of the two areas (Lower Fraser Valley and the Okanagan Basin) concentrations were greatest in surface water samples, followed by precipitation samples, with the lowest levels measured in the groundwater samples. The concentrations of diazinon, chlorpyriphos and DDT + metabolites in a few surface water samples from the Lower Fraser Valley exceeded the Canada Council of the Ministers of the Environment Water Quality Guideline for the protection of Aquatic Life for the respective chemical.




# Current-Use Pesticides in Surface Waters, Ground Waters and Precipitation of the Lower Fraser Valley and Okanagan

**Taina Tuominen, Mark Sekela, Melissa Gledhill, Basil Hii and Andrea Ryan**
**ECB, Environment Canada, PYR**

## Background:

• part of a national water surveillance project – Pesticide Science Fund

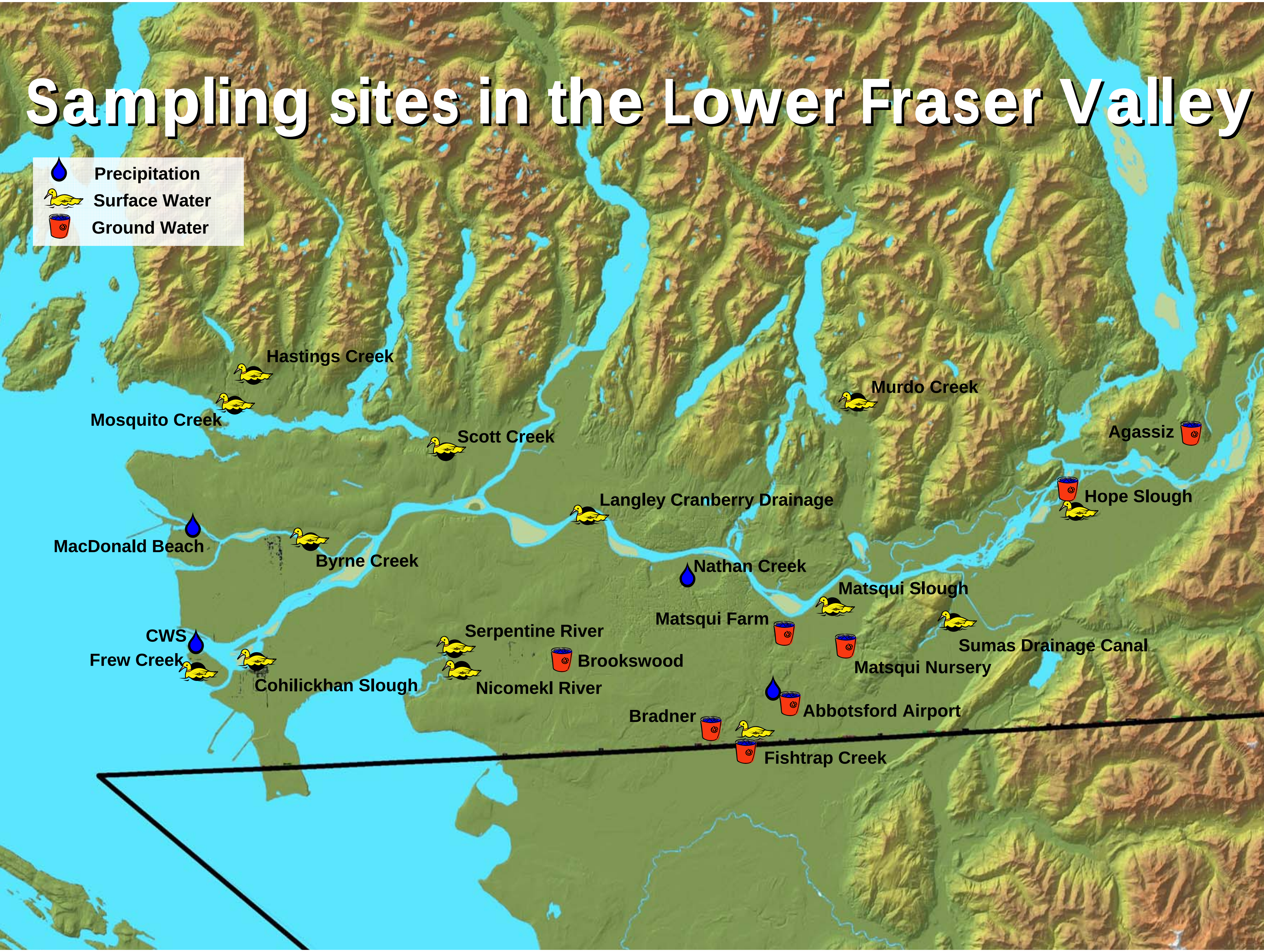
## Objectives:

• to improve our understanding of the presence of current-use pesticides in surface waters, groundwaters & precipitation from high pesticide use areas in BC: Lower Fraser Valley and Okanagan

• advise Pest Management Regulatory Agency on pesticide presence in waters of the region

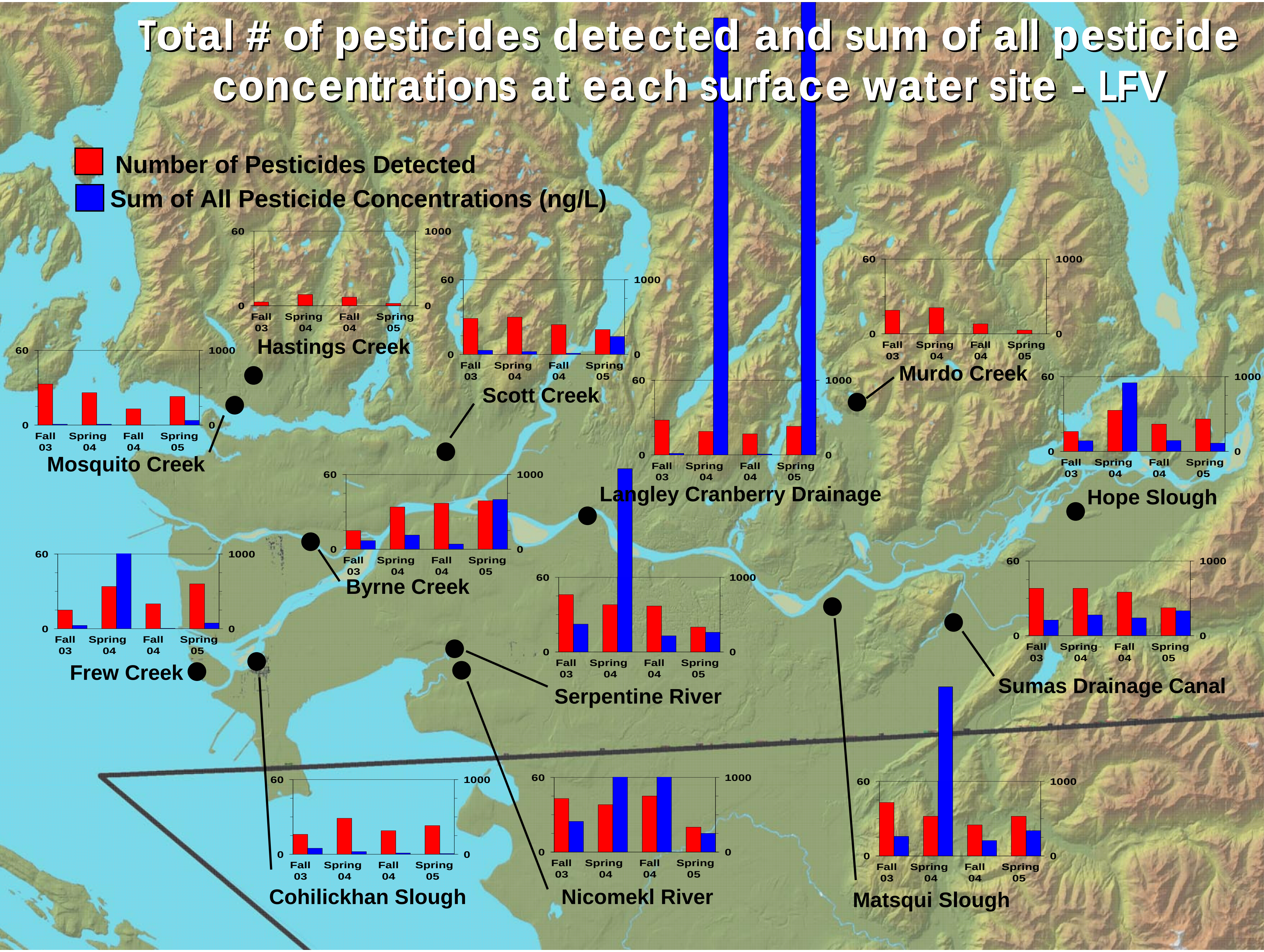
# Methods:

- Sampling – in fall and spring after rain events: 2003, 2004, 2005
- Collected with submersible pump
- 1 L samples
- Precipitation collected using an automated rain sampler and XAD resin, deployed for 60 days
- Analysis conducted at AXYS Analytical



Sampling sites in the Lower Fraser Valley
Precipitation
Surface Water
Ground Water
Hastings Creek
Mosquito Creek
Scott Creek
Murdo Creek
Agassiz
Hope Slough
Langley Cranberry Drainage
MacDonald Beach
Byrne Creek
Nathan Creek
Matsqui Slough
Matsqui Farm
Serpentine River
Sumas Drainage Canal
CWS
Brookswood
Matsqui Nursery
Frew Creek
Cohilickhan Slough
Nicomekl River
Abbotsford Airport
Bradner
Fishtrap Creek

# Total # of pesticides detected and sum of all pesticide concentrations at each surface water site - LFV



# Pesticides measured at the highest concentrations (ng/L) in LFV precipitation, surface water and groundwater, 2003-2005

## Precipitation

| | |
|---|---|
| Diazinon | 0.459 - 106 |
| Chlorothalonil | 1.269 - 52.1 |
| Diazinon-Oxon | 0.128 - 33.6 |
| Malathion | 0.152 - 29.8 |
| Azinphos-Methyl | 0.316 - 22.9 |
| Atrazine | 0.111 - 19.1 |
| Chlorpyriphos-Oxon | 1.79 - 10.8 |
| Simazine | 0.179 - 9.96 |
| Linuron | 1.51 - 8.16 |
| Metolachlor | 0.023 - 6.344 |

## Surface Water

| | |
|---|---|
| Diazinon | 0.04 - 12500 |
| 2,4-D | 0.623 - 1230 |
| Linuron | 0.412 - 1050 |
| MCPP | 0.11 - 917 |
| Simazine | 0.565 - 896 |
| MCPA | 0.076 - 789 |
| Dimethoate | 1.4 - 604 |
| Diazinon-Oxon | 0.021 - 233 |
| Dicamba | 0.084 - 179 |
| Metolachlor | 0.006 - 123 |

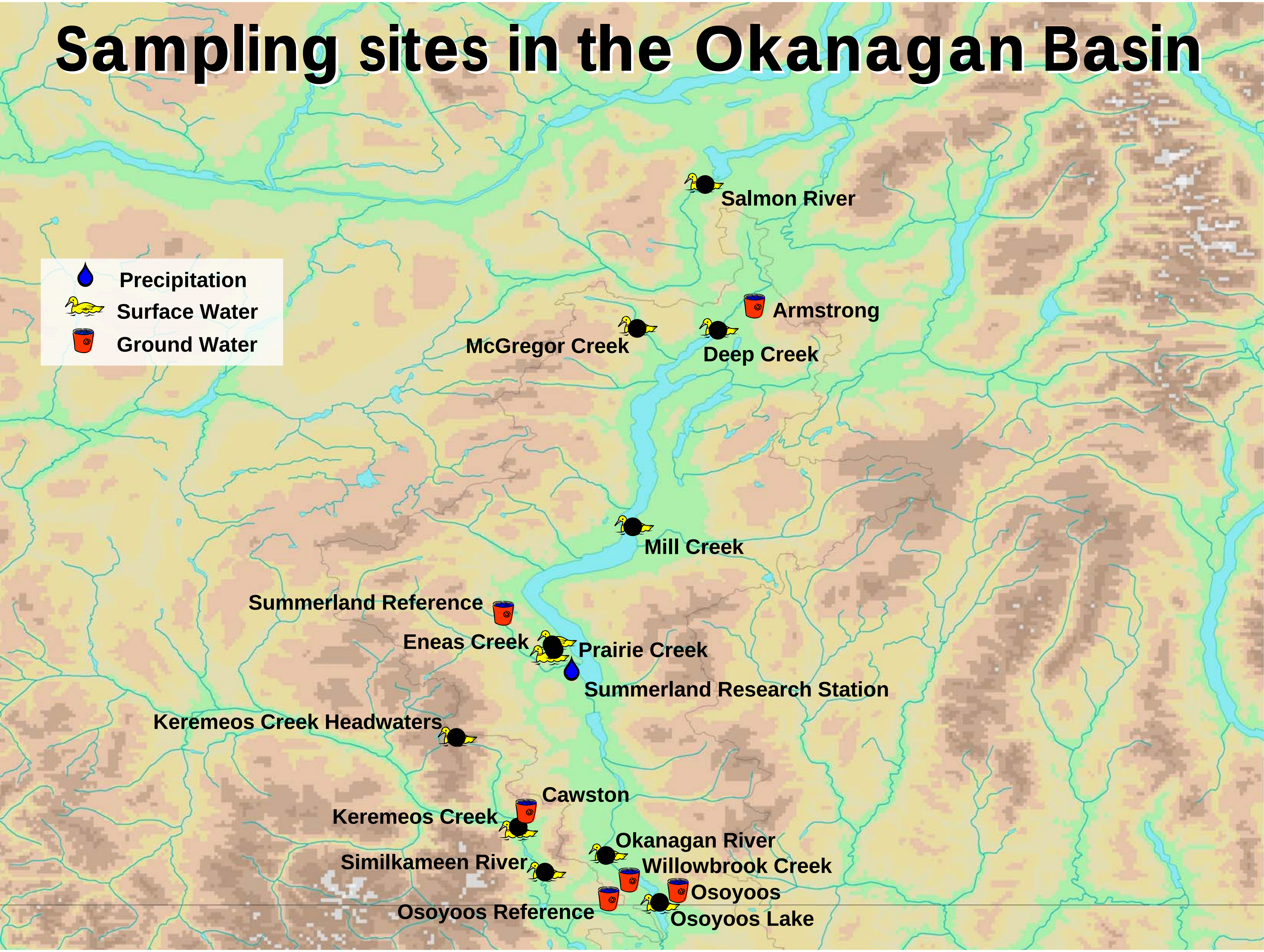
## Ground Water

| | |
|---|---|
| Simazine | 0.047 - 90 |
| MCPP | 0.066 - 14.5 |
| Atrazine | 0.009 - 10.7 |
| β-Endosulphan | 0.001 - 5.11 |
| 2,4-D | 5.01 |
| Desethylatrazine | 0.001 - 4.93 |
| α-Endosulphan | 0.001 - 3.17 |
| Dieldrin | 0.001 - 2.23 |
| Linuron | 0.213 - 2.08 |
| Endosulphan-Sulphate | 0.001 - 1.7 |

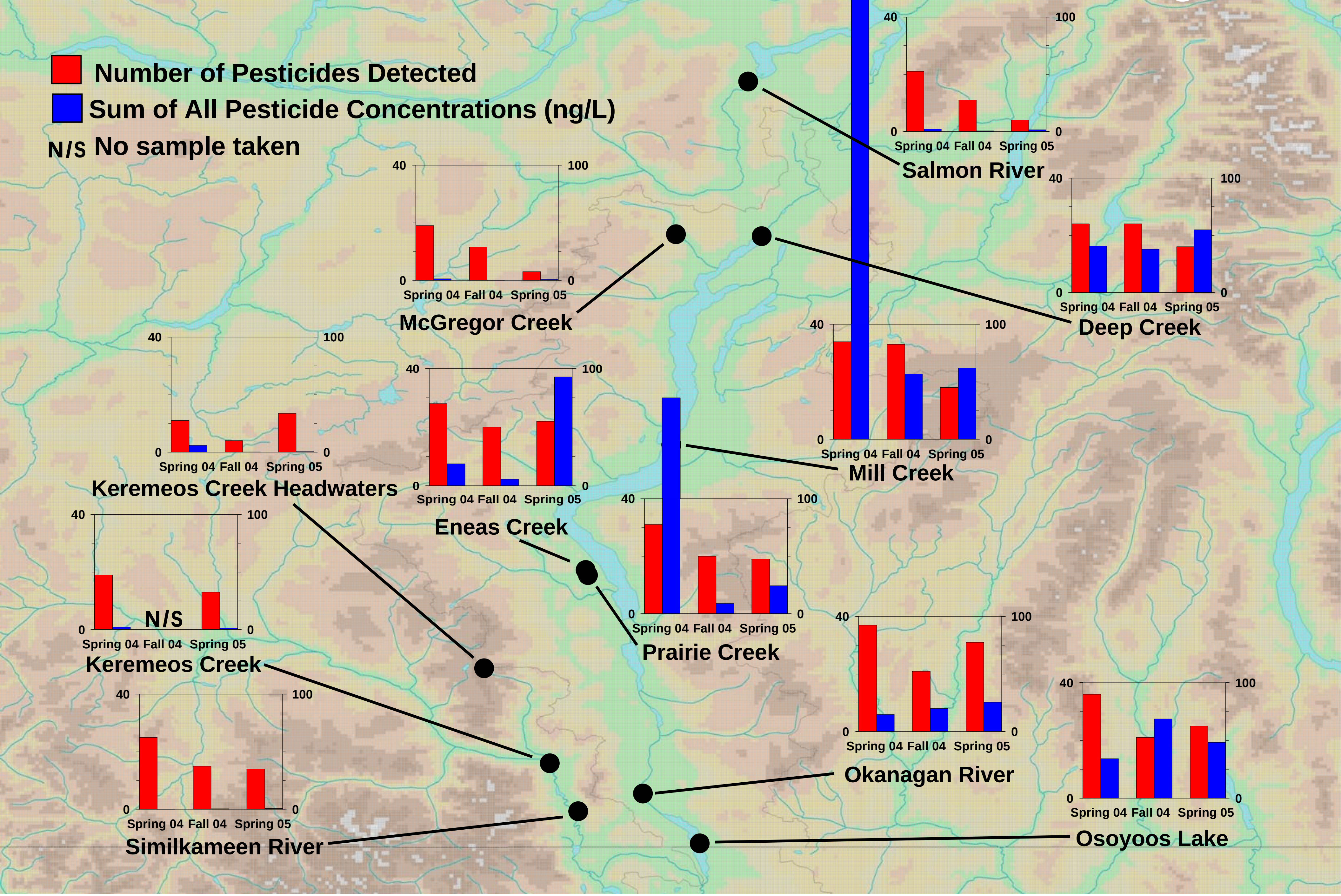
# Pesticides measured at the highest concentrations (ng/L) in LFV precipitation, surface water and groundwater, 2003-2005

| Precipitation | | Surface Water | | Ground Water | |
|---|---|---|---|---|---|
| Diazinon | 0.459 - 106 | Diazinon | 0.04 - 12500 | Simazine | 0.047 - 90 |
| Chlorothalonil | 1.269 - 52.1 | 2,4-D | 0.623 - 1230 | MCPP | 0.066 - 14.5 |
| Diazinon-Oxon | 0.128 - 33.6 | Linuron | 0.412 - 1050 | Atrazine | 0.009 - 10.7 |
| Malathion | 0.152 - 29.8 | MCPP | 0.11 - 917 | β-Endosulphan | 0.001 - 5.11 |
| Azinphos-Methyl | 0.316 - 22.9 | Simazine | 0.565 - 896 | 2,4-D | 5.01 |
| Atrazine | 0.111 - 19.1 | MCPA | 0.076 - 789 | Desethylatrazine | 0.001 - 4.93 |
| Chlorpyriphos-Oxon | 1.79 - 10.8 | Dimethoate | 1.4 - 604 | α-Endosulphan | 0.001 - 3.17 |
| Simazine | 0.179 - 9.96 | Diazinon-Oxon | 0.021 - 233 | Dieldrin | 0.001 - 2.23 |
| Linuron | 1.51 - 8.16 | Dicamba | 0.084 - 179 | Linuron | 0.213 - 2.08 |
| Metolachlor | 0.023 - 6.344 | Metolachlor | 0.006 - 123 | Endosulphan-Sulphate | 0.001 - 1.7 |

# Sampling sites in the Okanagan Basin



# Total # of pesticides detected and sum of all pesticide concentrations at each surface water site - Okanagan



# Pesticides measured at the highest concentrations (ng/L) in Okanagan precipitation, surface water and groundwater, 2004-2005

## Precipitation

| | |
|---|---|
| Azinphos-Methyl | 33.6 - 182 |
| Chlorothalonil | 5.13 - 18.1 |
| Phosmet | 16 |
| β-Endosulphan | 5.15 - 14.7 |
| α-Endosulphan | 4.43 - 13.1 |
| Diazinon | 2.85 - 12.7 |
| Simazine | 2.21 - 4.73 |
| Malathion | 2.13 - 4.61 |
| Dimethoate | 2.35 - 3.85 |
| Diazinon-Oxon | 1.24 - 3.78 |

## Surface Water

| | |
|---|---|
| Simazine | 0.818 - 2370 |
| Azinphos-Methyl | 1.04 - 135 |
| MCPP | 0.086 - 44.2 |
| 2,4-D | 0.586 - 41.8 |
| Diazinon | 0.01 - 41.2 |
| Quintozene | 0.004 - 8.12 |
| Phosmet | 0.004 - 6.68 |
| Atrazine | 0.016 - 6.36 |
| Diazinon-Oxon | 0.12 - 6.24 |
| Methoprene | 5.11 |

## Ground Water

| | |
|---|---|
| Desethylatrazine | 0.008 - 24.4 |
| Atrazine | 0.006 - 21.5 |
| Simazine | 0.124 - 9.15 |
| Diazinon | 0.007 - 2.14 |
| Permethrins | 0.014 - 0.474 |
| Diazinon-Oxon | 0.003 - 0.329 |
| MCPA | 0.11 - 0.311 |
| Metolachlor | 0.001 - 0.284 |
| α-Endosulphan | 0.003 - 0.215 |
| Dieldrin | 0.002 - 0.171 |

# Pesticides measured at the highest concentrations (ng/L) in Okanagan precipitation, surface water and groundwater, 2004-2005

| Precipitation | | Surface Water | | Ground Water | |
|---|---|---|---|---|---|
| Azinphos-Methyl | 33.6 - 182 | Simazine | 0.818 - 2370 | Desethylatrazine | 0.008 - 24.4 |
| Chlorothalonil | 5.13 - 18.1 | Azinphos-Methyl | 1.04 - 135 | Atrazine | 0.006 - 21.5 |
| Phosmet | 16 | MCPP | 0.086 - 44.2 | Simazine | 0.124 - 9.15 |
| β-Endosulphan | 5.15 - 14.7 | 2,4-D | 0.586 - 41.8 | Diazinon | 0.007 - 2.14 |
| α-Endosulphan | 4.43 - 13.1 | Diazinon | 0.01 - 41.2 | Permethrins | 0.014 - 0.474 |
| Diazinon | 2.85 - 12.7 | Quintozene | 0.004 - 8.12 | Diazinon-Oxon | 0.003 - 0.329 |
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| Dimethoate | 2.35 - 3.85 | Diazinon-Oxon | 0.12 - 6.24 | α-Endosulphan | 0.003 - 0.215 |
| Diazinon-Oxon | 1.24 - 3.78 | Methoprene | 5.11 | Dieldrin | 0.002 - 0.171 |

# Pesticide Concentrations Approaching or Exceeding Guidelines

## Lower Fraser Valley:

| Pesticide | Highest Measured Concentration (ng/L) | Maximum Value Guideline (ng/L) | Water Source |
|---|---|---|---|
| Diazinon | 12500 | 100* | surface water |
| Chlorpyriphos | 18.3 | 3.5*δ | surface water |
| DDT + metabolites | 4.2 | 1* | surface water |
| Malathion | 75.1 | 100* | surface water |
| Linuron | 1050 | 7000*δ | surface water |
| 2,4-D | 1230 | 4000* | surface water |

## Okanagan Valley:

| Pesticide | Highest Measured Concentration (ng/L) | Maximum Value Guideline (ng/L) | Water Source |
|---|---|---|---|
| Simazine | 2370 | 10000*δ | surface water |
| Chlorpyriphos | 2.99 | 3.5*δ | surface water |
| Diazinon | 41.2 | 100* | surface water |
| Atrazine | 428 | 1800δ | surface water |

*BC Ministry of Environment

δ Canadian Council of Ministers for the Environment

Environment Canada Environnement Canada

# Study Observations to date:

- current-use pesticides were detected at all sites sampled in the LFV and Okanagan & in all media—surface water, groundwater and precipitation

- 61 current-use pesticides and/or their transformation products were detected in the waters or precipitation of the Lower Fraser Valley; 54 were detected in the Okanagan area

- sites with agricultural activity have greater number of detects and higher total pesticide concentration

- in general, diversity of pesticides and total concentrations at sites were higher in Lower Fraser Valley than in the Okanagan

- there are similarities in pesticides detected in the 3 media--with:
  [surface water]>[precipitation]>[groundwater]

# Acknowledgements

We would like to acknowledge the following for their support to the different phases of this project:

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Axys Analytical, Sidney BC
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Stacey Verrin, DFO
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Vic Jensen, BCMOE
Jerry Vakenti, BCMOE
Agriculture & Agri-Food Canada
Eagle Rock Water District and landowners providing access to groundwater sources

# From the Field to the Lab: Characterizing Current Use Pesticide Impacts on Salmon in British Columbia

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Abstract
The widespread use of pesticides to control and eliminate pests, fungi and weeds can present a risk to non-target organisms, including sensitive aquatic species such as salmonids. Reductions in the health and performance of salmon populations may have consequence to higher level consumers, such as resident killer whales and humans. Despite these concerns, little is known about the fate and effects of the approximately 300 pesticides currently registered for use in British Columbia. We are carrying out a watershed-based study of pesticides in salmon-bearing tributaries of the Fraser River. Samples of air, water, sediment and coho salmon (*Oncorhynchus kisutch*) smolts were collected from three sites, representing urban (Musqueam River, Vancouver), agricultural (Nathan Creek, Burnaby), and remote (Koeye River, Central BC) areas. Fifty-one percent of the pesticides identified on the DFO Pacific list of priority current use pesticides were detected at the agricultural site, while 31% of DFO priority list were detected at the urban site. Total pesticide concentrations in water were 161 ng $L^{-1}$ at the agricultural site, and 11 ng $L^{-1}$ at the urban site. The agricultural site was dominated by the acid extractable herbicides MCPP, 2,4-D, and MCPA, with these compounds making up 68% of the total. The urban site was more diverse in its pesticide components, with beta-Endosulphan, MCPP, and MCPA accounting for 70% of the total. Juvenile salmonids use olfaction to imprint to their natal stream, thus pesticides that impair olfaction at sublethal levels are of concern. We examined the effects of 30-min laboratory exposures to the carbamate antisapstain IPBC and the herbicides atrazine and Roundup on juvenile (~30 g) rainbow trout olfaction and olfactory-mediated behaviour, and also swimming activity. The function of trout olfactory neurons and supporting cells was measured using electro-olfactograms (EOGs; nasal trans-epithelial voltage responses), which were recorded in response to $10^{-7}$ M of the amino acid L-histidine. This concentration had previously been shown to be both behaviourally relevant (trout showed preference behaviour) and at the upper end of environmentally-relevant concentrations. EOGs were measured prior to, during, and following exposing the olfactory tissues to various concentrations of

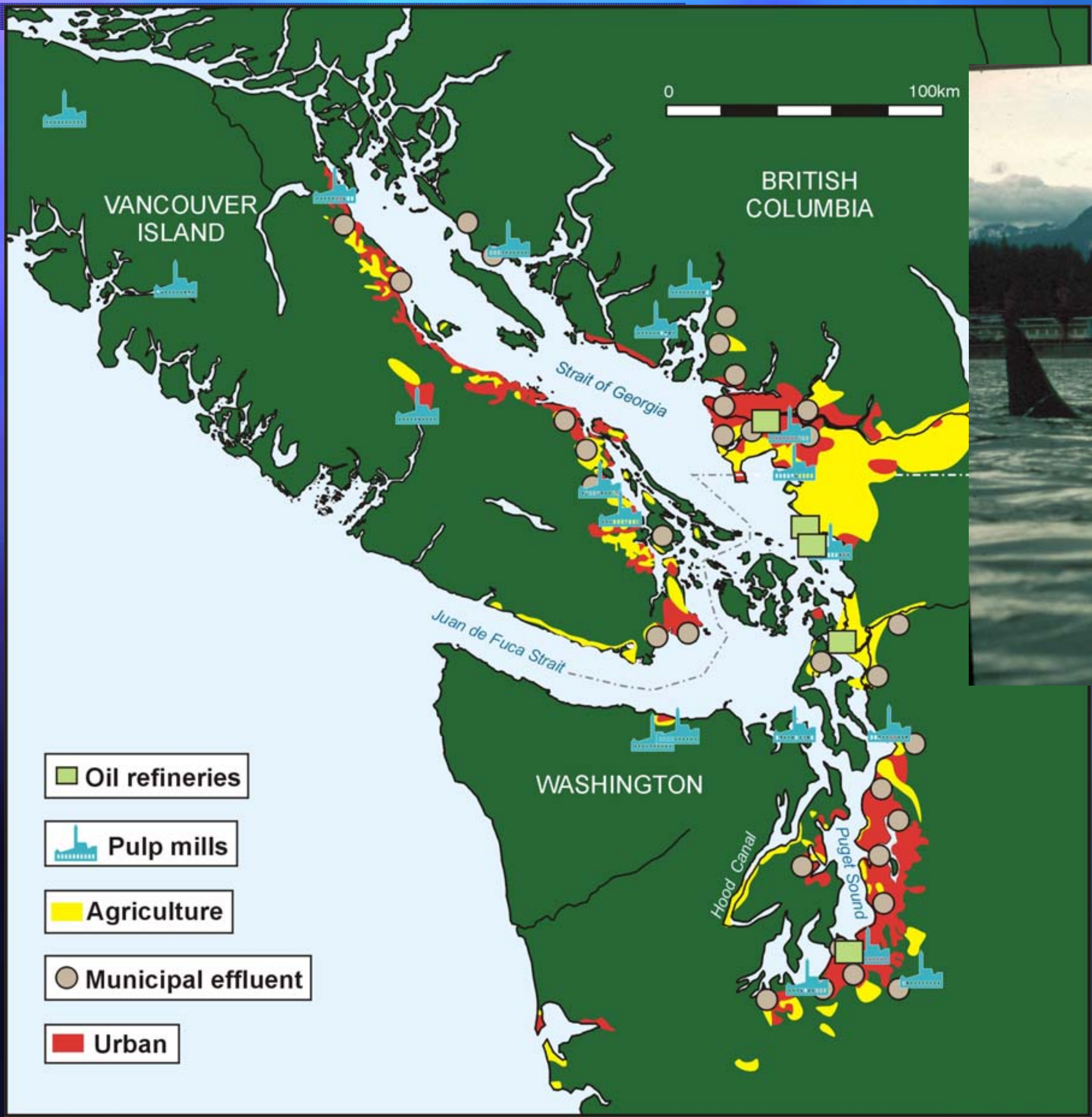
pesticides. Significant reductions in EOGs occurred within 25-min of exposure to 1 μg/l IPBC, within 10-min exposure to 10 μg/l atrazine, and within 2-min exposure to 100 μg/l (active ingredient [AI]: glyphosate isopropyl amine) Roundup. Increasing concentrations brought more rapid EOG decreases. Olfactory-meditated behaviour was altered in a similar manner: $10^{-7}$ M L-histidine preference behaviour was eliminated following 30-min exposure to 1 μg/l IPBC and atrazine, and 100 μg/l AI Roundup. Curiously, with atrazine exposure, trout exposed to 10 μg/l not only failed to exhibit preference behaviour, they exhibited avoidance behaviour. This behaviour was only noted previously with $10^{-3}$ M L-histidine. Atrazine and Roundup also altered general activity, with atrazine increasing swimming activity after 1 μg/l exposure and Roundup decreasing it after 100 AI μg/l. These results show that IPBC, atrazine and Roundup affect olfaction and the behaviours that depend on olfaction at μg/l concentrations within 30-min or less. Furthermore, atrazine and Roundup both affect swimming activity, suggesting that basic physiological processes in salmonids may be affected by exposure to currently used pesticides. The population-level consequences of these effects is presently unclear.

# From the Field to the Lab: Characterizing Current Use Pesticide Impacts on Salmon in British Columbia

*Peter S. Ross[1], Keith Tierney[2], Michael Sanborn[1], Neil Dangerfield[1], Tom G. Brown[1], Million Woudneh[3], and Chris Kennedy[2]*

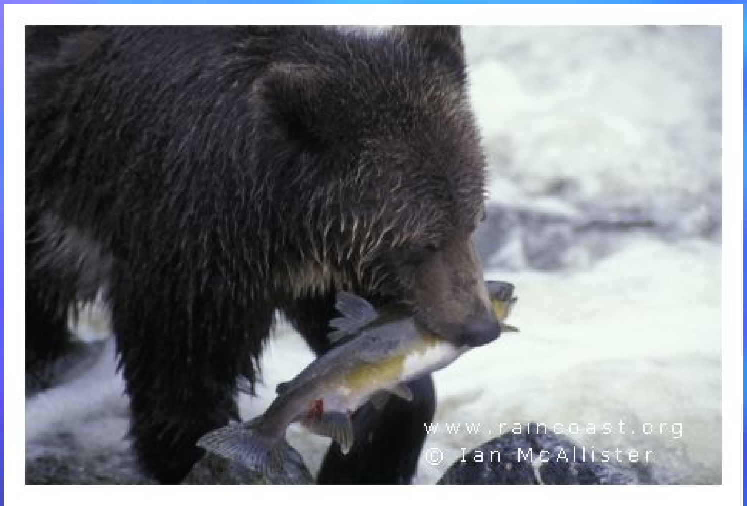
*1-Fisheries and Oceans Canada, 2-Simon Fraser University and 3-AXYS Analytical Services*

# Urban whales: Georgia Basin is local habitat for 84 southern resident killer whales




# Salmon represents 92% of annual diet of resident killer whales

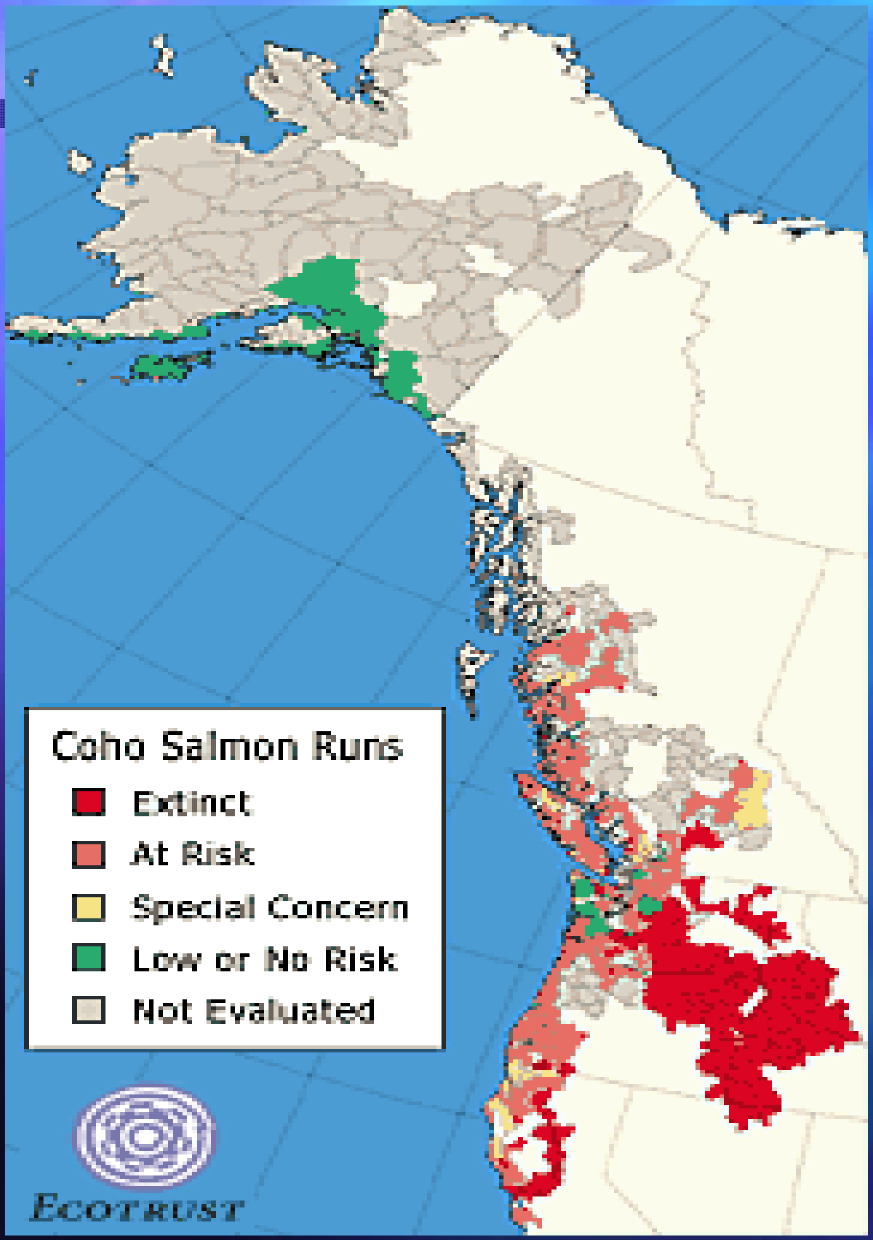
# Traditional food for killer whales, pinnipeds, seabirds and First Nations




# Pesticides and killer whales

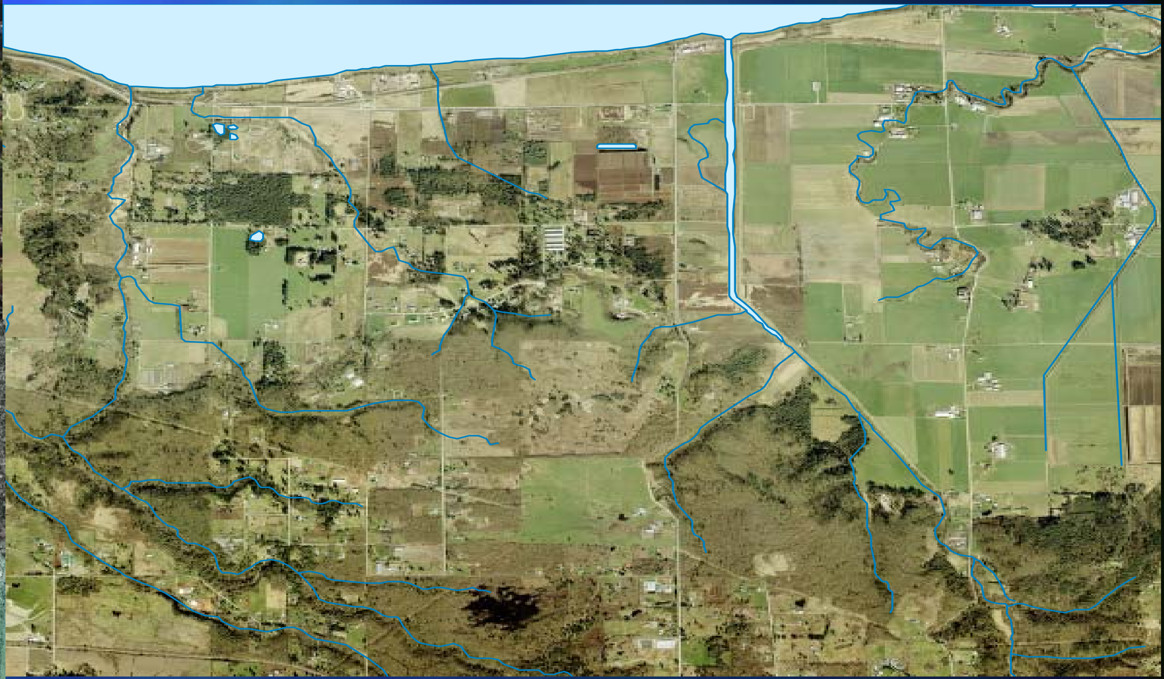
- Pesticides may impact killer whales in two ways:
  - Bioaccumulation and magnification in prey (e.g. salmon -> killer whale): PBT properties (e.g. DDT and fish-eating birds)
  - Impacts on prey base (e.g. salmon): non-PBT properties...?

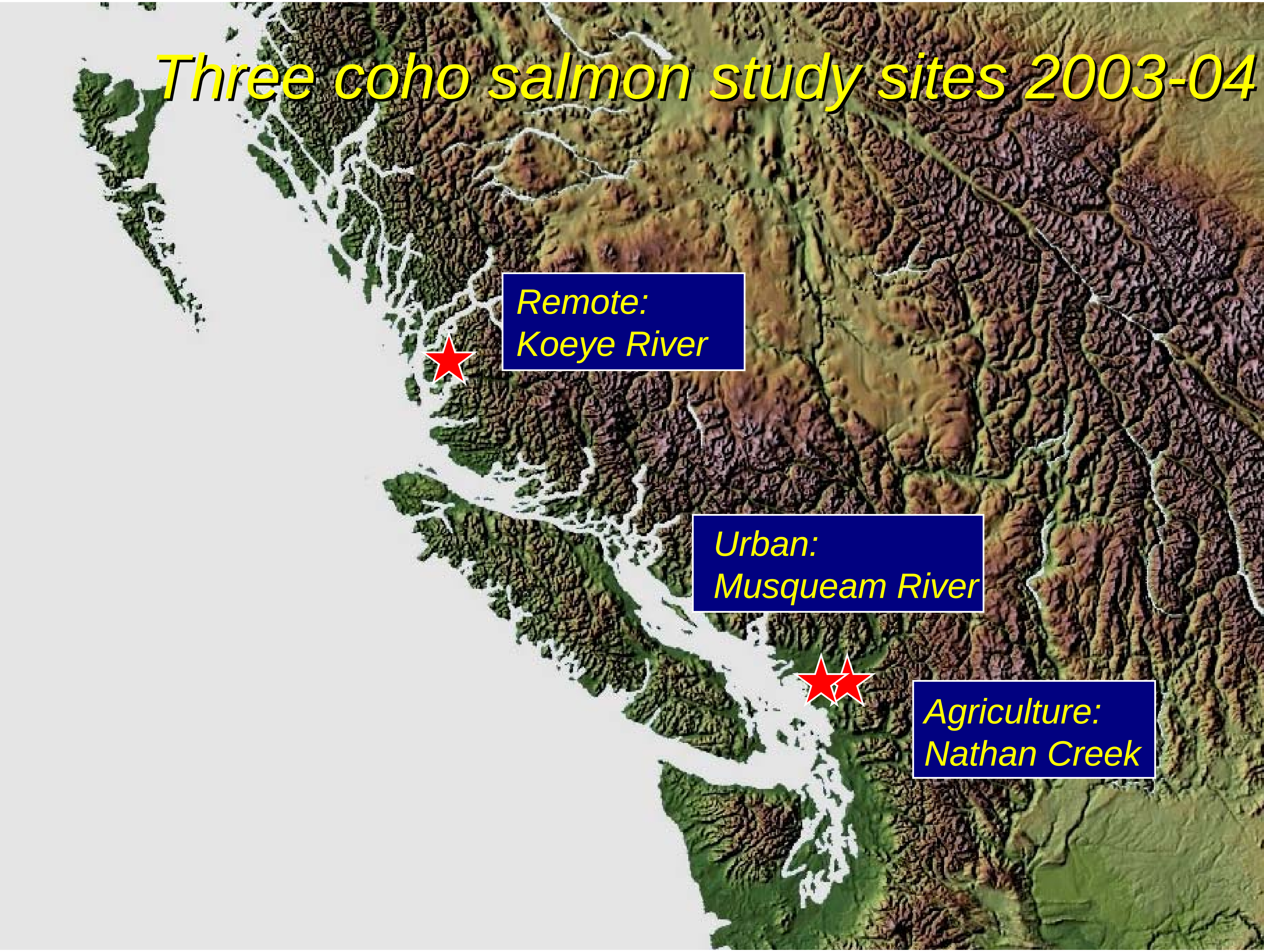
# *Coho at risk?*




- Spawning time – October to late February.
- Primary rearing/spawning location - Very small tributaries in Lower Fraser. Scattered distribution. Natal tributaries include sloughs and tidal channels of Fraser River estuary
- Rearing duration/location - 1-2 years; migrate to sea April-July.
- Age of migration to freshwater -2-3 years.

# Salmon habitat in Fraser system under assault from pesticides applied in forestry, agriculture and urban environments



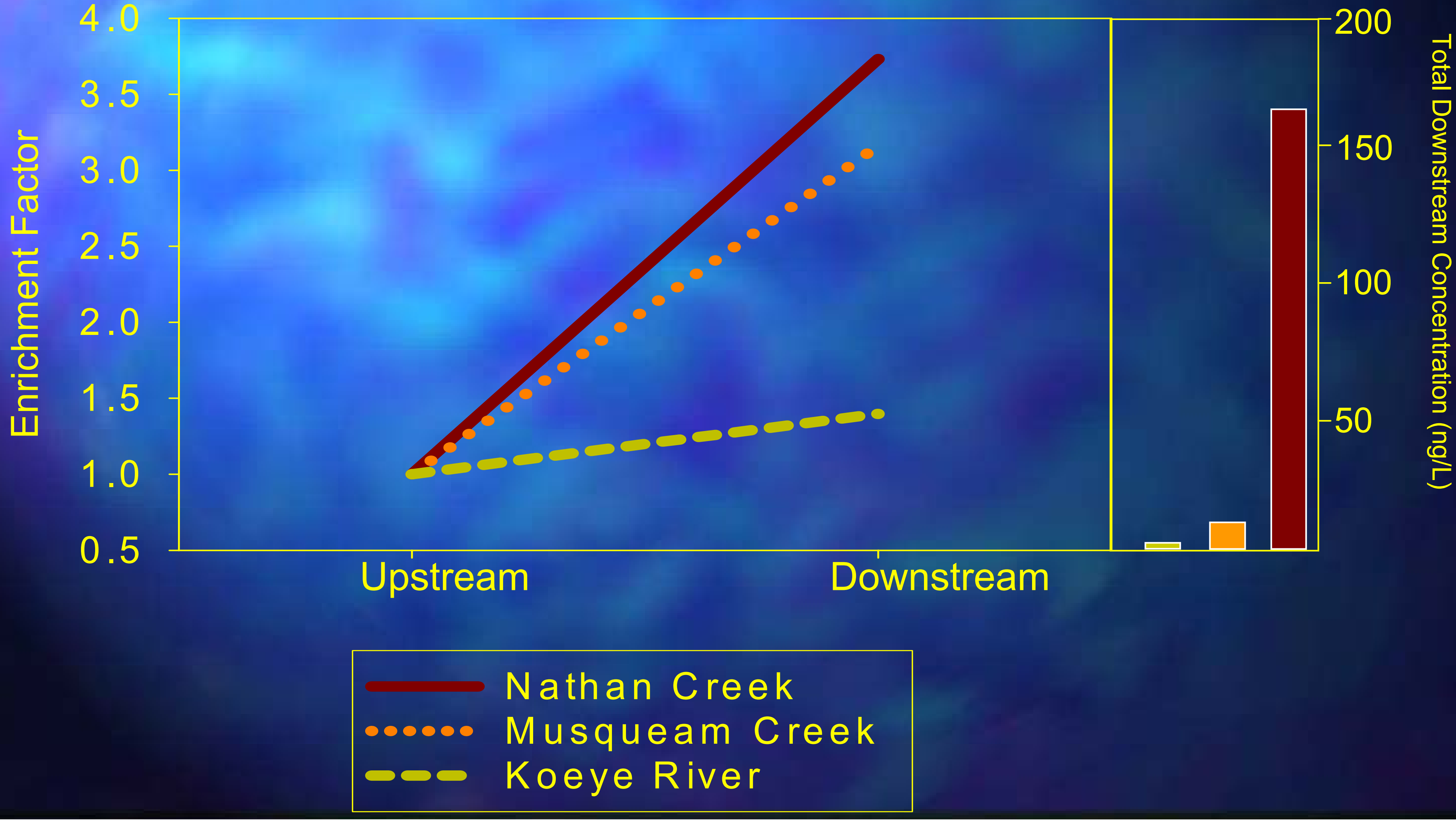


Three coho salmon study sites 2003-04
Remote:
Koeye River
Urban:
Musqueam River
Agriculture:
Nathan Creek

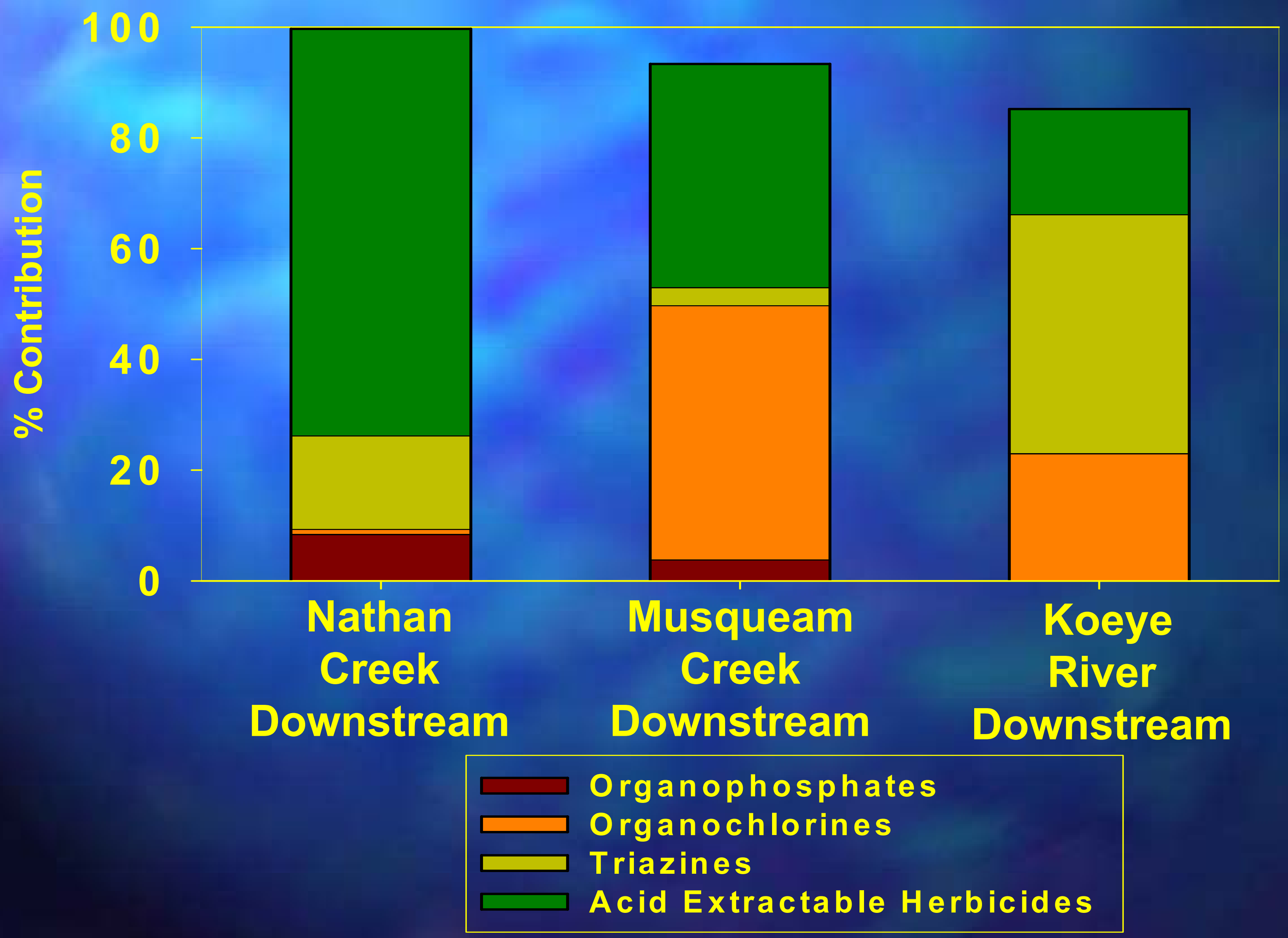
# Sample analysis: Progress

| | Multi-residue (OC's, OP's, triazines, carbamates) | Acid Extractable Herbicides |
|---|---|---|
| XAD (03) | Complete | Complete |
| Particulate (03) | Expected | Complete |
| Water (03/04) | Complete | Complete |
| Sediment (03/04) | Expected Dec 31 | Complete |
| Air (passive 04) | Expected Jan 31 | Expected Jan 31 |
| Tissue (03/04) | Expected Jan 31 | Expected Dec 31 |

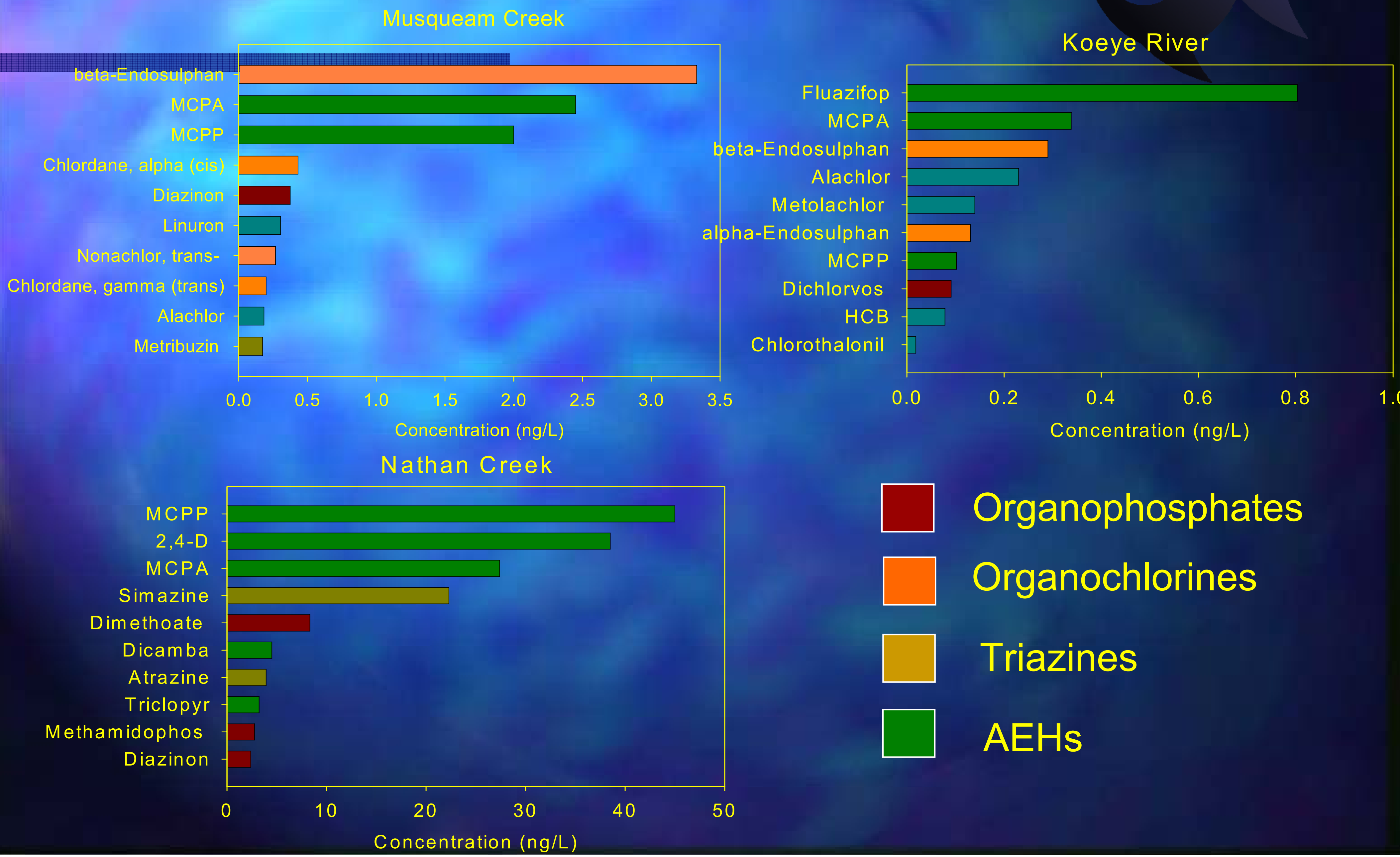
# Total pesticide concentrations increase downstream, especially in impacted areas



# Agricultural site (water) was dominated by AEH and triazine pesticides



# Top 10 pesticides



# *Preliminary conclusions*

- A wide variety of pesticides were detected at all three coho spawning streams;
- Levels were generally higher downstream, at impacted segments of the streams;
- The agricultural site had the highest concentrations, with herbicides dominating;
- The urban site had surprisingly low pesticide concentrations, despite two golf courses and a landscaped urban housing area.
- The remote site had relatively low levels of pesticides, dominated by triazines and OC's (North American vs Asian air pollution?).

# *Three-year CUP project to characterize CUP in coho salmon habitat, and effects on olfaction and behaviour*

- **Phase One: *habitat***
  - ✓ Establish PAC DFO priority CUP list (23)
  - ✓ Work with EC on priority list
  - ✓ Develop analytical methods (AXYS Analytical Services)
  - ✓ Assess CUP in coho salmon habitat: air, water, sediments
  - ❑ Assess CUP in juvenile coho
  - ❑ Assess in invertebrate prey/ sticklebacks?

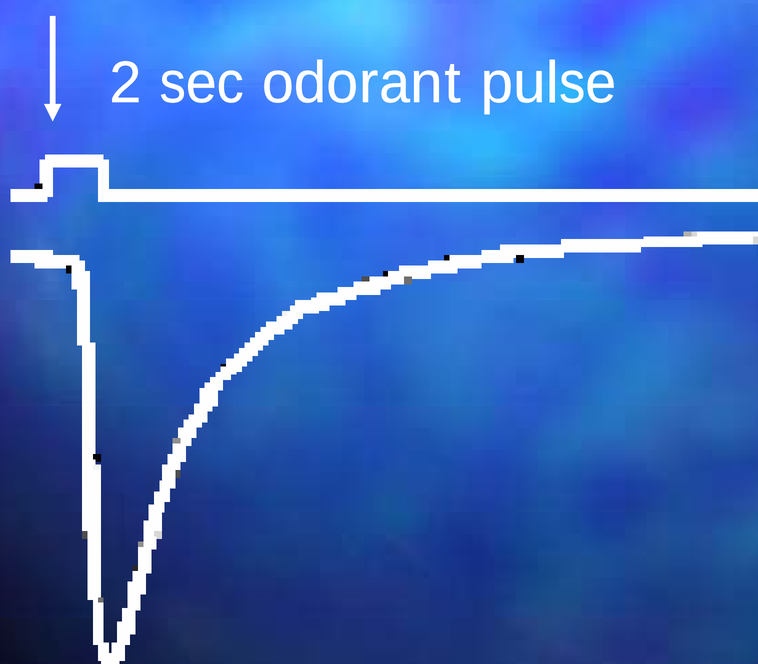
- **Phase Two: *effects***
  - ✓ Establish DFO CUP shortlist to assess effects (<12)
  - ✓ Set up methods to measure effects of CUP on olfaction and neurological responses in lab (SFU)
  - ✓ Conduct experiments in laboratory exposure setting
  - ❑ Compare effects thresholds to ‘real world’ levels measured in Phase One
  - ❑ Conduct study of effects of CUP on salmon *in situ*

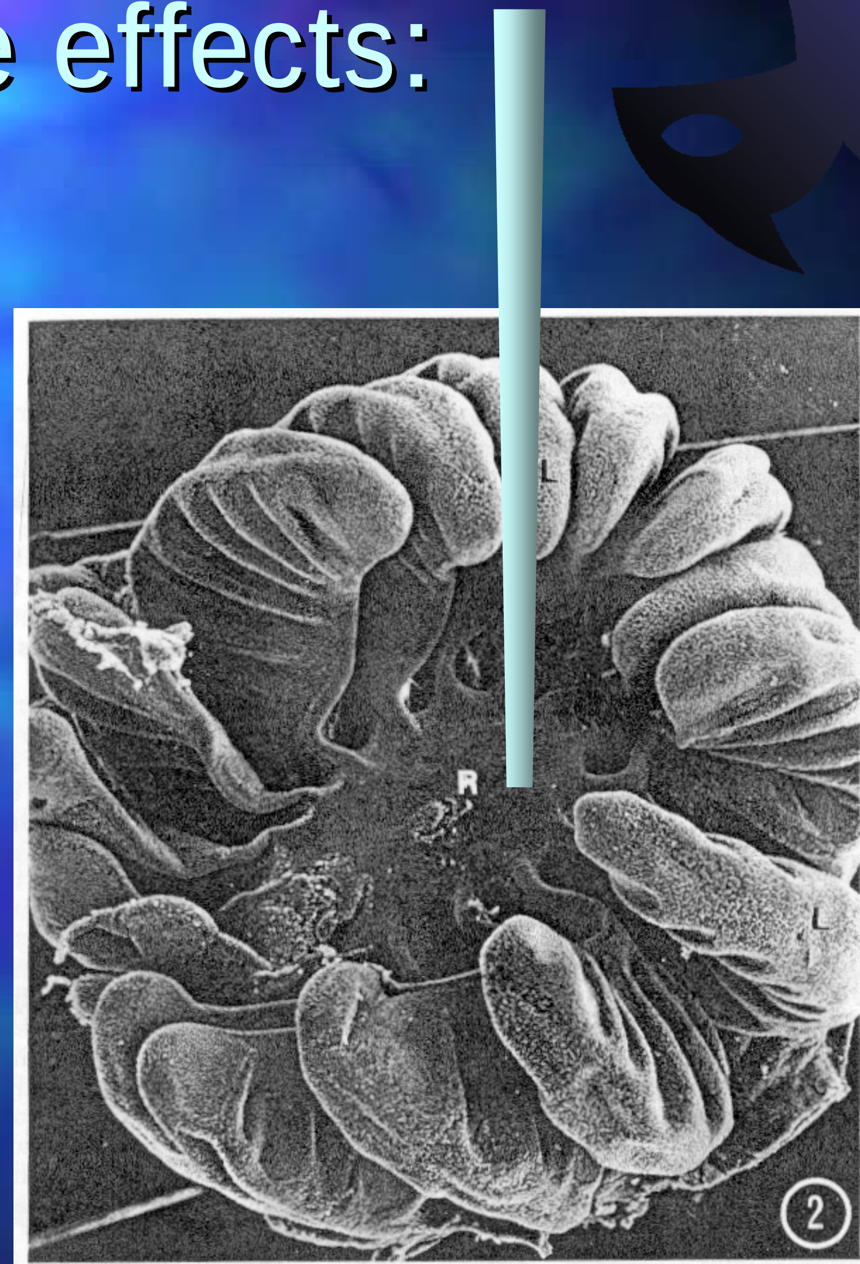
# Sublethal pesticide effects:

## neurophysiology

Ag Cl electrode

- Electro-olfactogram (EOG)

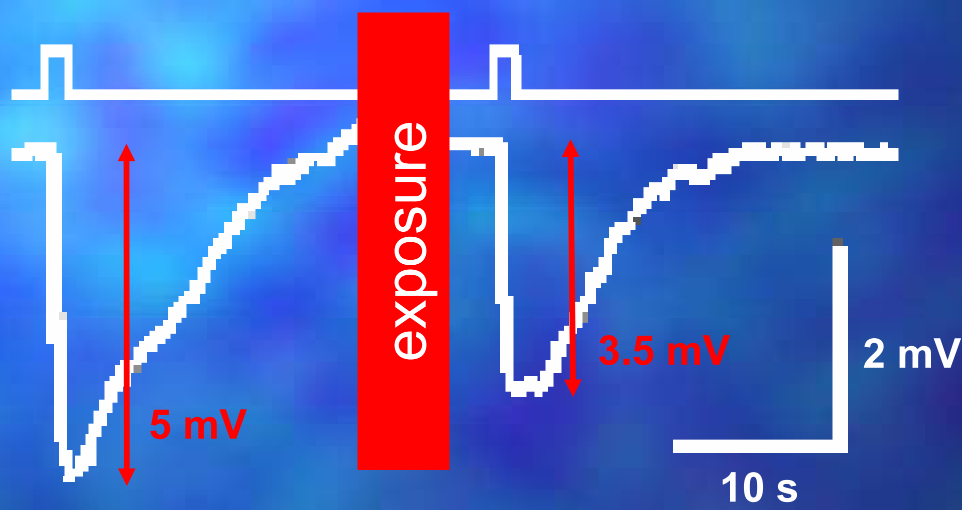



Moran et al. 1992

# Sublethal pesticide effects:
## neurophysiology

EOG reduction {




**Δ EOG**

**1- (3.5 / 5) = 0.3**

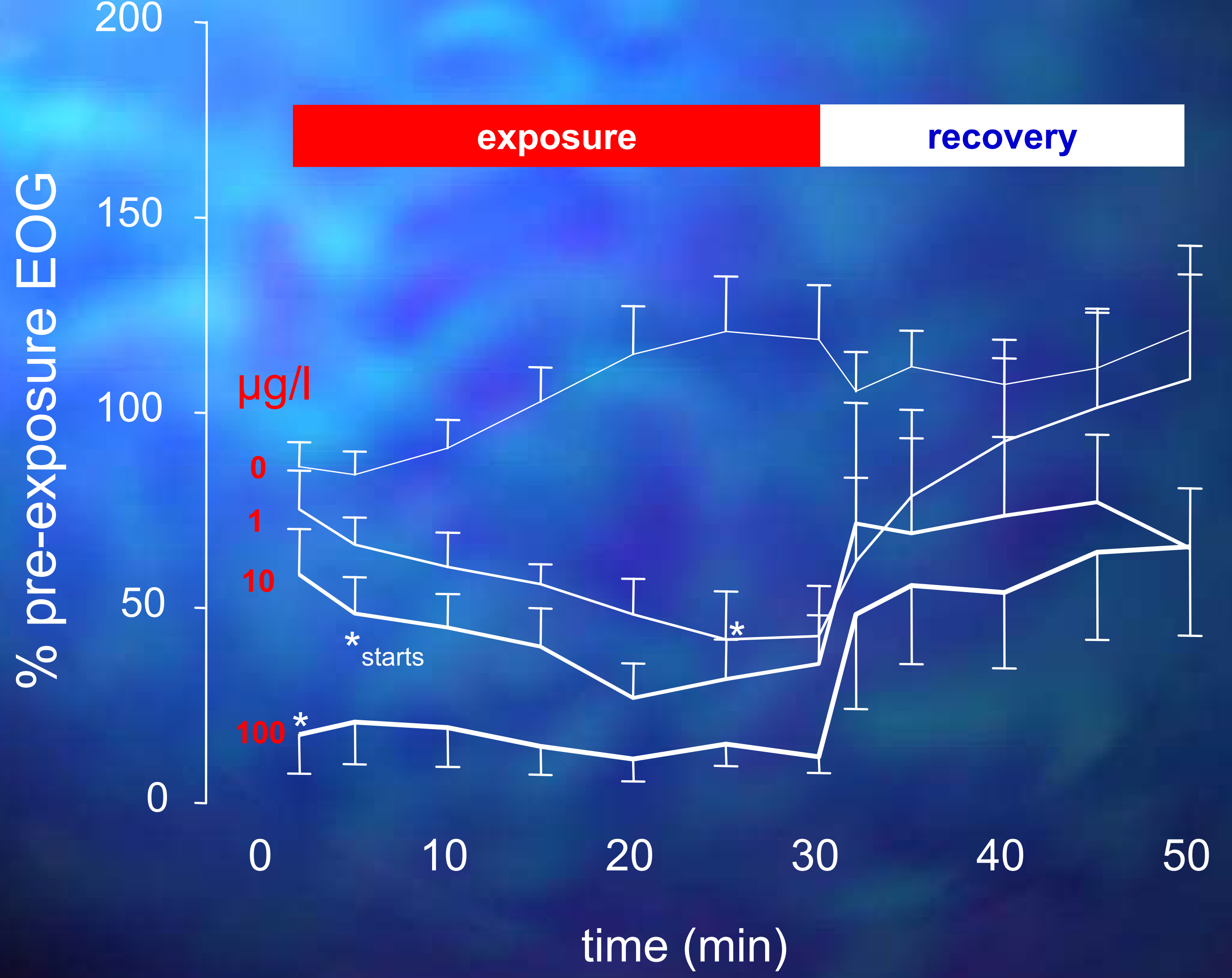
**or 30% reduction**

**Copper**
in CCA, Copper II
20% drop w/ 1 µg/L
(Baldwin et al. 2003)

**Triazines**
simazine, atrazine
1 µg/L total
10% drop for simazine, 12% atrazine, 17% for combination
(Moore & Lower 2001)

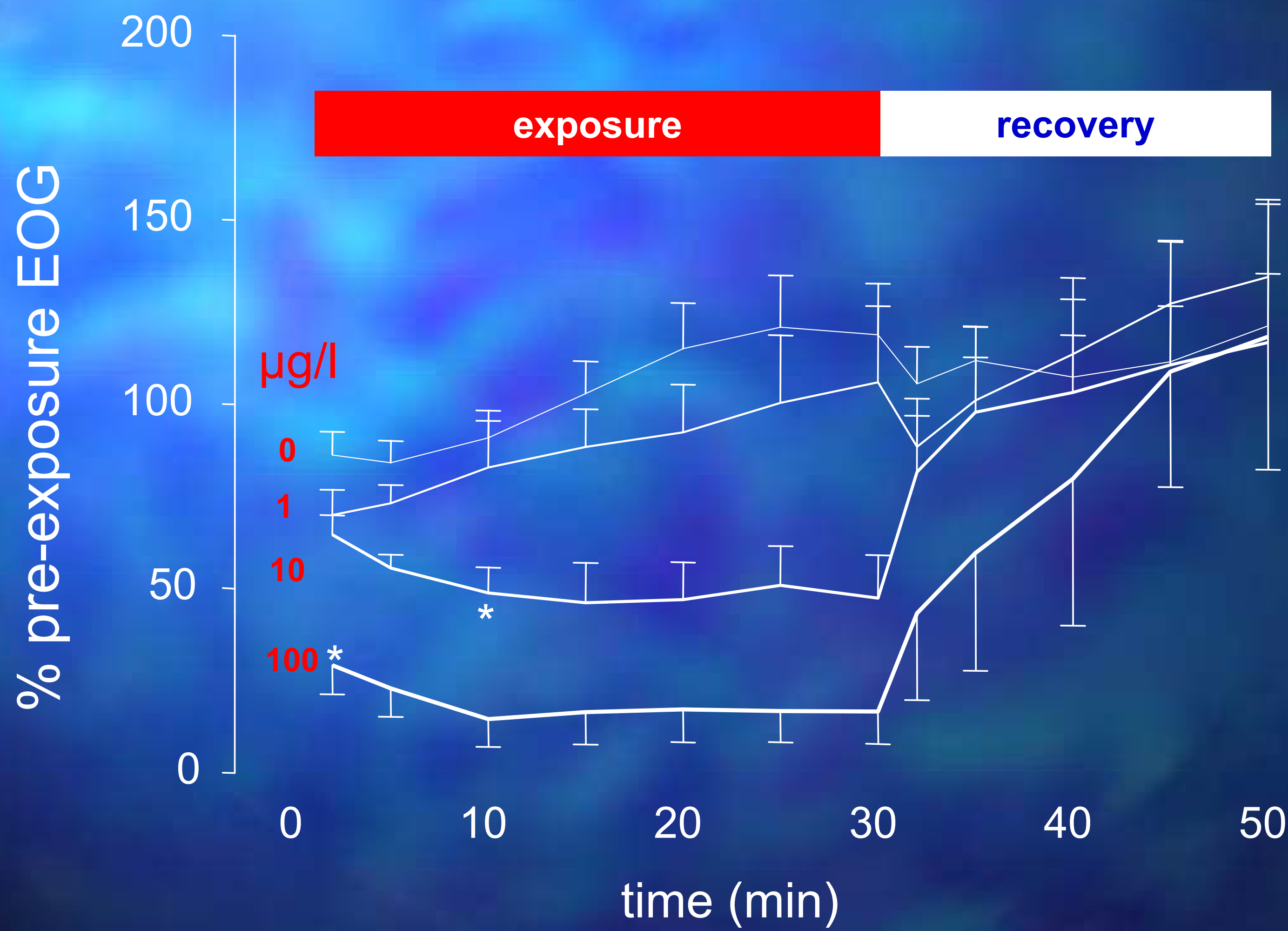
**Carbamates**
IPBC
50% drop w/ 1 µg/L
(Jarrard et al. 2004)

# Carbamate effects on EOG




*RM ANOVA, HS, p<0.05

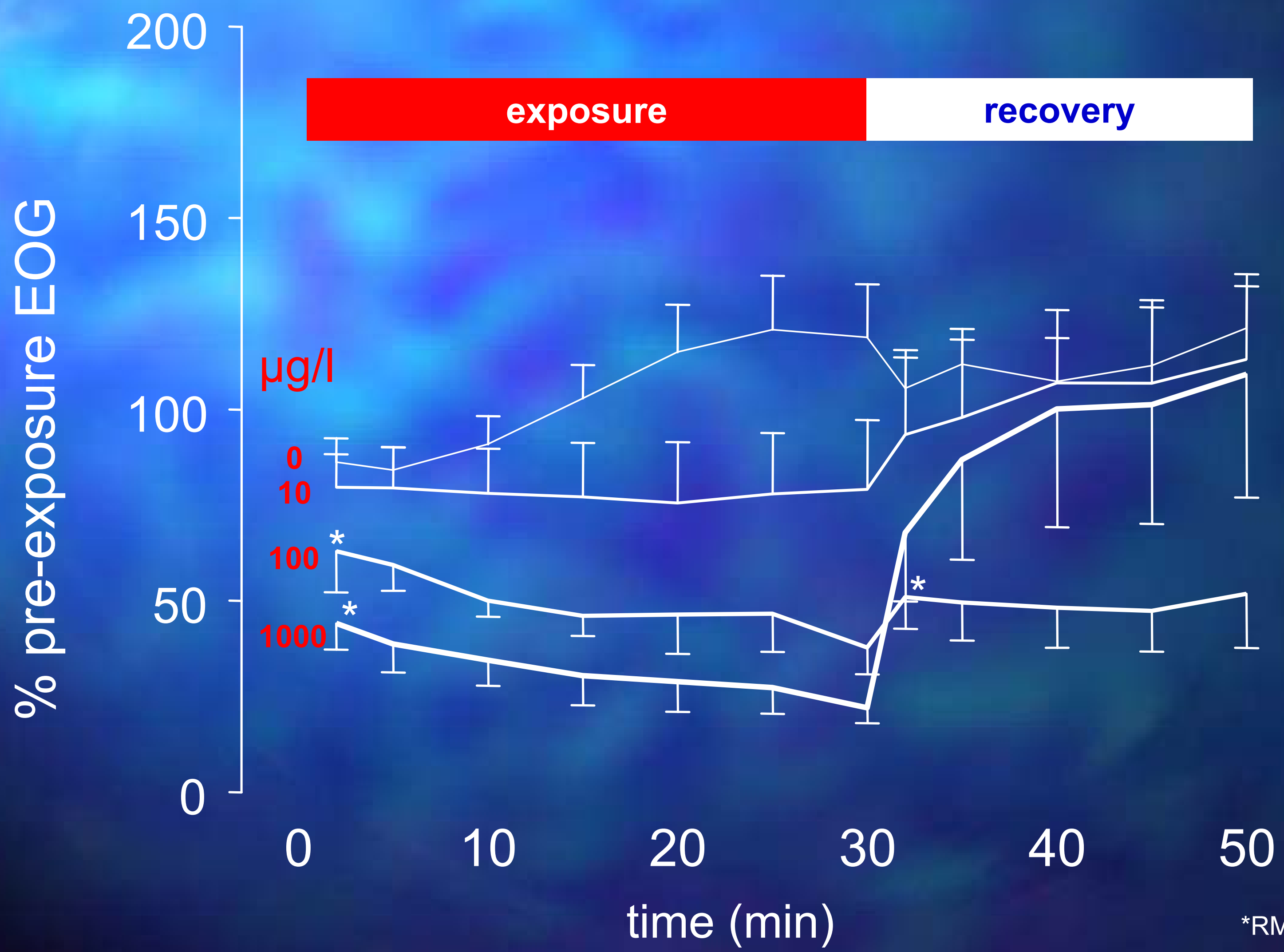
# Atrazine effects on EOG




*RM ANOVA, HS, p<0.05

Note: same 12% decrease w/ 1 µg/l as Moore & Lower 2001…

# Roundup® (~glyphosate) effects on EOG




*RM ANOVA, HS, p<0.05

# Pesticides and behaviour: preference/avoidance

0 sec

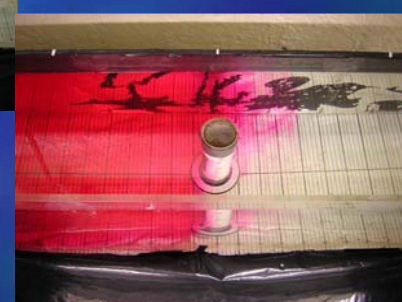
+

30 sec

+ / -

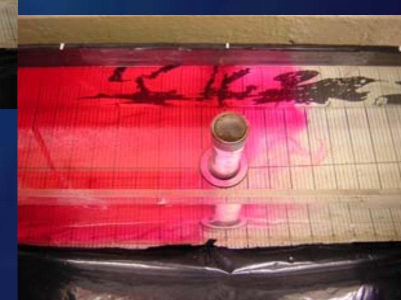
1 min

+ / -

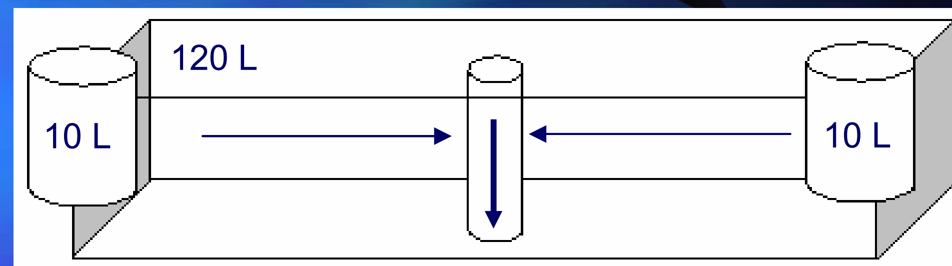


2 min

+ / -



10 min



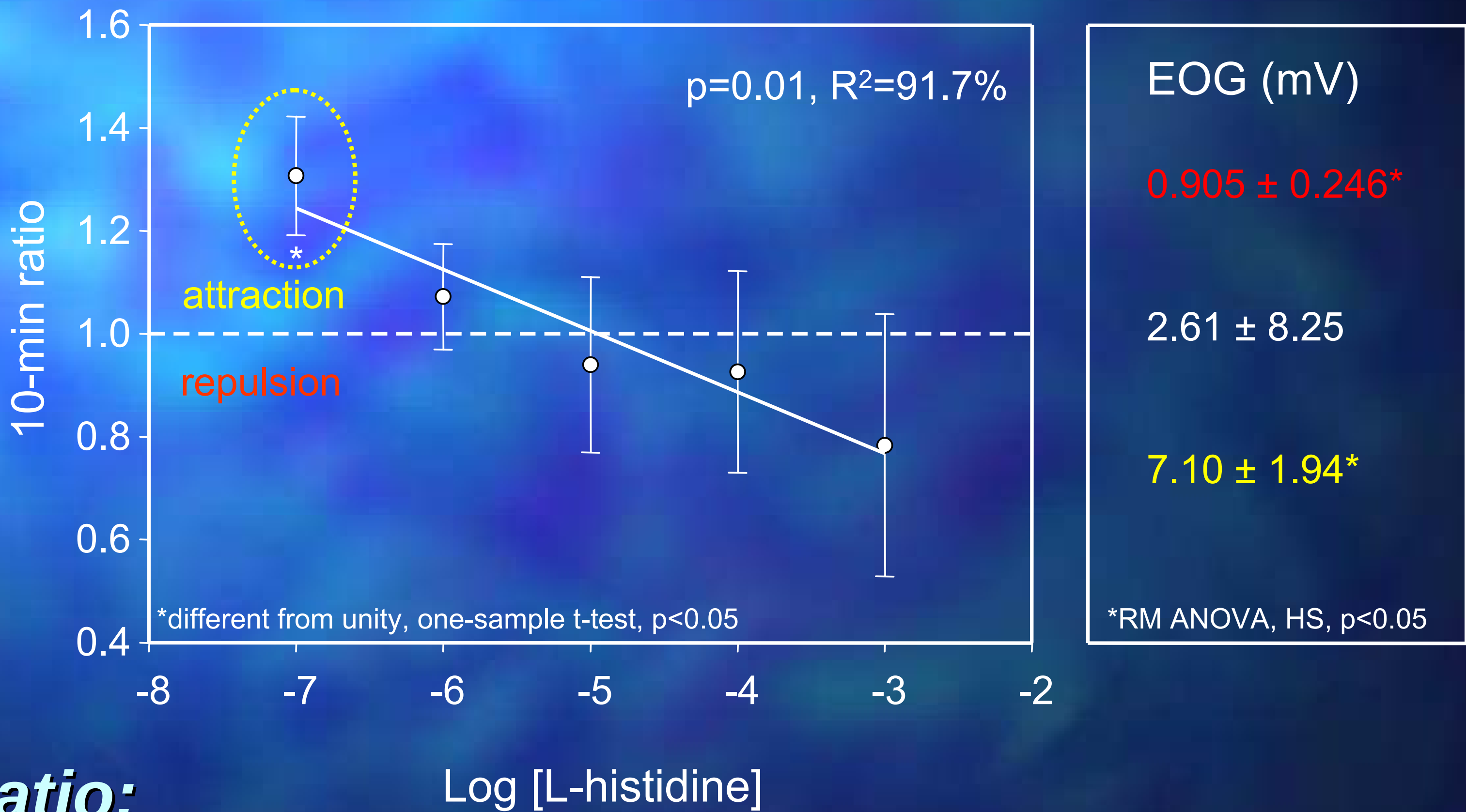

Fish position recorded by 5 cameras connected to a P4 PC

## Questions

- Are pesticides avoided?
- 30-min exposure
  - Is activity altered?
  - Is avoidance altered?

# Pesticides and behaviour: preference/avoidance

## L- histidine attraction and repulsion



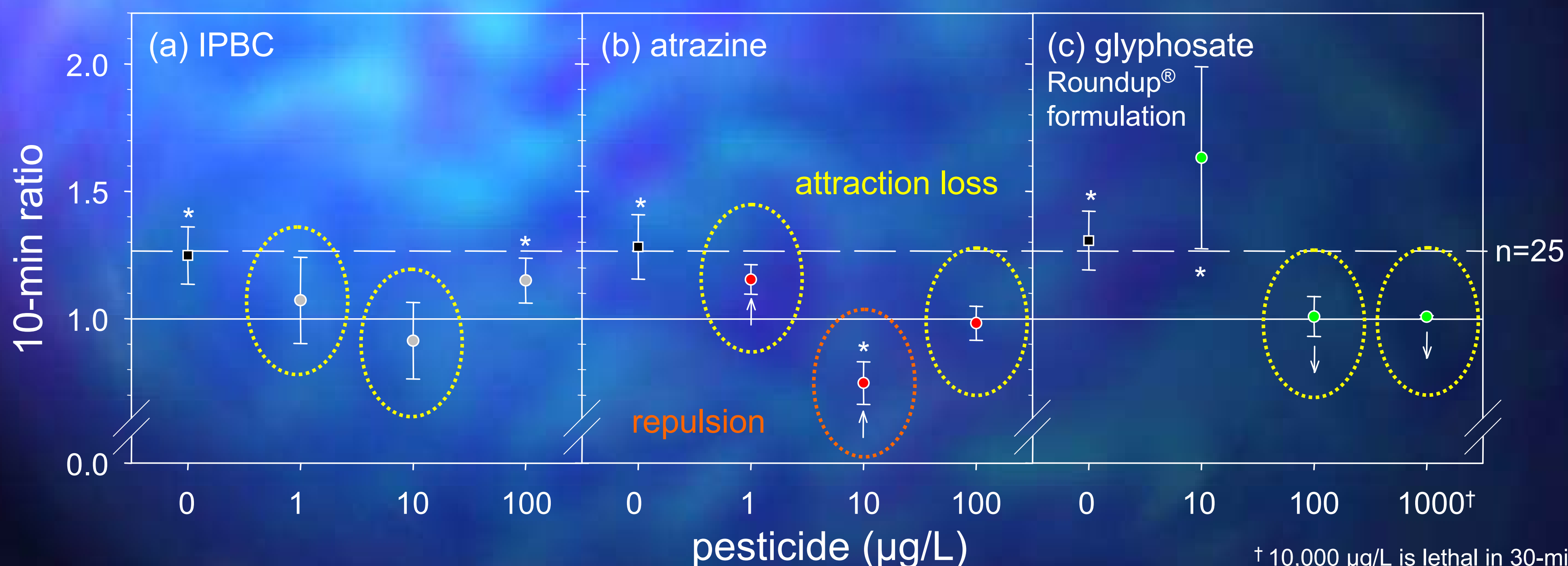

***The 10-min ratio:***

**following a 30-min acclimation,**

**time on (+) side before / time on (+) side after**

# Pesticides and behaviour: preference/avoidance

## L- histidine attraction and repulsion after 30-min exposure




**none avoided the test concentrations**

† 10,000 µg/L is lethal in 30-min, but is avoided

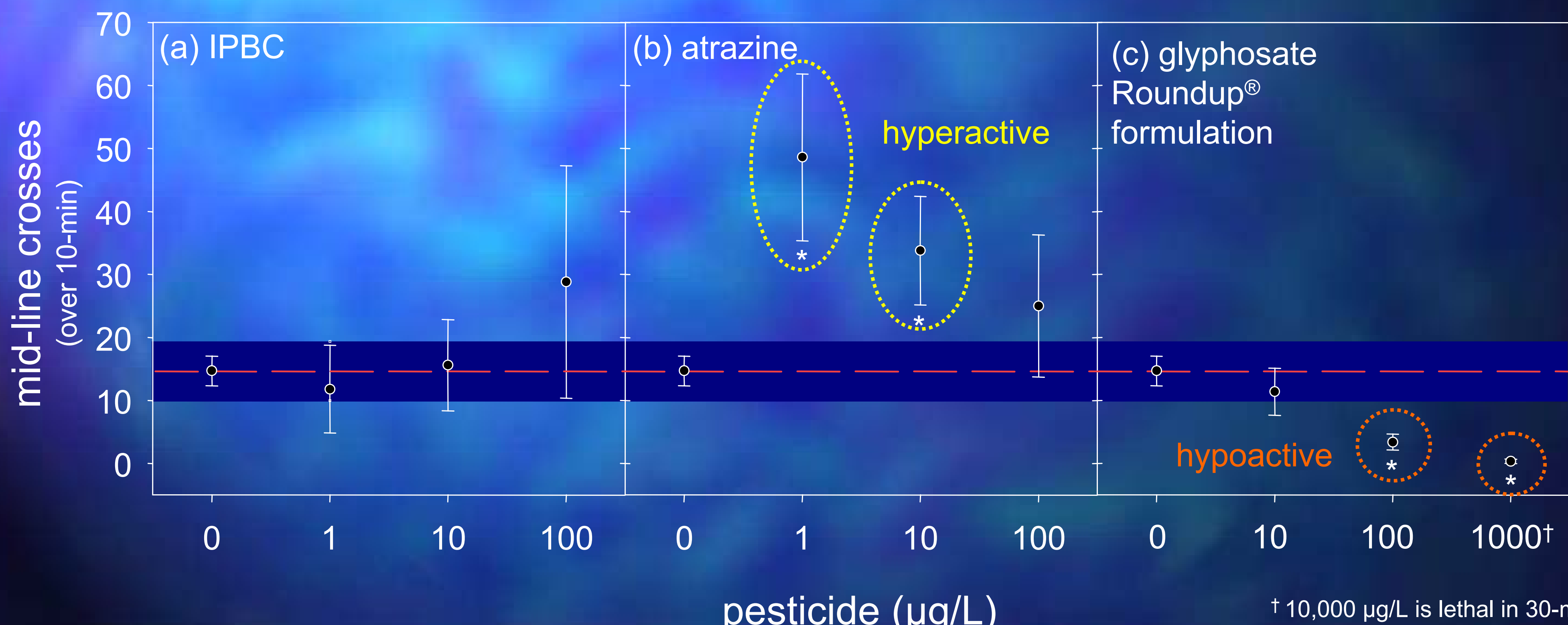
↑ hyperactive
↓ hypoactive

*n=6 per concentration; one-sample t-test against unity

96-hr $LC_{50}$ 22 [12-38] mg/l for 12 g coho salmon - Roundup® (Mitchell et al. 1987)

# Pesticides and behaviour: activity level

## IPBC, atrazine and Roundup®: effects on activity




**none avoided the test concentrations**

† 10,000 µg/L is lethal in 30-min, but is avoided

96-hr $LC_{50}$ 22 [12-38] mg/l for 12 g coho salmon - Roundup® (Mitchell et al. 1987)

*n=6 per concentration; RM ANOVA against control, $p<0.05$

# *A risk to salmonids?*

- Little is known about the population-level effects of these current use pesticides on salmon development, health and survival;
- Lab and lab-field studies will shed light onto effects of pesticides on salmon olfaction and related behaviours;
- Sensitive lifestages of coho and other salmon species may be vulnerable to toxic effects of pesticides or their ‘inert’ additives (e.g. Fairchild 1999);
- Reduced salmon viability may have implications for commercial fishers, First Nations and wildlife.

# *Linkages*

- *Environment Canada:* surveillance of surface and groundwater at 50+ locations in BC; seasonal samplings at our DFO 'salmon sites' (T. Tuominen and M. Sekela).
- *DFO pesticide research*: Center for Pesticide Research. Pesticide use in BC (2004). Types, applications and risks. Verrin, Begg and Ross. CTFAS no. 2517.
- *Simon Fraser University:* Effects of 12 priority CUP on coho olfaction and behaviour (lab) (K. Tierney and C. Kennedy).
- *AXYS Analytical Services:* development of methods to detect pesticides.

Acknowledgements

- DFO National Pesticide Research Fund;
- Our DFO friends: Terry Shortt, Gary Rawn, Stacey Verrin, Laurie Gallagher, Brad Mason;
- All the crew at Axys: Laurie Phillips, Coreen Hamilton;
- Musqueam First Nation; Heiltsuk First Nation;
- Our EC friends: Taina, Mark, Melissa, Pat, Christine, John, Marvin.

# Pesticide Exposure and Reproductive Effects in Native Amphibian Species Using Agricultural Habitat, South Okanagan, British Columbia (2003-2005)

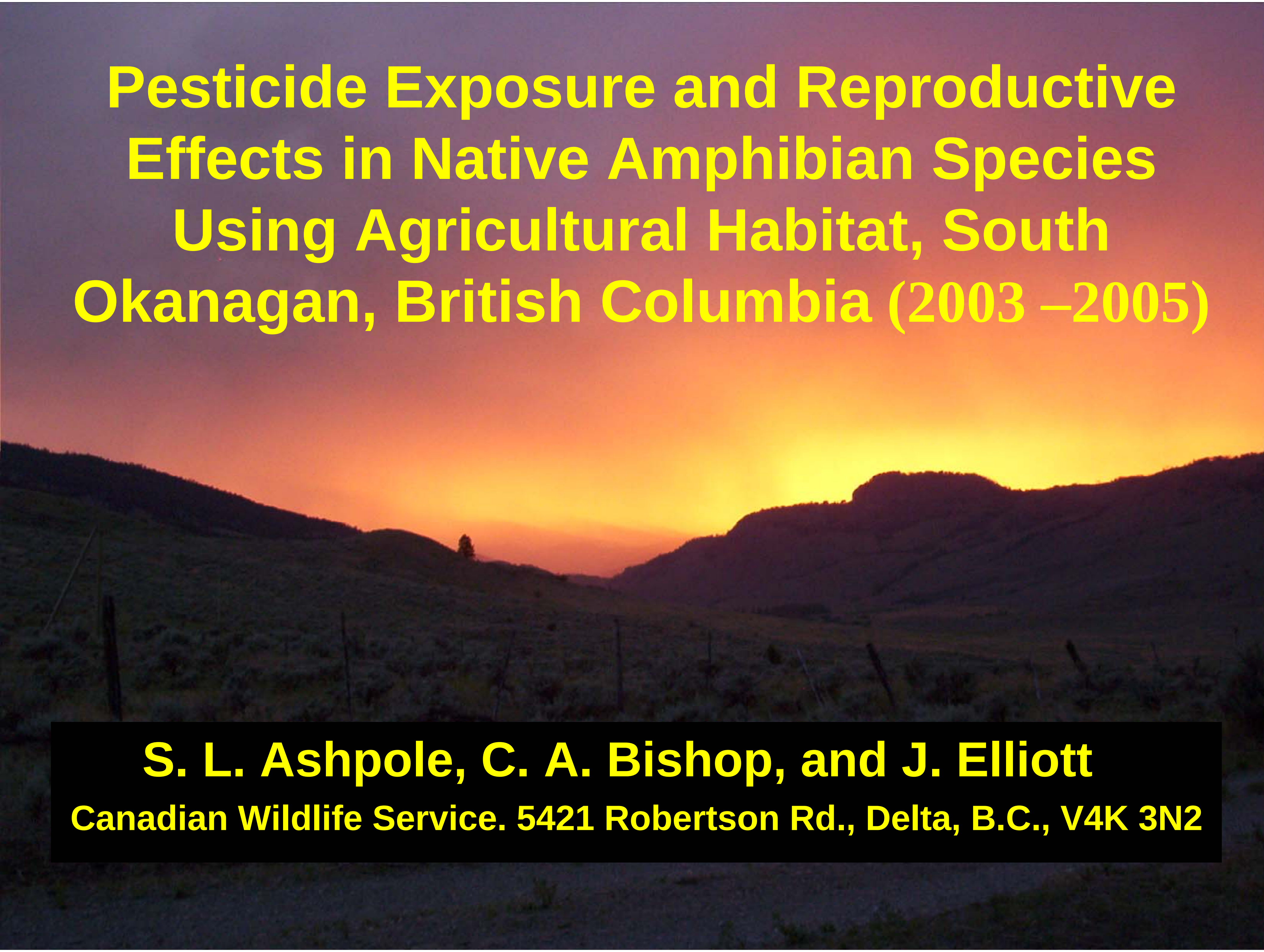
**Sara L. Ashpole, Christine A. Bishop, John Elliott,** Canadian Wildlife Service. 5421 Robertson Rd. Delta, British Columbia, V4K 3N2, Canada. (sashpole@uoguelph.ca; CAB.Bishop@ec.gc.ca; john.elliott@ec.gc.ca)

Abstract

The Okanagan valley in BC is an area of intensive agriculture where 80% of the natural wetlands and riparian zones have been drained or altered. In total, 64 ponds, including 23 agricultural ponds, were surveyed to determine adult breeding, larval productivity, and relative population densities (2003 – 2005). To assess the risk of amphibian populations to multiple stressor effects of pesticides, we conducted two *in situ* experiments focusing on early native amphibian stages of development. Hatching success, tadpole survival, and abnormalities were recorded. Enclosures with eggs were placed in ponds located in either conventional orchards and subjected to pesticide applications (azinphos-methyl, carbaryl, diazinon, endosulfan, pirimicarb), or in organic orchards, or non-agricultural control ponds. Water chemistry samples were collected on two occasions during early and mid tadpole development in each year. In 2004, water pesticide samples were collected from all sites at standard times after egg-enclosure entry and after known spray events. Samples were analysed for nine carbamates and 24 Organophosphates in 2004 by a government laboratory. Only Endosulfan (<5000 ng/L) was detected at Test Site-1 24hrs after egg entry, however only carbaryl (7600 ng/L) was detected at Test Site-1 after a known carbaryl spray event. The carbaryl concentration in the spray tank was 340 mg/L. All remaining pesticide analysis in 2004 was non-detectable. In 2005 water pesticide samples were collected two-days post heavy rain during early and mid tadpole development. A third sample was collected from two spray exposed sites during late tadpole development after known spray exposure. Samples in 2005 were analysed by the Axys laboratory for 92 current-use pesticides and acid extractable herbicides. Current-use pesticide concentrations found include: atrazine (1.65, 12.7 ng/L), azinphos-methyl (39.5, 14.7 ng/L), diazinon(27.8, 84.2 ng/L), endosulfan sulphate (134, 14.5 ng/L). Some pesticide data is currently being analysed. Historic contaminant levels in sediments were at relatively low to non-detectable levels, with the exception of DDT and its metabolites (DDT 0.24 - 47 ng/g d.w. (dry weight); DDE 2.52 – 1938.9 ng/g d.w.; DDD 5.26-1334.4 ng/g d.w.) (2003). In 2004, Spadefoot (*Spea intermontana)* and Western Toad (*Bufo boreas*) eggs were placed in conventional (N=2) and organic orchards (N=3). In 2004, substantial mortality was observed in both species at one of our conventional sites (92% and 100%); whereas, mortality was very low at one of our organic sites (3% and 4%). Mortality among remaining sites ranged between 15% and 38%. In 2005,

Spadefoot and Pacific Treefrog (*Pseudacris regilla*) eggs were placed in conventional orchards (N=3) and control ponds (N=3). Our conventional sites experienced 35 - 100% mortality; whereas our reference sites experienced less than 12% mortality.

# Pesticide Exposure and Reproductive Effects in Native Amphibian Species Using Agricultural Habitat, South Okanagan, British Columbia (2003 –2005)



**S. L. Ashpole, C. A. Bishop, and J. Elliott**

**Canadian Wildlife Service. 5421 Robertson Rd., Delta, B.C., V4K 3N2**

# Osoyoos, B.C.


Okanagan Lake
Naramata
Summerland
Penticton
Skaha L.
Okanagan Falls
Vaseux L.
Okanagan River
Keremeos
Similkameen River
Oliver
Osoyoos
Program Boundary
5 0 5 Kilometres

# Amphibians of the S. Okanagan

## Endangered
– Tiger Salamander

## Threatened
– Great Basin Spadefoot

## Special Concern
– Western Toad

## Not at risk
– Pacific Treefrog
– Colombia Spotted Frog
– Long-toed Salamander

## Extirpated
– Northern Leopard Frog

## Introduced
– American Bullfrog

Spadefoot *(Spea intermontana)*

# Project Purpose

Due to the presence of many rare species and the high potential for exposure to pesticides and the lack of natural habitat, it is necessary to assess the risk of amphibian populations to the impact of pesticides.

The objectives of the study are to:

1. inventory and determine the relative abundance and distribution of native amphibians
2. assess exposure and effects of current in-use and historic pesticides on developing amphibians in agricultural habitats of the South Okanagan

# Objective 1: Summary of Activities

(2003-2005)

### Species Inventory 2003-2005

- To determine, and species diversity relative abundance a total of 71 sites were surveyed between April and July of each year, and classified as:
  - conventional (n = 14) and organic (n = 13) orchards
  - low land (n = 12) and high elevation (n = 23) reference
  - residential (n = 4), miscellaneous(n = 5)
- Habitat landscape parameters were measured at all accessible sites

Water Chemistry: samples were collected annually at each site in July

Historic-use pesticides: sampled in sediment at a sub-sample of 11 low elevation sites (2003)

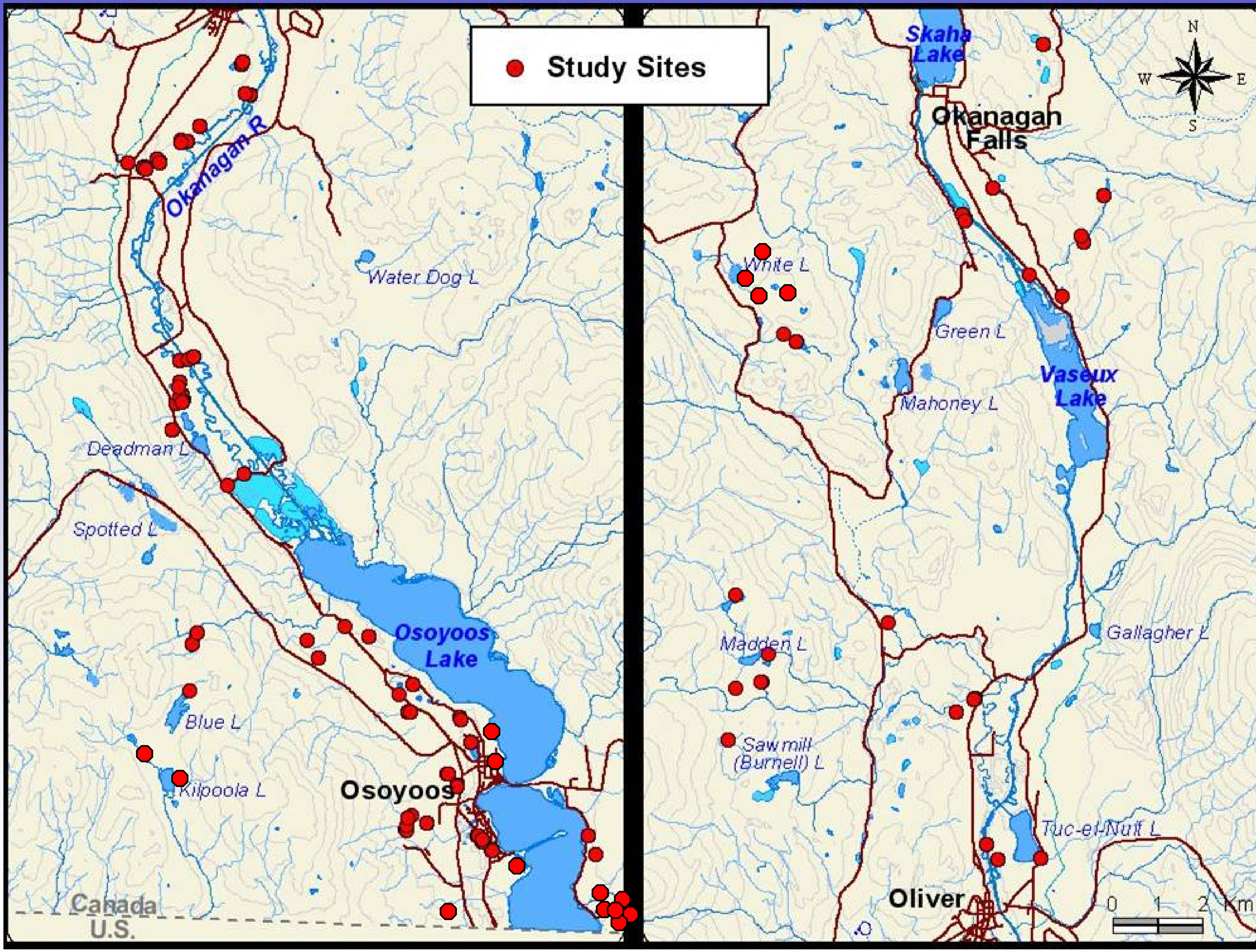
- samples had non-detectable PCB levels, and relatively low to non-detectable OC pesticides, *with the exception of DDT and its metabolites* (DDT 0.24 – 47, DDE 2.5 – 1938, DDD 5.3-1334 ng/g dry weight)

Tissue samples: (Road kill & mundane individuals)

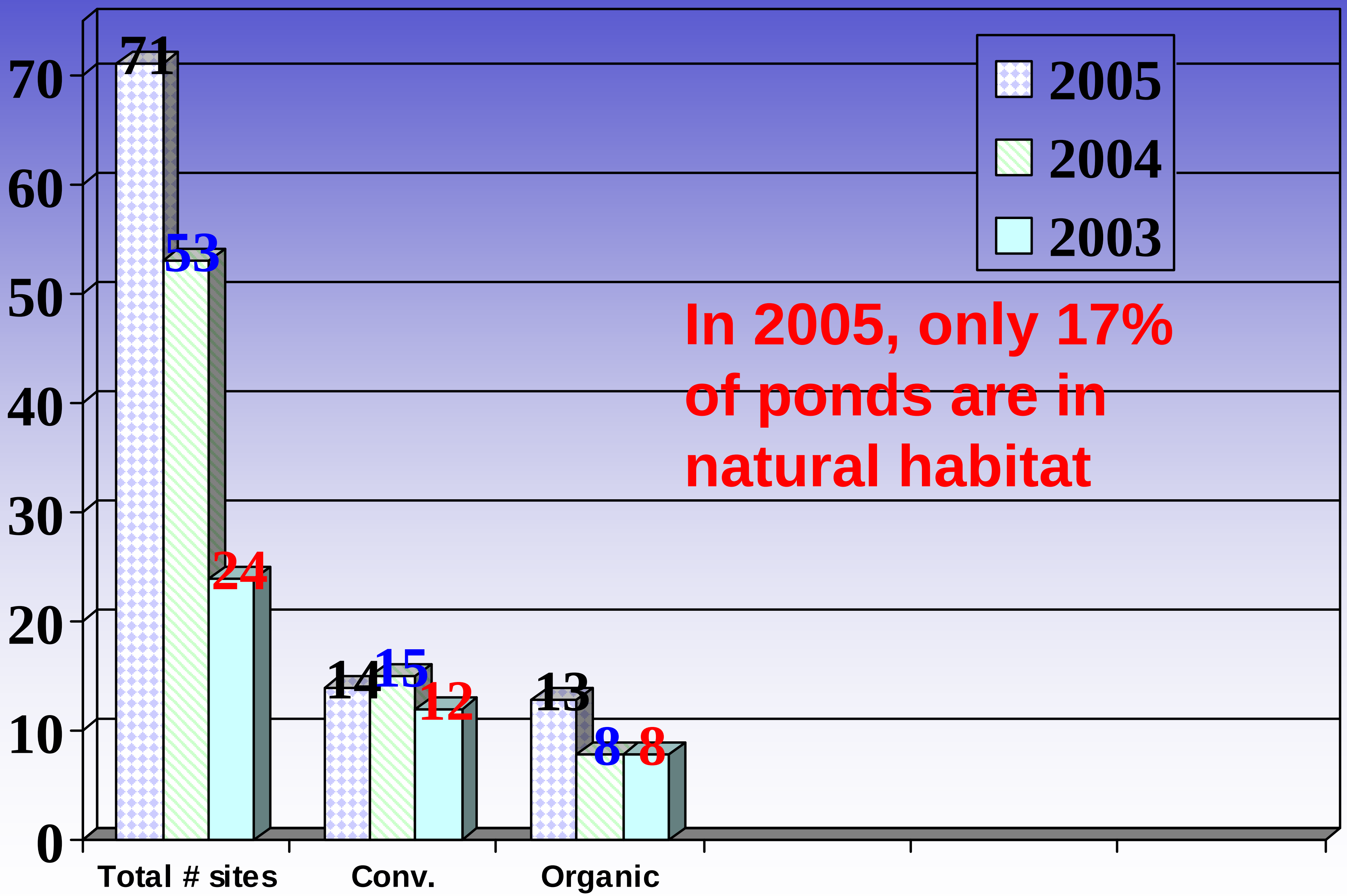
- Treefrog N = 5; Spadefoot N = 20; Tiger Salamander N = 14, Bullfrog N = 107 (disposed)

# Study Sites

# Inventory Sites 2003 - 2005



# Number of Ponds per Site Category

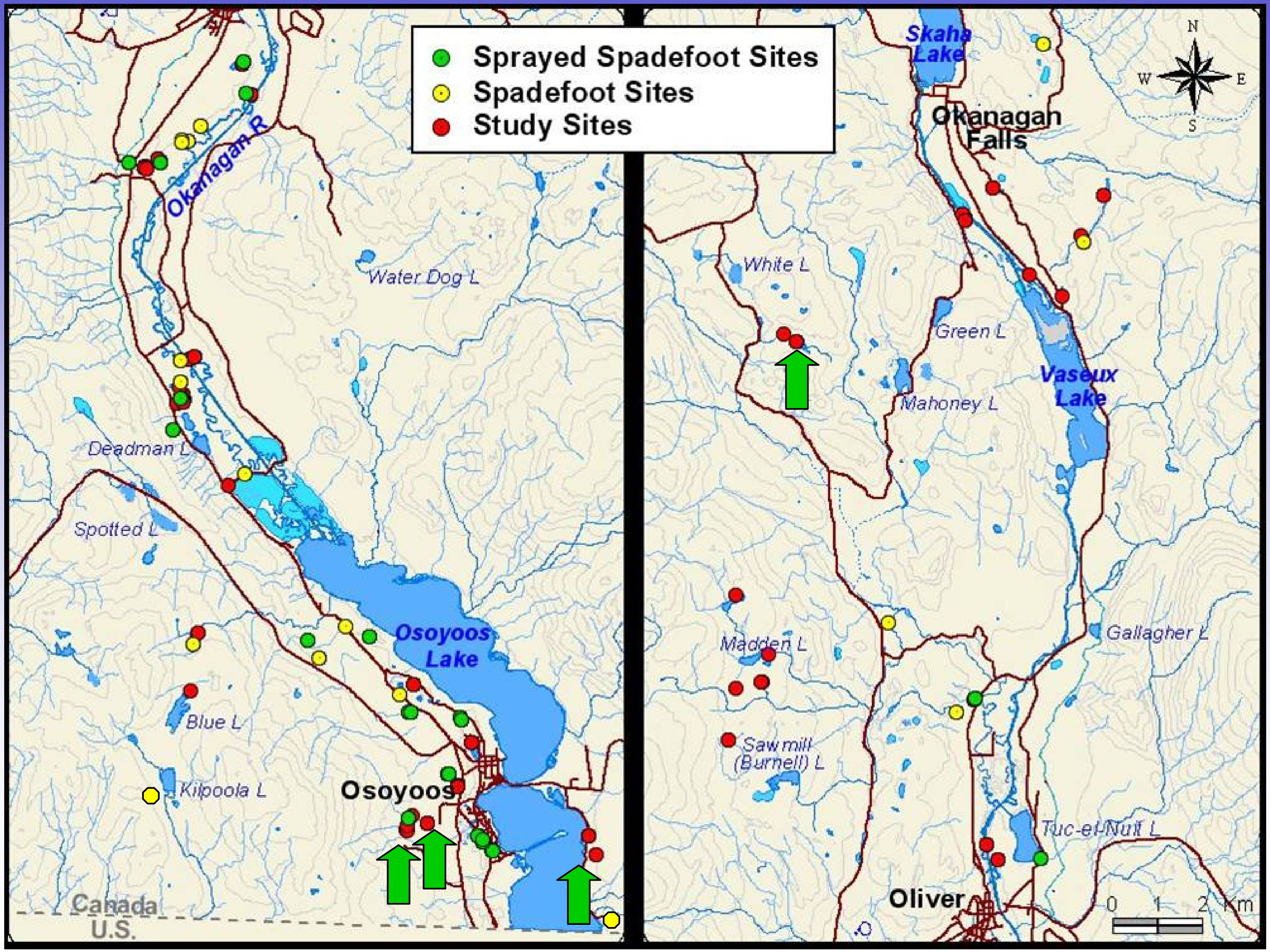



In 2005, only 17% of ponds are in natural habitat

# Brief Inventory Results

| Species | Number of Sites Observed | | | | | |
|---|---|---|---|---|---|---|
| | 2003, N = 23 sites | | 2004, N = 53 sites | | 2005, N = 71 sites | |
| | Any Stage | Reproductive | Any Stage | Reproductive | Any Stage | Reproductive |
| **Treefrog** | 20 | 13 | 45 | 18 | 61 | 26 |
| **Spadefoot** | 9 | 6 | 23 | 9 | 32 | 10 |
| **Western toad** | 7 | 3 | 3 | 1 | 3 | 2 |
| **Columbia Spotted frog** | 5 | 3 | 8 | 1 | 7 | 4 |
| **Tiger Salamander** | 4 | 3 | 3 | 1 | 7 | 7 |
| **Bullfrog** | 3 | 0 | 2 | 2 | 4 | 1 |
| **Long-toed Salamander** | 1 | 1 | 8 | 4 | 5 | 5 |

# Results: Sites with spray events and Spadefoot observations

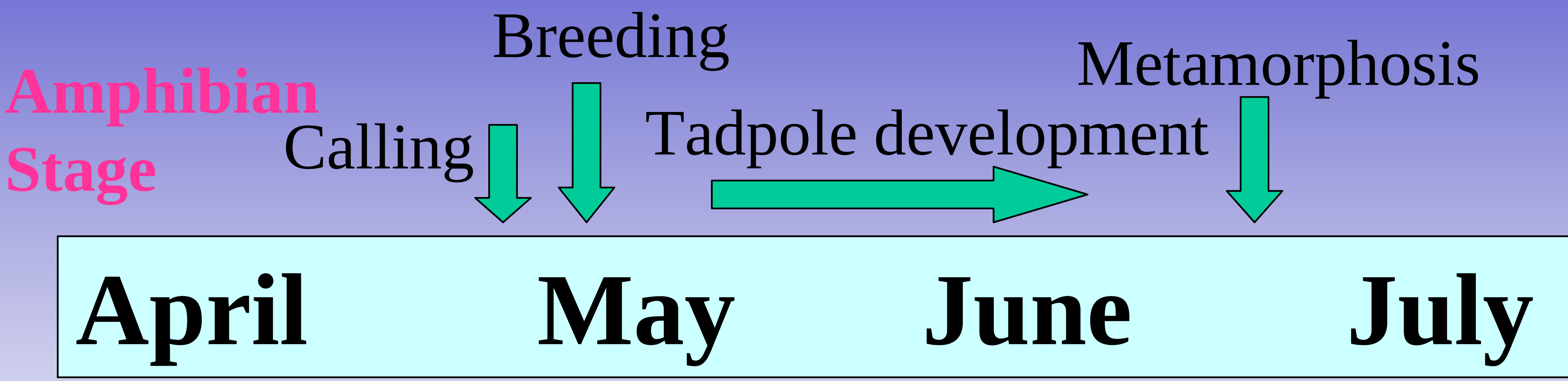


# Habitat Stressors

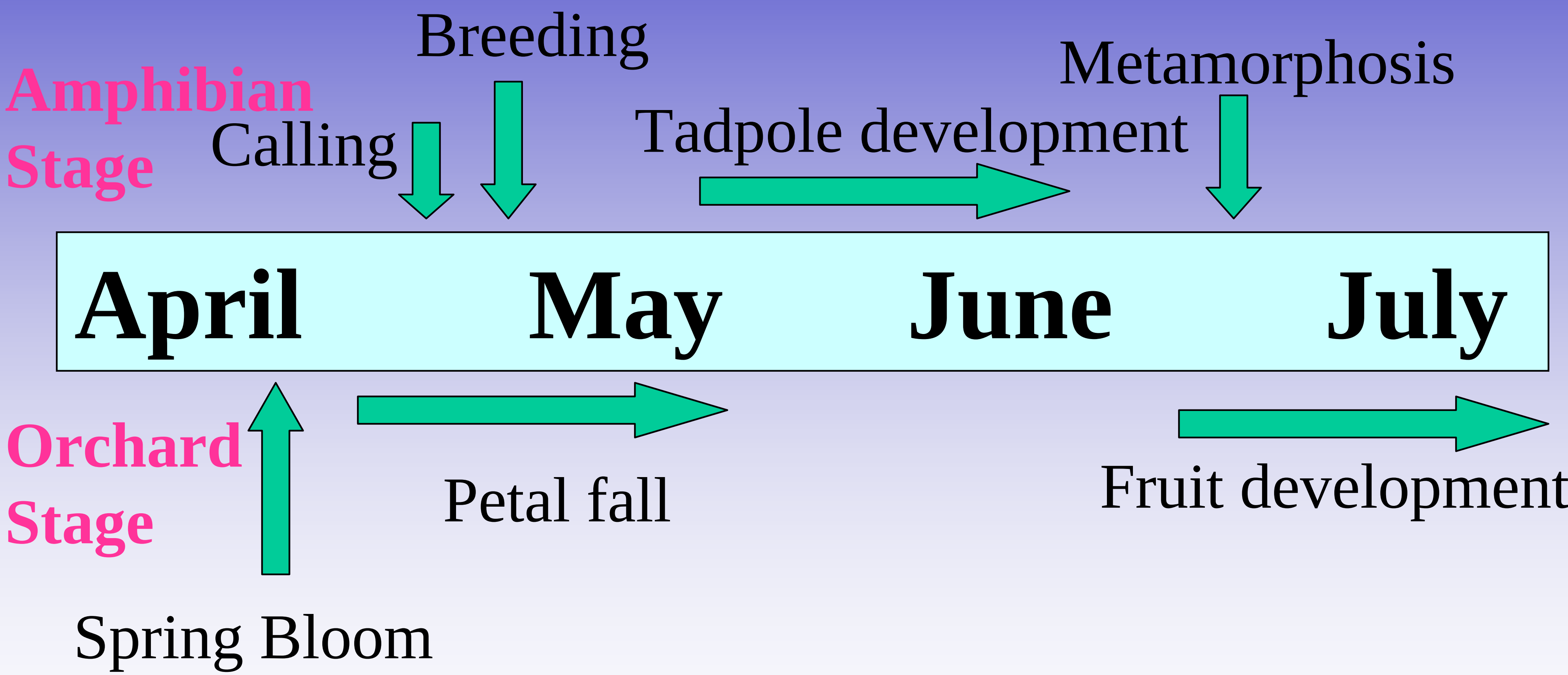
SMALL PONDS:

- Pond perimeter (mean 350m, range 30–809 m)
- SHALLOW PONDS:
- Water depth (mean 2.8m, range 0.72-4.85m)
- =POOR DILUTION CAPACITY
- OFTEN SUBJECT TO DRAINING
- Distance to fruit crops (mean 3.3m, range 0.2 – 17.9m)
  - many conventional ponds are groomed to the high water mark and the natural pond vegetation almost completely reduced
- Fish were detected in 38 of 66 natural ponds
  - 29 of 38 sites with fish had no amphibian reproduction detected and rarely were auditory calls heard

# Spadefoot Tadpole Development & Spray Chronology



# Spadefoot Tadpole Development & Spray Chronology



# Spadefoot Tadpole Development & Spray Chronology

**Amphibian Stage**

Breeding

**Tadpole development**

| April | May | June | July |
|---|---|---|---|

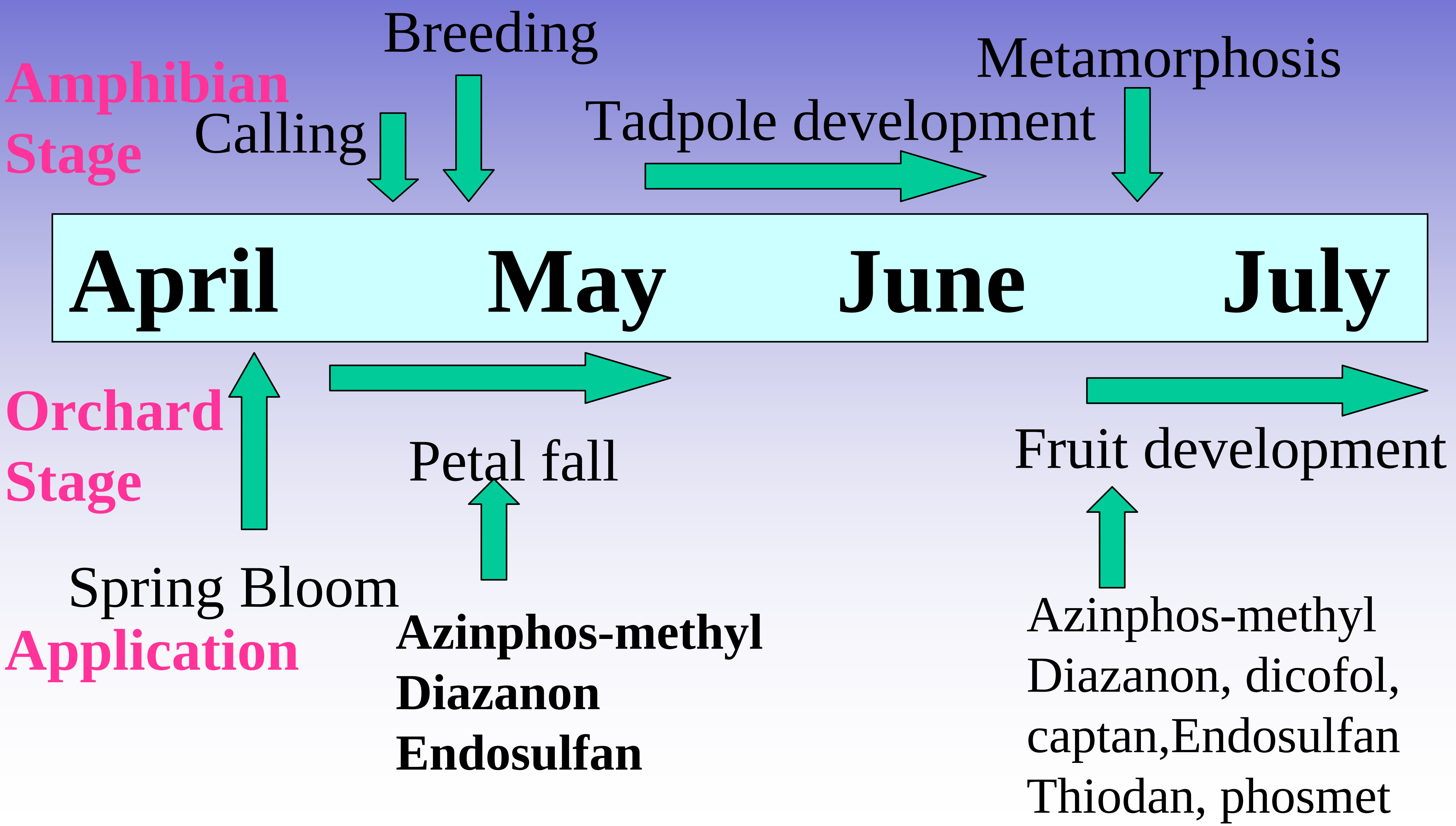
**Orchard Stage**

Petal fall

**Application**

**Azinphos-methyl**
**Diazanon**
**Endosulfan**

# Spadefoot Tadpole Development & Spray Chronology



# Objective 2 :

Assess exposure and effects of pesticides on developing amphibians

# Study Species

## Spadefoot (2004, 2005)

- each egg mass was divided into sub-samples and a portion placed in enclosures at each site ($N_{2004}$ = 5 enclosures, Trial 1: $N_{2005}$ = 5, and Trial 2: $N_{2005}$ = 5 test sites and N = 3 reference sites enclosures)
- 5-80 eggs per mass, hatching in 1-2 days, transform in 3-4 weeks

## Western Toad(2004)

- a single mass was divided among five enclosures at each site ($N_{2004}$ = 5 enclosures)
- 1000s eggs per mass, hatch in 3-12 days, transform in 6-8 weeks

## Pacific Treefrog(2005)

- whole egg masses were placed in enclosures at each site (Trial 1 $N_{2005}$ = 5, and Trial 2 $N_{2005}$ = 3 enclosures)
- 5-25 eggs per mass, hatch in 2-4 days, transform in 10-15 weeks

# Objective 2: Summary of Activities

## In Situ Toxicology Studies (2004-2005)

**2004:** Eggs collected from reference sites were placed in enclosures in either conventional (N = 2) or organic ponds (N = 3). Sites were visited every 48hrs, embryos were assessed mortality, at two days post-swim stage tadpoles were euthanized & abnormalities assessed

**Water Chemistry Sampling:** Sampled at 2 days post egg entry

**Pesticide Sampling:** Standard 24-hr post egg entry for 24 OPs and 9 carbamates & after known spray events, during study

**2005:** Eggs collected from reference sites were placed in enclosures in either conventional (N = 3) or lowland reference ponds (N = 3). In addition to endpoints measured in 2004, the experiment was replicated twice and a sub-sample of tadpoles were raised to metamorphosis

**Water Chemistry Sampling:** Sampled at 2 days post egg entry

**Pesticide Sampling:** Water samples were collected for 92 current–use pesticides and herbicides 2-days post heavy rain during early and mid tadpole development. A third sample was collected after known spray events at two conventional sites

# Study Design (2004)

**Organic Orchard**

**Conventional Orchard**

√ √ √

C C

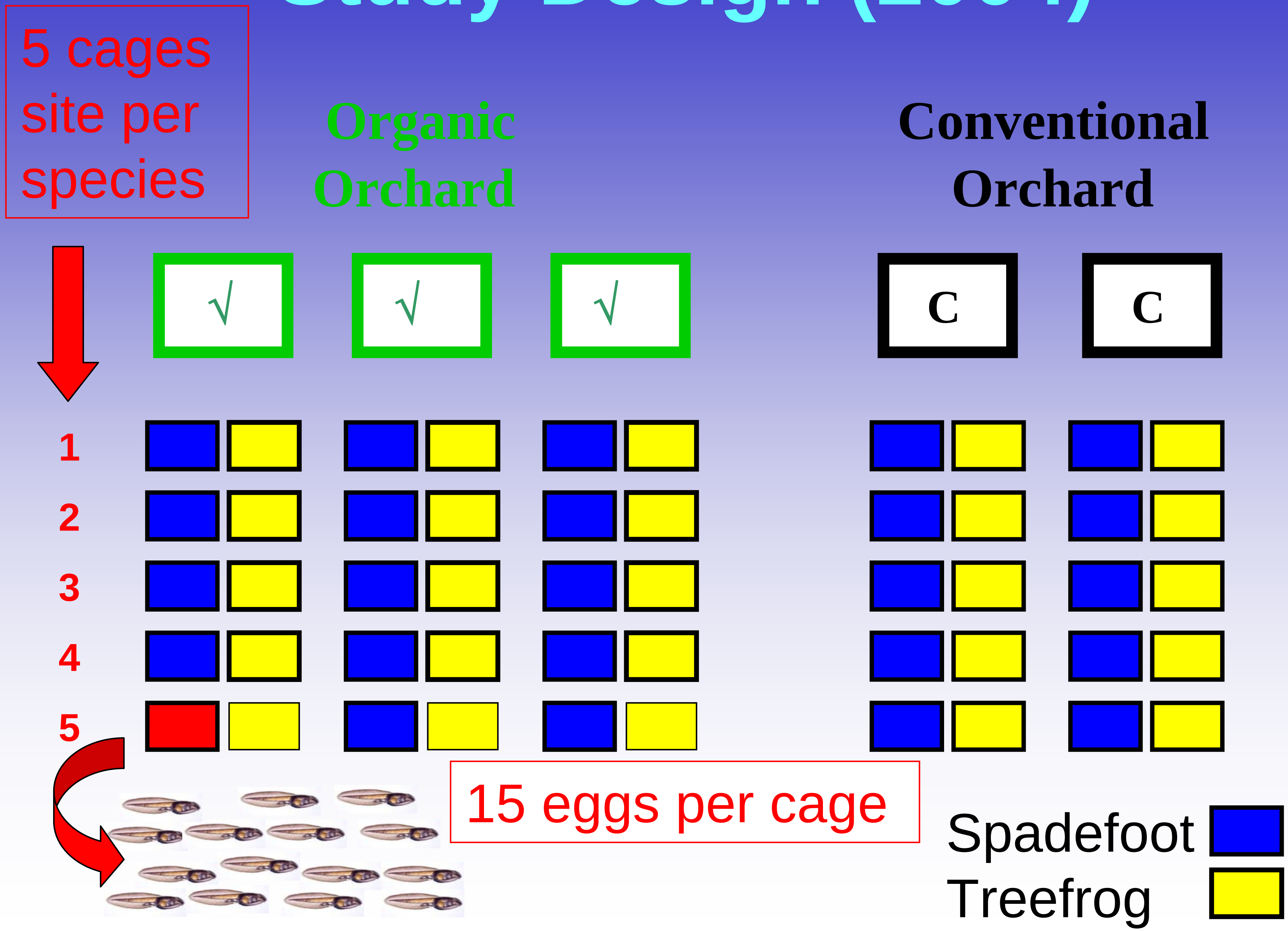
Two classes of sites: **Certified Organic** (N = 3) and **Conventional Orchards** (N = 2)

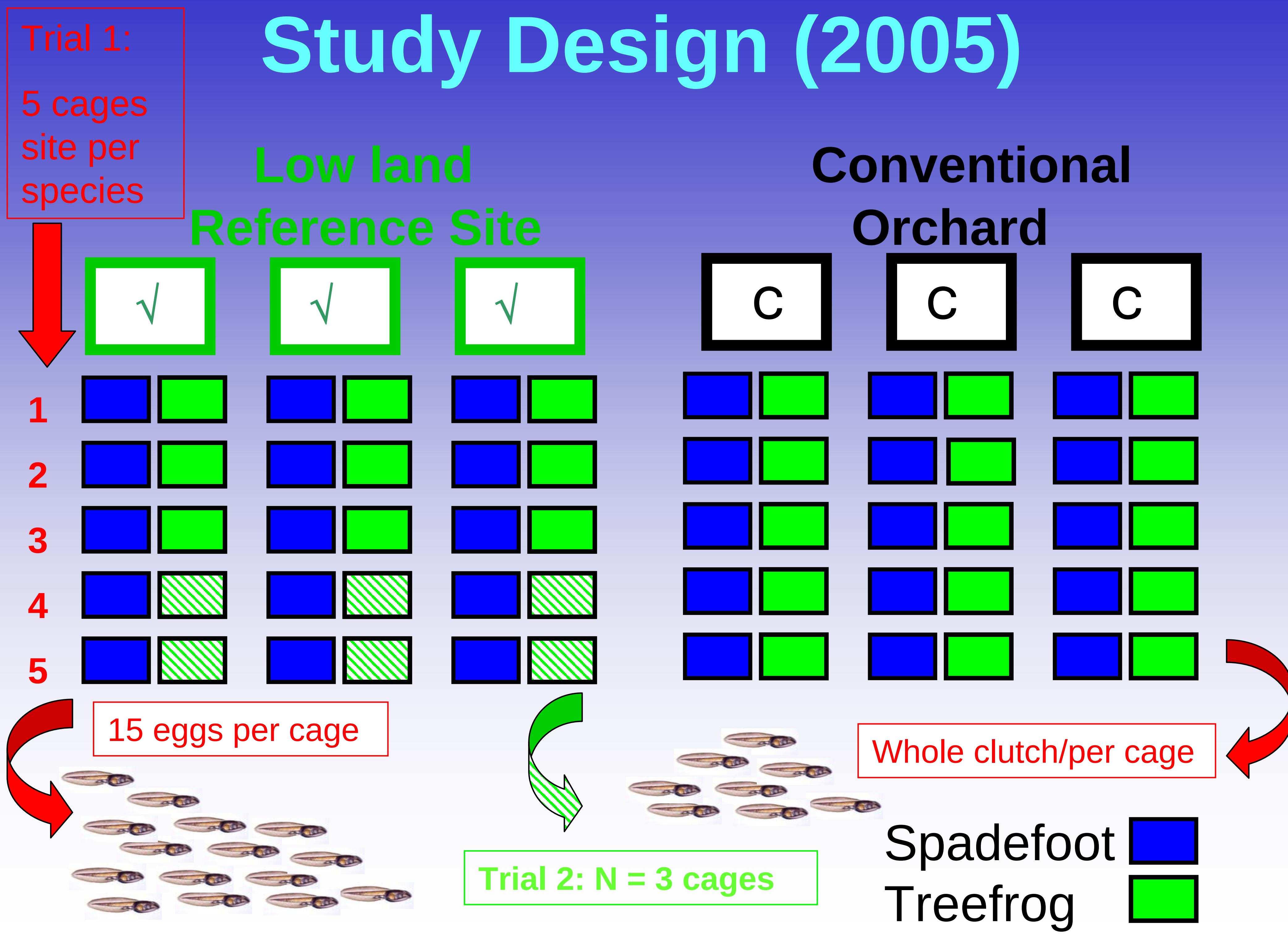
Two species selected

Spadefoot

Western Toad

# Study Design (2004)




Study Design (2005)
Trial 1:
5 cages site per species
Low land Reference Site
Conventional Orchard
√
√
√
C
C
C
1
2
3
4
5
15 eggs per cage
Trial 2: N = 3 cages
Whole clutch/per cage
Spadefoot
Treefrog

# Current-use Pesticide Sampling

## Sampling during reproductive experiment (2004)

| Date 2004 | Sample Type | Test Site | Pesticide sprayed or detected | MDL (mg/L) | Concentration |
|---|---|---|---|---|---|
| 27 April | Spray event | 1 | Endosulfan | 0.0005 | <0.0005 |
| 28 April | 24-post egg entry | All sites | *All non-detect* | | *Non detect* |
| 30 April | 24-post egg entry | All sites | *All non-detect, except Diazinon* | 0.0003 | 0.0003 |
| 12 May | Spray event | 2 | Pirimicarb | | ** |
| 12 May | Tank spike | 2 | Pirimicarb | | ** |
| 13 May | Spray event | 1 | Diazinon | 0.0003 | ** |
| 13 May | Tank spike | 1 | Carbaryl | 0.0005 | 340 |
| 21 May | Spray event | 1 | Carbaryl | 0.0005 | 0.0076 |

**Analysis in progress

# Water Chemistry (2003-2005 data)

| | MDL | Test 1 | Test 2 | Test 3 | Organic 1 | Organic 3 | Reference 1 | Reference 2 | Reference 3 |
|---|---|---|---|---|---|---|---|---|---|
| Sample Collection Dates | | May, June 2004, 2005 | May, June 2004, 2005 | May, June 2005 | May, June 2004, 2005 | May, June 2004 | May, June 2005 | May, June 2005 | May, June 2005 |
| BOD (mg/L) | 5 | 5 - 21 | <10 - 12 | <10 - 40 | 8 - 9 | <5 | <5 - 16 | <10 - 15 | <10 - 13 |
| Chloride (mg/L) | 0.5 | 56 - 97 | 24 - 25 | 15 - 18.6 | 14 - 15.5 | 89 - 112 | 6.2 - 11 | 17.2 - 36 | 19 - 32 |
| Fluoride (mg/L) | 0.01 | <0.001 - 1.67 | 0.28 - 0.35 | 0.46 - 0.51 | 0.53 - 0.73 | <0.01-0.13 | 0.32 - 0.45 | 0.36 - 0.53 | 0.41 - 0.48 |
| Sulphate (mg/L) | 3 | 1120 - 1560 | 52-55 | 62 - 76 | 53 - 91 | 1862 - 2980 | 74 - 590 | 133 - 138 | 99 - 116 |
| Bromide (mg/L) | 0.05 | 0.21 - 0.28 | <0.05 | <0.005 | <0.05 | 0.12 - 0.15 | <0.05 | <0.05 | <0.05 |
| Nitrate (mg/L) | 0.002 | <0.002 - 0.211 | <0.002 | 0.003 - 0.154 | <0.002 | 0.019 - 3.75 | <0.002 | <0.002 | <0.002 |
| Nitrite (mg/L) | 0.005 | <0.005 - 0.034 | <0.005 | <0.005 - 0.120 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Ortho-Phos. (mg/L) | 0.05 | <0.005 | <0.05 | <0.05 - 0.09 | 0.23 - 0.51 | <0.05 | <0.05 | <0.05 | <0.05 |
| pH | 0.01 | 8.29 - 9.79 | 8.39 - 8.5 | 7.92 - 8.20 | 7.64 - 7.82 | 7.7 - 7.8 | 7.52 - 7.95 | 7.84 - 9.03 | 8.18 - 8.52 |
| Conductivity (uS/cm) | 2 | 2280 - 3180 | 419 - 479 | 543 - 620 | 6.41 - 720 | 3100 - 4130 | 774 - 925 | 619 - 773 | 745 - 641 |
| Turbidity (NTU) | 0.05 | 2.25 - 24.3 | 5.17 - 10.1 | 1.11 - 52.5 | 5.35 - 7.26 | 0.69 - 0.98 | 1.02 - 6.95 | 0.87 - 2.93 | 0.59 - 1.11 |
| Ammonia (mg/L) | 0.005 | 0.012 - 6.3 | <0.005 - 0.015 | 0.058 - 0.25 | <0.005 - 0.096 | <0.005 - 0.029 | 0.037 - 0.097 | 0.053 - 0.071 | 0.007 - 0.017 |
| Total Nitrogen (mg/L) | 0.04 | 2.4 - 8.1 | 0.9 - 1 | 0.93 - 13.4 | 2.7 - 2.8 | 0.94 - 2.8 | 0.77 - 1.2 | 0.91 - 1.3 | 0.83 - 1.1 |
| o-PO4 diss. (mg/L) | 0.001 | 0.001 - 0.26 | <0.001 | 0.083 - 0.182 | 0.298 - 0.67 | 0.002 | 0.007 - 0.035 | 0.002 - 0.007 | <0.001 - 0.002 |
| Total DissPhos. (mg/L) | 0.004 | 0.028 - 0.59 | 0.003 - 0.11 | 0.110 - 1.35 | 0.35 - 0.75 | 0.009 - 0.015 | 0.024 - 0.058 | 0.015 - 0.039 | 0.015 - 0.025 |
| Total Phos. (mg/L) | 0.01 | 0.061 - 1.80 | 0.03 - 0.058 | 0.152 - 1.2 | 0.62 - 0.89 | 0.019 - 0.035 | 0.094 - 0.19 | 0.035 - 0.073 | 0.021 - 0.047 |

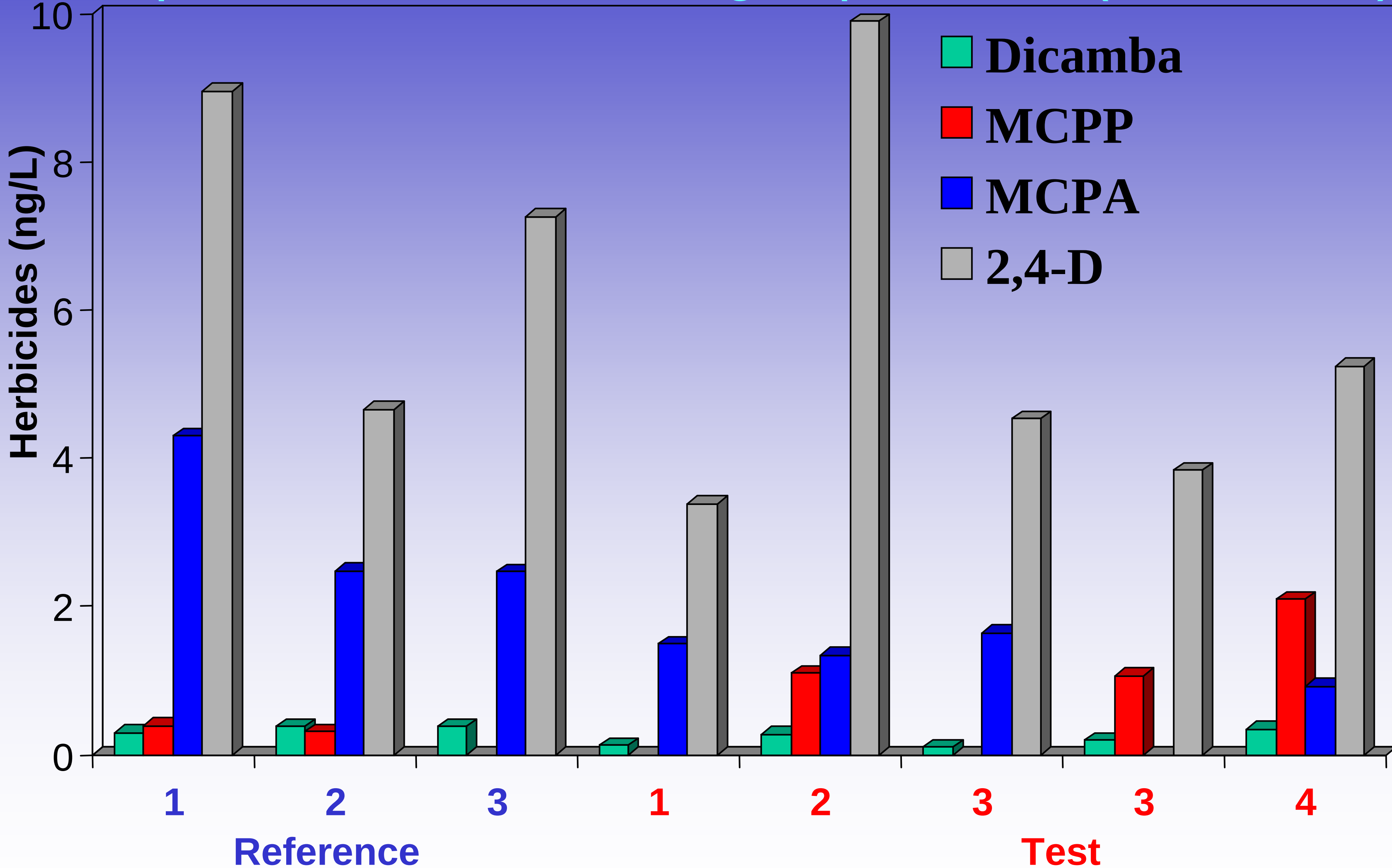
# Current-use Pesticide Sampling

## Sampling during & after reproductive experiment (2005)

- Standard sample for 92 current-use pesticides and nine acid extractable herbicides was collected after rain events during early & mid tadpole development
  - 20 May
  - 3 June*(acid extractable data presented)*
- Water samples were collected two days post heavy rain events that followed known spray exposures of diazinon and Azinphos-methyl
  - 4 July
  - Two samples were collected
    - One test site in study and a second heavy pesticide use site not in reproductive study (*data presented*)

# Acid Extractable Herbicides

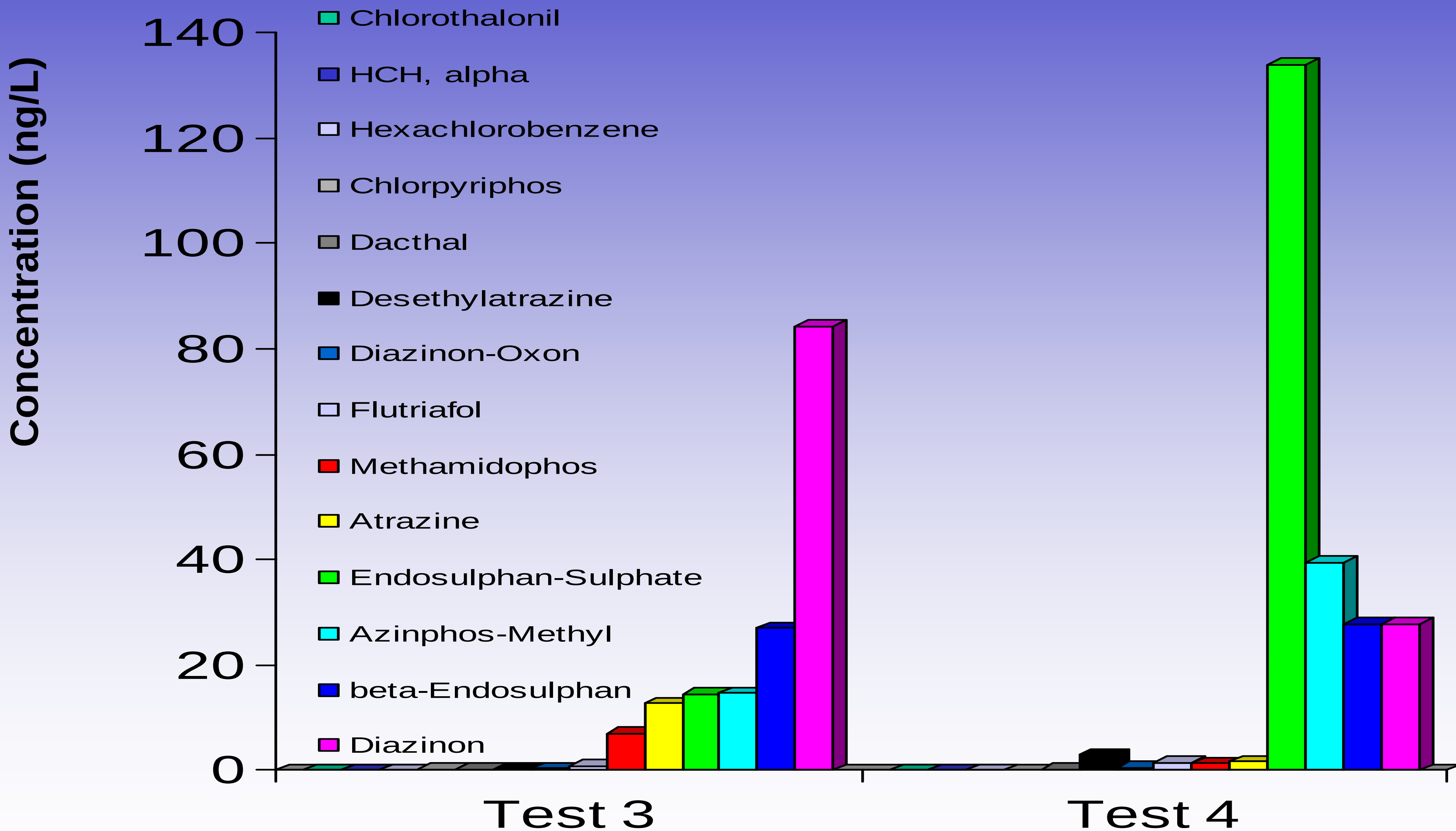
## Reproductive sites during experiment (2005 data)




**Note: Concentrations of Bromoxynil, Triclopyr, Flauzifop were non-detectable**

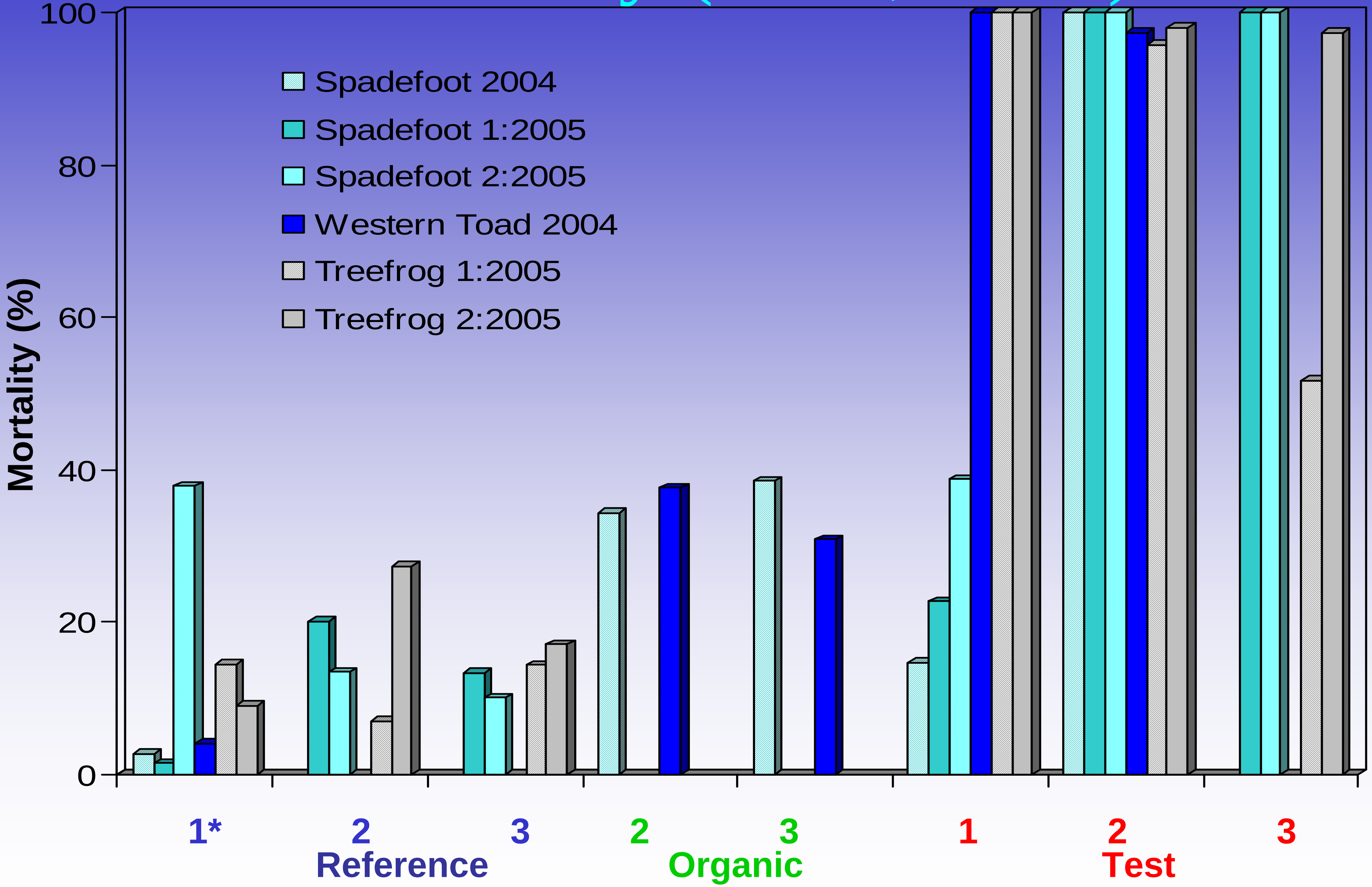
# Current-use Pesticides

## Conventional sites after reproductive exp. (2005 data)




**Note: Concentrations of Bromoxynil, Triclopyr, Flauzifop were non-detectable**

# Mortality (2004, 2005)

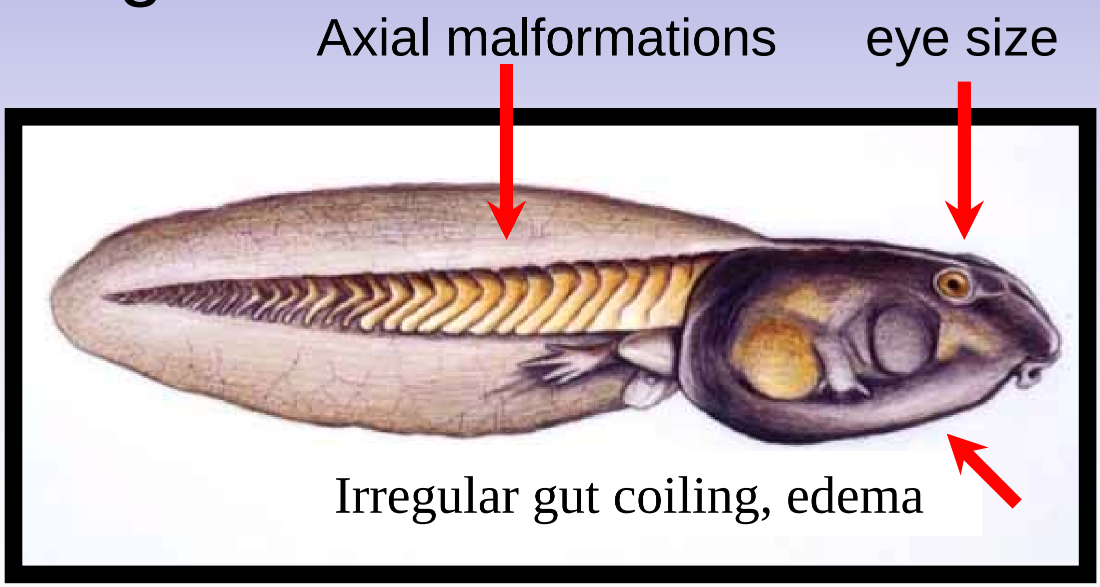



* Organic site 1 was reclassified in 2005 as a lowland reference site.

# Developmental Abnormalities
## FETAX

**RESULTS PENDING**

Morphological features are only examined on individuals that survive to two days post-swim stage.




# **Summary:** Reproductive Experiment (2004, 2005)

## Mortality

- For all species and in both years and trials amphibian mortality was significantly correlated with the site classification:

**Lowland Reference < Organic < Conventional Farming**

# Next Steps?

- Further refined field studies and water sampling
- Laboratory testing of individual chemicals and mixtures (spade foot)
- Acute effects on egg survival and development
- Chronic effects on juvenile development and adult reproductive capability

# PSF Project Collaborators

- Private Landowners
- The Land Conservancy
- The Nature Trust
- Ducks Unlimited
- South Okanagan-Similkameen Conservation Program

We would like to thank the landowners, B.Purvis, R.Noble, C.McNaughton, M.Sarell, and W.Schebel for their assistance

# Frequently Used Orchard Sprays

Insecticides (~34)

- Azinphos-methyl
- Carbaryl
- Clofentezine
- Cypermethrin
- Diazinon
- Dicofol
- Dimethoate
- Endosulfan
- Pirimicarb
- Pyridaben

Fungicides (~29)

- Captan
- Mancozeb

Herbicides (~9)

- Amitrol
- Glyphosate
- Metolachlor

Fertilizers/Nutrients

- Boron, Calcium, Copper, Iron, Manganese, Magnesium, Nitrogen, Phosphorus, Potassium Zinc

# POSTER PRESENTATIONS

# Research and Innovation in Integrated Pest Management in British Columbia Agriculture

## Projects underway from Fall 2005 through Spring 2006

**Tracy Hueppelsheuser**

[1]British Columbia Ministry of Agriculture and Lands, 1767 Angus Campbell Road, Abbotsford BC V3G 2M3 Email: tracy.hueppelsheuser@gov.bc.ca

### Background

The British Columbia Ministry of Agriculture and Lands has funded a number of projects addressing key plant health issues in 2004-06.

Funding was made possible through the Agriculture Policy Framework "Transition Program", a partnership between Agriculture and Agri-Food Canada and British Columbia Agriculture and Lands. Projects must be completed by March 31, 2006, at which time the funding program will be finished.

Following are projects that are underway this fall and winter to be completed by spring 2006. Please contact Tracy Hueppelsheuser or the project leads for more information.

### Best Practices Guide for Grapes for Commercial Growers

**Lead: Jim Campbell, BCMAL**

This would contribute to a much needed updating of a guide considered important to the grape industry. In general, revisions would include: On-Farm Food Safety chapter, Pesticide Safety update, IPM and Organic chapters update, and other crop production sections.

### Asian Vegetable Growers Project: Awareness and Adoption of Integrated Pest Management Practices and Improved Pesticide Use Practices

**Lead: Susan Smith, BCMAL**

This would be a continuation/extension of the 2005 project, and would include: creation of a Pest Identification Manual in three languages, development of a pesticide use record keeping system, development of factsheets/bulletins on good pesticide use practices, pests, and management.

### Field Guide to Invasive Insects/Mites and Plant Diseases

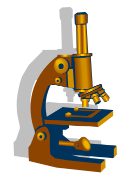
**Lead: Hugh Philip, BCMAL**

This guide would provide a tool to assist in the early detection of alien pests in British Columbia.

### Plant Lab Accreditation

**Lead: Leslie MacDonald**

Accreditation could become critical if the Plant Lab increases it's involvement in certification and regulatory programs.



### Biological Control of Tansy Ragwort in the Interior of British Columbia

**Lead: Michael Betts, BCMAL**

A Swiss strain of a cold adapted biological control agent (Flea beetle, *Longitarsus jacobaeae*) would be imported to British Columbia and evaluated for control of the poisonous plant, tansy ragwort (*Senecio jacobaea*).

### Investigation of New and Emerging Root and Crown Disease of Small Fruits

**Lead: Mark Sweeney, Siva Sabaratnum**

Study new and emerging root diseases of blueberry, raspberry, and strawberry, and develop effective management practices.

### Survey, Diagnosis and Management of Green Mould (*Trichoderma* sp) of Commercial Mushrooms

**Lead: Jennifer Curtis, Siva Sabaratnam**

This project would provide growers with local diagnostic resources and with management options for this devastating disease. The first workshop has been held, with guest scientists visiting from Pennsylvania and Ontario.


# 28 Day *Hyalella azteca* Sediment Toxicity Testing with Endosulfan Compounds

**Craig Buday**
**Grant Schroeder**
**Environment Canada**
**Pacific Environmental Science Centre,**
**North Vancouver, BC**

**Abstract:**
A test protocol based on Environment Canada's Biological Test Method: "Test For Growth and Survival In Sediment using the Freshwater Amphipod *Hyalella azteca*", Report EPS 1/RM/33, and the Standard Operating Procedure "*Hyalella azteca* Bioaccumulation and Toxicity Test Method using Imhoff Settling Cones" developed by U. Borgmann and W.P. Norwood at Environment Canada's National Water Research Institute has been used at the Pacific Environmental Science Centre (PESC) to determine the chronic lethal (survival) and sublethal (growth) toxic effects of compounds in sediment to the freshwater amphipod, *H. azteca* (Figure 1). The method involves exposing 2 to 9 day old *H. azteca* in 1 L Imhoff settling cones (Figures 2 and 3) at a 1:67 test sediment/water ratio for 28 days. The test endpoints are survival, growth based on weight, and where appropriate, a 28 day LC50. Statistical comparison analyses may also performed on the survival and growth results.

**Introduction:**
A 28 day *Hyalella* Survival and Growth test was conducted in November - December 2003 to determine the toxicity of the agricultural insecticides Endosulfan I, Endosulfan II, Endosulfan I + II, and Endosulfan Sulfate in sediment to the freshwater amphipod, *H. azteca*. Survival (mean survival and 28 day LC50) and growth (mean weight per animal) were used as the indicators of toxic effects.

Figure 1: *Hyalella azteca*


**Methods & Procedures**
Methods and procedures based on:
1) EPS, "Biological Test Method: Test For Growth And Survival In Sediment Using The Freshwater Amphipod *Hyalella azteca*". Report EPS 1/RM/33-December 1997. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.
2) Borgmann, U., and W.P. Norwood. 1999. "Sediment toxicity testing using large water-sediment ratios: an alternative to water renewal.". *Environ.Pollut.*106: 333-9.

Culturing *Hyalella azteca*
- Original *H. azteca* culture from CCIW Lab, Burlington, Ontario-1992 and EPA, Corvallis, Oregon-1995
- Culture renewed weekly with two water changes per week
- Culture fed YCT (Yeast, Cereal Leaves, Trout Chow) three times a week
- Two to nine day old test *H. azteca* collected from main culture two days prior to test start

**Endosulfan *Hyalella* Sediment Test Details**

| | |
|---|---|
| Test type: | Static test-no renewal |
| Vessel type: | 1 L Polycarbonate Imhoff settling cones with # 4 rubber silicone stoppers |
| Sediment Volume: | 15 mL |
| Water Volume: | 1000 mL |
| Sed./Water Ratio: | 1:67 |
| Overlying Water: | PESC Well (100 mg/L $CaCO_3$ Hardness) |
| Temperature: | 23 ± 1 °C |
| Photoperiod: | 16 h Light:8 h Dark |
| Light Intensity: | full spectrum, 500-1000 lux |
| Replicates per conc.: | 3 (normally 5) |
| Organism Age: | 2 to 9 day old *H. azteca* |
| *Hyalella* per rep: | 15 |
| Feeding per rep.: | 2.5 mg Tetramin 1x in week 1<br>2.5 mg Tetramin 2x in week 2<br>2.5 mg Tetramin 3x in week 3<br>5.0 mg Tetramin 2x in week 4 |
| Aeration: | continuous, 2-3 bubbles per second |
| Pre-aeration: | 1 day |
| Duration: | 28 days |
| Water Quality Parameters Measured: | temperature, dissolved oxygen, pH, conductivity, ammonia |
| Drying Time: | 24 hours at 60 °C (Figures 4 and 5) |

Figure 2: Test Setup Example with 1 L Imhoff Settling Cones

**Sample Pre-treatment**
- Endosulfan (1,4,5,6,7,7-hexachloro-8,9,10-trinorborn-5-en-2,3-ylenebismethyl-ene) sulfite
- Pure chemical was mixed with UBC Research Forest (Maple Ridge, BC) sediment
- Acetone was used as the solvent carrier
- Chemical was added to sediment in 1 L glass jars and rolled for 1 hour prior to introduction to test vessels
- After mixing, the 15 mL of test sediment was transferred to 1 L Imhoff cones and 1 L of PESC well water was added as the overlying water
- Test replicates were pre-aerated 1 day prior to test start

**Test Concentrations**
- Control Field (UBC)
- Control Lab (Roberts Bank)
- Control Acetone
- Endosulfan I - High (0.05 mg/kg)
- Endosulfan II - Low (0.1 mg/kg)
- Endosulfan II - Med (0.5 mg/kg)
- Endosulfan II - High (2.0 mg/kg)
- Endosulfan I + II - Low (0.1 mg/kg)
- Endosulfan I + II - Med (0.5 mg/kg)
- Endosulfan I + II - High (2.0 mg/kg)
- Endosulfan Sulfate - Low (0.1 mg/kg)
- Endosulfan Sulfate - Med (0.75 mg/kg)
- Endosulfan Sulfate - High (3.0 mg/kg)

Figure 3: 1 L Imhoff Settling Cone Close-up with Schematic Diagram

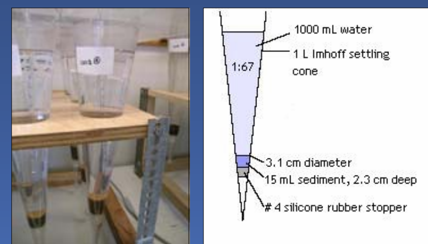



Figure 4: Test End-Preparation for Drying of Test *Hyalella*

**Test Endpoints, Statistics and Validity Criteria**
- Endpoints: Mean survival (± SD)
  Mean weight per *Hyalella* (± SD)
  28 Day LC50
- Statistics: Student's Equal Variance t-tests on survival and growth in comparison to UBC Field Control
- A mean 28 d *Hyalella* survival of ≥ 80% in the control is considered an acceptable test
- A mean 28 d weight of ≥ 0.1 mg per *Hyalella* in the control is considered to be an acceptable test
- A 96 hour LC50 water only copper reference toxicant test is conducted concurrently with the 28 day survival and growth sediment test to verify the health and sensitivity of the testing culture. The 96 h copper reference toxicant LC50 must be within ± 2 SD of the historical mean for the results from the 28 day test to be considered valid. The LC50 is the statistical concentration of copper estimated to cause a 50% mortality of *H. azteca*

**Results and Discussion:**
- The 28 Day *H. azteca* sediment test results are shown in Tables # 1 and 2 and Figures # 6 and 7
- The UBC Field Control passed the test validity criteria for survival and growth
- There was no statistical significant difference for survival among the UBC Field, the Robert's Bank Lab and Acetone Solvent Controls
- A statistical significant difference was observed for survival between the UBC Field Control and Endosulfan I+II High (2.00 mg/kg) and between the UBC Field Control and Endosulfan $SO_4$ High (3.00 mg/kg).
- There was statistical significant difference in growth between the UBC field and Robert's Bank control and between the UBC Field Control and Endosulfan I+II High (2.00 mg/kg). In both cases, the mean weight per *Hyalella* was greater than the UBC Field Control
- A dose response was observed in the Endosulfan I+II and Endosulfan $SO_4$ concentration series and 28 day LC50's were determined for both compounds (see Table 2)
- The 96 h LC50 for the copper reference toxicant was 249.89 µg/L (208.75-298.88) which was within ± 2SD of the historical mean

Figure 6: 28 Day *Hyalella* Mean Survival (with SD) vs. Treatment

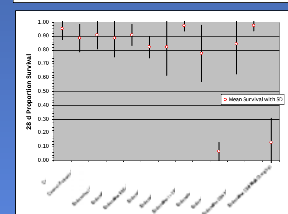



Figure 7: 28 Day *Hyalella* Mean Weight (with SD) vs. Treatment

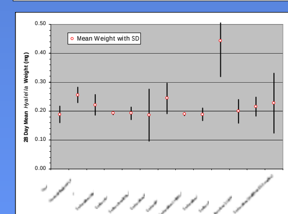



Figure #5: Test End - *Hyalella* in Aluminum Weigh Boat Prior to Drying

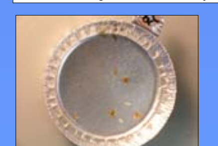


Table 1: Survival and Growth Results of 28 Day *Hyalella azteca* Endosulfan Sediment Test

| Treatment | Test Conc. (mg/kg) | Survival: Mean Survival % (± SD) | Survival: Survival Different from Field Control?* (p<0.05) | Growth: Mean Weight / *Hyalella* mg (± SD) | Growth: Weight Different from Field Control?* (p<0.05) |
|---|---|---|---|---|---|
| Control-Field (UBC Research Forest) | - | 96 (± 1.2) | - | 0.19 (± 0.03) | - |
| Control-Robert's Bank (Lab) | - | 89 (± 1.5) | No | 0.26 (± 0.03) | **Yes** |
| Control-Acetone | - | 91 (± 1.5) | No | 0.22 (± 0.04) | No |
| Endosulfan I High | 0.05 | 89 (± 2.1) | No | 0.19 (± 0.01) | No |
| Endosulfan II Low | 0.10 | 91 (± 1.2) | No | 0.19 (± 0.02) | No |
| Endosulfan II Medium | 0.50 | 82 (± 1.2) | No | 0.19 (± 0.09) | No |
| Endosulfan II High | 2.00 | 82 (± 3.1) | No | 0.24 (± 0.05) | No |
| Endosulfan I + II Low | 0.10 | 98 (± 0.6) | No | 0.19 (± 0.05) | No |
| Endosulfan I + II Medium | 0.50 | 78 (± 3.1) | No | 0.19 (± 0.02) | No |
| Endosulfan I + II High | 2.00 | 7 (± 1.0) | **Yes** | 0.44 (± 0.12) | **Yes** |
| Endosulfan $SO_4$ Low | 0.10 | 84 (± 3.2) | No | 0.20 (± 0.04) | No |
| Endosulfan $SO_4$ Medium | 0.75 | 98 (± 0.6) | No | 0.22 (± 0.03) | No |
| Endosulfan $SO_4$ High | 3.00 | 13 (± 2.7) | **Yes** | 0.23 (± 0.10) | No |

* Student's Equal Variance t-Test

Table 2: 28 Day *Hyalella* Endosulfan LC50's

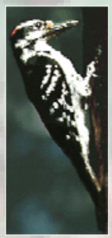
| Chemical | Nominal 28 Day LC50 (mg/kg) with 95% confidence limits |
|---|---|
| Endosulfan I | n/a |
| Endosulfan II | > 2.0 |
| Endosulfan I+II | 0.83 (0.67-0.99) |
| Endosulfan $SO_4$ | 1.73 (1.50-2.02) |

**Conclusions:**
- The PESC 28 Day *H. azteca* Survival and Growth sediment test can be used to determine the toxicity of spiked contaminants in sediment
- The test allows for the determination of the chronic lethal and sub-lethal effects of compounds spiked in sediment
- The test may be used to compliment other test protocols (i.e. solid phase microtox and chironomids) when determining the toxicity of spiked compounds in sediment

**References:**
- Borgmann, U., and W.P. Norwood. 1999. Sediment toxicity testing using large water-sediment ratios: an alternative to water renewal. *Environ.Pollut.*106: 333-9
- EPS, "Biological Test Method: Test For Growth And Survival In Sediment Using The Freshwater Amphipod *Hyalella azteca*". Report EPS 1/RM/33-December 1997. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario
- Michael T. Wan, Jen-ni Kuo, Craig Buday, Grant Schroeder, Graham van Aggelen, and John Pasternak. 2005. Toxicity of alpha-, beta-, (alpha+beta)- Endosulfan and their Formulated and Degradation Products to *Daphnia magna*, *Hyalella azteca*, *Onchorhynchus mykiss*, *Onchorhynchus kisutch*, and Biological Implications in Streams. Environmental Toxicology and Chemistry, Vol. 24, No. 5, p. 1146-1154

Environment Canada Environnement Canada

# Assessing Avian Exposure to Monosodium Methanearsonate (MSMA) as Used for Bark Beetle Control in British Columbia Forests




Christy Morrissey[1], Patti Dods[1], Courtney Albert[2], Laurie Wilson[1], William Cullen[3], Tony Williams[1] and John Elliott[1]

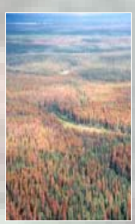
[1]Canadian Wildlife Service, Environment Canada, Delta, B.C. [2]Simon Fraser University, Burnaby, B.C., [3]University of British Columbia, Vancouver, B.C.



## ABSTRACT

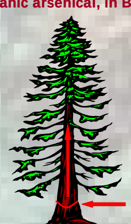
Recent and historical outbreaks of the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) have caused significant damage to forests in British Columbia through destruction of thousands of hectares of large diameter, mature lodgepole pine, ponderosa pine and white pine. Management strategies employ a variety of techniques to reduce timber losses from beetle outbreaks including the use an arsenic based insecticide monosodium methanearsonate (MSMA). Given that insectivorous birds, particularly woodpeckers, are attracted to beetle outbreak areas in forests due to increased food availability, they may be subsequently exposed to elevated concentrations of organic arsenicals through ingestion of wood boring insects from MSMA treated trees. We assessed the risk to avian predators through analysis of bark beetles from different life stages and in trees with MSMA treatment (4 weeks and 1 year after treatment) to determine levels of total arsenic and organic/inorganic arsenic speciation. MSMA metabolites were highest in adult mountain pine beetles relative to larval and pupal stages and other insects collected from trees at both 4 weeks and 1 year post treatment. Concentrations of total arsenic in mountain pine beetles from treated trees ranged from 0.22- 354.1 µg/g dw with the organic metabolite monomethyl arsine (MMAA) contributing over 90% to the total arsenic extracted. Mountain pine beetles from reference trees had low concentrations that averaged 0.11 µg/g dw total arsenic. Debarking indices and radio telemetry methods were used to identify woodpecker foraging on beetle infested trees with and without MSMA treatment. Debarking indices indicated woodpecker foraging of MSMA treated trees was significantly lower than non treated trees. However, approximately 30% of MSMA trees had some evidence of woodpecker foraging (5%-100% debarked), while focal observations and surveys confirmed woodpeckers use MSMA stands. Given the extent of mountain pine beetle infestation and the increasing use of MSMA in British Columbia forests, this study addresses important knowledge gaps on woodpecker exposure to MSMA.


### Mountain Pine Beetle (MPB) Outbreak in British Columbia, Canada



- •MPB attacks and kills large mature lodgepole pine, ponderosa pine and white pine.
- •B.C.'s MPB infestations have increased exponentially in past 5 years.
- •MPB red attack doubled in 2003 over 2002 (approx. 4.2 million ha attacked in 2002) and still increasing exponentially despite forest management efforts.

### Treatment of MSMA *(monosodium methanearsonate)*, an organic arsenical, in B.C. Forests




## Study Objectives / Methods

- •To assess As levels and As speciation (organic and inorganic) in mountain pine beetles and other wood boring insects of different life stages in trees with known MSMA treatment (4 wks and 1 yr post treatment) from study areas near Merritt, British Columbia, Canada;
- •To determine woodpecker use of MSMA treated and non-treated trees using debarking indices, blood sampling and radio-telemetry methods.
- •To determine the degree of MSMA uptake, elimination and target tissues in model songbirds (lab dosing study).

## Results: As in Bark Beetles

- Total arsenic (As) concentrations significantly higher in bark beetles from treated MSMA trees (geo mean = 91.7 µg/g, range 0.22- 354.1 µg/g) vs. nearby reference trees (geo mean = 0.11 µg/g, range 0 - 1.96 µg/g) for both green attack (4 wks) and red attack trees (1 yr after infestation) (Figure 1).
- Arsenic found in wood boring beetles from treated trees is primarily in the organic form of monomethyl arsine (MMAA), which is the deionized form of MSMA, regardless of insect life stage or species (Figure 2).

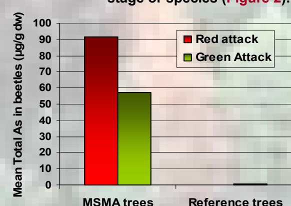



*Figure 1:* Geometric mean total As (µg/g dw) in bark beetles collected from MSMA and reference trees 4 weeks (green attack) and 1 year (red attack) after infestation and treatment.

Note: MPB larvae can survive concentrations over 100 µg/g dw. Some dead adult beetle samples contained up to 354 µg/g dw.

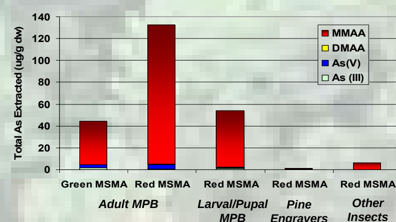



*Figure 2:* Arsenic speciation (organic and inorganic forms) in bark beetles (mountain pine beetle, pine engravers and other insects) collected from MSMA treated trees.

## Results: Evidence of Woodpecker Exposure from Foraging

- 402 beetle infested trees (reference) and 449 treated (MSMA) trees were scored for amount of debarking by woodpeckers (0 - 100% = index 0 - 7) immediately after treatment and 1 year after attack.
- Majority of MSMA treated trees (70%) were not debarked (index = 0, no foraging) compared to 13% of reference trees after 1 year. However 30% of treated trees had some foraging (5-100% debarked, index 1-7) (Figure 3).
- Mean total arsenic concentrations in bark beetles were negatively correlated with the amount of debarking on MSMA trees indicating woodpeckers were feeding more from trees with lower arsenic levels and possibly targeting larger live beetle broods (Figure 4).

## Woodpecker Foraging

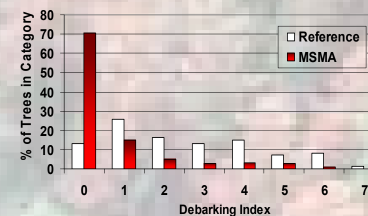



*Figure 3:* Index of woodpecker foraging: % of sampled trees (reference and MSMA) that are debarked (foraged on) one year after infestation (0 = no debarking, 1 = <5%, 2 = 5-10%, 3 = 10-20%, 4 = 20-40%, 5 = 40-60%, 6 = 60-80%, 7 = 80-100%).

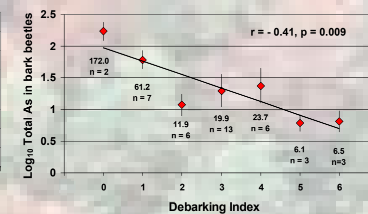
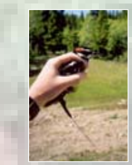



*Figure 4:* Mean concentrations of total As (µg/g dw) in bark beetles from treated trees with different levels of debarking (foraging). Values shown below points are geometric means and sample sizes.

## Woodpecker Exposure

- Woodpeckers that specialize in feeding on bark beetles (Hairy and Three-toed woodpeckers) had higher concentrations of As in blood than other species (Red-naped sapsuckers) occupying treatment areas (Figure 5).
- Focal observations of radio-tagged adult woodpeckers further confirmed birds were feeding on bark beetles from treated stands.



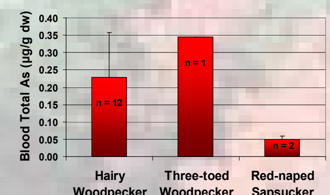
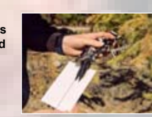



*Figure 5:* Mean (±SD) total As concentrations (µg/g dw) in blood of 3 species of woodpeckers from MSMA treated areas of Merritt, B.C.



## Summary

- Bark beetles from MSMA treated trees contained variable amounts of arsenic (geo mean = 23.1 µg/g dw, range 0.22 - 354.1µg/g)- adult mountain pine beetles had highest concentrations, primarily in organic form MMAA.
- Woodpeckers are foraging on treated trees but not selectively- likely because MSMA causes mortality of beetles and woodpeckers are foraging on larger live broods from non-treated trees.
- Woodpecker species that are known to forage on bark beetles were regularly observed feeding in treated stands and had elevated levels of arsenic in blood indicating exposure.
- Current research is focusing on dosing a model songbird (Zebra finches) in lab to determine the degree of uptake and elimination of MSMA and potential toxicity.

# Raptor & Waterfowl Exposure to Pesticides in Agricultural Ecosystems of Southwestern BC

**Laurie Wilson, Sandi Lee, John Elliott, Anna Birmingham**
**Canadian Wildlife Service**

## Introduction:

Chlorpyrifos (Pyrifos, Pyrinex) is the only effective chemical control remaining to decrease populations of wireworm, the principle potato pest in the lower Fraser Valley of BC. The Fraser Delta supports high populations of migratory birds that feed in the agricultural fields. Previously, anti-cholinesterase pesticides used in the area poisoned local waterfowl and caused secondary poisoning of raptor populations (fonofos, Dyfonate G). In recent years, reported sales of chlorpyrifos in the Lower Mainland doubled and a monitoring project was started.

## Hypothesis:

- Granular insecticides applied by end of June
- Pesticide granules persist in low pH soil for months
- Ducks use flooded fields in fall/winter
- Pesticide granules ingested while sieving sediments for food
- Ducks poisoned
- Poisoned ducks scavenged & raptors poisoned

## Objectives:

- Determine the proportion of waterfowl mortalities on agricultural fields treated with chlorpyrifos which are attributable to pesticides.
- Monitor incidence of secondary poisoning of raptors by currently used agricultural pesticides (OP/Carbamates).
- Achieve efficient wireworm control without killing wildlife
- Establish viable and effective agricultural pest control practices

## Methods:

**1. Field surveys**

Wildlife Counts

* Roadside survey - # & species of wildlife in fields

Wildlife Remains

* Survey for wildlife remains – transects 30m apart
* 2003-04: 1x / wk , 7 wks (Oct.28 – Dec.15)
* 2004-05: 1.5x/wk, 9 wks (Nov.15 – Jan.21)
* ID & rank (1-5) remains, collect suitable specimens

**2. Toxicology**

* Post-mortem exam – Cause of death & tissue collection
* Brain ChE, suspects GI-tract pesticide scan

**3. Search efficiency audit**

* 31 adult waterfowl carcasses intentionally placed in fields during study (15 females, 16 males)
* Search efficiency = 89% carcasses successfully located (females 85%, males 93%)

**4. Raptor collections**

* From rehab centers, BCWALP (Biologists & COs), taxidermists, public
* BAEA, RTHA, GHOW, accipiters, swans, any other species suspected of poisoning or unusual condition
* Blood sampled from live raptors (plasma ChE)

## Results:

- Waterfowl extensively used agricultural fields (all treatments)
- Most wildlife remains
  - –Scavenged (87%)
  - –Waterbirds (63%)

**Table 1.** Waterfowl cause of death 2003 - 05

| Species Type | Diagnosis | Granular Treated | Liquid Treated | Untreated |
|---|---|---|---|---|
| Waterfowl | Gunshot | | | 8 |
| | Trauma | | 1 | 1 |
| | Ruptured Colon | | | |
| | Infection | 1 | | |
| | Emaciation | | | 2 |
| | Undetermined | 3 | 1 | |
| Shorebird | Trauma | 1 | | 1 |
| | Emaciation | | | 3 |
| | Undetermined | | | 2 |
| Gull | Trauma | 1 | | |
| | Emaciation | 1 | | |
| Mammal | | 1 (head) | | 1 (crushed) |

Of 55 waterfowl carcasses tested, all were within normal ranges except for 6 birds:

**2003 – 04 :**

- 1 Mallard – liquid treated - **bChE 14.7** (normal 18.6 umol/min/g) – NO gut contents for residue analysis
- 1 Dunlin – untreated - **bChE 18.8** (normal 29.85 umol/min/g) – NO gut contents for residue analysis

* Caution against labeling as 'exposed'

**2004 – 05 :**

- 2 American Widgeons – granular treated **bChE 2.9** & **3.5 - residue analysis = 23.1 & 7 ppm Chlorpyrifos**
- 1 Gadwall – liquid treated **bChE 4.0 – residue analysis = 106 ppm Chlorpyrifos**
- 1 Mallard – liquid treated **bChE 9.9** – NO gut contents for residue analysis

**Table 2**. Poisoned raptor results of interest from 51 recovered during 2003-05

| Species | Date | Location | Plasma ChE | Brain ChE | Pesticide |
|---|---|---|---|---|---|
| RTHA | 18-Nov-03 | Richmond | NT | TBA | ND |
| BAEA | 17-Jan-04 | Ladner | NT | TBA | Fensulfothion 29ppm, Sulfotep 3.2ppm (stomach) |
| BAEA | 24-Jan-04 | Ladner | TBA | TBA | ND |
| BAEA | 3-Apr-04 | Campbell R | TBA | NT | Pyrethrins? * (feather) |
| PEFA | 22-July-04 | Vancouver | TBA | TBA | Malathion 0.26 ppm, DDE 7.9 ppm |

## Summary:

- Evidence of waterfowl exposure to anti-ChE pesticides, including chlorpyrifos
- Suggests use of chlorpyrifos for wireworm control in potatoes does seem to be poisoning waterfowl wintering in the Fraser River Delta
- But..
  - –Waterfowl – small sample size of intact carcasses; Raptor – no direct poisoning cases
- Continued field sampling for 2005-06 season

Acknowledgements: B. Allison, S. Charest, C. Coker, E. McMillan, J. Michel, B. Purvis, WRA, NIWRA, MARS, OWL

## Pesticides in Nathan Creek, British Columbia

**Vesna Furtula, George Derksen*, Randy Englar**, Pacific Environmental Science Centre, Science and Technology Branch, Environment Canada

* Environmental Stewardship Branch, Environment Canada

## Poster is not available.

# Recent Findings for Pesticide Sampling Programs in BC Summer of 2005

Brad McPherson
Pacific Environmental Science Centre
Science and Technology Branch

*Pesticide Information Exchange*
*November, 2005*

Environment Canada Environnement Canada

Under the auspices of the Georgia Basin Action Plan and the Pesticide Science Fund, several sampling programs were undertaken in British Columbia this summer.

These were done principally in the lower Fraser Valley and the Okanagan. Both soil/sediment samples and water samples were taken for analysis.

The requested analyses ranged from a suite of 5 compounds to as many as 60+.

- In an effort to deliver more useful data to our clients, water samples from two sample submissions this summer were prepared and analysed using a modification of our usual method.

- This allowed us to provide lower MDLs than our typical analysis and report more data. Soil/sediment sample analysis was not modified due to limitations in sample cleanup and the type of instrument used.

- Following are the results from both soil and water.

# Organochlorine Pesticides – Okanagan Valley

| | MDL, µg/g | Hits* | min, µg/g | max, µg/g |
|---|---|---|---|---|
| Alpha BHC | 0.02 | 0 | NA | NA |
| Beta BHC | 0.02 | 0 | NA | NA |
| Lindane (gammaBHC) | 0.02 | 0 | NA | NA |
| Delta BHC | 0.02 | 0 | NA | NA |
| Heptachlor | 0.02 | 0 | NA | NA |
| Aldrin | 0.02 | 0 | NA | NA |
| Heptachlor Epoxide | 0.02 | 0 | NA | NA |
| Endosulfan I | 0.02 | 0 | NA | NA |
| Dieldrin | 0.02 | 0 | NA | NA |
| p,p - DDE | 0.02 | 7 | 0.02 | 2.22 |
| Endrin | 0.02 | 0 | NA | NA |
| Endosulfan II | 0.02 | 0 | NA | NA |
| p,p - DDD | 0.02 | 2 | 0.02 | 0.58 |
| Endrin Aldehyde | 0.02 | 0 | NA | NA |
| Endosulfan Sulfate | 0.02 | 0 | NA | NA |
| p,p - DDT | 0.02 | 4 | 0.06 | 0.15 |
| Methoxychlor | 0.02 | 0 | NA | NA |

*N=12

# Organochlorine Pesticides – Okanagan and Fraser Valleys

| | MDL, µg/L | Hits* | min, µg/L | max, µg/L |
|---|---|---|---|---|
| Alpha BHC | 0.001 | 0 | NA | NA |
| Beta BHC | 0.001 | 0 | NA | NA |
| Lindane (gammaBHC) | 0.001 | 2 | 0.001 | 0.001 |
| Delta BHC | 0.001 | 0 | NA | NA |
| Heptachlor | 0.001 | 0 | NA | NA |
| Aldrin | 0.001 | 0 | NA | NA |
| Heptachlor Epoxide | 0.001 | 0 | NA | NA |
| Endosulfan I | 0.001 | 1 | 0.001 | 0.001 |
| Dieldrin | 0.001 | 3 | 0.002 | 0.006 |
| p,p - DDE | 0.001 | 0 | NA | NA |
| Endrin | 0.001 | 0 | NA | NA |
| Endosulfan II | 0.001 | 0 | NA | NA |
| p,p - DDD | 0.001 | 0 | NA | NA |
| Endrin Aldehyde | 0.001 | 0 | NA | NA |
| Endosulfan Sulfate | 0.001 | 4 | 0.001 | 0.003 |
| p,p - DDT | 0.001 | 0 | NA | NA |
| Methoxychlor | 0.001 | 0 | NA | NA |

*N=12

# OP and NP Pesticides – Okanagan and Fraser Valleys

| | MDL, µg/L | Hits* | min, µg/L | max, µg/L |
|---|---|---|---|---|
| Atrazine | 0.002 | 5 | 0.011 | 0.061 |
| Carbaryl | 0.01 | 1 | 0.01 | 0.01 |
| Hexazinone | 0.006 | 0 | 0.001 | 0.001 |
| Metalaxyl | 0.005 | 4 | 0.003 | 0.011 |
| Propazine | 0.002 | 0 | NA | NA |
| Simazine | 0.002 | 3 | 0.018 | 0.034 |
| Azinphos-Methyl | 0.04 | 0 | NA | NA |
| Chlorpyrifos | 0.002 | 1 | 0.003 | 0.003 |
| Demeton-O | 0.01 | 0 | NA | NA |
| Demeton-S | 0.01 | 0 | NA | NA |
| Diazinon | 0.002 | 8 | 0.006 | 0.029 |
| Dimethoate | 0.004 | 0 | NA | NA |
| Ethion | 0.004 | 0 | NA | NA |
| Malathion | 0.004 | 0 | NA | NA |
| Mevinphos | 0.004 | 0 | NA | NA |
| Dichlorvos | 0.02 | 0 | NA | NA |

*N=12

# Miscellaneous Pesticides – Okanagan and Fraser Valleys

| | MDL, µg/L | Hits* | min, µg/L | max, µg/L |
|---|---|---|---|---|
| α-chlordane | 0.002 | 0 | NA | NA |
| Chlorothalonil | 0.004 | 4 | 0.005 | 0.010 |
| Desethyl Atrazine | 0.004 | 1 | 0.001 | 0.001 |
| Dichlobenil | 0.002 | 3 | 0.010 | 0.021 |
| γ-chlordane | 0.002 | 0 | NA | NA |
| Methamidaphos | 0.1 | 0 | NA | NA |
| Methoprene | 0.01 | 0 | NA | NA |
| Metolachlor | 0.002 | 2 | 0.073 | 0.080 |
| Myclobutanil | 0.01 | 0 | NA | NA |
| Napropamide | 0.002 | 2 | 0.006 | 0.007 |
| Phosalone | 0.004 | 0 | NA | NA |
| Phosmet | 0.01 | 0 | NA | NA |
| Quintozene | 0.004 | 0 | NA | NA |
| Terbufos | 0.002 | 0 | NA | NA |
| Trifluralin | 0.002 | 1 | 0.002 | 0.002 |

*N=12

# Triazine Herbicides and Metolachlor
# Fraser Valley

| | MDL, µg/L | Hits* | min, µg/L | max, µg/L |
|---|---|---|---|---|
| Atrazine | 0.002 | 5 | 0.011 | 0.061 |
| Desethyl Atrazine | 0.002 | 1 | 0.010 | 0.010 |
| Metolachlor | 0.002 | 4 | 0.003 | 0.011 |
| Propazine | 0.002 | 0 | NA | NA |
| Simazine | 0.002 | 3 | 0.018 | 0.034 |

*N=19

# Triazine Herbicides and Metolachlor
# Fraser Valley

| | MDL, µg/g | Hits* | min, µg/g | max, µg/g |
|---|---|---|---|---|
| Atrazine | 0.02 | 11 | 0.01 | 5.99 |
| Desethyl Atrazine | 0.02 | 6 | 0.01 | 0.19 |
| Metolachlor | 0.02 | 8 | 0.02 | 9.23 |
| Propazine | 0.02 | 2 | 0.07 | 0.08 |
| Simazine | 0.02 | 3 | 0.05 | 0.10 |

*N=25

# Conclusions

•Both the Fraser valley and the Okanagan show a wide variety of pesticides and in significant concentrations – 19 different pesticides/herbicides (including one TP) as high as 9 ppm for soil/sediment and 80 ppb for water.

•Okanagan soil/sediment still has significant quantities of DDT and it's breakdown products – even after decades of being discontinued for use.

# Acknowledgments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# Evaluation of Buffer Zone Effectiveness in the Protection of Aquatic Environments in Prince Edward Island - 2004

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Sample Collector


Runoff after major rainfall


Placement of Sample Collectors


PEI stream vulnerable to agricultural runoff


Sample collector after major rainfall


Potato field with compacted sprayer track rows

## Abstract

Runoff from agricultural fields has lead to pesticide induced fish kills in PEI. To minimize the risk posed by row crops, PEI introduced legislation in 2000 which stipulates a 10 metre buffer must be maintained between water courses and agricultural fields with slopes less than 5%. Since 2001, Environment Canada has been involved in a study to assess the effectiveness of ten metre vegetative buffer zones in reducing toxicity, pesticide and nutrient loads to nearby aquatic ecosystems. In 2004, 11 potato fields were selected for runoff collection; sample collectors were placed at the edge of the field and 10, 15 and 20 m down slope in the buffer. Three rainfall events occurred; samples were collected within 24 hours and analysed for pesticides, water quality parameters and assayed for *Daphnia magna* toxicity. Although the 10 m buffer was generally effective at reducing field pesticide concentrations and *Daphnia* toxicity, some samples were still toxic to *Daphnia* at 10 m and pesticides were detected at levels exceeding their respective acute *Daphnia* $LC_{50}$. The fields where pesticide loadings were not sufficiently reduced to eliminate toxicity appear to be related to placement of sample collectors. In these cases, sample collectors were influenced by increased runoff from sprayer track rows which are known to channel and concentrate flow due to soil compaction. Future work should investigate cultural practices (e.g. bale busting in sprayer track rows and track elimination) to reduce flow from these high risk areas.

## Introduction

- Runoff from agricultural fields has lead to pesticide induced fish kills in PEI
- To minimize risk of fish kills, PEI's Environmental Protection Act requires:
  - minimum 10 m buffer zone between agricultural fields and water courses where the slope is less than 5%
  - minimum 20 m buffer zone between agricultural fields within 50 m of a water course with slopes greater than 5%
- Environment Canada has been studying the effectiveness of the 10 m vegetative buffer in reducing toxicity and pesticide loads to nearby water courses through the collection of runoff water from the edge of potato fields and various distances along their buffer
- This poster summarizes latest research from the 2004 season; results from the 2001-2003 seasons have been presented at previous ATWs

## Methods

- 11 fields selected for runoff collection
- Sample collectors were set up at edge of field (0 m), 10 m down slope of the field within the buffer, 15 m (one field) and 20 m (one field)
- Samples collected within 24 hours of rainfall event and analysed for:
  - Pesticides, both aqueous and particle phases (endosulfan, chlorothalonil, azinphos-methyl, azoxystrobin, carbofuran, metribuzin, linuron, metobromuron, carbaryl, dimethoate, metalaxyl, dithiocarbamates, ethylene thiourea)
  - Water quality parameters (chlorine, sulphates, nitrates, ammonia, magnesium, potassium, sodium, calcium, total phosphates, specific conductivity, pH, total suspended solids, hardness)
  - Acute toxicity to *Daphnia magna*

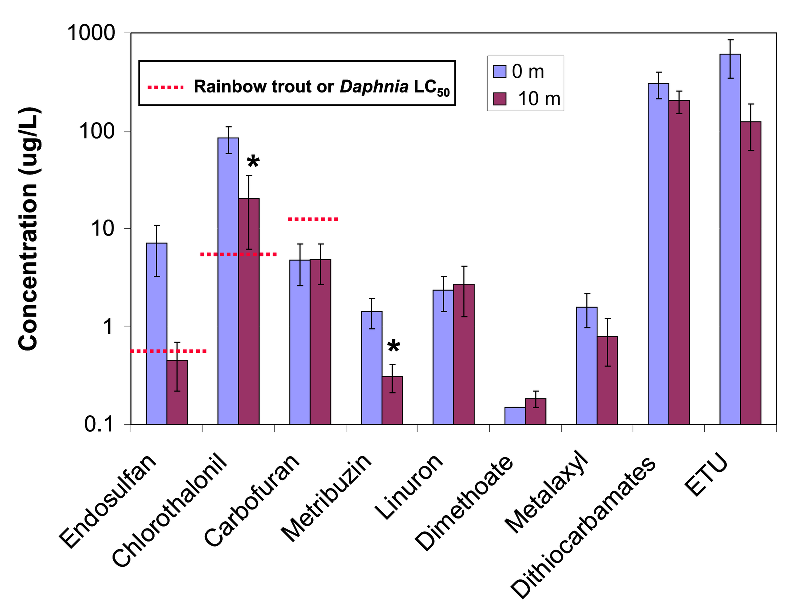


**Figure 1: Mean Aqueous Pesticide Concentrations (* p<0.05)**

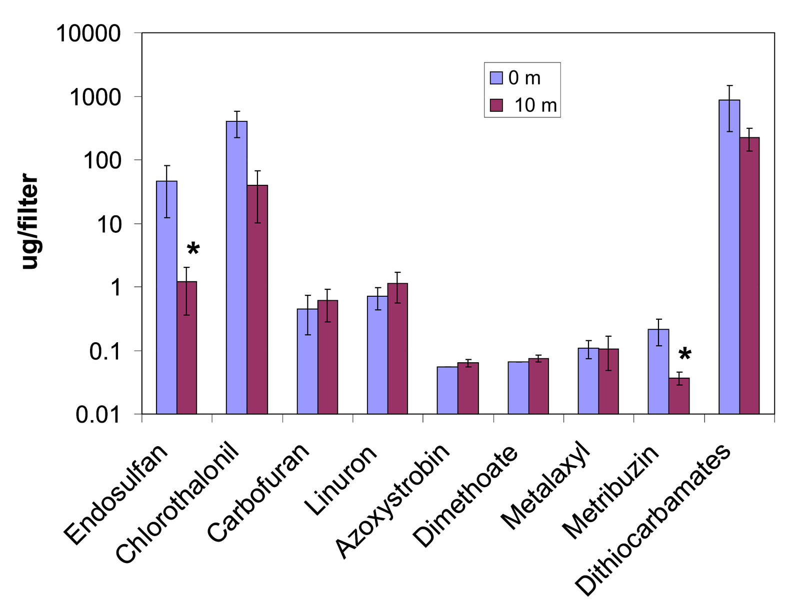


**Figure 2: Mean Filter Pesticide Amounts (*p <0.05)**

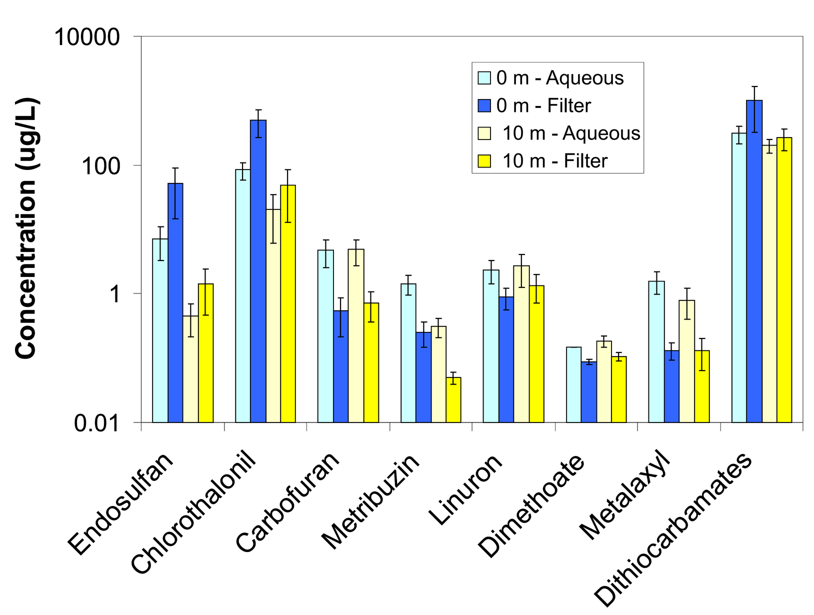


**Figure 3: Mean Filter and Aqueous Pesticide Concentrations**

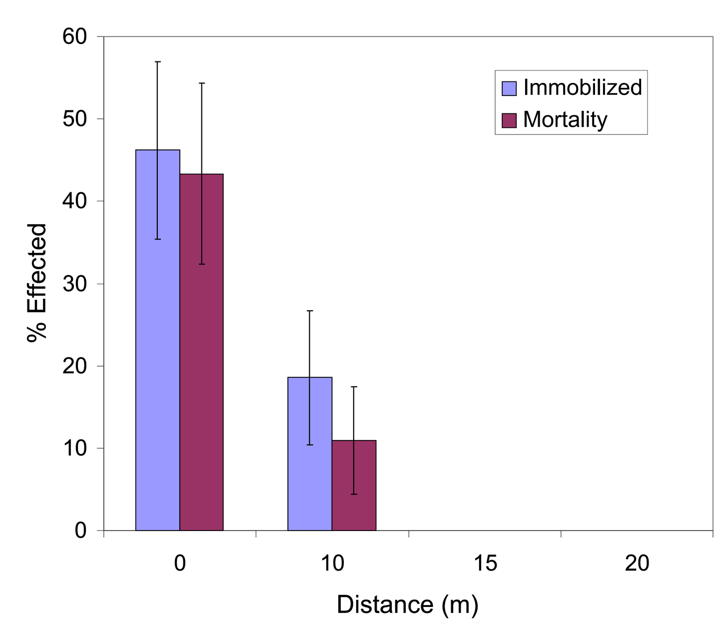


**Figure 4: Mean % *Daphnia* Immobilization and Mortality**

## Results - Pesticides

- 3 rainfall events occurred that were sufficient to produce runoff in one or more fields
- In general, pesticide concentrations and amounts on filters decreased with distance (Figures 1 and 2)
- Chlorothalonil and metribuzin concentrations were significantly reduced in water with an average 80% reduction between 0 and 10 m
- Endosulfan and metribuzin were significantly reduced in filters with an average 97% and 85% reduction for endosulfan and metribuzin, respectively
- In spite of pesticide reductions, at 10 m, pesticides were detected at concentrations exceeding $LC_{50}$ value:
  - Chlorothalonil: 16% of samples exceeded rainbow trout $LC_{50}$
  - Endosulfan: 21% of samples exceeded rainbow trout $LC_{50}$
  - Carbofuran: 5% of samples exceeded *Daphnia* $LC_{50}$
- Water soluble pesticides (e.g. carbofuran, metalaxyl, metribuzin) were detected at higher concentrations in water while less soluble pesticides (e.g. chlorothalonil, endosulfan) were detected at higher amounts in filters (Figure 3)
- There were insufficient volumes at 15 and 20 m for pesticide analysis

## Results - Toxicity

- Statistically significant reductions were observed in % *Daphnia* mortality and % immobilization between 0 m and 10 m ($p<0.05$) (Figure 4)
  - Mean *Daphnia* mortality decreased from 43% at 0 m to 11% at 10 m
  - Mean *Daphnia* immobilization decreased from 46% at 0 m to 19% at 10 m
  - No effects were observed at 15 m (1 sample) or 20 m (2 samples)
- 6 samples at 10 m exhibited immobilization; of these, 3 were explained by pesticide concentrations exceeding their respective *Daphnia magna* $LC_{50}$ and 2 appeared to be within experimental error
- Regression analysis revealed chlorothalonil concentrations to be significantly correlated to *Daphnia* toxicity ($r^2=0.72$; $p<0.001$)

## Conclusions

- 10 m buffer was generally successful at reducing *Daphnia* toxicity and pesticide concentrations
- In spite of the reductions, some samples at 10 m were still toxic to *Daphnia* and pesticide concentrations exceeded their respective acute *Daphnia* or rainbow trout toxicity values
- Most *Daphnia* toxicity observed at 10 m is attributed to detected pesticides
- The fields where pesticide loadings were not sufficiently reduced to eliminate *Daphnia* toxicity appear to be related to placement of sample collectors
- In these cases, sample collectors were influenced by increased runoff from sprayer track rows which are known to channel and concentrate flow due to soil compaction
- Future work should investigate cultural practices (e.g. bale busting in sprayer track rows and track elimination) to reduce flow from these high risk areas
- In addition, further research should examine what effect other buffer characteristics (e.g. vegetation type, plant density) have on buffer performance

Environment Canada    Environnement Canada

# HANDOUTS

**Gevan Mattu** (EC) - Survey of Pesticide Use in British Columbia: 2003
The report can be accessed via the BCMOE Pesticide IPM web site at http://www.env.gov.bc.ca/epd/epdpa/ipmp/tech_reports.html
or http://www.env.gov.bc.ca/epd/epdpa/ipmp/technical_reports/pesticide_survey2003/survey_2003.html
and the English/French abstract will be posted on the PYR GBAP web site: http://www.pyr.ec.gc.ca/georgiabasin/resources/publications_e.htm.

**Mike Wan** (EC) - **Wan MT, Buday C, Schroeder G, Kuo J, & Pasternak J. (2006).** Acute toxicity to *Daphnia magna, Hyalella azteca, Oncorhynchus kisutch, O. mykiss, O. tshawytscha, and Rana catesbeiana* of Atrazine, Metolachlor, Simazine and Their Formulated Products. (MS accepted by *Bull Eenviron Contam Toxicol* - Aug 2005).

**Mike Wan** (EC) - **Wan MT, Kuo J, & Pasternak J. (2005).** Toxicity of α-, β-, (α+β)-endosulfan and their formulated and degradation products to *Daphnia magna, Hyalella azteca, Oncorhynchus mykiss, O. kisutch* and biological implications in streams. *Envrion Toxicol Chem (2005) 24:1146-1154.*

**Mike Wan** (EC) - **Wan MT, Kuo J, & Pasternak J. (2005).** Residues of endosulfan and other selected organochlorine pesticides in farm areas of the Lower Fraser Valley, British Columbia, Canada. *J Environ Qual (2005) 34:1186-1193.*