Annapolis River Watershed
Pesticide Inventory Report

Prepared by:
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January 2006

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Contents

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Executive Summary

Over the period of January to December 2005, pesticide use data were gathered from seven sectors in the Annapolis River watershed in an effort to gain a better understanding of the types and quantities of pesticides used within the watershed's boundaries. Data were gathered from the following sectors: agriculture, domestic, forestry, large facilities and institutions, marine, municipal and miscellaneous, which examined pesticide use by lawn care and pest control companies as well as the use of wood preservatives in the watershed.

Once data collection was completed, it was determined that in excess of 55,000kg of active ingredients were applied in the watershed over the 2004 calendar year. Excluding data obtained from the agricultural sector, the most commonly used active ingredients were calcium hypochlorite, a disinfectant used for killing microorganisms in swimming pools and spas; chlorine, used to disinfect wastewater in sewage treatment plants; chromated copper arsenate (CCA) a wood preservative found in utility poles and guardrails; and glyphosate, a commonly used herbicide.

Agriculture was determined to be the sector with the highest level of pesticide application (53% of the total amount of active ingredients applied in the watershed), followed by domestic (24%), municipal (12%), miscellaneous (6%) and forestry (3%) sectors. The remaining two sectors, large facilities and institutions and marine each accounted for 1% of the total.

In the agricultural sector, data were gathered by obtaining the sales records of commercial pesticide vending establishments and through consultations with farmers and crop specialists. Sales records indicated that 29,136kg of active ingredients were sold in 2004, whereas estimates obtained from farmers and crop specialists totaled 38,247kg. Of these information sources, sales data were considered to be more accurate as estimates obtained from crop specialists were not complete. Use intensity in this sector was determined to be 8.68kg of active ingredients per hectare.

In the domestic sector, data were gathered by conducting a household pesticide use survey and by acquiring sales data from retail stores. Survey results, which, at the 80% confidence level, are accurate to $\pm$ 5%, indicate that on average during 2004, 0.84kg of active ingredients are applied per watershed household, for a total of 13,400kg of active ingredients. Extrapolation of sales data obtained from retail establishments indicated that a much lower quantity (1,140kg) of active ingredients were sold in the watershed. This discrepancy can be explained by the fact that the extrapolation was based on limited sales data and therefore did not accurately portray pesticide sales.

Pesticide application approvals obtained from the Environmental Registry of the Nova Scotia Department of Environment and Labour indicate that 1,857kg of active ingredients were applied by the forestry sector, all of which were herbicides. Of this amount, 94% of applications were aerial and 6% were ground applications. It was also determined that this sector had an average use intensity of 1.74kg of active ingredients per hectare.

In excess of 650kg of active ingredients were applied in the large facilities and institutions sector. Approximately three quarters of this total was applied on golf courses. Fungicides are the most commonly applied pesticide type on golf courses; it was calculated that participating golf courses have an estimated use intensity of approximately 74kg of fungicide active ingredients per hectare on greens. Excluding golf courses, other facilities and institutions applied herbicides, mainly glyphosate and 2,4-D, either to remove weeds on hard surfaces such as walkways and parking lots or on cut stumps to reduce the re-sprouting of cut trees.

In the marine sector, one active ingredient (cuprous oxide) was applied. Cuprous oxide is found in antifouling paints that are sold in marine supply stores and applied to the hulls of ships in boatyards. Pesticide use in aquaculture was also examined; it was determined that no antifouling agents were used in aquaculture operations in the watershed.

The miscellaneous sector included wood preservative use as well as pesticide use by pest control and lawn care companies. It was estimated that over the last year, approximately 2,616kg of the wood preservative CCA were used as treated wood products in the watershed in new utility poles and guardrails. No information could be obtained on the sale of pressure treated lumber for residential use. Following extrapolation of data, it was determined that pest control and lawn care companies applied approximately 560kg of active ingredients in the watershed. Insecticides were the most commonly applied pesticide type; carbaryl and diazinon were the most frequently applied active ingredients.

It was determined that 6,596kg of active ingredients were applied in the municipal sector. Almost all pesticides applied (99.99%) were disinfectants. Of this total, 93% was chlorine used to disinfect wastewater whereas the remaining 7% were used to disinfect public swimming pools, as the majority of towns and villages contacted operate outdoor public swimming pools in the summertime. Minute amounts of herbicides and insecticides were used for spot treatment on municipal grounds.

1.0 Introduction

The Annapolis River Watershed Pesticide Inventory is the first inventory of its type to be conducted in the Annapolis River watershed. To the best of our knowledge, it is also the first time this type of inventory, which encompasses all use sectors, is conducted on a scale as broad as a watershed. The approach taken was thus experimental in assessing various data sources, in order to identify the most effective data sources and improve the accuracy of results. Given the innovative nature of this project, the results contained in this report should be viewed as a first approximation of pesticide usage in the Annapolis River watershed.

The Annapolis River Watershed Pesticide Inventory Report details the methodology followed throughout the project; it states how the methodology was developed, the methods by which data were acquired, the sources from which data were collected and how data were managed following its acquisition. This methodology is a trial; individuals or organizations wishing to complete a similar pesticide inventory in the future may use this as a reference. This document also describes the types and quantities of pesticides applied in the watershed, including agriculture, domestic, forestry, large facilities and institutions, marine, municipal and other uses, and provides an overview of pesticide use in the Annapolis River watershed.

2.0 Methodology

2.1 General

Clean Annapolis River Project

This inventory was conducted by Clean Annapolis River Project (CARP), a charitable, non-governmental organization that works with other organizations and the community to conserve, restore and sustain use of the freshwater and marine ecosystems in southwestern Nova Scotia's Annapolis River watershed. The fact that the inventory was conducted by a community-based, non-regulatory, third party organization may have contributed to the ease with which the inventory was conducted. Individuals and organizations approached to participate did not feel threatened or targeted when questioned on their use of pesticides, a topic some may have viewed as sensitive.

CARP's objectives in proceeding with this project were twofold. CARP firstly sought to improve the tools available for understanding pesticide usage, particularly at watershed scales. CARP also wished to provide a factual, science-based, estimate of all pesticides used in the Annapolis River watershed. This was seen as an essential first step in a dialogue between members of the public, industry and regulators on the appropriate use of pesticides.

In the implementation of the pesticide inventory, CARP sought to maintain a valve-neutral perspective with respect to pesticides. This was felt to be critical in building trust with stakeholders, gaining access to data sources and the preparation of a balanced final report.

Steering Committee

At the inception of this project, a steering committee was formed to provide input on the methodology, identify data sources and review the draft reports. The steering committee was comprised of individuals from the principal players in pesticide management; these are the Nova Scotia Department of Environment and Labour, Nova Scotia Department of Natural Resources, Environment Canada and Health Canada's Pest Management Regulatory Agency. Each of these departments was approached and asked to participate in the pesticide inventory. Departments were asked to recommend an individual knowledgeable in this field that could bring forth their expertise to assist and advise over the course of the project. One individual from each of these departments was appointed to the committee.

The steering committee played a vital role throughout the project. It was pivotal in helping identify information sources over the course of the inventory. As the inventory progressed, the steering committee was continuously consulted on various matters, ranging from assisting in the development of a database to reviewing the questionnaire of a domestic pesticide use survey to answering questions on where to find specific information. Without the assistance and guidance of the steering committee, many data sources and methods used to gather information would have been overlooked.

Methodology Development

An extensive literature search was conducted at the onset of this project to gain familiarity with pesticides, namely, their composition, uses, methods of application, regulation, toxicity, etc. Numerous pesticide-related websites were reviewed in addition to many other background documents. A search for journal articles published on the topic of pesticides was conducted in Web of Science, Science Direct, Springer LINK Search and Pub Med indices, focusing on articles dealing with pesticide use surveys. An online search was also conducted for evidence of similar pesticide inventories previously conducted.

It was determined that while surveys of pesticide use had been conducted elsewhere, it appeared that none were on a scale as extensive as a watershed. The methodology that was subsequently developed was thus partly experimental and partly for the purpose of gathering pesticide use data. The methodology was developed to utilize multiple data sources wherever possible and appropriate. It sought to:

- Compare various data collection sources, allowing for an assessment of their relative effectiveness
- Allow the data from multiple sources to be compared and triangulated
- Maximize the accuracy of results

It was determined that seven sectors would be examined: Agriculture, Domestic, Forestry, Large Facilities and Institutions, Marine, Municipal and Miscellaneous (sources of pesticide use that did not fit in any other sectors). All individuals and companies that were to be contacted over the length of the inventory were determined. This was done in collaboration with the project's steering committee, as its members were knowledgeable on pesticide usage in the watershed. Sector by sector, contact information for all individuals and companies that were to be approached was found. Phone numbers, mailing addresses and email addresses were sought. Although this process was very lengthy, it allowed for rapid progression once the inventory was under way.

Table 1 summarizes the methods used to collect data in all sectors. It also specifies the number of individuals contacted and the percentage that responded. The amount of time invested by the researcher to gather data and the quality of data obtained are also noted for each collection method.

Table 1. Pesticide inventory methodology summary.

Sector	Collection method	# Contacted	% Participating	Time Invested* (high/med/low)	Quality of Data** (high/med/low)
Agriculture	Direct interviews with farmers	17	53	high	low
	Commercial vendors sales records	5	100	high	high
	Interviews with crop specialists	4	100	low	med
	Nurseries	5	80	low	high
Domestic	Survey of household pesticide use	1,000	17	high	high
	Retail stores sales records	24	54	med	low
Forestry	Direct interviews with forestry companies	3	67	low	med
	Pesticide application approvals from Environmental Registry	3	100	low	high
Large Facilities & Institutions	Directly contacted large facilities & institutions listed in methodology	14	86	high	high
Marine	Aquaculture	1	100	low	high
	Boatyards	3	100	low	high
	Marine supply stores	2	100	low	high
Municipal	Directly contacting municipalities	11	100	med	high

Sector	Collection method	# Contacted	% Participating	Time Invested* (high/med/low)	Quality of Data** (high/med/low)
Other	Obtain wood preservative sales records	7	0	low	low
	Industrial wood preservative use	2	100	low	med
	Lawn care companies	3	100	low	high
	Pest control companies	3	67	low	med

*Time invested: high = >2 weeks, medium = 1 to 2 weeks, low = less than one week
**Quality of data: high = 75 to 100% of required data was obtained, medium = 50-75% of required data was obtained, low = <50% of required data was obtained

An introductory letter to the inventory was prepared. The letter explained the purpose of the inventory and the specific data it was looking to gather, as well as how data would be reported once collected. The letter was sent to all individuals and companies listed in the methodology and followed up with a phone call to gather pesticide use information. The letter is included in Appendix B.

The introductory letter served a number of purposes including:

- Educating individuals on the purpose of the inventory
- Reassuring participants that they are not being singled out but rather are part of a large, neutral and groundbreaking study
- Allowing individuals the opportunity to gather the required information prior to follow up

In order to raise public awareness on the project, a press release was prepared at the onset of the inventory and sent to four local newspapers and a radio station. The press release, as the introductory letter, stated the reasoning behind the initiation of the inventory, its purpose, what data it will gather and how findings will be communicated once collected.

Database Development

Approximately three months into the project, development of a database to store accumulated data was initiated. It was decided that Excel worksheets would be used to store the data, as this program was able to accommodate all gathered data and was relatively easy to use. In collaboration with the project's steering committee, it was determined the worksheet would be similar to Table 2. Data contained in all tables of the methodology section of this report is for exemplary purposes only.

Table 2. Typical worksheet format used throughout the pesticide inventory.

ID #	Product Name	PCP #	Active Ingredient (ai)	Area Sprayed (ha)	Rate of app (L/ha or kg/ha)	Guar (g/L or %)	# of app/yr	Total ai Used/yr (kg)	Total ai Used/yr (L)	Type	Target Species	App Method	Comments
1	Roundup	13644	glyphosate	30	1 L/ha	360	2	21.6		herb	weeds	sprayer	---
2	Laddok	16641	atrazine	50	2.5L/ha	200	1	25		herb	weeds	sprayer	---
3	Captan	24613	captan	50	3kg/ha	80%	6	720		fung	scab	sprayer	---

It was concluded that each sector would have its own worksheet, containing whichever column headings necessary to represent data collected in that sector.

A product's quantity of active ingredient (ai) applied was calculated using the following formula:

total ai used/yr = area sprayed(ha) x rate of application(L/ha or kg/ha) x # of applications/yr x guarantee (g/L or %)

This resulted in either kilograms or liters of active ingredient. All amounts had to be converted to one common unit, kilograms of active ingredient, in order to be reported. To convert liters to kilograms, the quantity of liquid active ingredient was multiplied by the pesticide's specific gravity. A product's specific gravity is indicated on its Material Safety Data Sheet (MSDS), which can be obtained from its manufacturer's website.

In other instances, the quantity of active ingredient sold had to be calculated. This was achieved by multiplying the product's guarantee by the amount sold. This resulted in either kilograms or liters of active ingredient sold. Again, liters of active ingredient were converted to kilograms of active ingredient using the product's specific gravity.

Pesticide Management Regulatory Agency (PMRA)'s Electronic Label Database

Throughout the pesticide inventory, the PMRA's online database, http://eddenet.pmra-arla.gc.ca/4.0/4.01.asp, was used extensively. This database contains an electronic copy of the label of every pesticide currently or historically registered under the Pest Control Products Act (PCPA). Pesticide labels contain information such as

- Product name
- PCP registration number
- Active ingredient
- Active ingredient guarantee
- Product application rates
- Crop on which the product is approved for use
- Target species

While collecting information, most individuals only provided the trade name of the pesticide they had applied. In such cases, the database proved to be an extremely useful tool, as it allowed easy access to additional information.

2.2 Agricultural Sector

Data Acquisition

In agriculture, pesticides are mainly used to control or destroy unwanted vegetation, diseases or animals such as insects or rodents in crops. Data on the agricultural use of pesticides were gathered using three methods. The first method consisted of collecting pesticide use information from farmers; the second required acquiring sales records from the establishments that sell agricultural pesticides in the area. Lastly, crop specialists and other individuals knowledgeable on the use of pesticides in the watershed were consulted.

Farmers

Farmers in the watershed were contacted and asked to voluntarily share information on pesticide use on their farms. 5 fruit, 2 vegetable, 3 grain, 3 dairy, 1 beef, 1 poultry and 2 Christmas tree farmers were randomly selected and contacted. Of these, 3 fruit, 1 vegetable, 1 grain, 2 dairy, 1 beef and 1 Christmas tree farmer chose to participate.

Farmers were asked to specify their crop types as well as the acreage of each crop type. They were asked to cite each pesticide product they had applied over the last year and elaborate on each product by stating:

- the total area to which the pesticide was applied
- its application rate
- number of applications per year
- application method
- target pest(s)

Some farmers were cooperative and readily answered these questions; others were not. In the end, 53% of farmers contacted were willing to participate.

The initial steps of this process were the most time consuming. Finding farmers in the watershed, their mailing address and phone numbers was a very laborious process. There was no known accessible database from which this information could be procured; therefore extensive searches were conducted before this information was obtained. Unfortunately, the acquired information was not always up to date, or in other cases, the contact information was correct but farmers were not willing to participate.

Generally, farmers operating smaller farms were more willing to participate than the operators of larger farms. This could be due to the fact that larger farms tend to use more pesticides and farmers might fear this would be perceived badly by others. This may bias the results.

Reportable Sales

Another method by which information was obtained in this sector was by acquiring sales data from the pesticide vendors that sell to farmers in the watershed. Vendors selling commercial and restricted class pesticides must provide a yearly summary of sales to the Department of Environment and Labour in order to renew their vending license. This summary lists every commercial and restricted pesticide product the establishment sold in the last year. Active ingredient, guarantee, Pest Control Product (PCP) number and quantity sold are also specified for each product. These sales records are accessible to the public through the Freedom of Information and Protection of Privacy Act (FOIPOP). To access these

records, an application form was filled out, specifying sales data from pesticide vendors in Kings and Annapolis Counties for the years 2004, 2003 and 2002 were sought. The required fee was also paid.

These documents included all pesticides sold by the vendor, whose sales extended beyond the watershed. To obtain a more accurate estimate of the quantity of pesticides sold within the watershed, managers of the five pesticide vending establishments were contacted and asked what proportion of their sales were made in the watershed. The total amount of active ingredients sold by each of these establishments was calculated and subsequently multiplied by the percentage of sales made in the watershed.

Other Information Sources

Crop specialists from AgraPoint International Inc. were also consulted. The tree fruit specialist, berry specialist, vegetable specialist and field crop specialist were contacted and informed of the pesticide inventory. They were consulted on:

- crop types grown in the watershed
- acreage of each crop type
- prevalent pests (diseases, insects and weeds) in each crop type
- products used to control these pests
- proportion of crops in the watershed that typically require pesticide treatment
- number of applications per year
- pesticide application rates

Some specialists were able to provide all the above-mentioned information; others could only provide some of it.

An Agricultural Resource Coordinator from the Department of Agriculture & Fisheries was also contacted and asked for statistics on land use in the Annapolis River watershed. Using a digital watershed map, the Resource Coordinator was able to provide statistics from the Agricultural Land Identification Project on the crop types present in the watershed as well as the area the crop types occupy. Although the data were approximately four years old, it was still believed to be accurate.

Nurseries and Greenhouses

Pesticide use data were also collected from plant nurseries in the watershed. Six nurseries were contacted and nursery operators were asked the following questions:

- Were any pesticides used on their plants
- If so, name all pesticide products applied in the last year
- For each product,
    - what amount was applied
    - how many applications per year
    - to which plant was this product applied
    - what pests were being targeted

There is also one large vegetable nursery in the watershed. It was contacted but was not able to provide pesticide use information.

Data Management

Gathering information from these various sources resulted in a significant amount of data to be entered in the project database. Farmers' and nurseries' data were entered in a worksheet similar to that illustrated in Table 3.

Table 3. Example of worksheet in which farmers' and nurseries' data were entered.

Sub-sector	ID #	Product Name	Active Ingr.	PCP #	Area Sprayed (ha)	Rate of app (L or kg/ha)	Guar	# of app/ yr	Total ai Used/yr (kg)	Total ai Used /yr (L)	Type	Target Species	App Method	Comment
Fruit	1	Captan	captan	24613	50	3	80%	6	720		fung	scab	orchard sprayer	----
Veg	2	Prowl	pendi-methalin	23439	20	1.7	400	1	13.6		herb	weeds	sprayer	---
grain	3	Converge	atrazine	26277	20	2.1	470	1	19.7		herb	weeds	sprayer	---

Data from the pesticide vendors were entered in a separate worksheet; one similar to that shown in Table 4.

Table 4. Example of worksheet in which vendors' data were entered.

Vendor #	Year	Pesticide Type	Product Name	PCP #	Active Ingredient	Guarantee (g/L or %)	Quantity Sold	Total ai Sold (L)	Total ai Sold (kg)
1	2004	herb	Aatrex	18450	atrazine	451	1638L		738.7
1	2004	fung	Aliette	24458	fosetyl al	80%	29kg		23.2
1	2004	herb	Garlon	21053	triclopyr	480	48L		23.0

Inputting vendors' data was a very lengthy process as there was a considerable amount of data to be entered. Following data entry, the total amount of active ingredients sold by each vending establishment was multiplied by the proportion of sales made in the watershed for agricultural purposes.

Some inconsistencies were encountered as data were being entered. In some cases, the PCP number and product name for a certain pesticide did not match. For example, in one case product information was given for 2,4-D but the PCP number was for Captan. In these instances, the proper PCP number or product name was assigned based on product formulation.

Information obtained from crop specialists was entered in a table similar to Table 5.

Table 5. Example of table in which information from crop specialists was entered.

Pest	Treatment (ai or Trade Name)	Application Rate (L/ha or kg/ha)	# of app/yr	% Treated	Total Estimated ai Applied	Comments
Fruit rot	Captan	2.75-4.25	1	>95%	650-1000kg	Infection @ bloom
weeds	Sinbar	275-850g	4	>95%	260-800kg	
insects	Thiodan	5L	1	>95%	1190	

2.3 Domestic Sector

Data Acquisition

Pesticides are used around the home to control, destroy or repel unwanted plants, insects and rodents. They are also used to disinfect swimming pools and spas and protect outdoor wooden structures from microorganisms that cause decay. Gathering pesticide use data from homeowners was a particularly challenging and time consuming task. It was determined this information would be gathered in two ways. The first method would be to directly survey homeowners. The second method would be to obtain sales data from retail stores that sell domestic pesticides in the area.

Survey of Domestic Pesticide Use

The first step was determining the number of households in the watershed. These were obtained from the Canada Post website at http://www.canadapost.ca/cpc2/addrm/hh/current/indexp/cpALL-e.asp. Once all postal codes in the watershed were determined, the total number of households (and therefore population size) was calculated to be approximately 16,000. After consulting three statistics sources, *Statistical Methods in the Biological and Health Sciences* and *Monitoring Plant and Animal Populations* as well as http://www.macorr.com/ss_methodology.htm, formulas to calculate sample size at the desired confidence levels and confidence intervals were determined.

An assessment was made of various methods of carrying out a survey. The options were mail, telephone, door-to-door and online. Table 6 summarizes the advantages and disadvantages of each method.

Table 6. Costs and benefits of various methods of conducting a survey.

Survey Method	Advantages and Disadvantages
Door-to-door	-too costly and time consuming
Online	-only reach individuals with internet access, eliminating survey randomness -may tend to get more responses from biased individuals -less expensive -recipients can fill out at their own convenience
Mail	- may tend to get more responses from biased individuals -postage can be expensive -recipients can fill out at their own convenience
Phone	-allows for random selection -would have to hire staff to make calls, therefore must find qualified individuals willing to do this work and additional salary costs are incurred

The options of door-to-door and online surveys were dismissed. After careful deliberation, it was determined that a mail survey would be conducted. There is only a short window of time during the evening when people can be contacted for phone surveys; finding individuals willing to dedicate their evenings to conduct this survey might be a problematic task. A mail survey eliminates this challenge, as no extra help must be hired and survey recipients can fill out their questionnaire at a time convenient to them.

A preliminary survey was conducted on July 30th at the Farmers and Traders market in Annapolis Royal. The pesticide inventory researcher circulated amongst the crowd and asked watershed residents to complete the survey. Eighteen

watershed residents participated. This preliminary survey allowed a variety of questions to be assessed and aided in the development of the trial questionnaire.

Due to financial and time constraints, it was not possible to conduct a full mail survey of the watershed. It was ultimately decided that one thousand copies of the survey would be mailed as unaddressed admail; two hundred copies of the survey would be mailed from five of the larger post offices that span the watershed. This option was chosen as it would reach more individuals yet remained within budget limitations.

Unaddressed admail significantly reduces mailing costs, however, surveys mailed this way tend to produce lower response rates than when mailed as addressed mail (Creative Research Systems, 2003 and StatPac Inc., 2005). Consequently, it was determined prizes would be used to motivate survey recipients to respond. Respondents that included their name and phone number with their completed survey were entered in a draw for one of twenty prizes, water conservation kits with an approximate retail value of $15 donated by CARP.

Prior to survey mail out, a questionnaire was drafted and circulated amongst CARP staff members and the project's steering committee. All provided input on ways to improve the layout and questions. Comments and suggestions were incorporated into the questionnaire. The survey was then assessed by twelve watershed residents. The purpose of this trial was to identify any potential problems with the questionnaire prior to mailing. Results obtained were then entered into an Excel worksheet in order to test the format's efficiency. The questionnaire is included in Appendix C. The survey was then prepared to be mailed. This process took approximately three person days and included photocopying, stapling and folding questionnaires as well as adding CARP labels and stamps to envelopes.

On September 12th, two hundred copies of the survey were dropped off at five post offices spanning the watershed: Digby, Annapolis Royal, Bridgetown, Middleton and Kingston. Each of these post offices contained more than 200 lock boxes belonging to homes or apartments (1431, 338, 520, 1100 and 518, respectively). Surveys were randomly placed into the lock boxes of homes or apartments by post office staff. Unfortunately, the survey's limited budget did not allow it to reach mailboxes on rural routes. This may introduce a bias in survey results since respondents are more likely to reside in urban rather than rural areas of the watershed. Survey recipients were given a two-week period to complete the survey. One hundred and seventy completed questionnaires were received; therefore the survey has a confidence level of 80% with a confidence interval of 5%.

In order to raise public awareness of the survey, a press release containing general information on the survey such as its topic, purpose, prizes and response time was prepared and sent out to four local newspapers in the watershed. Once completed questionnaires were received, they were numbered and the post office from which they were received was noted.

Retail Store Data

The second method by which data were gathered in this sector was from retail stores. Domestic pesticides include:

- herbicides
- insecticides
- insect repellents
- fungicides
- rodenticides
- slug and snail baits
- flea/tick collars, shampoos, powders, etc
- swimming pool and spa disinfectants
- preservative paints and primers
- pressure treated lumber

Unlike vendors of commercial and restricted class pesticides, vendors of domestic label pesticides are not required to report pesticide product sales, therefore the acquisition of such information necessitated that retail stores be contacted individually and asked for this information. Table 7 summarizes the quantity and types of stores that were contacted as well as the number of stores that participated in the inventory.

Table 7. Type and number of stores contacted and number of stores choosing to share pesticide sales data.

Type of Store	# Contacted	# Participating
Department store	3	2
Hardware store	6	3
Garden centre	5	3
Veterinarian's office	5	3
Grocery store	2	1
Pet store	1	0
Swimming pool & spa supply store	1	0
Building supply store	1	1
TOTAL	**24**	**13**

All stores were visited in person. Store managers were approached and the pesticide inventory was explained. It was pointed out that the best way of gathering information on domestic pesticide use was by obtaining sales records of these products; store mangers were then asked to share the last year's pesticide sales data. It was specified that all information provided would remain confidential and only sales quantities were needed, no dollar values. Stores in towns bordering both ends of the watershed were also asked what proportion of their customers resides in the watershed.

Some managers readily shared sales data. They provided a record listing the quantity of each pesticide product sold over the course of the last year. However, other managers were not able to share this data, mainly because company policy did not allow the release of such information. Most of the thirteen stores that provided sales data were amongst the smaller stores that were contacted. Few of the larger stores were able to participate; therefore it is reasonable to assume that less than half of the retail sales data were acquired.

Data Management

The worksheet in which survey data were entered is similar to Table 8.

Table 8. Example of worksheet in which survey data were entered.

Respondent #	Product Name	PCP#	Active Ingredient	Guarantee	Amount Used	Total Active Ingredient Used
1	End All	26587	pyrethrins	0.5%	200mL	0.0010L
2	Ant-B-Gon Ant Traps	23372	borax	5%	15g	0.0008kg
3	Muskol Insect Repellent	23204	DEET	25%	50g	0.0125kg

These columns, excluding respondent #, were repeated four times per question; as four products could be specified per question. This layout was repeated for the first eight questions while the last four questions were yes/no or multiple choice questions whose answers were entered directly into the spreadsheet.

Data from retail stores were entered into the project database in a worksheet comparable to Table 9.

Table 9. Example of retail store data worksheet.

Vendor #	Product Name	PCP #	Active Ingredient	Guarantee	Quantity Sold	Total ai Sold (kg)	Total ai Sold (L)	Pesticide Type	Comments
1	Roundup RTU	24299	glyphosate	7	22L	0.1540		herbicide	
1	Raid Ant Baits	22221	chlorpyrifos	0.03%	1.24kg	0.0003		insecticide	
1	Rosepride Funginex	15727	triforine	6.50%	0.25L		0.0163	fungicide	

The handling of swimming pool and spa disinfecting products data was slightly different. Most domestic class swimming pool and spa disinfecting chemicals are scheduled rather than registered under the Pest Control Products Act (PCPA). Scheduled products meet certain criteria established by the PMRA and do not require an individual registration number. If products do not have a registration number, they are not included in the electronic database. In this case, information on product formulation was acquired by copying the desired information directly from the product label. Not all swimming pool and spa disinfecting products are scheduled; some are registered and included in the PMRA's database.

2.4 Forestry Sector

Data Acquisition

Herbicides are used to manage unwanted vegetation in forests. Data on use of herbicides were acquired using two methods. The first method consisted of contacting forestry companies in the watershed; the second method involved acquiring pesticide application approvals from the Environmental Registry of the Nova Scotia Department of Environment and Labour (NSDOEL).

Forestry Companies

The three main forestry companies in the watershed were contacted by phone and asked what pesticides had they applied on their land over the last three years. For each pesticide, they were asked to specify:

- the area sprayed each year
- application rate
- application method
- target species
- how often they re-applied the pesticide

One company openly shared this information, another stated they had not used pesticides in the last three years and the third company suggested accessing this information from the records of the Environmental Registry of the NSDOEL.

Environmental Registry

The second method by which information was gathered was through the Environmental Registry of the NSDOEL. In order to apply pesticides to forested land, a company must be approved by the NSDOEL for pesticide application on a specific land plot. Copies of these approvals are accessible to the public through the NSDOEL's Environmental Registry. Application was made to obtain copies of the approvals of two major forestry companies as well as those of a private company that regularly acquires contracts to apply pesticides aerially for landowners. Records were not sought for the forestry company claiming it had not used pesticides in the last three years. Information was received for pesticide application approvals in 2002, 2003 and 2004 in Annapolis, Kings and Digby Counties.

The process of acquiring data in this sector was completed in approximately five weeks.

Data Management

The forestry sector's worksheet contained the column headings indicated in Table 10.

Table 10. Example of forestry sector worksheet.

ID #	Year	Prod Name	PCP #	Active Ingredient	Area Sprayed	Rate of app	Guar	# of app/yr	Total ai Used/yr	Target Species	App Method	Comments
1	2004	Vision	19899	glyphosate	100ha	4.7	356	1	167.32	Competing vegetation	aerial	
2	2004	Vision	19899	glyphosate	250ha	4.7	356	1	418.30	Competing vegetation	aerial	
3	2004	Vision	19899	glyphosate	22ha	4.7	356	1	39.16	Competing vegetation	ground	

Information collected from both the Environmental Registry and personal communications was entered into this worksheet.

Some of the documents received from the Environmental Registry neglected to mention the rate at which the pesticides were to be applied. Records stated pesticides were to be applied "as per label directions". Since product labels contain a range of application rates rather than one specific value, it was assumed they were applied at a rate of 5L/ha, as this rate was the one mentioned on most approvals.

It was assumed that pesticides were applied to all areas in which application was approved.

2.5 Large Facilities & Institutions Sector

Data Acquisition

The facilities and institutions contacted in this sector use pesticides for a variety of reasons including right-of-way vegetation management and control of weeds on hard surfaces such as sidewalks or parking lots. Golf courses use pesticides to control unwanted vegetation, insects and diseases on course turf.

Data were acquired by contacting the following facilities and institutions and inquiring about their use of pesticides:

- District Health Authority
- Regional School Board
- Community College campuses
- Department of National Defense
- Parks Canada
- six golf courses
- Department of Transportation and Public Works
- Nova Scotia Power
- an amusement park

Individuals from property services were contacted at the District Health Authority, Regional School Board, Community College campuses, Parks Canada and the amusement park. The environmental officer was contacted at the Department of National Defense facility and either greens superintendents or course managers were the golf course contacts. At the Department of Transportation and Public Works, the appropriate area manager was contacted and the Nova Scotia Power contact was the forestry manager. The following questions were asked to the contacts:

- What pesticides were applied on facility or institution grounds in the last three years
- Over what area was each pesticide applied
- At what rate was each pesticide applied
- How was each pesticide applied
- How many times per year was each pesticide applied
- What species were being targeted by each pesticide

Acquisition of data in this sector was extended over a period of approximately two months as facilities and institutions were contacted in a staggered manner.

Variable information was received from golf courses in the watershed. Pesticide application records were obtained from one course, another provided a pesticide application forecast for the coming golf season whereas others recited products used over the last three years without going through their records, but rather by listing products and application rates from memory. Consequently, information received from some courses was more accurate than others.

Some facilities in this sector applied a herbicide/fertilizer combination product. Products containing both fertilizers and pesticides are regulated by the Canadian Food Inspection Agency (CFIA) and are registered under the CFIA's Fertilizer Act rather than the Pest Control Products Act, as are other pesticides. The facility using this product was able to provide the

product's Fertilizer Act registration number, therefore information on this product's formulation was obtained from the CFIA's website, http://www.inspection.gc.ca/english/plaveg/fereng/list/fertpesticidee.shtml.

Data Management

Data from this sector were entered in an Excel worksheet resembling Table 11.

Table 11. Model of large facilities and institutions worksheet.

ID #	Product Name	PCP #	Active Ingredient	Area Sprayed (ha)	Rate of app(L/ha, kg/ha)	Guar	# of app/ yr	Total ai Used (kg)	Total ai Used (L)	Type	Target sp.	App Method	Comments
1	Roundup	13644	glyphosate	2	1	356	2	1.42		herb	weeds	sprayer	
2	Rovral	24379	iprodione	2	10	240	4	19.20		fung		sprayer	
3	Sevin	19531	carbaryl	1.5	10	466	1	6.99		insec	ants	sprayer	

In some cases, the area to which a pesticide had been applied was unknown. However, the total quantity of pesticide that had been applied in the last year was known. This was sufficient since this amount could be used, along with the product's guarantee, to calculate the total amount of active ingredient used in the last year.

2.6 Marine Sector

Data Acquisition

Antifouling agents are pesticides used in marine environments. Antifouling paints are applied to the hulls of boats to prevent the attachment of marine organisms such as barnacles and algae. These organisms add to the weight of the ship, reduce its speed and increase its fuel consumption. Other antifouling agents can be applied to gear such as ropes, nets, etc. Sales of antifouling agents by marine supply stores and use of these agents by boatyards was examined. The use of insecticides for controlling sea lice infestations was also examined.

Aquaculture

A meeting was arranged with a fisheries representative from the Nova Scotia Department of Agriculture and Fisheries to discuss pesticide use in aquaculture. This individual was very helpful; he contacted the provincial aquaculture veterinarian who was able to provide information on pesticide and drug use in aquaculture pens. This individual also contacted growers in the watershed and obtained information on the application of antifouling products on pens, nets or other equipment. It should be noted that aquaculture in the watershed is not extensive as there are only two finfish operations.

Marine Supply Stores

Two marine supply stores in the watershed were visited. Store mangers were asked if they could share the last year's antifouling agent sales data, specifically what products they sold and in what quantities. Since these stores were located in a town bordering the watershed, contacts were also asked to estimate the proportion of clients from the watershed.

Boatyards

Three boatyards in the watershed were also contacted and questioned on their use of antifouling agents. The boatyard managers were asked what antifouling agents were used at their facility and what quantity of these products had been applied over the course of the last year.

Data Management

Table 12 illustrates the manner in which data from this sector were entered in the project database.

Table 12. Example of marine sector worksheet.

ID #	Product Name	PCP#	Active Ingredient	Guarantee	Quantity Sold (L)	Total ai Used /yr (L)	Comments
1	Atlantic AF	23511	cuprous oxide	9.70%	200	19.40	
1	Pettit AF	21703	cuprous oxide	37.50%	50	18.75	
2	Atlantic AF	23511	cuprous oxide	9.70%	90	8.73	

2.7 Miscellaneous Sector

Data Acquisition

This sector gathered information on wood preservative use as well as pesticide use by lawn care companies and pest control companies. The possibility of airborne inputs of pesticides was also examined.

Wood Preservatives

The use of wood preservatives in the watershed was examined. This comprised of asking five hardware stores and two building supply stores whether they could provide information on the amount of pressure treated wood sold in the last year. Unfortunately, none of the stores were able to provide this information; therefore retail sales of pressure treated wood is not included.

The industrial use of pressure treated wood was also examined. Information on the quantity of utility poles installed in the watershed over a period of a year was acquired from Nova Scotia Power. Pole specifics such as type of wood, length and type of preservative with which they were treated were also obtained. The concentration at which the preservative was added to the wood was then determined so the total amount of active ingredient in these poles could be calculated.

The amount of guardrails and signposts installed on highways and other roads in the watershed was also examined. This information was gathered from the Department of Transportation and Public Works. Only an approximation of the amount of pressure treated wood installed in the watershed was obtained, however, information on the type of preservative used was acquired. As in the case of utility poles, the concentration at which the preservative was added to the wood was determined, and an estimation of the quantity of active ingredient introduced to the watershed via guardrails and signposts was calculated.

Lawn Care & Pest Control Companies

Three lawn care and three pest control companies were contacted. Company owners or area managers were asked the following questions:

- What type of pesticides (ie. herbicide, insecticide) does the company apply
- What products were applied in the last year
- How much of each product was applied in the watershed in the last year
- What are the main pests in the area

Airborne Deposition of Pesticides

A search for journal articles relating to the airborne deposition of pesticides was conducted. Five articles, based on studies conducted in Quebec, the Prairies, France and North America as well a review article were obtained. Information was also obtained from Environment Canada on studies conducted on Prince Edward Island. No information on the airborne deposition of pesticides in the watershed was obtained.

Data Management

In the case of wood preservatives, only one active ingredient was involved; it was noted in the database. The following formula was used to calculate the total amount of active ingredient introduced in the watershed:

Total volume of treated wood (m^3) x the concentration of active ingredient (kg/m^3) = total amount of active ingredient

Lawn care and pest control companies' data were entered in the project database as illustrated in Table 13.

Table 13. Example of miscellaneous sector worksheet.

ID #	Product Name	PCP #	Active Ingredient	Guarantee	Amount Used/yr	Total ai Used/yr (kg)	Total ai Used/yr (L)	Pesticide Type	App Method	Target Species	Comments
1	Prelude	24469	permethrin	500	2L	1		insecticide		crawling insects	
2	Diazinon	11889	diazinon	500	10	5		insecticide		chinch bug	
3	Sevin	19531	carbaryl	466	50	23.3		insecticide		various insects	

2.8 Municipal Sector

Data Acquisition

The use of herbicides, insecticides, fungicides and rodenticides on municipal grounds was examined in this sector, as was the use of swimming pool, spa and wastewater disinfectants. The majority of towns and villages in the watershed operate a public swimming pool during the summer months and many municipalities and towns also manage wastewater treatment plants. Data were acquired by contacting all municipal, town and village councils in the watershed.

The Chief Administrative Officers (CAO) or clerk treasurers of the following rural municipalities, town councils and villages were contacted:

- Municipality of the County of Annapolis
- Municipality of the County of Kings
- Municipality of the District of Digby
- Town of Annapolis Royal
- Town of Bridgetown
- Town of Digby
- Town of Middleton
- Village of Aylesford
- Village of Greenwood
- Village of Kingston
- Village of Lawrencetown

The following questions were asked to CAOs and clerk treasurers:

- Had any pesticides been applied on municipal grounds in the past three years
- If so, what were the product names and where were they were applied
- At what rate was each pesticide applied
- For each pesticide, how many applications per year, what application method was used, and what pests were being targeted

Although letters were mailed to CAOs and clerk treasurers, most felt individuals in their public works departments would be better suited to answer these questions, as they were the ones who either applied the pesticides or hired contractors to apply them. These individuals were subsequently contacted.

While talking to municipal contacts, it was important to specify that "pesticides" referred not only to herbicides and insecticides, but other products such as slimicides used in cooling systems, structural pesticides and swimming pool disinfectants so that these pesticides would not be overlooked.

In the case of wastewater treatment, a representative of the Water and Wastewater Branch of the Environmental and Natural Areas Management Division of the Nova Scotia Department of Environment and Labour was contacted for information on methods used to disinfect wastewater in treatment plants throughout the watershed. Subsequently,

operators of treatment plants using chlorine disinfection were contacted and asked to provide information on average daily flow rates, method of chlorination and average quantity of disinfectant used on a daily basis.

Data acquisition in this sector was completed over a period of three weeks.

Data Management

Data from the municipal sector were entered in a table identical to Table 13.

3.0 Results

3.1 Overview

Combining results obtained from all seven sectors indicates that in excess of 55,000kg of active ingredients were applied in the Annapolis River watershed in 2004. Table 14 indicates the total amount of active ingredients determined to be applied in each sector as well as the percentage each sector contributes to the total amount of active ingredients applied. The data source column indicates the source from which the quantity of active ingredients applied originates.

Table 14. Estimated quantity of active ingredients applied per sector in one year.

Sector	Quantity of Active Ingredients Applied (kg)	% of Total Amount of Active Ingredient Applied in the Watershed	Data Source
Agriculture	29,150	53%	Sales data from pesticide vendors in Annapolis Valley. Acquired estimate of watershed sales, assumed all pesticides sold were applied.
Domestic	13,400	24%	Extrapolated data from domestic survey
Municipal	6,596	12%	Contacted all municipal units and acquired data.
Miscellaneous	3,175	6%	Gathered data on industrial wood preservative use, and some pest control and lawn care companies; extrapolated data.
Forestry	1,857	3%	Acquired pesticide application approval documents.
Large Facilities & Institutions	650	1%	Acquired data from large facilities & institutions; extrapolated data.
Marine	572	1%	Sales data from marine supply stores, as well as antifouling paint application in boatyards.
TOTAL	**55,400**	**100%**	

No data on pesticide use from other watersheds could be obtained for comparison; however, provincial statistics were available. In 2003, Nova Scotia reported selling over 442,000kg of active ingredients (excluding domestic sales), while in 2002, Prince Edward Island agricultural pesticide sales were estimated at 814,100kg of active ingredients (Brimble et al, 2005). Saskatchewan is reported as being the largest pesticide user in the country with sales in excess of 12,000,000kg of active ingredients in 2001. The province with the lowest pesticide use level is Newfoundland, which reported selling 42,400kg of active ingredients in 2003. This figure includes domestic, commercial and restricted pesticide sales (Brimble et al, 2005).

The proportion of the total amount of active ingredients applied by each sector is illustrated in Figure 1. As is indicated in both Table 14 and Figure 1, the agricultural sector is the main user of pesticides in the watershed, applying 53% of all pesticides. The domestic sector is next, accounting for 24% of the total amount of active ingredients. The municipal sector accounts for 12%, the miscellaneous sector 6% and the forestry sector 3% of the watershed total. The remaining two sectors each account for 1% of pesticide application in the watershed. These data seem to be somewhat consistent with data obtained from 2001 sales records from the province of Québec. As in the case of the watershed, agriculture was the dominant sector, accounting for 80% of pesticide sales followed by the domestic sector, which accounted for 11% of sales. Lawn care companies, industrial uses, forestry and other uses accounted for the remaining 11%. (Ministère du Développement durable, Environnement et Parcs, 2005).

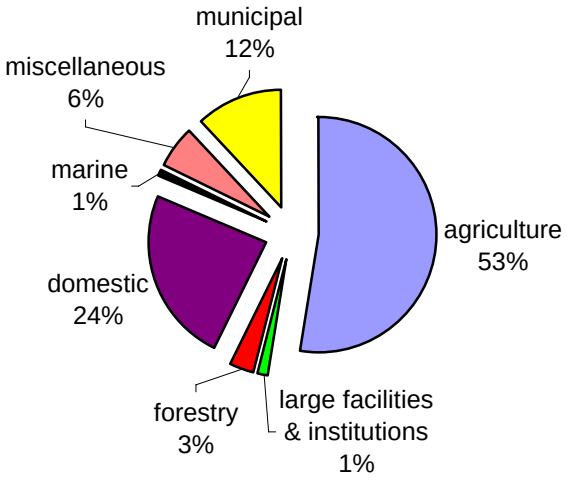

Figure 1. Percentage each sector contributes to the total amount of active ingredients applied in the watershed.

Table 15 lists active ingredients applied in the watershed in the last year, as well as the quantity applied, type of each active ingredient and the sector(s) of use. Active ingredients from the agricultural sector are not included in this table, with the exception of active ingredients applied in nurseries. This exclusion is due to the fact that only a total quantity of active ingredients sold in the watershed was obtained; this total could not be broken down into sales quantities of individual active ingredients. See the reportable sales section of the Agriculture sector for further detail. For a list of trade names corresponding to each active ingredient, see Appendix D.

Table 15. Active ingredients applied in the watershed in the last year, listed in decreasing order.

Active Ingredient	Quantity Applied (kg)	Pesticide Type	Sector(s) of Use
calcium hypochlorite	11,198	disinfectant	Domestic, Municipal
chlorine	6,139	disinfectant	Municipal
CCA	2,616	wood preservative	Miscellaneous
glyphosate	1,867	herbicide	Agriculture, Domestic, Forestry, Large Facilities & Institutions, Municipal
ferrous sulphate	593	herbicide	Domestic
cuprous oxide	572	antifouling agent	Marine

Active Ingredient	Quantity Applied (kg)	Pesticide Type	Sector(s) of Use
2,4-D	431	herbicide	Agriculture, Domestic, Large Facilities & Institutions, Municipal, Miscellaneous
carbaryl	318	insecticide	Domestic, Large Facilities & Institutions, Miscellaneous
sodium hypochlorite	267	disinfectant	Municipal
mecoprop	229	herbicide	Agriculture, Domestic, Large Facilities & Institutions, Municipal, Miscellaneous
silicon dioxide	225	insecticide	Domestic,
DEET	144	insect repellent	Domestic
chlorothalonil	121	fungicide	Large Facilities & Institutions
insecticidal soap	80	insecticide	Agriculture, Domestic
triclopyr	65	herbicide	Forestry
diazinon	50	insecticide	Miscellaneous, Municipal
iprodione	35	fungicide	Large Facilities & Institutions
calcium polysulphide	32	fungicide	Domestic
azoxystrobin	32	fungicide	Large Facilities & Institutions
quintozene	24	herbicide	Large Facilities & Institutions
thiram	20	fungicide	Large Facilities & Institutions
propiconazole	18	fungicide	Large Facilities & Institutions
imidacloprid	16	insecticide	Domestic
picloram	15	herbicide	Large Facilities & Institutions
dicamba	13	herbicide	Agriculture, Domestic, Large Facilities & Institutions, Municipal, Miscellaneous
tributyltin oxide	13	fungicide/molluscicide	Domestic
folpet	13	fungicide	Domestic
piperonyl butoxide	10	insecticide	Domestic
permethrin	10	insecticide	Domestic, Miscellaneous
copper	9.3	fungicide	Domestic
carbathiin	7.8	fungicide	Large Facilities & Institutions
metaldehyde	7.5	molluscicide	Domestic
zinc	6.2	fungicide	Domestic
borax	4.5	insecticide	Domestic
tetrachlorvinphos	3.5	insecticide	Domestic
trifloxystrobin	2.4	fungicide	Large Facilities & Institutions
propoxur	2.1	insecticide	Domestic
oxycarboxin	2.0	fungicide	Large Facilities & Institutions
pyrethrins	1.6	insecticide	Domestic
thiophanate-methyl	1.4	fungicide	Agriculture
triforine	1.3	fungicide	Agriculture, Domestic

Active Ingredient	Quantity Applied (kg)	Pesticide Type	Sector(s) of Use
dimethoate	1.1	insecticide	Agriculture, Domestic
tetramethrin	1.1	insecticide	Domestic
chlorpyrifos	1.1	insecticide	Large Facilities & Institutions
Bacillus thuringiensis	1.0	insecticide	Agriculture
n-octyl bicycloheptene dicarboximide	0.98	insecticide	Domestic
benomyl	0.71	fungicide	Domestic
captan	0.70	fungicide	Agriculture
myclobutanil	0.70	fungicide	Large Facilities & Institutions
ferric phosphate	0.43	molluscicide	Agriculture, Domestic
cyfluthrin	0.30	insecticide	Miscellaneous
d-trans allethrin	0.30	insecticide	Domestic
rotenone	0.29	insecticide	Domestic
trinexapac-ethyl	0.24	plant growth regulator	Large Facilities & Institutions
s-methoprene	0.22	insecticide	Domestic
malathion	0.19	insecticide	Domestic
warfarin	0.09	rodenticide	Domestic
resmethrin	0.05	insecticide	Domestic
pyriproxyfen	0.04	insecticide	Domestic
metalaxyl	0.02	fungicide	Agriculture
brodifacoum	0.0047	rodenticide	Miscellaneous
difethialone	0.0014	rodenticide	Miscellaneous
diphacinone	0.0010	rodenticide	Miscellaneous
bromadiolone	$<$0.0001	rodenticide	Domestic
chlorophacinone	$<$0.0001	rodenticide	Domestic

Table 15 indicates that four active ingredients were applied in excess of one thousand kilograms. Calcium hypochlorite, a disinfectant used for killing microorganisms in swimming pools and spas, is the most commonly used active ingredient by a significant margin. This is followed by chlorine, a disinfectant used in wastewater treatment plants throughout the watershed, and chromated copper arsenate (CCA), a wood preservative approved for industrial use. CCA is found in utility poles and highway guardrails throughout the watershed. Glyphosate, the active ingredient in herbicides such as Roundup, is one of the most commonly used herbicides; its use was reported in five of seven sectors. Glyphosate is not only commonly used in the watershed; according to Brimble et al (2005), it was also the active ingredient sold in the highest quantity in Canada, with sales in excess of 4.6 million kg reported. Three additional herbicides were applied in five of seven sectors; these are 2,4-D, mecoprop and dicamba.

Figure 2 presents a breakdown of the pesticides listed in Table 15 by type. As in Table 15, active ingredients from the agricultural sector are not included, with the exception of active ingredients applied in nurseries. Disinfectants appear to be the most commonly used pesticide type by a significant margin (70%) followed by herbicides (13%) and wood preservatives (10%). Insecticides, antifouling agents and fungicides account for 3, 2 and 1% respectively. Other, which includes insect repellents, rodenticides, plant growth regulators and molluscicides, accounts for 1% of pesticide application.

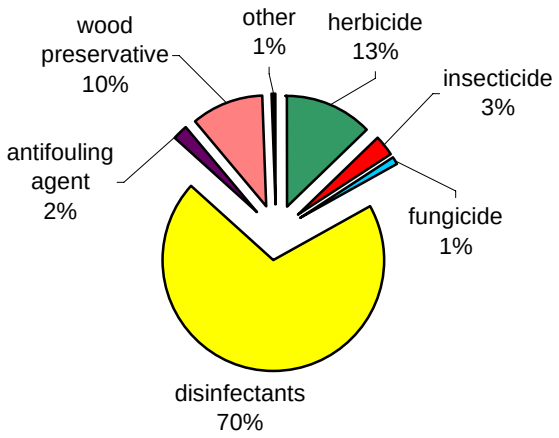

Figure 2. Breakdown of pesticides applied in the watershed by type.

The use intensity of active ingredients in certain sectors was calculated; results are indicated in Table 16. Further detail on calculation of these values can be found in corresponding sectors. As indicated in Table 16, the use of fungicides on golf course greens, 74.27kg of active ingredients/hectare (a.i./ha) is the most intense by a significant margin. The agricultural sector is next, with a use intensity of 8.68kg of a.i./ha. A second use intensity value was calculated for golf courses, 5.65kg of a.i./ha, this value includes all types of pesticides (fungicides, herbicides and insecticides) applied over the entire golf course area (fairways, greens and roughs) as opposed to the first golf course value, which accounts only for fungicide use on greens. Forestry came next with a use intensity of 1.74kg of a.i/ha. Domestic survey results indicated that 0.84kg of active ingredients were applied per household. Based on information acquired from lawn care companies, it was determined that on average, 0.33kg of active ingredients were applied per customer property.

Table 16. Calculated use intensities of given sectors and subsectors.

Sector/Subsector	Average Use Intensity
Golf Courses (fungicides on greens only)	74.27kg of a.i./ha
Agriculture	8.68kg of a.i./ha
Golf Courses (entire course)	5.65kg of a.i./ha
Forestry	1.74kg of a.i./ha
Domestic	0.84kg of a.i./ household
Lawn Care Companies	0.33kg of a.i./customer

3.2 Agricultural Sector

Reportable Sales

Managers of commercial pesticide vending establishments were asked what proportion of their sales was made in the watershed. Consequently, the total amount of active ingredients sold by each establishment was multiplied by the percentage of sales made in the watershed. Proceeding in this manner did not allow the determination of amounts of individual active ingredients sold in the watershed; only a total quantity of active ingredients sold was obtained. For example, if 50% of Vendor 1's customers were from the watershed, the total amount of active ingredients sold by Vendor 1 was multiplied by 50%. It would not be appropriate to assume that 50% of each active ingredient was sold in the watershed; therefore specific sales amounts of active ingredients could not be determined.

Vendors do not solely supply farmers. They also supply other certified pesticide applicators, for example, those employed by lawn care and pest control companies. They may also sell pesticides for use in forestry or on golf courses. Managers of vending establishments were specifically asked what proportion of watershed sales was made for agricultural purposes; only this proportion of sales was included in Table 17.

There are five commercial pesticide-vending establishments in Kings and Annapolis Counties; three reported having customers in the watershed. The amount of active ingredients sold in the watershed by these establishments totals 29,136kg, as indicated in Table 17. It should be noted that a small percentage of farmers in the watershed might buy pesticides from vendors other than those listed below. Should this be the case, the quantity of active ingredients indicated in Table 17 might be under reported.

Table 17. Calculation of the total amount of active ingredients sold in the watershed by commercial vending establishments.

Vendor	Total Active Ingredients Sold in the Watershed (kg)
1	13,043.38
2	3,541.70
3	12,550.82
4	0.00
5	0.00
TOTAL	**29,135.90**

Use Intensity

According to Brian MacCulloch, Agricultural Resource Coordinator from the Department of Agriculture & Fisheries, there are approximately 3,355ha of orchard, berry, vegetable and grain crops in the Annapolis River watershed. Assuming all active ingredients sold in the watershed in 2004 were applied in that year, use intensity in the agricultural sector is 8.68kg of active ingredients per hectare (a.i./ha). Comparatively, in the year 2000, Prince Edward Island had a use intensity of 4kg a.i./ha on agricultural crops, most of which were potatoes (Prince Edward Island Department of Fisheries, Agriculture & Environment). In Ontario in 2003, average use intensity was 1.09kg of a.i./ha, however, a breakdown per crop type indicated a range of use intensities, notably, 19.14kg of a.i./ha on tobacco crops, 9.87kg of a.i./ha on fruit crops and 0.58kg of a.i./ha on grain crops (Brimble et al, 2005). Alberta had a use intensity of 0.79kg

a.i./ha on agricultural crops in 1998, whereas Manitoba's was 0.48kg a.i./ha in 2003 (Brimble et al, 2005). Use intensity in the Prairie Provinces tends to be lower than in other provinces; this can be attributed to the fact that grain crops, which generally require less pesticide treatment, are the dominant crop type in this area.

Farmers and Other Information Sources

Tree Fruit

Approximately 95% of all tree fruit in the watershed are apples (B. MacCulloch, personal communication, August 23, 2005). There is also a small quantity of pears and stone fruit. Table 18 lists ten of the most commonly used pesticides in orchards, based on pesticide use estimates obtained from farmers and Bill Craig, tree fruit specialist for AgraPoint International Inc. The quantity applied was estimated based on information obtained on the proportion of the crop normally treated, application rates and number of applications per year. For further detail, see Appendix E. It should be noted that numerous other active ingredients are applied to tree fruit; only most commonly applied active ingredients are listed in Table 18.

Table 18. Active ingredients commonly used in watershed orchards.

Active Ingredient	Estimated Quantity Applied According to Farmers & Crop Specialists (kg)	Pesticide Type
dormant oil	16,347	insecticide
metiram	7,688	fungicide
captan	6,178	fungicide
mancozeb	3,614	fungicide
sulphur	874	fungicide
glyphosate	530	herbicide
phosmet	365	insecticide
carbaryl	315	insecticide
phosalone	92	insecticide
2,4-D	78	herbicide
TOTAL	**36,081**	

Berries

Strawberries, cranberries, grapes, highbush blueberries and raspberries are grown in the watershed according to John Lewis, berry specialist for AgraPoint International Inc. Table 19 lists active ingredients commonly used on these crops, based on estimates acquired from Mr. Lewis. Estimates are based on the proportion of crops normally treated, application rates and the number of applications per year. See Appendix E for further detail on calculations performed to obtain the values in Table 19. It should be noted that Table 19 is not exhaustive, only the most commonly applied active ingredients are listed.

Table 19. Pesticides commonly used on berry crops in the watershed.

Active Ingredient	Estimated Quantity Applied According to Crop Specialist (kg)	Pesticide Type
chlorothalonil	340	fungicide
captan	100	fungicide
sulphur	99	fungicide
dichlobenil	98	herbicide
simazine	29	herbicide
endosulfan	23	insecticide
iprodione	21	fungicide
2,4-D	16	herbicide
terbacil	13	herbicide
glyphosate	10	herbicide
paraquat	7	herbicide
TOTAL	**756**	

Field Crops

Hay, soybean, barley, oats and corn are the most commonly grown field crops in the watershed (B. MacCulloch, personal communication, August 23, 2005). Jack van Roestel, field crop specialist for AgraPoint International Inc. stated that herbicides are the main pesticide type applied to field crops, as insect pests and disease are not as common in these crop types. Table 20 lists some of the most commonly applied herbicides as well as an estimation of the amount applied. See Appendix E for further detail. Additional herbicides are used on field crops; Table 20 lists the most commonly used active ingredients.

Table 20. Active ingredients applied to field crops in the watershed as well as an estimation of the quantity applied.

Active Ingredient	Estimated Quantity Applied According to Crop Specialists (kg)	Pesticide Type
atrazine	613	herbicide
pendimethalin	363	herbicide
s-metolachlor	247	herbicide
dicamba	87	herbicide
glyphosate	32	herbicide
MCPA	31	herbicide
2,4-D	25	herbicide
isoxaflutole	11	herbicide
mecoprop	1	herbicide
thifensulfuron methyl	0.3	herbicide
tribenuron methyl	0.2	herbicide
TOTAL	**1,410.5**	

Vegetables

Little information was gathered on vegetable crops. According to Viliam Zvalo, vegetable specialist for AgraPoint International Inc., potatoes, cabbage, broccoli, cauliflower, onions, carrots, turnip, parsnip, lettuce, tomatoes, peppers and squash are some of the crops grown commercially in the watershed. The area of each crop type could not be determined. In terms of land usage, vegetable crops are less significant than fruit and grain crops in the watershed. They occupy approximately half the area of fruit crops and approximately one third the area of grains (B. MacCulloch, personal communication, August 23, 2005).

Despite questioning numerous sources, no specifics on pests and pest management in vegetables could be obtained. Documents listing possible pest problems and pesticides approved for pest treatment in vegetable crops were examined, however, these documents did not mention which pests were prevalent in the area or which treatments were more commonly used. No conclusive information could be gathered from these documents.

Combining the estimated quantities applied to tree fruit, berries and field crops, a total of 38,247kg of active ingredients is obtained. It should be noted however, that no data for vegetable crops are included in this total and that Tables 18,19 and 20 are by no means exhaustive; only the most commonly used active ingredients have been listed.

Comparison of Data Sources

The amounts of active ingredients obtained by the two data sources differ by a significant quantity (29,136kg vs 38,247kg). Estimates obtained from crop specialists and farmers resulted in a higher quantity of active ingredients even in the absence of data on vegetable crops. It is possible that the estimates obtained were based on a typical year whereas the sales data contained information for a below average year in sales. Pest pressures change from year to year, therefore estimates accurately describing pesticide application patterns one year may not apply to other years. It is also possible that managers of vending establishments underestimated their proportion of sales in the watershed or alternatively, some farmers may have obtained pesticides from sources other than local vendors. A combination of these factors could be responsible for this marked difference.

The most accurate information obtained in the agricultural sector was that obtained directly from farmers. However, only a small proportion of farmers in the watershed participated in the inventory, resulting in the acquisition of an insufficient quantity of data on which to base pesticide use estimations applicable to the entire watershed. Of the remaining two methods by which data were acquired (reportable sales and crop specialists) reportable sales seems to be the best approximation of the amount of agricultural active ingredients applied in the watershed, since sale of these pesticides is regulated and must be reported. It was assumed all pesticides were applied in the year they were purchased. Information acquired from crop specialists was incomplete, as it did not include estimates of pesticide use on vegetable crops. Since reportable sales seemed to be the most complete source of information, the quantity of active ingredients obtained using this method is included in the overview.

Information acquired in this sector is insufficient to allow assessment of usage trends. It cannot be determined whether agricultural pesticide use in the watershed is increasing or decreasing as this depends on numerous factors. For example, certain environmental conditions may lead to an increase or decline of pests whereas economic factors may also play a role in the amount of pesticide application.

Nurseries and Greenhouses

There are seven nurseries and greenhouses growing various types of shrubs, trees, and ornamental plants commercially in the watershed. Of these, five were approached. It was determined that two nurseries had applied pesticides in the last year, two had not applied pesticides and one chose not to participate in the inventory.

Table 21 lists the fourteen active ingredients applied in the last year by the two participating nurseries. Collectively, they total 5.84kg. Since two nurseries/greenhouses did not apply any pesticides in the last year, data can be extrapolated to include the remaining five. An average of 2.92kg of active ingredients were applied per nursery/greenhouse, therefore extrapolation results in a total of 14.60kg of active ingredients applied in plant nurseries over a year.

Table 21. Active ingredients, listed in decreasing order, applied by plant nurseries in the watershed over the course of a year.

Active Ingredient	Total Applied (kg)	Pesticide Type
thiophanate-methyl	1.40	fungicide
Bacillus thuringiensis ssp. kurstaki	1.00	insecticide
captan	0.70	fungicide
iprodione	0.65	fungicide
soap	0.64	insecticide
triforine	0.48	fungicide
carbaryl	0.21	insecticide
2,4-D	0.19	herbicide
glyphosate	0.14	herbicide
mecoprop	0.10	herbicide
ferric phosphate	0.07	molluscicide
metalaxyl	0.02	fungicide
dicamba	0.02	herbicide
dimethoate	0.01	insecticide
TOTAL	**5.63**	

There is also one major commercial vegetable nursery in the watershed growing tomatoes and cucumbers. Pesticide use data were not acquired from this establishment. After consulting the greenhouse's website, it was determined that an Integrated Pest Management system is used to control pests. Practices such as crop monitoring and sanitation, cultural and mechanical control as well as beneficial insects and mites are discussed. Although the website mentioned insect predators were used to combat insect pests, there was no mention of methods used for disease control. It also indicated that water used for irrigation is reused rather than permitted to leach through the ground. Water is treated with UV light before being reused, eliminating water disinfection as a source of pesticide use.

Further information on greenhouse tomatoes was obtained from the Crop Profile for Greenhouse Tomatoes in Canada (Agriculture and Agri-Food Canada, 2005). This document indicated that weeds tend not to be a problem in hydroponic greenhouse systems as they can be removed by hand, eliminating the need for herbicides. It also indicated that in most cases where problems with field mice arise, trapping suffices to rid the problem.

As for diseases, the crop profile indicated that on a national scale, bacterial canker, botrytis and Pepino mosaic virus are the most serious diseases (Agriculture and Agri-Food Canada, 2005). Copper hydroxide is listed as the active ingredient used to control canker, and the active ingredients dicloran, iprodione, fenhexamid and ferbam are listed as active ingredients used for control of botrytis. No active ingredient was listed for the control of Pepino mosaic virus (Agriculture and Agri-Food Canada, 2005). It should be noted that although these diseases are problematic on a national scale, they may not necessarily be a nuisance in the Annapolis River watershed.

3.3 Domestic Sector

Domestic Survey

Of the one thousand questionnaires mailed out to homes in the watershed, one hundred and seventy completed questionnaires were returned. This is equivalent to a response rate of 17%. At an 80% confidence level, survey results are accurate to ± 5%, assuming a random distribution of questionnaires.

Possible Biases in Survey Results

Survey results might be biased in a number of ways. First, respondents may have tended to be individuals with a bias against the use of pesticides. Should this be the case, results might reflect a below average quantity of active ingredients being reported, since some respondents may make a conscious effort to apply as little pesticide products as possible around their homes. The second bias rises from the fact that questionnaires were only mailed to lock boxes and not mailboxes on rural routes. Consequently, most respondents likely reside in the more urban areas of the watershed rather than the more rural areas; this may limit the validity of extrapolating the results over the entire watershed. Based on information obtained from the Canada Post householder counts website, http://www.canadapost.ca/cpc2/addrm/hh/current/indexa/taNSr-e.asp, approximately one third of the watershed's households are in towns, two thirds are outside of towns.

Geographic Distribution of Respondents

The distribution of the 170 respondents is illustrated in Figure 3. Annapolis Royal had the highest number of respondents, followed by Bridgetown, Kingston, Middleton and Digby.

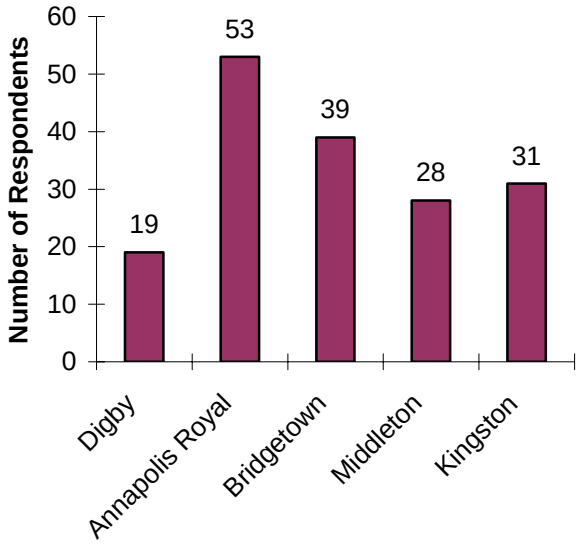

Figure 3. Number of respondents vs. town from which completed questionnaires were received.

Pesticide Use Statistics

Of the 170 individuals completing the survey, 39 did not use any pesticides; this is equivalent to 23% of respondents. Alternatively, 131 respondents used at least one type of pesticide.

Figure 4 indicates the percentage of respondents using each type of pesticide included in the questionnaire. Insect repellents are the most commonly used pesticide type; they are used by over 46% of respondents. Insecticides are also widely used, followed by flea control products, herbicides and pressure treated lumber.

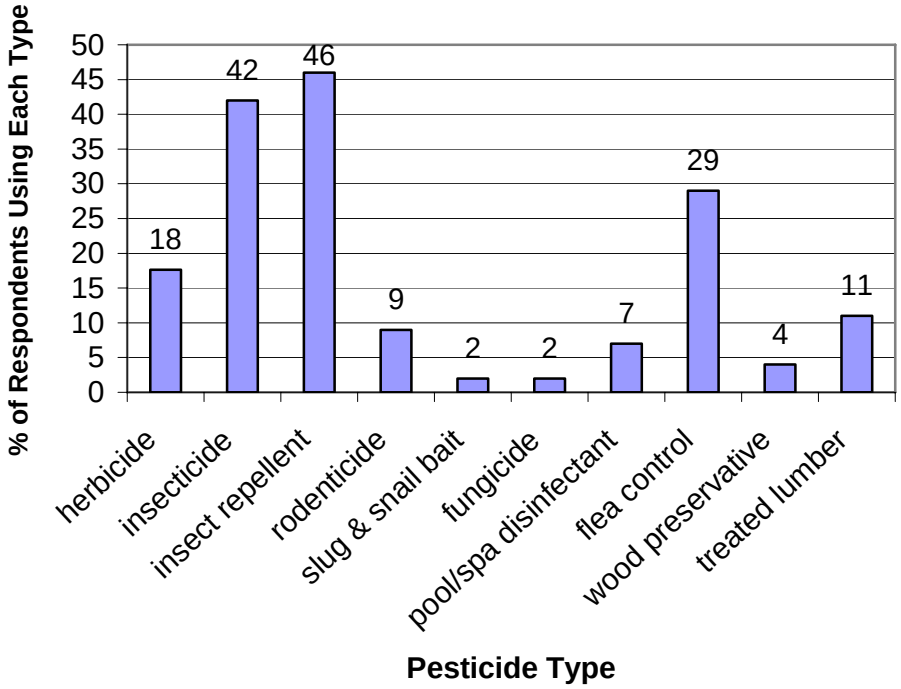

Figure 4. Pesticide types included in the survey questionnaire vs. percentage of respondents having used these products in the last year.

Table 22 lists the types of pesticides identified in the questionnaire. For each pesticide type, the amount applied by respondents as well as the percentage of the total applied is indicated. The total amount of active ingredients applied by respondents was 142.40kg. Swimming pool and spa disinfectants make up the majority of this total (87.56%), followed by herbicides and insecticides.

Table 22. Amount of active ingredients applied in the last year for domestic uses per pesticide type by survey respondents.

Pesticide Type	Amount of Active Ingredients Applied (kg)	% of Total Active Ingredients Applied
herbicide	10.8	7.60
insecticide	4.3	3.02
insect repellent	1.5	1.05
rodenticide	0.005	0.00
slug & snail bait	0.1	0.06
fungicide	0.3	0.22
swimming pool/spa disinfectant	124.7	87.56
flea control product	0.3	0.19
wood preservative	0.4	0.30
pressure treated lumber	n/a	n/a
TOTAL	**142.4**	**100**

Swimming pool and spa disinfectants make up a significant proportion of the total since they have a very high concentration of active ingredient compared to other pesticide types included in this survey. They are also used in greater quantities. Calcium hypochlorite, a commonly used swimming pool disinfectant, has a guarantee of 65% whereas the most commonly used insecticide, Raid House & Garden Bug Killer, has a guarantee of 1.5%. Furthermore, many kilograms of calcium hypochlorite may be used by a homeowner over one year whereas one 350g can of Raid House & Garden Killer normally suffices over a similar time period.

Extrapolation of Results

Responses were received from 170 households in the watershed; these households were determined to use a total of 142.40kg of active ingredients over the course of a year. This is equivalent to an average of 0.84kg of active ingredients per household per year. Extrapolating to the 16,000 households in the watershed results in a total of 13,400kg of domestic active ingredients applied yearly in watershed households.

Contractors

Eight respondents had hired contractors to apply pesticides on their property. Three reported hiring contractors for herbicide application, four for insecticide application and one for both insecticide and rodenticide application. Active ingredients and quantities applied are not included in this sector; they are tabulated in the miscellaneous sector with lawn care and pest control companies.

Commonly Used Pesticides and Active Ingredients

Table 23 indicates the ten pesticide products used by the most respondents. Product ranks are based on the number of respondents using the products, not the quantity of active ingredient applied. Table 24 lists all active ingredients used by survey respondents in decreasing order. For each active ingredient, the average quantity applied per household is indicated, followed by the confidence interval of this average, which was calculated based on the survey's confidence level and sample size. Calculations were made assuming a normal distribution around the mean. As a result of this assumption, some confidence intervals have negative values. The average of this range was subsequently extrapolated to all 16,000 households in the watershed.

Table 23. Top 10 domestic class pesticide products used by survey respondents.

Product Rank	Product Name	# of Respondents Using This Product
1	Off! Skintastic Insect Repellent	38
2	Advantage Flea Adulticide (for Dogs & Cats)	35
3	Deep Woods Off! Insect Repellent	26
4	Raid House & Garden Bug Killer	23
5	Muskol Insect Repellent	14
6	Roundup Weed & Grass Killer	12
7	Ant-B-Gon Ant Traps	9
8-10	Scott's Turf Builder Lawn Fertilizer	8
	Warfarin Rat & Mouse Killer Pellets	8
	Granular chlorine (various brands)	8

Table 24. Active ingredients applied by survey respondents.

Rank	Active Ingredient	Type of Active Ingredient	Average Quantity Applied Per Household (g)	Confidence Interval of Average Quantity (g)	Extrapolation of Average Quantity to All Watershed Households (kg)
1	calcium hypochlorite	disinfectant	688	± 459	11,008
2	ferrous sulphate	herbicide	37	± 35	592
3	2,4-D	herbicide	17	± 9	272
4	silicon dioxide	insecticide	14	± 8	224
5	DEET	insect repellent	9	± 2	144
6	mecoprop	herbicide	9	± 5	144
7	insecticidal soap	insecticide	5	± 5	80
8	carbaryl	insecticide	4	± 4	64
9	calcium polysulphide	fungicide	2	± 2	32
10	imidacloprid	insecticide	1	± 1	16
11	tributyltin oxide	fungicide/molluscicide	0.79	± 1.01	13
12	folpet	fungicide	0.79	± 1.01	13
13	glyphosate	herbicide	0.75	± 0.64	12
14	piperonyl butoxide	insecticide	0.65	± 0.15	10
15	copper	fungicide	0.58	± 0.71	9.3
16	metaldehyde	molluscicide	0.47	± 0.47	7.5
17	zinc	fungicide	0.39	±0.49	6.2
18	borax	insecticide	0.28	± 0.12	4.5
19	tetrachlorvinphos	insecticide	0.22	± 0.17	3.5
20	propoxur	insecticide	0.13	± 0.058	2.1
21	pyrethrins	insecticide	0.098	± 0.023	1.6
22	tetramethrin	insecticide	0.071	± 0.023	1.1

Rank	Active Ingredient	Type of Active Ingredient	Average Quantity Applied Per Household (g)	Confidence Interval of Average Quantity (g)	Extrapolation of Average Quantity to All Watershed Households (kg)
23	dimethoate	insecticide	0.071	± 0.090	1.1
24	permethrin	insecticide	0.068	± 0.049	1.1
25	n-octyl bicycloheptene dicarboximide	insecticide	0.061	± 0.046	1.0
26	triforine	fungicide	0.048	± 0.061	0.77
27	benomyl	fungicide	0.044	± 0.056	0.70
28	ferric phosphate	molluscicide	0.022	± 0.029	0.35
29	dicamba	herbicide	0.022	± 0.016	0.35
30	d-trans allethrin	insecticide	0.019	± 0.013	0.30
31	rotenone	insecticide	0.018	± 0.023	0.29
32	s-methoprene	insecticide	0.014	± 0.0093	0.22
33	malathion	insecticide	0.012	± 0.015	0.19
34	warfarin	rodenticide	0.0059	± 0.0028	0.09
35	chlorpyrifos	insecticide	0.0035	± 0.0045	0.06
36	resmethrin	insecticide	0.0029	± 0.0037	0.05
37	pyriproxyfen	insecticide	0.0024	± 0.0030	0.04
38	bromodialone	rodenticide	<0.0001		<0.0001
39	chlorophacinone	rodenticide	<0.0001		<0.0001

Pesticide Purchase

Survey recipients were asked where they had purchased pesticide products. Of the 107 respondents answering this question, more than half declared they had purchased pesticides at their local hardware store. Many pesticide products were also purchased at veterinarian's offices and grocery stores. Results are illustrated in Figure 5. Respondents could choose more than one answer; hence the total number of answers exceeds the number of respondents. Respondents answering "other" were asked to elaborate. They indicated either the Farmers and Traders Market in Annapolis Royal, building supply store or swimming pool and spa store.

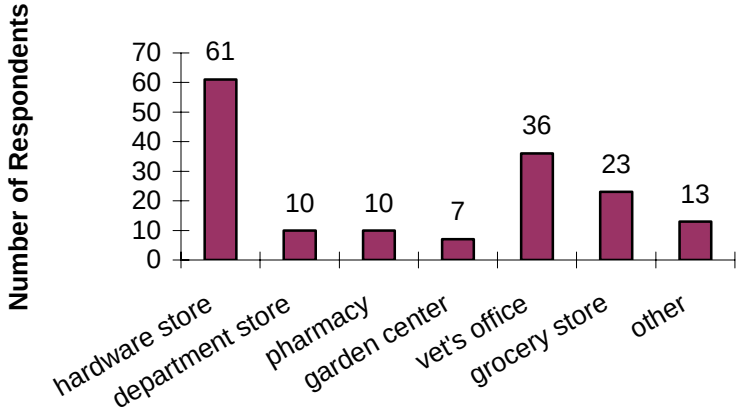

Figure 5. Number of respondents vs. type of store at which pesticide products were bought.

Retail Store Data

Of the twenty-four stores contacted, thirteen provided information on domestic pesticide sales. Three stores reported not selling any type of pesticide while the remaining ten sold 254kg of active ingredients. Figure 6 illustrates a breakdown of types of active ingredients sold.

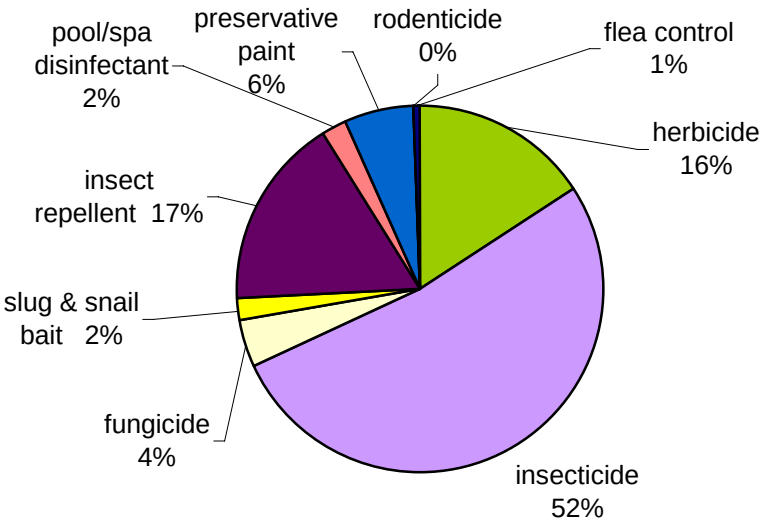

Figure 6. Types of pesticides sold in ten retail stores in the watershed.

Figure 6 illustrates that insecticides are the most commonly sold pesticide type, as opposed to Table 24, which indicated that swimming pool and spa disinfectants were used in greater quantity. This discrepancy can be explained by the fact that very little information on the sale of swimming pool and spa disinfectants was obtained; therefore these quantities are grossly underestimated in Figure 6. Insect repellents sales came in second, closely followed by herbicides.

Extrapolation of Data

A total of 254kg of active ingredients were sold in ten stores in the watershed in one year. This averages 25.4kg of active ingredients sold per store per year. There are forty-five retail operations in the watershed selling domestic pesticides; this number was calculated by counting all stores of the types indicated in Figure 5. Once extrapolated to all stores in the watershed, the total quantity of active ingredients sold is equivalent to approximately 1,143kg.

This is a significantly lower quantity than what was obtained by the extrapolation of household survey results. Possible explanations for this difference are:

- Most of the data from which the extrapolation was made were obtained from small retail operations. Since very little information from large retail operations was obtained, the quantity of active ingredients sold was underestimated.
- Domestic survey results indicated that swimming pool and spa disinfectants are the most commonly applied active ingredients in the watershed by a significant margin. Very little data were acquired on the sale of these products in retail stores, once again resulting in an underestimation of the quantity of active ingredients sold.

Comparison of Data Sources

When comparing both methods of obtaining data in this sector, it seems that the domestic survey is the most accurate. A sufficient number of respondents made the survey statistically valid and allowed an estimation of the amount of active ingredients applied in watershed households. However, as previously mentioned, survey results may be biased as questionnaires were mailed to the more urban areas of the watershed and some respondents may have had a bias against the use of pesticides. The retail store approach was less successful. Only slightly more than half of the contacted stores provided the requested information and most of the responsive stores were amongst the smaller retail operations contacted. This resulted in the acquisition of a very small proportion of total watershed sales.

Information acquired in this sector is insufficient to allow assessment of usage trends, as there is no data from other years with which to compare.

3.4 Forestry Sector

Pesticide application approvals obtained from the Environmental Registry of the Nova Scotia Department of Environment and Labour indicated that 1,857kg of active ingredients were applied on forested land in the watershed in 2004. All pesticides applied were herbicides.

Two active ingredients were used, glyposate and triclopyr. Glyphosate was used in 96.5% of herbicide applications whereas triclopyr was used in the remaining 3.5% of applications. The quantity applied of each of these active ingredients is indicated in Table 25.

Table 25. Active ingredients applied by the forestry sector in the watershed in 2004.

Active Ingredient	Quantity Applied (kg)	Pesticide Type
glyphosate	1,791.99	herbicide
triclopyr	64.79	herbicide
TOTAL	**1,856.78**	

Application method

A total of 1068.20ha was treated with herbicides in the watershed in 2004. Of this amount, 5.92% (63.25ha) were ground applications, whereas the remaining 94.08% (1,004.95ha) were aerial applications.

Use intensity

1856.78kg of active ingredients were applied to 1068.20ha. This is equal to an average use intensity of 1.74kg of active ingredient per hectare.

Although pesticide application approval records for the years 2004, 2003 and 2002 were acquired from the environmental registry, 2003 and 2002 data were incomplete, therefore it is not possible to assess usage trends in this sector.

3.5 Large Facilities & Institutions Sector

Of the fifteen facilities and institutions contacted in this sector, pesticide use information was obtained from thirteen; of these thirteen, six reported not using any type of pesticide. The remaining seven facilities and institutions applied a total of 563.67kg of active ingredients.

Golf Courses

Of all the active ingredients applied to the large facilities and institutions sector, 76% or 429.49kg were applied on golf courses. Through interviews with greens superintendents, it was determined that fungicides were used most frequently, followed by herbicides and insecticides. Insecticides are only applied to specific areas once an insect problem arises. Herbicides are normally applied to fairways and roughs once a year; further spot treatment may result if a weed problem arises. Fungicides are applied to greens and tees on a more frequent basis, as they are more prone to disease than fairways and roughs. Fungicide application to greens and tees ranges from five to ten applications per year. Active ingredients applied to golf courses are indicated in Table 26.

Table 26. Active ingredients, listed in decreasing order, applied on golf courses over a year. The type and quantity of active ingredient applied are also specified.

Active Ingredient	Quantity Applied (kg)	Pesticide Type
chlorothalonil	121.37	fungicide
mecoprop	65.92	herbicide
2,4-D	52.40	herbicide
iprodione	34.67	fungicide
azoxystrobin	31.68	fungicide
quintozene	23.62	fungicide
carbaryl	20.96	insecticide
thiram	19.51	fungicide
fosetyl-al	19.18	fungicide
propiconazole	17.73	fungicide
dicamba	8.30	herbicide
carbathiin	7.81	fungicide
trifloxystrobin	2.41	fungicide
oxycarboxin	1.95	fungicide
chlorpyrifos	1.04	insecticide
myclobutanil	0.70	fungicide
trinexapac-ethyl	0.24	plant growth regulator
TOTAL	**429.49**	

Pesticide use data were obtained from four of the five golf courses in the watershed. These courses had a total area of approximately 76ha and applied approximately 429.49kg of active ingredients. It was determined that the use intensity of pesticides on golf courses in the watershed is approximately 5.65kg of active ingredients per hectare. Use intensity of fungicides on greens was also calculated. The four courses applied an estimated 280kg of fungicides on 3.77ha of greens. This is equivalent to a use intensity of 74.27kg of active ingredients per hectare. These figures

demonstrate that although pesticide application on golf courses does not make up a large proportion of total pesticide application in the watershed, the use intensity of pesticides, especially fungicides on greens, is quite elevated.

In 1998, the Alberta Environmental Protection, Chemical Assessment and Management Division published a report on pesticide use on Alberta golf courses. This report indicated that average use intensity on golf courses was 1.2kg of a.i./ha. It was also stated that Alberta golf courses have fewer insect and disease problems than ones in eastern Canada, as eastern Canadian courses tend to be exposed to higher humidity levels in the summer, conditions favourable to a higher incidence of disease (Alberta Environment Protection, Chemical Assessment and Management Division, 1998).

Other Facilities & Institutions

The remaining three facilities and institutions that participated applied 134.18kg of active ingredients, all of which were herbicides. In two cases, herbicides were used for the removal of weeds on surfaces such as walkways and parking lots. In the other case, herbicides were used on cut stumps, a practice used to eliminate or significantly reduce the re-sprouting of cut trees. See Table 27 for active ingredients applied.

Table 27. Active ingredients, listed in decreasing order, applied by large facilities & institutions (excluding golf courses) over the course of a year. The type and quantity of active ingredient applied are also specified.

Active Ingredient	Quantity Applied (kg)	Pesticide Type
glyphosate	62.66	herbicide
2,4-D	56.28	herbicide
picloram	15.24	herbicide
TOTAL	**134.18**	

Extrapolation of Data to All Facilities & Institutions

Thirteen of fifteen facilities and institutions provided pesticide use data; they reported using 563.67kg of active ingredients. This is equivalent to an average of 43.36kg of active ingredients per facility/institution. Extrapolating to all fifteen facilities and institutions results in a total of 650.39kg of active ingredients.

Information acquired in this sector is insufficient to allow assessment of usage trends.

3.6 Marine Sector

In this sector, data were gathered from all sources listed in the methodology. It was determined that the marine sector applied approximately 571.58kg of one active ingredient, cuprous oxide, in the last year. Below is a breakdown of this total between marine supply stores and boatyards. Information gathered on pesticide use in aquaculture in the watershed is mentioned as well.

Aquaculture

Data collected from the aquaculture industry indicates that no pesticides are used in aquaculture in the watershed. According to William Whitman, a fisheries representative from the Nova Scotia Department of Agriculture and Fisheries, the major insect pest in the industry is the sea louse. The current practice for treatment of sea lice is to add a medication, specifically, emamectin benzoate, to the feed of the fish. Since a pesticide is defined as a product applied externally to combat pests, and this product is taken internally, it is classified as a drug rather than a pesticide and therefore has not been included in this inventory.

As for the use of antifouling agents in aquaculture in the watershed, it was determined that none were used. Local growers stated that rather than applying antifouling agents to cages and other equipment used in their operations, they physically scrape off organisms (W. Whitman, personal communication, April 20 2005). Also, cages are occasionally disinfected when out of the water with an iodine solution.

Marine Supply Stores

Antifouling paint was the sole antifouling agent sold in watershed marine supply stores. Three different paint brands were sold, however, all contained the same active ingredient, cuprous oxide. The guarantee of cuprous oxide varied, ranging from approximately ten to forty one percent. The amount of cuprous oxide sold in the watershed was determined to equate 40.58kg. Antifouling paints were purchased for application on both commercial vessels and personal watercrafts.

Boatyards

It was determined that three boatyards in the watershed applied a total of 531kg of cuprous oxide to boats in the last year. As with marine supply stores, antifouling paints were the only antifouling agents applied.

Pesticide usage trends could not be assessed based in the information acquired in this sector.

3.7 Miscellaneous Sector

Information obtained in this sector indicates that an estimated 3,175kg of active ingredients were introduced in the watershed either via industrial wood preservatives or by application by lawn care and pest control companies. No information was acquired on the sale of pressure treated wood for domestic use.

Wood Preservatives

No data on the sale of alkaline copper quaternary (ACQ) or copper azole (CA) pressure treated wood for residential use were obtained. The only information gathered on this topic was in the household pesticide use survey. As reported in the domestic sector, 11.18% of respondents stated they had purchased pressure treated lumber in the last year.

Information on the industrial use of wood preservatives in the watershed was gathered. It was determined that 320 utility poles were added to the watershed in 2004. A precise number of guardrails added to the watershed could not be obtained, however, an estimate of 500 was obtained from the Nova Scotia Department of Transportation and Public Works. Poles and guardrails were treated with the wood preservative chromated copper arsenate (CCA). An approximation of the amount of CCA introduced in the watershed in the last year is indicated in Table 28. Bridge construction is another possible source of industrial wood preservative use. Unfortunately, no data on bridge construction in the watershed in the last year were acquired.

Table 28. Approximations of the amount of CCA added to the watershed via utility poles and guardrails.

Active Ingredient	Quantity Applied (kg)
CCA - utility poles	2,574
CCA - guardrails	42
TOTAL	**2,616**

Lawn Care and Pest Control Companies

Four of the six lawn care and pest control companies that were contacted provided information on the pesticides they applied in the watershed in the last year. This information is indicated in Table 29. One lawn care company was able to provide information on the products it used, but was unable to specify the amounts applied. This company reported applying the herbicides 2,4-D, mecoprop and dicamba as well as the insecticides diazinon and carbaryl. Consequently, the quantity applied of these active ingredients in Table 29 is slightly underestimated.

Table 29. Active ingredients applied in the watershed by lawn care and pest control companies.

Active Ingredient	Quantity Applied (kg)	Pesticide Type
carbaryl	233.00	insecticide
diazinon	50.05	insecticide
2,4-D	49.65	herbicide
mecoprop	26.00	herbicide
permethrin	9.07	insecticide
dicamba	4.68	herbicide
cyfluthrin	0.30	insecticide
brodifacoum	0.005	rodenticide
difethialone	0.001	rodenticide
diphacinone	0.001	rodenticide
TOTAL	**372.76**	

Active ingredients in Table 29 amount to approximately 373kg. Insecticides were the most used pesticide type followed by herbicides. Only a small amount of rodenticides were applied compared to herbicides and insecticides; this is due to the fact that rodenticides contained a very small percentage of active ingredient, often less than one hundredth of a percent.

The two lawn care companies participating in the inventory had a total of 396 customers in the watershed. They applied a total of 130.38kg of active ingredients, averaging approximately 0.33kg of active ingredients per customer per year. This information cannot be calculated for pest control companies as their number of customers varies on a monthly basis and not all customers require pesticide application; trapping suffices in some cases.

Extrapolation of Data

Data can be extrapolated to all six pest control and lawn care companies. The two lawn care companies from which data were obtained applied 130kg of active ingredients, an average of 65kg per lawn care company. Extrapolating to include the third lawn care company results in a total of 196kg of active ingredients. The two pest control companies from which data were obtained applied 242kg of active ingredients, an average of 121kg per pest control company. Extrapolation of these data to include the third pest control company results in a total of 364kg of active ingredients.

Following extrapolations, the total amount of active ingredients applied by both pest control and lawn care companies was determined to be 559kg of active ingredients, which accounts for approximately one percent of the watershed total.

Nationally, pesticide use by lawn care companies seems to be more elevated in urban areas. A 2001 Toronto study on lawn care indicated that one third of residential lawns were serviced by a professional lawn care company (Basrur, 2002). A survey conducted in the Greater Vancouver Regional District in February of 2002 showed that 19.4% of households hired a lawn care company for property maintenance (Vancouver Park Board and Vancouver Coastal Health Authority, 2002). In contrast, five percent of watershed residents admitted to hiring a lawn care company.

Air Concentrations of Pesticides

Another potential source of pesticides in the watershed is pesticides carried by air from other areas. A search for journal articles on the topic of air concentrations of pesticides was conducted. Articles from various locations in Canada and around the globe were obtained, however, none dealt with studies conducted in the watershed area. Individuals

conducting studies on ambient air concentrations of pesticides in the Maritime provinces were contacted; they also indicated no studies of this type had been conducted in the watershed. Estimations cannot be made based on data gathered from other areas as many factors influence the air concentrations of pesticides. These include the properties of the pesticide in question, application method, quantity applied and weather conditions such as wind speed, temperature and humidity (Van Dijk and Guicherit, 1999).

Information acquired in this sector is insufficient to allow assessment of usage trends.

3.8 Municipal Sector

Data were collected from all eleven rural municipalities, town councils and villages in the watershed. From these data, it was concluded that approximately 6,596kg of active ingredients were applied in the watershed in the last year.

Two of the eleven municipalities, towns and villages approached did not apply any type of pesticide.
Active ingredients applied in this sector are listed in Table 30.

Table 30. Active ingredients, listed in decreasing order, applied by the municipal sector over the course of a year.

Active Ingredient	Quantity Applied (kg)	Pesticide Type
chlorine	6,138.63	disinfectant
sodium hypochlorite	266.74	disinfectant
calcium hypochlorite	190.45	disinfectant
glyphosate	0.17	herbicide
diazinon	0.03	insecticide
2,4-D	0.0015	herbicide
mecoprop	0.0009	herbicide
dicamba	0.0001	herbicide
TOTAL	**6,596.02**	

The vast majority of pesticides applied, 99.99%, were disinfectants. Of this total, 93% (6,138.63kg) was chlorine gas, used to disinfect wastewater. There are thirteen wastewater treatment plants in the watershed; six disinfect using chlorine, seven use ultraviolet (UV) light. Of the six wastewater treatment plants disinfecting with chlorine, two are in the process of converting to UV light. Once the conversion is complete, use of chlorine gas in the watershed will be reduced. It should also be mentioned that two of the six chlorinating plants dechlorinate using sulphur dioxide prior to releasing the treated wastewater in the environment.

The remaining 7% of disinfectants were used in swimming pools. Five of the eight towns and villages in the watershed have outdoor public swimming pools that operate during the summer. Calcium hypochlorite was the active ingredient in 41.7% (190.45kg) of swimming pool disinfectants while sodium hypochlorite was the active ingredient in the remaining 58.3% (266.74kg) of disinfectants.

Minute amounts of herbicides and insecticides were used for spot treatment on the grounds of some municipalities, towns and villages.

Based on the fact that some wastewater treatment plants in the watershed will be converting from chlorine disinfection to UV dsinfection, it can be concluded that pesticide usage in this sector will decline.

4.0 Conclusions

The Annapolis River Watershed Pesticide Inventory was successful in determining that approximately 55,400kg of active ingredients were applied in 2004 in the Annapolis River watershed. The majority of this total (53%) was applied in the agricultural sector, followed by the domestic (24%), municipal (12%), miscellaneous (6%) and forestry (3%) sectors. The remaining two sectors, large facilities and institutions and marine were less significant sources of pesticide use; each accounted for approximately one percent of pesticide application in the watershed. In terms of active ingredients, calcium hypochlorite was determined to be the most commonly applied active ingredient, followed by chlorine, CCA, glyphosate and ferrous sulphate.

Of the three methods used to gather information in the agricultural sector, information gathered from farmers was the most accurate; however, an insufficient amount of information was collected to accurately describe use patterns in this sector. Commercial pesticide vendors provided a complete estimate of pesticide use through their sales records, however, only a total amount of pesticide sales could be obtained, the total could not be broken down into sales quantities for individual active ingredients. Pesticide use estimates obtained from crop specialists was incomplete as no data were obtained on the use of pesticides on vegetable crops.

Based on the amount of agricultural land in the watershed and the total amount of active ingredients sold by commercial vendors in 2004, it was determine the agricultural sector had an average use intensity of 8.68kg of a.i./ha. This figure is elevated compared to similar figures obtained from other provinces; this is due to the fact that grain crops were the predominant crop type in these provinces. Grain crops generally require much less pesticide input than fruit and vegetable crops, both of which are grown in the watershed. Based on estimates obtained from crop specialists and farmers, tree fruit crops seem to have a much more intense use than other crop types, followed by berry then grain crops. No data were gathered on vegetable crops; their use intensity is unknown.

Results indicated pesticide input from plant nurseries was low, however, information was not acquired from all. One of the major nurseries in the watershed chose not to participate. Furthermore, no data were obtained from commercial vegetable greenhouses in the watershed. There is one large commercial operation in the watershed that did not participate. Lack of data from both of these operations resulted in an underestimation of the amount of active ingredients applied in the agricultural sector.

In the domestic sector, the most complete source of information was the household pesticide use survey. Although there was a margin of error associated with the estimated quantities of active ingredients applied, the survey provided a reasonable estimate of pesticide use in the domestic sector. Currently there exists no system to report the use or sale of domestic pesticides therefore this inventory was capable of providing a first approximation of where the domestic sector stands amongst other sectors. The retail store approach was not as successful as had been anticipated. Should a similar inventory be undertaken in the future, a different strategy should be employed to gather information from retail operations.

The forestry sector ranked fifth in terms of the total amount of active ingredients applied in a year, accounting for three percent of the watershed total. Use intensity (active ingredients per hectare) was calculated to be five times lower in the forestry sector than in the agricultural sector.

Golf courses were the main source of pesticide use in the large facilities and institutions sector. Golf course pesticide application only accounts for one percent of the watershed total, however, since active ingredients are applied to such a small area, an elevated use intensity results. Greens are highly prone to numerous diseases due to high humidity levels and short length of grass. As a result, they must be treated often, either as a curative or preventative measure.

The marine sector accounts for approximately one percent of total watershed input. Although this sector used the least amount of pesticides, only one active ingredient (cuprous oxide) was applied. Cuprous oxide ranks as the sixth most commonly applied active ingredient in the watershed.

Information collected in the miscellaneous sector indicated that the industrial wood preservative CCA, found in utility poles, guardrails and signposts was the most commonly applied active ingredient in this sector. Insecticides were determined to be the most commonly applied pesticide type by lawn care and pest control companies (78% of pesticides were insecticides), followed by herbicides (22%) and a minute amount of rodenticides ($<$0.002%).

The municipal sector accounted for 12% of watershed pesticide use. Chlorine accounts for the majority of this total, as it is used daily in significant quantities to disinfect wastewater exiting treatment plants. This total will decrease in the near future as some wastewater treatment plants are converting to UV light disinfection.

To the best of our knowledge, this is the first time an inventory of pesticide use encompassing all sectors has been conducted on a scale as extensive as a watershed. As a result of this inventory, quantitative information on the use of pesticides within watershed borders is now available. Information on the types and quantities, as well as usage patterns of pesticides has been gained. This knowledge can be used to assist regulatory bodies, organizations and individuals in making decisions on the appropriate use of pesticides.

5.0 Recommendations

No major difficulties were encountered over the course of the pesticide inventory. There are, however, a few recommendations that could be made in order to ensure no serious problems are encountered should a similar project be undertaken elsewhere.

- The inventory was conducted over a period of one year. Should another inventory of this type and scale be undertaken, an equivalent time period should be allotted for its completion.

- It is essential to have a steering committee knowledgeable on pesticides, their regulation, uses and users. Without such a group to offer guidance and answer questions as the inventory progresses, difficulties and obstacles will be encountered along the way.

- Establishing the methodology to be followed throughout the inventory before commencing data collection was very practical. This allowed for rapid and organized progression once the inventory was under way.

- At the onset of the project, pesticide use data for the past three years were acquired from some sources. This proved to be unnecessary given that only data for the previous year could be provided in most cases. The older data were not used, therefore it is recommended pesticide use data be gathered for one year only.

- When gathering data from the forestry sector, it is recommended that approval documents from the Environmental Registry be acquired initially. Data obtained by this method were more specific than those acquired by directly contacting forestry companies. Once data from the Environmental Registry were obtained and reviewed, forestry companies could be contacted should any additional information be sought.

- In the domestic sector, a more efficient method of obtaining sales data from retail stores should be established. In this case, store managers were approached at a very busy time of year (late spring/early summer) and did not view gathering sales data as one of their top priorities. Requesting this information at a time of year that is more convenient to store managers or offering some kind of incentive with which to reward the stores might be options.

- Should a mail survey of domestic pesticide use be conducted, it is recommended that the survey be mailed as addressed mail. Although more expensive, addressed mail surveys tend to result in higher response rates. Lists of mailing addresses for any area can be obtained from list broker companies for a fee of a few hundred dollars or more depending on the quantity of addresses desired.

- A significant amount of time and resources were spent on the acquisition of domestic pesticide sale and use data. This process would have been less laborious had there been a pre-existing database of pesticide sales from which information could have been obtained. Commercial and restricted pesticides sold in the province must be reported, however, there is no data on the sale of domestic pesticides, which, according to results obtained in the household survey, account for a significant proportion of pesticide use in the watershed.

- Inventories of this type should be repeated to ensure pesticide use data do not become outdated. Pesticides are evolving; new products are consistently added to the market while others are removed. Conducting pesticide use inventories on a regular basis would ensure the availability of current data.

- Data acquired over the course of this inventory provide a baseline that could be utilized to assist further investigations on pesticide use in the watershed. A risk ranking of pesticides, in which the toxicity and exposure of a pesticide are taken into account, could be completed. Soil, air and water samples could be collected and analyzed for pesticide residues in areas where pesticide use is the most intense.

6.0 Lessons Learned

Numerous lessons were learned over the course of this inventory, as it was the first time such a methodology was undertaken. Listed below are some of those lessons.

- A non-regulatory, neutral, third party organization may be in the best position to undertake this type of inventory, as participants may not feel as threatened when questioned on an issue as sensitive as pesticide use. Organizations in a regulatory position may face more challenges in undertaking such a task.

- When numerous attempts to contact individuals via phone and/or email proved to be fruitless, personal visits tended to be effective.

- Whenever possible, it is helpful to gather information from numerous sources in order to obtain a more accurate estimate of the quantity of pesticides used. This also helps validate the acquired data.

- In the agricultural sector, gathering pesticide use data from farmers was the most challenging task. A significant amount of time should be allotted to this task. It would be more efficient to contact farmers during the winter months, as they are less occupied at this time.

- Obtaining sales records from pesticide vendors was very useful; it provided a good estimation of the total amount of active ingredients sold in the watershed. However, since the sales data obtained extended beyond the watershed, it was not possible to determine how much of each active ingredient was sold in the watershed; only a total amount was obtained.

- In the domestic sector, it was determined that although a survey of domestic pesticide use requires significant time and energy to prepare, it yields valuable information on household pesticide use. It should be noted, however, that conducting a random survey of the entire watershed is very expensive.

- Gathering sales data from retail stores did not require as much time and effort as the domestic pesticide use survey, but it rendered less information. Some stores serve customers outside the watershed; the proportion of sales made to these customers must not be included.

- In the forestry sector, the Environmental Registry was a very useful source of information. The main setback with this data source is that the organizations or individuals for which pesticide application approvals are sought must be named individually on the application forms. Approvals granted on a specific geographical area cannot be obtained; consequently, it is essential to determine the identity of all companies and individuals who apply pesticides in the designated area.

- When contacting municipal units as well as some facilities and institutions, it was necessary to specify all types of pesticides on which data were being gathered. If this was left unmentioned, individuals tended to assume pesticides referred to herbicides and insecticides only; they failed to recognize products such as swimming pool disinfectants as pesticides, which in the case of municipal units turned out to be an important type of pesticide used.

References

Agriculture and Agri-Food Canada. 2005. Crop Profile for Greenhouse Tomato in Canada. http://www.agr.gc.ca/env/pdf/tomato_greenhouse_e.pdf. Accessed December 22, 2005.

Alberta Environmental Protection, Chemicals Assessment and Management Division, Pesticide Management Branch. 1998. Pesticides Factsheet Golf Course Pesticide Use and Monitoring 1998. http://www3.gov.ab.ca/env/protenf/pesticide/publications/factsheets/fs-golfcoursepesticideuseandmonitoring.pdf. Accessed December 16, 2005.

Basrur, S.V. 2002. A Survey of Toronto Residents' Awareness, Uses and Attitudes Towards Lawn Pesticides. Toronto Public Health. http://www.toronto.ca/health/hphe/pdf/pesticides_survey.pdf. Accessed December 21, 2005.

Brimble, S., P. Bacchus and P.-Y. Caux. 2005. Pesticide Utilization in Canada: A Compilation of Current Sales and Use Data. Environment Canada. 3p, 31p.

Canada Post. 2005. Householder Counts & Maps. http://www.canadapost.ca/cpc2/addrm/hh/current/indexp/cpALL-e.asp. Accessed September 9, 2005.

Creative Research Systems. 2003. The Survey System. http://www.surveysystem.com/sdesign.htm. Accessed February 15, 2005.

Elzinga, C.L., D.W. Salzer, J.W. Willoughby and J.P. Gibbs. 2001. Monitoring Plant and Animal Populations. Blackwell Science. 301p.

Environment Canada. 2004. A Compendium of Information on Pesticides Used in Atlantic Canada. Environment Protection Branch Atlantic Region.

Macorr Inc. 2003. Sample Size Optimization. http://www.macorr.com/ss_methodology.htm. Accessed February 16, 2005.

Milton, J.S., 1999. Statistical Methods in the Biological and Health Sciences. McGraw Hill. 272p.

Ministère du Développement durable, Environnement et Parcs du Québec. 2005. Gardening . . . all naturally. http://www.mddep.gouv.qc.ca/pesticides/jardiner-en/consumer.htm#if-company. Accessed December 14, 2005.

Pesticide Management Regulatory Agency. 2004. Pesticide Terminology. http://www.pmra-arla.gc.ca/english/aboutpmra/term-e.html. Accessed: November 21, 2005.

Planning and Operations, Vancouver Park Board and Vancouver Coastal Health Authority. 2002. Pesticide Use Options for Private Properties in Vancouver. http://www.city.vancouver.bc.ca/ctyclerk/cclerk/020723/A5.htm. Accessed December 21, 2005.

Prince Edward Island Department of Fisheries, Aquaculture and Environment. 2003. State of the Environment. http://www.gov.pe.ca/photos/original/fae_soe_report.pdf. Accessed December 16, 2005.

Standing Committee on Environment and Sustainable Development. 2000. Pesticides Making the Right Choice for the Protection of Health and the Environment: Report of the Standing Committee on Environment and Sustainable Development. http://www.parl.gc.ca/InfoComDoc/36/2/ENVI/Studies/Reports/envi01/10-ch3-e.html. Accessed December 8, 2005.

StatPac Inc. 2005. Questionnaire & Survey Design. http://www.statpac.com/surveys/index.htm#toc. Accessed February 15, 2005

United States Environmental Protection Agency. 2005. Types of Pesticides. http://www.epa.gov/pesticides/about/types.htm. Accessed: November 22, 2005.

Van Dijk, H.F.G. and R. Guicherit. 1999. Atmospheric Dispersion of Current-Use Pesticides: A Review of the Evidence from Monitoring Studies. Water, Air and Soil Pollution. 115: 21-70.

Appendices

Appendix A: Glossary

Definitions were obtained from the Pesticide Management Regulatory Agency (PMRA) and the United States Environmental Protection Agency.

Active ingredient: The ingredient of a pesticide that actually controls the targeted pest.

Antifouling agent: Kills or repels organisms that attach to underwater surfaces, such as boat bottoms.

Disinfectant: Kills or inactivates disease-producing microorganisms on inanimate objects.

Fungicide: A pesticide used to control or destroy fungi, including blights, mildews, molds, and rusts.

Guarantee: The amount of active ingredient contained in a product, expressed as either a percentage or a weight.

Herbicide: A pesticide designed to control or kill plants, weeds, or grasses.

Insecticide: A pesticide compound specifically used to kill or prevent the growth of insects.

Molluscicides: A pesticide used to kill snails and slugs.

Pest: Any injurious, noxious or troublesome insect, fungus, bacterial organism, virus, weed, rodent or other plant or animal.

Pesticide: Any product, device, organism, substance or thing that is manufactured, represented, sold or used as a means for directly or indirectly controlling, preventing, destroying, mitigating, attracting or repelling any pest. Control products include active ingredients used in the manufacture of end-use products and the end-use products themselves. Includes herbicides, insecticides, fungicides, antimicrobial agents, pool chemicals, microbials, material and wood preservatives, animal and insect repellents, and insect- and rodent-controlling devices.

It should be noted that the term pesticide applies only to products applied externally to combat pests. Products taken internally for the same purposes are classified as drugs rather than pesticides. For example, flea control products given to pets internally (pills) are classified as drugs whereas flea control products applied externally (topical solutions) are classified as pesticides, even if the active ingredient in both products is similar.

Plant growth regulator: Substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants.

Rodenticide: A pesticide or other agent used to kill rats, mice and other rodents or to prevent them from damaging food, crops, or forage.

Wood preservative: Active ingredients used in treatment of wood to protect it from insects, fungi and other pests.

Appendix B: Introductory Letter

Mr. XYZ
21 Saint Anthony St
Annapolis Royal
NS B0S 1A0

July 14, 2005

Dear Mr. XYZ,

Clean Annapolis River Project (CARP) is currently conducting an inventory of pesticide use within the western Annapolis Valley. This study will identify the types of pesticides used, quantities used, usage patterns and application methods. The purpose of the inventory is to document pesticide use by all sectors in the western Annapolis Valley and to develop a framework that may allow a similar project to be undertaken in other areas. To the best of our knowledge, this is the first time a project of this type and scale has been undertaken in Canada. We are conducting the inventory from a neutral perspective, i.e. that pesticides are neither good nor bad. Data will be gathered from a range of sectors including forestry, agriculture, marine, residential, municipal, industrial and large institutional.

In order to successfully complete the inventory, specific data on pesticide use within the last two to three years will be gathered. This includes pesticides used (product registration number, product name and active ingredient), application rate, number of applications per year, method of application and size of area treated.

The information gathered will be aggregated into a report in such a way as to ensure the confidentiality of individual information sources. A copy of the report will be made available to you, industry groups, government and the public once completed.

Janice Comeau, our pesticide inventory researcher, will follow up this letter with a phone call in the next few weeks to gather the above-mentioned information. In the meantime, should you have any questions please contact me at 1-888-547-4344 or email at carp@annapolisriver.ca.

Yours truly,

Stephen Hawboldt
Executive Director

Appendix C: Domestic Survey Questionnaire

HOUSEHOLD PESTICIDE USE SURVEY

Clean Annapolis River Project (CARP) is currently conducting an inventory of pesticide use within the western Annapolis Valley. The purpose of the inventory is to gather information on pesticide use from numerous sectors to gain a better understanding of types and quantities of pesticides used in the Annapolis River watershed. In order to successfully complete this project, information on household pesticide use must be gathered.

Please take a few minutes to complete this survey, as it is essential to the completion of the inventory. All information you provide will be kept confidential. **Please complete and return the survey by mail to Clean Annapolis River Project in the enclosed stamped envelope by Monday, September 26, 2005.** Fill in your name and phone number in the space provided at the end only if you wish to enter a draw for a chance to win one of twenty water conservation kits (15$ retail value).

Should you have any questions regarding this survey, please contact Janice Comeau at the CARP office at 1-888-547-4344 or 532-7533 locally.

1. HERBICIDES

Herbicides are pesticides used to control unwanted vegetation on lawns as well as in fruit, vegetable or flower gardens. They are also used on vegetation around hard surfaces such as driveways and sidewalks. Examples of herbicides are *Roundup Grass & Weed Control, Killex Lawn Weed Control* and *Weed and Feed* fertilizers.

Have you applied any herbicides on your property in the last year? Yes_____ No_____
If so, please indicate in the table below the complete product name(s) and the amount(s) used in one year (example: 1 litre).

Herbicide product name	Amount used /year
1.	
2.	
3.	
4.	

Did you hire a landscape contractor to apply these herbicides or did you apply them yourself?
Landscaping company_____ Self_____

2. INSECTICIDES

Insecticides are pesticides used to kill insects such as earwigs, ants, chinch bugs, spiders, wasps, mosquitoes, etc. Examples of insecticides are *Raid House & Garden Bug Killer, Ant-B-Gon Ant Traps, Sevin Garden Dust Insecticide, Safer's Insecticidal Soap* and *Insectigone Crawling Insect Killer.*

Have you used insecticides in the last year? Yes_____ No_____
If so, please indicate the complete product name(s) and the amount(s) used in one year (example: 500mL) in the following table.

Insecticide product name	Amount used /year
1.	
2.	
3.	
4.	

Did you hire a contractor (ex: landscape contractor or exterminator) to apply these insecticides or did you apply them yourself?
Contractor_____ Self_____

3. INSECT REPELLENTS

Insect repellents are also classified as pesticides. Examples of commonly used insect repellents are *Muskol Insect Repellent Aerosol, Deep Woods Pump Spray Insect Repellent* and *Off! Skintastic for Kids.*
Have you used insect repellents in the last year? Yes_____ No_____
If so, indicate in the table below the specific name of all insect repellents you have used and the amount(s) used.

Insect repellent product name	Amount used /year
1.	
2.	
3.	
4.	

4. RODENTICIDES AND SLUG & SNAIL BAITS

Rodenticides are products used to kill rodents in or around your home, for example, *Wilson Warfarin Rat & Mouse Killer Pellets* and *Later's Rat & Mouse Baits*. Slug and snail baits are also classified as pesticides (example: *Safer's Slug & Snail Bait* and *Corry's Slug & Snail Pellets*).
Have you used any of these products in the last year? Yes_____ No_____
If so, please list the product name(s) and the total amount(s) used in below.

Rodenticide or slug/snail bait product name	Amount used /year
1.	
2.	
3.	
4.	

Did you hire a contractor to apply these products or did you apply them yourself?
Contractor_____ Self_____

5. FUNGICIDES

Fungicides are pesticides used to kill plant fungal diseases. Black spot and powdery mildew are examples of these diseases. Products such as *Safer's Defender Garden Fungicide* and *Funginex* are used to treat these pests.
Have you used any fungicides in the last year? Yes_____ No_____
If so, list the product name(s) and the amount(s) used in the space provided below.

Fungicide product name	Amount used /year
1.	
2.	
3.	
4.	

Did you hire a contractor to apply these fungicides or did you apply them yourself?
Contractor_____ Self_____

6. SWIMMING POOL & SPA DISINFECTING AGENTS

Disinfecting agents used to control the growth of bacteria, viruses and algae in swimming pools and spas are classified as pesticides. Examples of disinfectants are *Clearwater Algaecide 5%* and *HTH Extra Super Shock for Swimming Pools*. Products that regulate pH, water clarifiers or products that reduce foam buildup are **not** classified as pesticides.
Do you have a swimming pool or spa? Yes_____ No_____
If so, please indicate in the table below all disinfecting agents you have used in the last year and indicate the amount used per year.

Swimming pool or spa disinfecting agent	Amount used /year
1.	
2.	
3.	
4.	

7. FLEA, TICK, MITE CONTROL PRODUCTS

Many products used on household pets for flea, tick or mite control are pesticides. These products include flea/tick shampoos, flea collars, ear mite treatments and flea/tick sprays and powders. *Advantage 18 Flea Adulticide for Cats, Hartz 2 in 1 rid Flea Shampoo for Dogs* and *Sergeant's Flea and Tick Powder for Dogs* are examples of such products.
Have you used products to control fleas, ticks or mites on your cat(s), dogs(s) or other household pets in the last year? Yes_____ No_____

If so, please indicate the product name(s) as well as the amount(s) used below.

Flea, tick or mite control product name	Amount used / year
1.	
2.	
3.	
4.	

8. WOOD PRESERVATIVES

Wood preservatives used to coat outdoor wooden structures are classified as pesticides. They contain an active ingredient that kills molds and other microorganisms, preventing them from decomposing wood. Examples of wood preservative products are *Olympic Clear Wood Preservative* and *Copper II Green Preservative*.

Have you applied wood preservatives to any wooden structure in the last year? Yes___ No___
Please indicate the specific product name(s) and the amount(s) used below.

Wood preservative product name	Amount used /year
1.	
2.	
3.	
4.	

9. In the last year, have you bought any pressure treated wood treated with ammoniacal copper quaternary (ACQ) or copper azole (CA) for outdoor construction projects?

Yes_____ No_____

10. Where did you buy the pesticide products indicated in questions 1 to 9? Circle all that apply.

a) hardware store
b) department store
c) pharmacy
d) garden centre
e) veterinary's office
f) grocery store
g) other:_____

11. Has your use of pesticides increased, decreased or remained the same in the last five years?

a) increased
b) decreased
c) no change

12. In light of the publicity pesticides have been receiving over the last few years, are you:

a) more concerned about using pesticides around your home?
b) less concerned about using pesticides around your home?
c) no more or less concerned?

Will be detached

Thank you for taking the time to answer our survey! Provide your name and phone number below ONLY if you wish to enter a draw for a chance to win 1 of 20 water conservation kits.

NAME:_____

TELEPHONE
NUMBER:_____

Appendix D: Trade Names Corresponding to Active Ingredients

Table D1. Active ingredients and the products in which they are found.

Active Ingredient	Trade Name
2,4-D	2,4-D, Killex, Par III, Weedex
atrazine	Atrazine, Primextra II Magnum
azoxystrobin	Heritage
Bacillus thuringiensis ssp. kurstaki	Dipel
benomyl	Later's Benomyl
borax	Ant-B-Gon, CIL, Raid
brodifacoum	Final
bromadiolone	Co-op Bromone
calcium hypochlorite	Tabex
calcium polysulphide	Wilson fungicides
captan	Captan, Maestro
carbaryl	Bug-B-Gon, Sevin, Wilson insecticides
carbathiin	Arrest
chlorophacinone	Wilson rodenticides
chlorothalonil	Bravo, Daconil
chlorpyrifos	Dursban
chromated copper arsenate (CCA)	no corresponding trade name
copper	various wood preservatives
cuprous oxide	various antifouling paints
cyfluthrin	Tempo
d-trans allethrin	Black Flag, Garden Master, Raid insecticides
DEET	Deep Woods, Muskol, Off! Skintastic, Watkins
diazinon	Diazinon
dicamba	Banvel II, Killex, Target, Weedex
dichlobenil	Casoron
difethialone	Generation
dimethoate	Cygon
diphacinone	Generation
endosulfan	Thiodan
ferric phosphate	Safer's garden products
ferrous sulphate	Scott's lawn care products
folpet	various wood preservatives
fosetyl-al	Aliette
glyphosate	Forza, Roundup, Vantage, Vision
imidacloprid	Advantage
insecticidal soap	Safer's
iprodione	Rovral
isoxaflutole	Converge
malathion	Wilson insecticides

Active Ingredient	Trade Name
mancozeb	Dithane, Manzate, Penncozeb
MCPA	MCPA, Target
mecoprop	Compitox, Killex, Target, Weedex
metalaxyl	Subdue
metaldehyde	Corry's garden products
metiram	Polyram
mineral oil	Superiot Oil
myclobutanil	Eagle
n-octylbicycloheptene dicarboximide	Bug-B-Gon, Hartz, Raid, VetKem, Zodiac
oxycarboxin	Arrest
pendimethalin	Prowl
permethrin	Raid, Sergeant's, Zodiac
phosalone	Zolone
phosmet	Imidan
picloram	Tordon
piperonyl butoxide	Black Flag, Bug-B-Gon, Garden Master, Hartz, Raid, Wilson, VetKem, Zodiac
propiconazole	Banner Maxx
propoxur	Bug-B-Gon, Raid
pyrethrins	Bug-B-Gon, Hartz, Raid, Sergeant's, VetKem
pyriproxyfen	Sergeant's
quintozene	fertilizer-herbicide combination products
resmethrin	Bug-B-Gon insecticides
rotenone	Green Earth insecticides
s-methoprene	Hartz, VetKem, Zodiac
s-metolachlor	Primextra II Magnum
silicon dioxide	Insectigone, Raid, Scott's insecticides
simazine	Simazine
soap (potassium salts of fatty acids)	Safer's
sodium hypochlorite	Atlantic
sulphur	Kumulus, Microscopic Sulphur
terbacil	Sinbar
tetrachlorvinphos	Hartz
tetramethrin	Raid
thifensulfuron methyl	Refine Extra
thiophanate-methyl	Senator
thiram	Arrest
tribenuron methyl	Refine Extra
tributyltin oxide	various wood preservatives
triclopyr	Release
trifloxystrobin	Compass
triforine	Funginex

Active Ingredient	Trade Name
trinexapac-ethyl	Primo Maxx
warfarin	various rodenticides
zinc	wood preservatives

* Source: A Compendium of Information on Pesticides Used in Atlantic Canada, Environmental Protection Branch Atlantic Region, 2004. Brand names for domestic active ingredients were obtained from completed survey questionnaires.

Appendix E: Agricultural Sector Calculations

Tree Fruit

Pesticide use data for tree fruit in Nova Scotia were obtained from Bill Craig, a tree fruit specialist for AgraPoint International Inc. It was determined that there are 2800ha of tree fruit in the province (B. Craig, personal communication, July 18, 2005) and approximately 817ha in the watershed (B. MacCulloch, personal communication, August 23, 2005); consequently, 29.18% of orchards in the province are located in the watershed.

The next step consisted of multiplying the estimated number of hectares treated with each active ingredient in Nova Scotia by 29.18% to obtain an estimated area treated for the watershed. This information is listed in the "Estimated ha treated" column in Table E1. It was assumed that the proportion of crops treated on the provincial level is identical to the proportion treated on the watershed level.

The total estimated range applied was then calculated in the following manner:
low: estimated hectares treated x low application rate indicated on product label x # of app/yr x guarantee
high: estimated hectares treated x high application rate indicated on product label x # of app/yr x guarantee

The average estimated quantity applied was determined by calculating the average of the high and low estimated totals.

Table E1. Active ingredients commonly applied to tree fruit crops and the average estimated quantity applied over a year.

Active Ingredient (ai)	Estimated ha Treated	Application Rate (kg/ha)	# of app/yr	Guarantee (g/L or %)	Total Estimated ai Range Applied (kg)	Average Estimated Quantity ai (kg)
dormant oil	292	65	1	99%	18,790 X 0.87 (specific gravity)	16,347
metiram	572	3.6 – 4.8	4	80%	6,590-8,786	7,688
captan	572	1.5 – 3.0	6	80%	4,118-8,237	6,178
mancozeb	292	3.75 – 4.5	4	75%	3,285-3,942	3,614
sulphur	7	19.5	8	80%	874	874
glyphosate	292	0.8 – 4.3	2	356	166-894	530
phosmet	292	0.5 – 2.0	2	50%	146-584	365
carbaryl	409	1 – 2.3	1	466	191-439	315
phosalone	146	0.25 – 1	2	500	37-146	92
2,4-D	175	0.95	1	470	78	78
TOTAL						**36,081**

It should be noted that these pesticides are the most commonly used pesticides on tree fruit, however, they are not the only pesticides used.

Berry Crops

Calculations performed to determine the estimated quantity of active ingredients applied to berry crops were performed in a manner similar to tree fruit. Estimates of pesticide use on berry crops were obtained from John Lewis, berry specialist for AgraPoint International Inc.

Commonly used active ingredients are listed in the first column of Table E2. Estimates on the proportion of strawberries, cranberries, grapes, highbush blueberries and raspberries treated with these active ingredients were obtained from Mr. Lewis; this information was entered in the "Estimated ha treated" column of Table E2.

The following calculation was then performed to determine the total quantity of active ingredients applied:
estimated hectares treated x application rate x # of app/yr x guarantee
The application rate was acquired from the product's label on the PMRA's online database, http://eddenet.pmra-arla.gc.ca/4.0/4.0.asp.

Table E2. Active ingredients commonly applied to berry crops and the estimated quantity applied over a year.

Active Ingredient (ai)	Estimated ha Treated	Application Rate (kg/ha or L/ha)	# of Applications/yr	Guarantee (g/L or %)	Estimated Total ai Applied (kg)
dichlobenil	49	50	1	4%	98
chlorothalonil	cranberries 32	6.8	3	500	326
	strawberries 8	3.5	1	500	14
sulphur	9	3	4	92%	99
endosulfan	23	2.5	1	400	23
captan	strawberries 20	2.75	2	80%	88
	raspberries 3	2.5	2	80%	12
simazine	12	3	1	80%	29
2,4-D	15	2.2	1	470	16
iprodione	21	2	1	500	21
terbacil	29	0.275	2	80%	13
glyphosate	13	2.25	1	356	10
paraquat	6	5.5	1	200	7
TOTAL					**756**

It should be noted that these active ingredients are the most commonly applied on berries, however, they are not the only pesticides used. Furthermore, the application rates listed for some of the active ingredients mentioned above may vary under certain conditions. For example, different rates may be used to treat different pests on the same crop or alternatively, different rates may be used for different application timings (ex: spring versus after renovation). In these cases, the most commonly use application rate is indicated.

Field Crops

Information on herbicides commonly used on field crops as well as on the proportion of crops receiving herbicide treatment was acquired from Jack van Roestel, field crop specialist for AgraPoint International Inc. Additional information on the area of field crops in the watershed was acquired from Brian MacCulloch, Agricultural Resource Coordinator from the Department of Agriculture & Fisheries. The active ingredients, guarantees and application rates

were determined from product labels that were accessed on the PMRA's labels database, http://eddenet.pmra-arla.gc.ca/4.0/4.0.asp. All information was entered in Table E3.

The estimated quantity of active ingredient applied was calculated using the following formula:
estimated hectares treated x application rate x # of app/yr x guarantee.

Table E3. Active ingredients commonly applied to field crops and the estimated quantity applied over a year.

Active Ingredient (ai)	Estimated ha Treated	# of app/yr	Application Rate (/ha)	Guarantee (g/L or %)	Estimated Quantity ai Applied (kg)
2,4-D	36	1	1.5L	470	25
MCPA	36	1	1.5L	500	27
MCPA	14	1	1L	275	4
dicamba	14	1	1L	62.5	1
mecoprop	14	1	1L	62.5	1
tribenuron methyl	29	1	20g	25%	0.2
thifensulfuron methyl	29	1	20g	50%	0.3
pendimethalin	216	1	4.2L	400	363
atrazine	216	1	2.5L	480	259
isoxaflutole	144	1	105g	75%	11
atrazine	144	1	2L	480	138
s-metolachlor	180	1	1.5L	915	247
atrazine	180	1	2.5L	480	216
dicamba	180	1	1L	480	86
glyphosate	36	1	2.5L	360	32
TOTAL					**1,410.5**

Data obtained from farmers in the watershed were compared to information acquired from crop specialists. Active ingredients applied, application rates and number of applications per year from both sources were compared and found to be compatible.