

RECYC-QUÉBEC – SOGHU

Review of the Recovery Rate for Used Oil in Quebec

Final Report

Date: September 28, 2010
O/Ref.: 052-P032139-0102-MR-0001-01

DESSAU



RECYC-QUÉBEC – SOGHU

Review of the Recovery Rate for Used Oil in Quebec

Final Report

Prepared by:

[Signature]

Benoît Proulx,
NI Environnement

[Signature]

Julien Rosset,
Dessau

Approved by:

[Signature]

Frederik Richard
President, NI Environment

[Signature]

Philippe Vaillancourt, Biologist, M.Sc. Env.
Team Leader, Dessau

TABLE OF CONTENTS

SUMMARY	1
GLOSSARY.....	7
WARNINGS AND LIMITATIONS.....	9
1 REVIEW OF EXISTING PROGRAMS AND STUDIES.....	10
1.1 Recovery programs.....	10
1.2 Methods for calculating used oil resources.....	12
1.2.1 <i>European Union Countries</i>	12
1.2.2 <i>Overview of methods</i>	13
1.2.3 <i>ADEME study</i>	14
1.2.3.1 Background – Objective.....	14
1.2.3.2 Methodology	14
1.2.3.3 Results.....	15
1.2.4 <i>BCUOMA study</i>	15
1.2.4.1 Background – Objective.....	15
1.2.4.2 Methodology	15
1.2.4.3 Results.....	15
1.3 Information used to determine the methodology	15
2 DESCRIPTION OF THE QUEBEC CONTEXT	16
2.1 Oils taken into account.....	16
2.2 Definition of an application.....	17
2.2.1 <i>Types of oil marketed</i>	17
2.2.1.1 Definition.....	17
2.2.1.2 Quantification parameters.....	17
2.2.1.3 Results and interpretation	18
2.3 Segmentation by economic sector.....	20
2.3.1 <i>Relative weights of the various sectors</i>	20
2.3.2 <i>Proposed segmentation</i>	21
2.4 Annual sales breakdown	23
3 METHODOLOGICAL APPROACH	23
3.1 Quebec oil flow diagram and identification of variables.....	24
3.2 Data acquisition methodologies	26
3.3 Definition of recoverable oil.....	27
3.4 General formulas for calculating the recovery rate for used oil	28
3.5 Calculation steps.....	28

TABLE OF CONTENTS

4	SAMPLING PLAN DEVELOPMENT AND IMPLEMENTATION.....	29
4.1	Definition and sampling parameters for total Top-up oil (D + E) and drained oil (H).....	29
4.1.1	<i>Quantification parameters</i>	29
4.1.1.1	Garage sampling program	29
4.1.1.2	Oil consumer data.....	30
4.1.2	<i>Data acquisition bias correction</i>	31
4.1.3	<i>Target sample size</i>	31
4.1.3.1	Passenger car motor oil.....	32
4.1.3.2	Other oils	32
4.2	Other parameters that may affect the calculation of the recovery rate for used oil.....	32
4.2.1	<i>Oil in vehicles, machinery and products marketed in Quebec (B)</i>	32
4.2.1.1	Definition.....	32
4.2.1.2	Quantification parameters.....	32
4.2.2	<i>Oil contained in new vehicles, machinery and products marketed outside Quebec (C)</i>	32
4.2.2.1	Definition.....	32
4.2.2.2	Quantification parameters.....	33
4.2.3	<i>Oil remaining in containers (J)</i>	33
4.2.3.1	Definition.....	33
4.2.3.2	Quantification parameters.....	33
4.2.4	<i>Oil in end-of-life vehicles and machinery (G)</i>	33
4.2.4.1	Definition.....	33
4.2.4.2	Quantification parameters.....	33
4.2.5	<i>Oil in filters (I)</i>	34
4.2.5.1	Definition.....	34
4.2.5.2	Quantification parameters.....	34
4.3	Sampling plan implementation.....	34
4.3.1	<i>Sampling passenger car motor oil in garages</i>	34
4.3.1.1	Planning and implementation.....	34
4.3.1.2	Sampling plan results.....	35
4.3.2	<i>Sampling heavy duty motor oil in garages</i>	36
4.3.3	<i>Telephone interviews with oil users</i>	36
5	DATA AQUISION RESULTS.....	37
5.1	Garage sampling program	37
5.2	Business survey	38
5.3	Estimated rates for each application.....	39
5.4	Oil in vehicles, machinery and products sold in Quebec (B)	39

TABLE OF CONTENTS

5.5	Oil in new vehicles, machinery and products sold outside Quebec (C).....	40
5.6	Oil remaining in containers (J)	40
5.7	Oil in end-of-life vehicles and machinery (G).....	41
5.8	Oil in filters (I).....	42
6	CALCULATION OF THE PERCENTAGE OF RECOVERABLE OIL	43
6.1	Percentage calculation.....	43
6.2	Discussion.....	1
6.2.1	<i>Accuracy of the result and sensitive parameters</i>	<i>1</i>
7	RECOMMENDATIONS CONCERNING USE OF THE RATES AND FREQUENCY OF UPDATES	1

Tables

Table 1	– Annual oil sales (%) by sector and type of oil.....	3
Table 2	– Recovery rate for used oil by type of oil and sector.....	4
Table 3	– Volumes of recoverable used oil by type of oil and sector (thousands of litres per year).....	5
Table 4	– Calculation of the overall recovery rate for used oil based on the total volume of oil marketed in Quebec	6
Table 5	– Overview of existing used oil recovery programs	10
Table 6	– Overview of existing methodologies and segmentation methods.....	13
Table 7	– Overall recovery rate for used oil calculated in the ADEME study for France	15
Table 8	– Comparison of annual oil sales (1,000 l) identified by RECYC-QUÉBEC and the Lubricants Profile	17
Table 9	– Distribution of sales of oil not consumed in use in Quebec and British Columbia in 2008 – % (Lubricants Profile).....	19
Table 10	– 2006 GDP in millions of dollars (value = current dollars, Statcan).....	21
Table 11	– Type of segmentation selected	22
Table 12	– Annual oil sales (%) by sector and type of oil in Quebec (Appendix 2)	23
Table 13	– Description of the blocks in the oil flow diagram, and preliminary identification of data sources	25
Table 14	– Data acquisition methods	26
Table 15	– Data acquisition method used for each application to determine recovery rates for used oil.....	27
Table 16	– Relative weight of each data acquisition method based on quantities of used oil	27
Table 17	– Factors that may bias data	31
Table 18	– Age classes in the sample versus those in the Quebec car fleet	35
Table 19	– Data collected from companies by sector.....	36
Table 20	– Weighted rate calculation for passenger car motor oil	37
Table 21	– Overall recovery rate for used oil by sector	38
Table 22	– Recovery rate for used oil by type of oil and sector.....	39
Table 23	– Estimated quantity of oil (in litres) in imported vehicles or machines marketed in Quebec	40

TABLE OF CONTENTS

Table 24 – Estimated quantity of oil (in litres) remaining in containers after use.....	41
Table 25 – Estimated quantity of oil contained in end-of-life vehicles and machinery.....	42
Table 26 – Estimated quantity of recoverable oil remaining in used filters.....	42
Table 27 – Calculation of the overall percentage of recoverable oil based on the total volume of oil marketed in Quebec	43

Figures

Figure 1 – Oil flows and calculation methods.....	12
Figure 2 – Oil flows before and after use.....	24

Appendices

Appendix 1 – Oil Sales
Appendix 2 – Detailed approach leading to segmentation
Appendix 3 – Estimated recovery rate for used oil per application
Appendix 4 – Garage sampling campaign
Appendix 5 – Transmission repair shop survey
Appendix 6 – User sector survey
Appendix 7 – Data collection forms, questionnaires and documents
Appendix 8 – Test for identifying sensitive parameters

Ownership and confidentiality

"This engineering document was produced by Dessau and is protected by law. This report was prepared exclusively for the purposes mentioned herein. Any reproduction or adaptation, in whole or in part, is strictly prohibited without prior written authorization from Dessau and its client.

Test results obtained during this study are only valid for the samples described in this report.

Dessau subcontractors who have performed site or laboratory work are duly qualified in accordance with the procurement procedure described in our quality manual. For any additional information, please contact your Project Leader."

RECORD OF REVISIONS AND VERSIONS		
Revision number	Date	Description of the amendment and/or version
01	2010-09-27	Final Report – Revision 1
00	2010-09-13	Final Report – Final Version
0B	2010-08-05	Final Report – Draft Version
0A	2010-05-26	Preliminary Report

SUMMARY

BACKGROUND

Based on the principle of extended producer responsibility, the Government of Quebec introduced regulations in 2004 requiring owners of brands sold in Quebec to recover and recycle used oil, containers and filters. The industry therefore created a not for profit agency, the Société de Gestion des Huiles Usagées (SOGHU), which included 234 members in 2009. SOGHU represents the vast majority of the industry's members in Quebec. Only four companies¹ decided not to join, and implemented their own recovery systems.

SOGHU signed an accreditation agreement with RECYC-QUÉBEC in November 2004. The agreement established a target recovery rate, under which 75% of the volume of used recoverable oil was to be recovered. In order to achieve these goals, nearly 765 collection facilities were established throughout Quebec, including 400 commercial and 365 municipal sites. In 2009, SOGHU nearly achieved a 100% recovery rate, well above its 75% target. The recoverable amounts of used oil were calculated based on volumes sold annually, to which a recovery rate for used oil was applied, taking into account the fact that part of the oil was consumed in use.

Currently, the single average rate used in this calculation is 67%. Considerable thought went into establishing the rate. However, it has not been documented and there is currently no certainty as to whether this figure is valid in the Quebec context. The wide range of oil properties and uses has made it difficult to determine the recovery rate for used oil. There is a different recovery rate for used oil for each application, which combines the type of oil and sector, such as heavy duty engine oil used in forestry.

RECYC-QUÉBEC would now like to validate the average recovery rate for used oil to be utilized in the Quebec context. Accordingly, RECYC-QUÉBEC intends to obtain detailed information on the recovery rate for used oil for each application, and then estimate the average recovery rate for used oil based on sales data.

The aim of the study is therefore to develop and implement a methodology specific to Quebec that allows us to estimate the recovery rate for used oil (or emission factors), taking the various applications into account. The rate must be reliable, representative of the Quebec situation, and the various players involved must reach a consensus on the rate.

¹ Canadian Tire, Safety Kleen, Lubrifiants Saint Laurent and Lubrifiants PFL

METHODOLOGY

To achieve our objective, we began by conducting a literature review of the situation in various countries throughout the world to identify methodologies that might apply. We subsequently documented the characteristics of the oil market in Quebec, and then developed the methodology and implemented the sampling plan. Finally, we analyzed the data and calculated the rates.

The literature review identified two studies of particular interest:

- ▶ “Examen des méthodes de détermination du gisement d’huiles usagées utilisées dans les États membres et révision de la méthode utilisée par l’ADEME pour l’actualisation du gisement français d’huiles usagées” [Review of methods for determining used oil resources in the member states and review of the method used by ADEME for discounting French used oil resources], Bio Intelligence Service and AriaConsult for ADEME [French Environment and Energy Management Agency], March 2004, hereinafter the “ADEME study”;
- ▶ “Consumed in Use Study – Draft Report”, Rob Spence – RGS Consulting, for BCUOMA (British Columbia Used Oil Management Association), August 2005, hereafter the “BCUOMA study.”

The method presented in the BCUOMA study—breaking down sales by application, and determining recovery rates for used oil for each application—was interesting. It was also readily applicable to Quebec, since the data sources and classification of oils were similar. The ADEME study provided us with some complementary parameters to be evaluated and some rates, which were used in applications where we had not obtained any data.

The study used three data acquisition methods. They are presented below in order of decreasing accuracy:

- ▶ Field surveys: physical measurements;
- ▶ Analysis: annual oil consumer data;
- ▶ Expert opinions, professional experience and data from other studies.

Sales were broken down by type of oil and sector. We used oil consumption ratios for the relevant unit, which were based on annual oil consumer data extrapolated for all of Quebec. For example, we took the total annual volume of hydraulic fluid consumed by the construction industry and calculated the volume per machine, and multiplied that ratio by the total number of machines in the construction industry. In the utilities sector, we took the total annual volume of heavy duty engine oil consumed per resident, and multiplied the ratio by the total number of Quebec residents.

The field measurements involved passenger car motor oil. We could not take samples of the other types of oil, because the number of oil changes per garage was low and unpredictable since vehicle maintenance could be performed in-house or externally. In addition, the data would have been of little use, since the amount of oil added to keep levels topped up was much greater than it was for passenger car motor oil and it was difficult to obtain accurate information on the quantities added. Values measured this way would not be usable. We conducted a telephone survey

involving companies in various sectors to collect data on oil consumption and used oil generation. Since the used oil was all mixed together, we were only able to obtain an overall recovery rate for used oil. To establish rates by type of oil, we used some specific rates from the survey, and in cases where there was no data, we took some rates from the BCUOMA and ADEME studies and adjusted the rate for hydraulic fluid or heavy duty engine oil to produce results consistent with the overall rate from business survey.

We also attempted to complete some of the missing data. To achieve this objective, we began by modelling oil flows to determine the parameters to be taken into account and those to be estimated.

The volume of virgin oil in vehicles, machinery or products marketed in Quebec was estimated at 8,872,101 litres, nearly 8% of sales.

In addition, we assessed the quantity of recoverable used oil from end-of-life vehicles and machinery at 5,788,684 litres, or almost 7% of the estimated amount of recoverable oil for 2008. The user surveys did not include these quantities because the users did not manage their equipment's end-of-life cycle. They therefore need to be added to the quantities calculated based on the rate per application.

RESULTS

Table 1 shows the breakdown of sales per application.

Table 1 – Annual oil sales (%) by sector and type of oil

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	OVERALL
Automotive	100%				27.9%			43.7%		8.0%	41.6%
Agriculture		9.3%		74.0%						1.1%	5.9%
Construction		12.1%	30.2%	7.8%	16.9%			13.7%		2.7%	8.1%
Forestry		4.5%	19.8%	13.0%	6.2%			5.0%		0.9%	4.6%
Manufacturing		4.4%	18.9%		12.3%			3.1%	100%	73.4%	9.3%
Marine							100%				4.8%
Mining		10.5%	12.4%	5.2%	12.1%			9.2%		3.2%	5.1%
Rail						100%					2.5%
Trucking		49.6%	8.2%		17.9%			20.1%		2.6%	13.8%
Utilities		7.9%	4.6%		6.6%			5.1%		3.6%	2.9%
Other sectors		1.7%	5.9%							4.5%	1.3%
TOTAL		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2 presents the rates by application and the overall rates by sector and type of oil. The overall rate was 73.5% of recoverable used oil.

Table 2 – Recovery rate for used oil by type of oil and sector

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	OVERALL RATE	
Automotive	85.1%				78.1%			80.0%		95.0%	84.8%	
Agriculture		71.8%		81.0%						90.0%	77.7%	
Construction		59.0%	67.0%	81.0%	75.5%			80.0%		90.0%	66.5%	
Forestry		43.0%	29.9%	81.0%	75.5%			80.0%		80.0%	44.3%	
Manufacturing		59.0%	67.1%		78.1%			80.0%	90%	90.0%	80.1%	
Marine								40.0%				40.0%
Mining		55.5%	36.2%	81.0%	75.5%			91.2%		80.0%	80.0%	55.0%
Rail							36.7%					36.7%
Trucking		71.6%	70.0%		77.6%			80.0%			80.0%	72.2%
Utilities		78.0%	70.0%		77.6%			80.0%			80.0%	76.6%
Other sectors		64.2%	70.0%									69.6%
OVERALL		85.1%	66.9%	56.4%	81.0%	77.1%	36.7%	40.0%	81.0%	90.0%	88.9%	73.5%

We then applied these results to the annual amounts reported in 2008 by SOGHU members and the four non-member firms, which were published by RECYC-QUÉBEC, to calculate the quantities of recoverable used oil in thousands of litres. Table 3 presents the results.

Table 3 – Volumes of recoverable used oil by type of oil and sector (thousands of litres per year)

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	TOTAL	
Automotive	37,878				989			967		355	40,188	
Agriculture		1,741		3,407						47	5,195	
Construction		1,870	2,905	359	579			302		113	6,128	
Forestry		502	851	599	213			111		33	2,309	
Manufacturing		681	1,818		436			69	2,387	3,092	8,494	
Marine								2,203				2,203
Mining		1,530	644	239	414			232		120	3,180	
Rail							1,057					1,057
Trucking		9,305	823		629			444		99	11,299	
Utilities		1,608	467		233			113		136	2,559	
Other sectors		294	598							167	1,059	
TOTAL		37,878	17,530	8,107	4,604	3,493	1,057	2,203	2,239	2,398	4,164	83,673

Finally, the formula for calculating the rate was adjusted as follows:

$$\frac{\text{Volume of used oil for each application} + \text{volume of oil in end-of-life vehicles and machinery}}{\text{Total volume of virgin oil marketed} + \text{volume of virgin oil in vehicles, machinery and products sold in Quebec}}$$

Table 4 presents the results of the calculation and the theoretical overall recovery rate for used oil, i.e., the rate which takes into account all oil marketed in Quebec.

Table 4 – Calculation of the overall recovery rate for used oil based on the total volume of oil marketed in Quebec

2008 VALUES	VOLUME (L)
Virgin oil marketed in Quebec	113,799,566
Virgin oil contained in vehicles, machinery and products sold in Quebec	8,872,101
Oil used in the applications	83,672,792
Used oil in end-of-life vehicles and machinery	5,788,684
OVERALL RATE	72.9%

The recoverable amount of used oil in 2008 was estimated at 89,461,476 litres.

GLOSSARY

Application: combination of a type of oil and a user sector. For example, gear oil used in manufacturing or heavy duty engine oil used in the trucking industry.

AMVOQ: Association des Marchands de Véhicules d'Occasion du Québec [Quebec used vehicle merchant association]

ARPAC: Association des Recycleurs de Pièces d'Autos et de Camions au Québec [Quebec auto and truck part recyclers association]

Other sectors: This term, which is used throughout the study, includes the following sectors: air transport, oil, gas and coal extraction, all services, and trade.

Other oils: This term, which is used throughout the study, includes other motor oils, oil from the natural gas and aviation industry, circulating oil, compressor oil, paper machine oil, as well as other industrial oils.

ADEME study: Study conducted by Bio Intelligence Service and AriaConsult for ADEME, in 2004, "Examen des méthodes de détermination du gisement d'huiles usagées utilisées dans les États membres et révision de la méthode utilisée par l'ADEME pour l'actualisation du gisement français d'huiles usagées" [Review of methods for determining used oil resources in the member states and review of the method used by ADEME for discounting French used oil resources].

BCUOMA study: Study conducted by Rob Spence – RGS Consulting for BCUOMA (British Columbia Used Oil Management Association) published in 2005, "Consumed in Use Study – Draft Report"

Lubricants Profile: Lubricant marketing profile, as reported by manufacturers and brand owners in Canada

GDP: Gross domestic product

EPR: Extended producer responsibility

SAAQ: Société de l'assurance automobile du Québec [Quebec automobile insurance corporation]

Types of oil: Definitions and French equivalents:

- ▶ Passenger car motor oil (PCMO) = oil used in automobile engines [huile moteur pour voiture];
- ▶ Heavy duty engine oil (HDEO) = oil used in truck and heavy equipment engines [huile moteur service sévère];
- ▶ Hydraulic fluid = oil used in hydraulic systems [fluide hydraulique];

- ▶ Tractor hydraulic fluid = blended oil for transmissions, differentials and hydraulics (TDH) [fluide hydraulique pour tracteur];
- ▶ Automatic transmission fluid (ATF) = oil used in automatic transmissions [huile pour transmissions automatiques];
- ▶ Differential gear oil = oil used in vehicle differentials [huile pour différentiels];
- ▶ Locomotive engine oil = oil used in locomotive engines [huile secteur ferroviaire];
- ▶ Marine engine oil = oil used in motor boats other than for leisure craft [huile secteur maritime];
- ▶ Industrial gear oil = oil used in industrial gears [huile pour engrenage industriel];
- ▶ Other oils = this category includes paper machine oil, compressor oil, circulating oil, differential gear oil, oil for the aviation sector, other automotive oils and other industrial oils;
- ▶ Consumed-in-use, unrecoverable oil = two-stroke engine oil, metalworking fluid, rustproofing oil, saw guide oil, chain saw oil, oil for pneumatic drills and tools, grease, and process oil.

WARNINGS AND LIMITATIONS

We endeavoured to minimize the margin of error for each data element by optimizing the sampling plan. The margins of error obtained using these methods were generally satisfactory, especially for the overall results.

However, we could not achieve a satisfactory margin of error for some data, which therefore must be used with due care.

Also, several biases relating to the constraints of the study could influence results. In particular, the physical sampling was conducted at a specific time of year. Results could vary if the information were collected during another season.

In addition, a great deal of data came from aggregate data generated by the companies' accounting and environmental systems. We endeavoured to minimize bias relating to unreported external purchases or stocks effects, but this data may not accurately reflect reality.

Finally, when we could not obtain certain values, we used values from other studies.

The values presented in the tables were rounded to two decimal places but the unrounded values were used in the calculations.

1 REVIEW OF EXISTING PROGRAMS AND STUDIES

1.1 RECOVERY PROGRAMS

We consulted 68 sources (studies, reports and websites) from 3 continents and 11 countries. In all, we reviewed the used oil management policies of 14 (provincial, state or national) governments.

Table 5 summarizes the situation in various countries, states or provinces throughout the world.

We studied other countries, but they did not report any recovery rates for used oil or recoverable oil:

- ▶ In the United States: Arizona, Florida, Missouri, Oregon, Tennessee and Texas
- ▶ In Canada: New Brunswick, Ontario and Prince Edward Island

Table 5 – Overview of existing used oil recovery programs

LOCATION	MANAGEMENT METHOD	PERCENTAGE OF RECOVERABLE OIL (% OF SALES)	RECOVERY RATE FOR USED OIL (% OF SALES)	RECOVERY RATE FOR USED OIL (% OF RECOVERABLE VOLUME)
EUROPE				
France	by the State (ADEME)	62.2% (2008) ²	N/A	65.8% (2008) ²
Italy	EPR:	42.9% (2008) ³	40.1% (2008) ³	93.5% (2008) ³
United Kingdom	Owner of the hazardous waste	Approximately 50% (2001) 55.0% (2007) ³	43.8% (2007) ²	Approximately 80% (2001) 79.5% (2008) ³
Germany	Motor and transmission oil: Distributor Other oil: Market	45.7% (2008) ³	45.7% (2008) ³	100% (2008) ³
Belgium	EPR:	42.2% (2008) ³	40.4% (2008) ³	96.0% (2008) ³

² Calculated using data from the “Synthèse du rapport annuel de l’Observatoire des flux physiques et économiques de la filière huiles usagées, pour l’année 2008 ADEME” [Summary of the annual report produced by the Observatory of physical and economic flows of used oils, for 2008, ADEME].

³ Calculated based on the February 2010 “Étude de la gestion de la filière de collecte et de valorisation des huiles usagées dans certains pays de l’UE – ADEME” [Management study of used oil collection and recycling in some EU countries – ADEME].

LOCATION	MANAGEMENT METHOD	PERCENTAGE OF RECOVERABLE OIL (% OF SALES)	RECOVERY RATE FOR USED OIL (% OF SALES)	RECOVERY RATE FOR USED OIL (% OF RECOVERABLE VOLUME)
Denmark	Recyclable oil: Financed by the producers, managed by the Danish Lubricants Association Other oil: Market	45.8% (2008) ³	32.7% (2008) ³	71% (2008) ³
Spain	EPR:	39.2% (2008) ³	37.1% (2008) ³	94.7% (2008) ³
Finland	by the State	64.2% (2008) ³	48.8% (2008) ³	76.0% (2008) ³
UNITED STATES				
Federal Government	Federal and state laws	58.0% (2008) ³	40.0% (2008) ³	68.9% (2008) ³
California	Managed by Evergreen Oil Fees charged to distributors	N/A	42.4% (2005) 42.8% (2006) 48.4% (2007)	N/A
OCEANIA				
Australia	Tax system managed by Product Stewardship for Oil (PSO)	56.6% (2001–2002) ⁴ 57.8% (2007–2008) 59.8% (2008) ³	42.5% (2001–2002) 49.8% (2007–2008) 49.6% (2008) ³	70.9% (2001–2002) 83.0% (2007–2008) 82.9% (2008) ³
CANADA				
British Columbia	EPR:	69.9% (2007) ⁵	49.1% (2007)	70.3% (2007)
Alberta	EPR:	47.3% (2008) ³	39.3% (2008) ³	83.0% (2008) ³
Nova Scotia	Returned to the distributor (vendor)	N/A	N/A	Estimated at 70%
Saskatchewan	EPR:	N/A	N/A	80.2% (2008) 77% (2009)

⁴ Calculated percentage of recoverable oil based on the study: Meinhardt Infrastructure & Environment Group 2002, Used Oil in Australia, Environment Australia

⁵ BCUOMA study

1.2 METHODS FOR CALCULATING USED OIL RESOURCES

1.2.1 European Union Countries

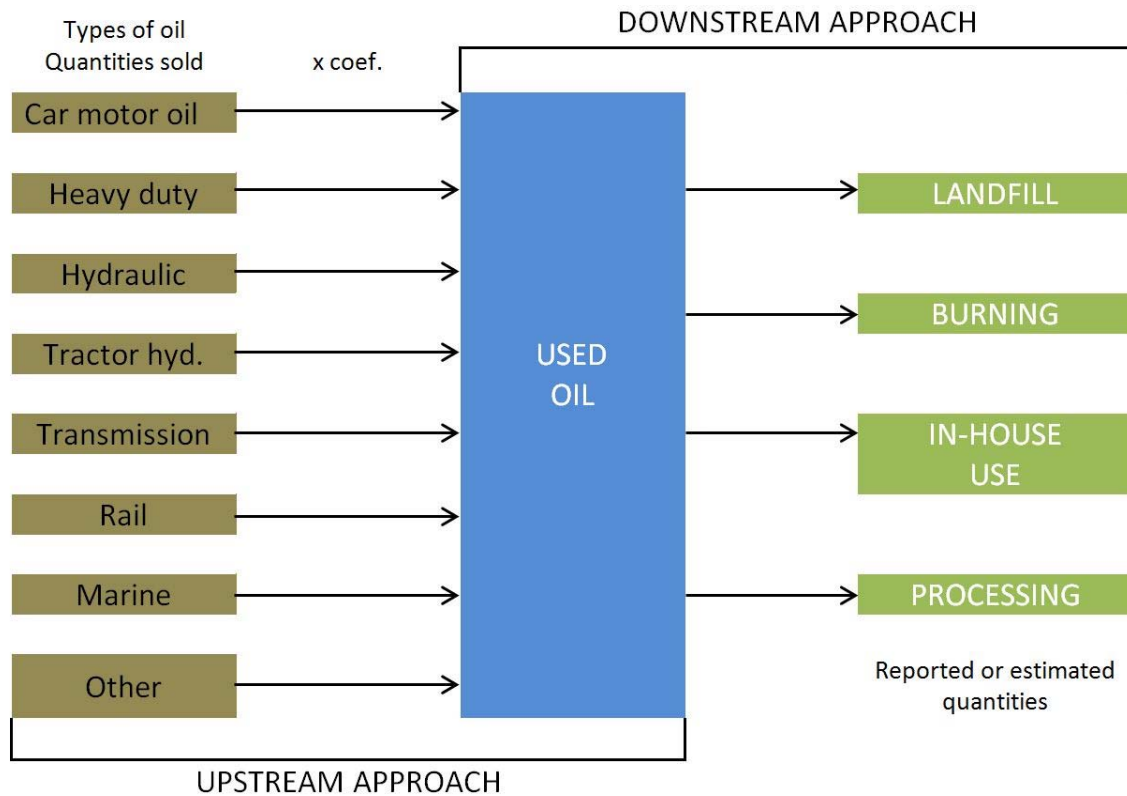
European Union countries are required to report to the European Commission the quantities of used oil generated annually within their borders. Each country has adopted a calculation method. There are two types of methods:

- ▶ Upstream method: one or more rates are used to calculate the volume based on sales;
- ▶ Downstream method: quantities in the various disposal processes are calculated based on statements and estimates, and the amount of water or other products is subtracted. The resources in all the various disposal processes are added to determine the total resource.

The upstream method can then be refined to a certain extent. One rate may be used to calculate the volume based on all sales, or various rates may be used based on the types of oil, and sometimes the sector. The United Kingdom and France use this method for some oils.

Figure 1 shows oil flows by type of oil and disposal process, and the items involved in each method.

Figure 1 – Oil flows and calculation methods



1.2.2 Overview of methods

Table 6 presents the methodologies used to estimate the used oil resource and the segmentation method.

Table 6 – Overview of existing methodologies and segmentation methods

LOCATION	METHOD	SEGMENTATION
EUROPE		
Germany	Downstream	Rate by types of oil
United Kingdom	Upstream	Rate by types of oil (Europalub)
Belgium	Downstream	N/A
Finland	Upstream	No
France	Upstream	Rate by types of oil (CPL ⁶)
Italy	Upstream	Rate by types of oil (Europalub)
UNITED STATES	No data on the calculation of rates of recoverable oil	
OCEANIA	No data on the calculation of rates of recoverable oil	
CANADA		
British Columbia	Upstream	Rate for each application
Alberta	Upstream	Rate for each application
Saskatchewan	Upstream	Rate for each application
Manitoba	Upstream	Rate for each application

Only two studies that presented more accurate methods for calculating rates of recoverable oil were identified:

- ▶ “Examen des méthodes de détermination du gisement d’huiles usagées utilisées dans les États membres et révision de la méthode utilisée par l’ADEME pour l’actualisation du gisement français d’huiles usagées” [Review of methods for determining used oil resources in the member states and review of the method used by ADEME for discounting French used oil resources], Bio Intelligence Service and AriaConsult for ADEME [French Environment and Energy Management Agency], March 2004;
- ▶ “Consumed in Use Study – Draft Report,” Rob Spence – RGS Consulting, August 2005.

We will present these methods in greater detail in subsequent sections.

⁶ Centre Professionnel des Lubrifiants – France

1.2.3 ADEME study

1.2.3.1 Background – Objective

Every year, ADEME estimates the used oil resource using a method developed in 1988, which is based on emission factors for each type of oil. These factors or recovery rates for used oil were reviewed in 1999. The purpose of the 2004 study was to review the methodology and rates.

1.2.3.2 Methodology

Seven principles were used to determine the method:

- ▶ Segmenting the life cycle of the vehicle or facility: assembly and filling with various fluids—useful life—end-of-life.
- ▶ Virgin oil parameter used: The virgin oil parameter used for the study was oil in the CPL lubricant category, except for oil consumed in use and process oils.
- ▶ Evaluation of the upstream oil change resource (virgin oil sales by volume) rather than the downstream resources (quantity of used oil recovered).
- ▶ CPL statistics were used to calculate virgin oil consumption.
- ▶ Procedures for evaluating upstream emission factors: based on theoretical calculation of consumed in use losses or expert opinions / user surveys.
- ▶ Evaluation of the specific resource associated with the disposal of end-of-life vehicles and equipment.
- ▶ Updates conducted more or less frequently depending on the parameters: annually for virgin oil market data, every five years for emission factors data based on trends in technology and maintenance behaviour.

One emission rate was developed for each application (kilogram of oil emitted per kilometre travelled or hour worked). These rates were then multiplied by the number of kilometres or hours of operation per year for each vehicle or equipment segment.

An Excel spreadsheet was developed to compile all the data. The spreadsheet was used to calculate the recovery rate for used oil for each application. There was no field measurement data, only expert opinions.

1.2.3.3 Results

The results are presented in Table 7.

Table 7 – Overall recovery rate for used oil calculated in the ADEME study for France

	1999	2000	2001	2002
Total sales (tonnes / year)	703,491	701,317	686,489	675,016
Recoverable resource (t / year)	432,545	429,257	422,214	416,781
Overall percentage of recoverable oil	61.5%	61.2%	61.5%	61.7%

1.2.4 BCUOMA study

1.2.4.1 Background – Objective

The purpose of the 2005 study was to calculate use consumption factors for each application, determine the total volume of oil consumed in use and the overall consumed in use factor for British Columbia. The recovery rate for used oil was 100%—the consumed in use factor.

1.2.4.2 Methodology

The study was conducted in three phases: development of the data collection methodologies, the data collection itself, and finally, the data analysis.

Virgin oil market data was taken from the Lubricants Profile. Market segmentation was primarily based on the opinions of professional vendors and GDP analyses. Finally, consumer oil data and expert advice were used to calculate loss rates. Some Canadian Tire field measurement data was used to calculate the rate for passenger car motor oil.

The consumed in use factor was defined as the amount of top-up oil used between oil changes, divided by the total quantity of oil purchased during the period. It should be clearly stated whether the difference between the amount of virgin oil added and the amount drained was taken into account.

1.2.4.3 Results

The overall rate of recovery for used oil in British Colombia was 69.9% (= 100% - 30.1%).

1.3 INFORMATION USED TO DETERMINE THE METHODOLOGY

Most of the countries that had introduced extended producer responsibility used the upstream method. It was more accurate than the downstream method, which tended to underestimate

quantities, because it did not take into account all flows not collected, such as internal uses, lubricants, burning, etc.

In addition, Quebec was already using this method, but with a single overall rate of 67%. The studies that we reviewed indicated that the percentage of recoverable oil varied with the types of oil and industries. It seemed necessary to provide additional details on this single rate, by establishing a rate for each relevant application (sales by types of oil and sector).

The BCUOMA study was useful because it was the most recent and was conducted by an oil industry specialist in a Canadian province, which made it easier to apply the study's findings to Quebec. The ADEME study's methodology seemed relevant because it focused on the entire life cycle of oil-consuming vehicles. However, the data was based on the European economy and standards, which precluded its use in Quebec.

These two studies did not provide detailed descriptions of the overall method they used to calculate the rate and the tools they used to gather information. Also, they contained little or no actual field measurements. These were points that we attempted to develop.

Finally, the BCUOMA study indicated that the recovery rates for used oil were very similar for some applications.

2 DESCRIPTION OF THE QUEBEC CONTEXT

2.1 OILS TAKEN INTO ACCOUNT

Section 2 of the Regulation respecting the recovery and reclamation of used oils, oil or fluid containers and used filters⁷ states that this Regulation applies to mineral, synthetic or vegetable oils used for lubrication, heat insulation or transfer in motorized vehicles or equipment or in the operation of hydraulic or transmission systems. These oils include:

- ▶ gasoline or diesel engine oil;
- ▶ domestic marine engine oil;
- ▶ industrial gear oil or car differential oil;
- ▶ circulating oil or turbine oil;
- ▶ paper machine oil;
- ▶ refrigeration system oil;
- ▶ mineral, polyalphaolefin (PAO) or diesel based compressor oil;
- ▶ heat transfer oil;

⁷ QUEBEC [Q-2, r.18.1.2, Sec. 2]

QUEBEC, Government of (2009) R.Q. c. Q-2, r.18.1.2, Regulation respecting the recovery and reclamation of used oils, oil or fluid containers and used filters;

- ▶ transformer dielectric oil;
- ▶ hydraulic or trans-hydraulic system oil;
- ▶ power steering oil;
- ▶ manual or automatic transmission oil.

Consumed in use oil and process oils, which do not produce recoverable used oil, are not included in the Regulation.

2.2 DEFINITION OF AN APPLICATION

An application is the combination of the type oil and the economic sector in which it is used. For example, heavy duty engine oil used in forestry or hydraulic fluid used in construction.

2.2.1 Types of oil marketed

2.2.1.1 Definition

These types of oil are sold in Quebec. They do not include oil in imported vehicles, machinery and products marketed in Quebec. These quantities are taken into account and estimated in Section 4.2.1.

2.2.1.2 Quantification parameters

RECYC-QUÉBEC publishes the total quantities of oil reported by SOGHU and four other non-member companies. But these quantities are not broken down by type of oil. The Lubricants Profile provides this type of information. Industry professionals consider it a reliable, comprehensive source of data obtained through surveys of the various oil vendors. Table 8 compares total sales from both sources.

Table 8 – Comparison of annual oil sales (1,000 l) identified by RECYC-QUÉBEC and the Lubricants Profile

	2005	2006	2007	2008
4 companies	7,837,535	7,952,540	7,608,364	8,285,987
SOGHU	111,998,532	110,910,112	106,617,546	105,513,579
Total reported to Recyc-Québec	119,836,067	118,862,652	114,225,910	113,799,566
Lubricants Profile total ⁸	124,711,000	115,973,000	113,135,000	110,551,000
Difference	11%	4%	6%	4%

The difference between the two values was approximately 5%. 2005 was the only year in which the difference was greater than 10%. The differences were attributable to the margin of error in the surveys and differences in the types of oil taken into account, including whether or not there were

⁸ We excluded consumed in use oil which could not be recovered: two-stroke engine oil, metalworking fluid, rustproofing oil, saw guide oil, chain saw oil, oil for pneumatic drills and tools, grease, and process oil.

any consumed in use losses, and the fact that some major users bought their oil in other provinces for use in Quebec. In these cases, the Lubricants Profile did not report the oil, whereas RECYC-QUÉBEC did.

However, we found that the difference was not significant for 2008 and the Lubricants Profile sales data could be used to estimate the percentage of oil used in each application. The volumes published by RECYC-QUÉBEC were then used to estimate the quantities of recoverable used oil.

2.2.1.3 *Results and interpretation*

Appendix 1 presents detailed data (in litres) for Quebec and the western provinces. Table 1 compares British Columbia and Quebec sales.

Certain types of oil are consumed in use, which mean that they are not technically recoverable. The following types of oil are consumed in use: two-stroke engine oil, metalworking fluid, rustproofing oil, saw guide oil, chain saw oil, oil for pneumatic drills and tools, grease, and process oil. These types of oil are used in external applications, such as rustproofing, chain saw oil or grease, used as chemicals, as in the case of process oil, or two-stroke engine oil, which is mixed with fuel.

Table 9 shows sales of oil **not** consumed in use by type of oil.

Table 9 – Distribution of sales of oil not consumed in use in Quebec and British Columbia in 2008 – % (Lubricants Profile)

TYPE OF OIL	QUEBEC	BC
Passenger car motor oil	39.1%	25.8%
Automatic transmission oil	4.0%	4.4%
Differential gear oil	2.4%	2.2%
Heavy duty engine oil	23.0%	24.9%
Other automotive oil	0.7%	0.1%
Natural gas sector	0.1%	5.6%
Aviation sector	0.1%	0.1%
Rail sector	2.5%	3.3%
Marine sector	4.8%	2.4%
Hydraulic fluid	12.6%	16.9%
Tractor hydraulic fluid	5.0%	6.2%
Circulating oil	0.9%	1.3%
Industrial gear oil	2.3%	2.5%
Compressor oil	0.5%	1.9%
Paper machine oil (paper mills)	1.2%	1.1%
Other industrial oils	0.7%	1.3%
TOTAL	100.0%	100.0%

This table shows that passenger car motor oil accounted for a greater percentage of sales in Quebec than in BC.

Oils that account for more than 2% of sales in Quebec in order of importance:

- ▶ Passenger car motor oil: 39.1%
- ▶ Heavy duty engine oil: 23.0%
- ▶ Hydraulic fluid: 12.6%
- ▶ Tractor hydraulic fluid: 5.0%
- ▶ Marine oil: 4.8%
- ▶ Automatic transmission fluid: 4.0%
- ▶ Locomotive engine oil: 2.5%
- ▶ Differential gear oil: 2.4%
- ▶ Industrial gear oil: 2.3%

These oils represented nearly 96% of sales.

We propose that the remaining types of oil be grouped in an “Other oils” category.

2.3 SEGMENTATION BY ECONOMIC SECTOR

Although the sales data was listed by types of oil, there was no information on sales by sector. However, the calculation process used in this study involved distinguishing recovery rates for used oil by sector.

Estimating sales segmentation was a complex task involving a series of calculations and adjustments. It was based on the data collected from oil consumers from the various sectors, and involved comparing the British Columbia figures produced by the BCUOMA study, based on GDP.

The process involved 11 steps:

- 1- Selecting the applications;
- 2- Summary classification of the oils used by one sector;
- 3- Estimating oil consumption ratios for each type of oil, per unit depending on the sectors: per machine, per company, per capita, etc.;
- 4- Determining total values for each parameter;
- 5- Extrapolating the unit values by multiplying them by the total units for the sector;
- 6- Determining the quantities by sector using the British Columbia data presented in the Spence study, based on GDP;
- 7- Adjusting the extrapolated field data, based on GDP values;
- 8- Determining segmentation in the “tractor hydraulic fluid” category;
- 9- Determining segmentation in the “transmission fluid” and “differential gear oil” categories;
- 10- Determining segmentation in the “other oils” category;
- 11- Applying the final results to the total quantities published by RECYC-QUÉBEC.

Appendix 2 presents a detailed description of the process.

2.3.1 Relative weights of the various sectors

The economic sectors that produced used oil were those that utilized vehicles, machinery and other mechanical equipment that needed oil to operate.

To assess the importance of the various economic sectors that generated used oil, we compared Quebec and BC's 2006 GDPs, as shown in Table 10.

Table 10 – 2006 GDP in millions of dollars (value = current dollars, Statcan)

SECTOR (NORTH AMERICAN CLASSIFICATION SYSTEM)	QUEBEC	BC
Crops and livestock [111-112]	2,821.2	1,132.8
Forestry and logging [113]	1,247.2	2,640.5
Fishing, hunting and trapping [114]	68.8	130.7
Agriculture and forestry support activities [115]	410.0	614.3
Oil and gas drilling and coal mining [211-2121]	1.7	7,835.5
Mineral mining [2122-2123]	2,279.1	2,259.7
Mining and oil and gas drilling support activities [213]	202.2	687.3
Utilities [22]	10,431.3	2,791.7
Construction [23]	15,003.3	12,139.9
Manufacturing [31-33]	48,018.6	15,795.9
Commerce [41, 44, 45]	31,429.8	17,975.0
Transportation and warehousing	11,430.9	10,469.2
Administrative and support services, waste management and remediation services [56]	7,333.1	3,807.6
Government [91]	17,068.9	8,398.7
Other services	115,754.0	80,793.0
TOTAL	263,500.1	167,471.8

This table shows that Quebec’s economic structure is not the same as British Columbia’s. The major differences are presented below:

- ▶ Quebec has a very small oil, gas and coal industry;
- ▶ Agriculture is more important than forestry, which is not the case in BC;
- ▶ The utilities sector is almost four times greater;
- ▶ Manufacturing is almost three times greater.

As a result, we did not select the oil, gas and coal industry as a single category, as was the case in the BCUOMA study. It was included in the “Other sectors” category. In contrast, given its importance, we included the manufacturing sector. The entire service sector, which consumes little oil, was included in the “Other sectors” category.

2.3.2 Proposed segmentation

The BCUOMA study was one of the few studies on determining the recovery rate for used oil. It was also the most recent study and the only one conducted in Canada. It was based on surveys of major vendors, which could not be conducted in Quebec, because there were more intermediaries in the Quebec market. Given these factors, we used the segmentation presented in the BCUOMA study and adapted it to the Quebec context, based on Quebec’s economic data and data from oil user surveys.

Adjustments were made to take the Quebec context into account and facilitate the study. The adjustments are presented in Appendix 2.

We are proposing the segmentation presented in Table 11. The data for an application is to be entered in the white boxes. The volume of oil sold and the percentage of recoverable used oil will have to be determined for each of the 46 applications.

Table 11 – Type of segmentation selected

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS ⁹
Automotive										
Agriculture										
Construction										
Forestry										
Manufacturing										
Marine										
Mining										
Rail										
Trucking										
Utilities										
Other sectors ¹⁰										

⁹ Other motor oils, natural gas sector, aviation sector, circulating oil, compressor oil, paper machine oil, other industrial oils

¹⁰ Aviation, oil and gas drilling and coal mining, all services, trade

2.4 Annual sales breakdown

The calculation details are presented in Appendix 2. Table 12 presents a summary of the results.

Table 12 – Annual oil sales (%) by sector and type of oil in Quebec (Appendix 2)

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	OVERALL
Automotive	100%				27.9%			43.7%		8.0%	41.6%
Agriculture		9.3%		74.0%						1.1%	5.9%
Construction		12.1%	30.2%	7.8%	16.9%			13.7%		2.7%	8.1%
Forestry		4.5%	19.8%	13.0%	6.2%			5.0%		0.9%	4.6%
Manufacturing		4.4%	18.9%		12.3%			3.1%	100%	73.4%	9.3%
Marine							100%				4.8%
Mining		10.5%	12.4%	5.2%	12.1%			9.2%		3.2%	5.1%
Rail						100%					2.5%
Trucking		49.6%	8.2%		17.9%			20.1%		2.6%	13.8%
Utilities		7.9%	4.6%		6.6%			5.1%		3.6%	2.9%
Other sectors		1.7%	5.9%							4.5%	1.3%
TOTAL		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

3 METHODOLOGICAL APPROACH

The literature review and the definition of the Quebec context provided us with an initial impression of the methodologies used elsewhere and enabled us to break down sales by application. Before developing the sampling plan, we now had to comprehensively identify the parameters that influenced the calculation of the recovery rate for used oil, and select the most effective data collection methods.

This activity was conducted in two steps, and is described in the sections below:

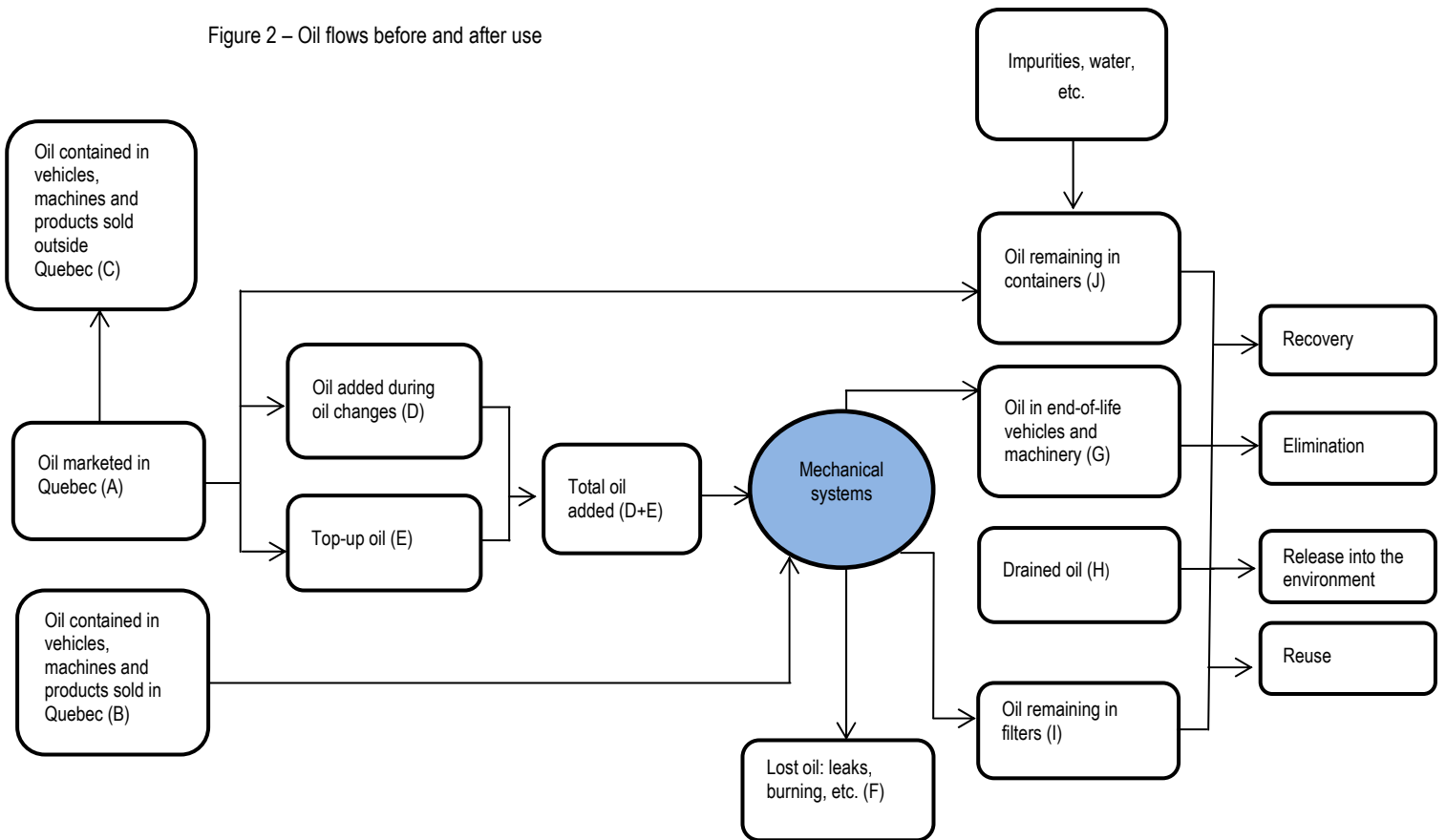
- 1- Step 1 involved drawing a diagram of the flow of virgin and used oils in Quebec;
- 2- Step 2 involved studying the methods of calculating the parameters, and acquiring the initial data for these calculations.

3.1 QUEBEC OIL FLOW DIAGRAM AND IDENTIFICATION OF VARIABLES

To identify the parameters to be taken into account, the work team spent time on the Quebec oil flow diagram. This involved identifying the supplies of virgin oil in Quebec, the oil's use, and the production of used oil until its final disposal (referred to as end-of-life).

Figure 2 shows the virgin and used oil flows and the data required.

Figure 2 – Oil flows before and after use



The oil actually used in Quebec is equal to: Oil marketed (A) + Oil in vehicles, machinery and products sold in Quebec (B) – Oil in the vehicles or machinery sold outside Quebec (C).

Table 13 illustrates the potential sources of data for quantifying the various parameters.

Table 13 – Description of the blocks in the oil flow diagram, and preliminary identification of data sources

BLOCK	PARAMETER DESCRIPTION	REQUIRED DATA	POTENTIAL DATA SOURCE	DATA COLLECTION METHOD
A	Oil marketed in Quebec	Sales data	RECYC-QUÉBEC	Report from SOGHU and the 4 non-member companies
B	Oil in vehicles, machinery and products sold in Quebec	Number of vehicles involved, technical ratios	SAAQ AMVOQ, manufacturers	Statistics Interviews
C	Oil in vehicles, machinery and products sold outside Quebec	Number of vehicles involved, technical ratios	SAAQ AMVOQ, manufacturers	Statistics Interviews
D	Oil added during oil changes	Volume of virgin oil added during oil changes	Measurements taken during oil changes; annual consumer data	Physical sampling Interviews
E	Oil added for top-ups	Volume of virgin oil added between oil changes	User statements, annual consumer data	Survey
F	Oil losses	Not applicable	Not directly measurable	Not applicable
G	Oil in end-of-life vehicles and machinery	Number of vehicles and machines involved, technical ratios	RECYC-QUÉBEC, ARPAC, automobile recycling companies	Statistics Interviews
H	Oil drained	Volume of oil recovered during oil changes	Measurements taken during oil changes; annual consumer data	Physical sampling Interviews
I	Oil remaining in filters	Volume of used oil in filters	Measurements taken during oil changes; filter recycling companies	Physical sampling Interviews
J	Oil remaining in containers	Volume of virgin oil remaining in containers	Container recycling companies	Interviews

The purpose of this study was not to quantify the used oil not recovered by the program, which was disposed of through other channels, such as landfill, unconventional use not reported to SOGHU (used as boiler fuel, lubricants and wood preservatives) or releases into the environment. These quantities may be assessed in a future study to confirm estimated recoverable amounts.

3.2 DATA ACQUISITION METHODOLOGIES

Three methods were used to obtain data. They are summarized in Table 14:

1. Field surveys: Sampling and weighing during oil changes in garages: each data element obtained corresponded to an oil change.
2. Analysis: study of annual virgin oil consumption and used oil recovery data. The data obtained equaled the sum of all oil changes on all the company’s equipment over a year. To limit bias due to changes in inventory, several years of data was requested if the companies did not have inventory figures for the end of the period.
3. Expert opinions: experience of professionals and data from other studies

Table 14 – Data acquisition methods

PARAMETER	DATA ACQUISITION METHOD		
	Field survey	Analysis	Expert opinions
Oil added during oil changes (D)	Physical sampling	Purchasing data ¹¹	Experience of professionals, other studies
Oil added for top-ups (E)	Operator questionnaire		
Drained oil (H)	Physical sampling	Recovery reports ¹²	

Ideally, it would be interesting to take samples of all types of oil on site at many oil change facilities, in all sectors and regions. This would involve extensive travel and a great deal of time to obtain random results, which would be incompatible with the study’s deadlines and allocated budget.

After checking the data several times, we found that only passenger car motor oil sampled in garages met these criteria. We therefore decided to concentrate on sampling this type of oil. We could not perform this type of sampling for the other oils and sectors, because the number of oil changes per garage was small and unpredictable, and maintenance was not necessarily performed internally. In addition, the data would have been of little use, since the amount of oil added to keep levels topped up was much greater than it was for passenger car motor oil and it was difficult to obtain accurate information on the quantities added. Values measured this way would not be usable. We therefore gathered comprehensive information from companies in the various sectors.

¹¹ We had to subtract any direct sales, which some users (e.g.: garages) may make, from the total purchases.

¹² Any internal uses (burning, lubrication) not included in the recovery data had to be added.

Table 15 presents the data acquisition method for each application: field survey (1), analysis (2) or expert opinions (3).

Table 15 – Data acquisition method used for each application to determine recovery rates for used oil

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	
Automotive	1				2			3		3	
Agriculture		2		2						3	
Construction		2	2	2	2			3		3	
Forestry		2	2	2	2			3		3	
Manufacturing		2	2		2			3	3	3	
Marine								3			3
Mining		2	2	2	2			2			3
Rail							2				3
Trucking		2	3			2			3		3
Utilities		2	3			2			3		3
Other sectors		2	3								

The quantities of used oil identified in the following sections provided us with an idea of each method's relative weight in the results, as shown in Table 16.

Table 16 – Relative weight of each data acquisition method based on quantities of used oil

METHOD	FIELD SURVEY	ANALYSIS	EXPERT OPINIONS
Percentage based on volumes of used oil	45.3%	39.6%	15.1%

3.3 DEFINITION OF RECOVERABLE OIL

Recoverable oil is the sum of:

- ▶ oil in end-of-life vehicles (G);
- ▶ oil changed during maintenance of vehicles and machinery, regardless of their use (H);
- ▶ oil remaining in filters (I);
- ▶ oil remaining in containers (J).

3.4 GENERAL FORMULAS FOR CALCULATING THE RECOVERY RATE FOR USED OIL

Calculating the overall recovery rate for used oil based on oil losses would appear to be the simplest method, but oil losses were continuous and impossible to measure or quantify in reality.

It was therefore necessary to estimate the recovery rate for used oil for each application, which was equal to:

$$(H) / (D+E)$$

H = volume of oil drained, D = volume of oil added during oil changes and E = volume of oil added during top-ups.

Most of the work involved estimating the recovery rate for used oil for each application.

However, there were secondary parameters, presented in the flow diagram, such as the oil in vehicles, machinery and products sold in Quebec (B), oil from end-of-life vehicles (G), oil remaining in containers (J) and the oil remaining in filters (I), which could influence the calculation of the recovery rate for used oil.

The general formula for calculating the overall rate was as follows:

$\frac{\text{Total volume of oil used in the applications} + \text{volume of oil in end-of-life vehicles and machinery (G)} + \text{volume of oil remaining in containers (J)} + \text{volume of oil remaining in filters (I)}}{\text{Total volume of oil marketed (A)} - \text{volume of oil contained in vehicles, machinery and products sold outside of Quebec (C)} + \text{volume of oil in vehicles, machinery and products sold in Quebec (B)}}$

3.5 CALCULATION STEPS

Estimating the recovery rates for used oil was a complex task involving a series of calculations and adjustments.

The procedure involved six steps:

- 1- Data acquisition;
- 2- Determining a sector's overall rate based on the companies' survey data;
- 3- Determining the rates by type of oil based on the companies' survey data when available, and data from the BCUOMA and ADEME studies;
- 4- Adjusting the rates for heavy duty engine oil or hydraulic fluid, in order to meet the sector's overall rate indicated in step 2;

- 5- Determining the rates in certain sectors: automotive and marine;
- 6- Calculating the rates by type of oil and calculating the overall rate.

The details of the procedure are presented in Appendix 3.

4 SAMPLING PLAN DEVELOPMENT AND IMPLEMENTATION

The discussions and consensual decision-making process that led to the development and implementation of the sampling plan can be divided into three main parts:

- ▶ Part 1: Identifying the key variables and deciding how to quantify them.
- ▶ Part 2: Identifying all the parameters that could influence key variables or the mathematical process leading to the recovery rate for used oil.
- ▶ Part 3: Finalizing and implementing the sampling plan.

4.1 DEFINITION AND SAMPLING PARAMETERS FOR TOTAL TOP-UP OIL (D + E) AND DRAINED OIL (H)

4.1.1 Quantification parameters

These parameters varied for each application. We therefore had to find out the total amount of oil added and changed for each application. The recovery rate for used oil for an application “n” was the fraction $H_n / (D_n + E_n)$.

4.1.1.1 *Garage sampling program*

Different information was recorded for each sample. The information was either measurable, estimated or reported. In addition to the parameters directly involved, i.e. information on the quantities of virgin oil added and the quantities of used oil generated, additional information was recorded to characterize and possibly make adjustments to the samples that were measured. This applied to the age of the vehicles.

Measurable values

- ▶ Vehicle make and model
- ▶ Weight of the oil drained, by vehicle
- ▶ Exact volume of oil added during an oil change
- ▶ Weight of the used filter
- ▶ Weight of the new filter
- ▶ Vehicle age (available on the vehicle compliance label)
- ▶ Vehicle kilometrage
- ▶ Kilometrage at last oil change

Estimated or reported values

- ▶ Volume of oil added during top-ups
- ▶ Oil change always performed at the garage or sometimes by oneself
- ▶ Oil pan volume
- ▶ Annual frequency of oil changes
 - average number of kilometres driven annually
 - frequency of oil, changes in kilometres
- ▶ Annual frequency of filter changes
 - average number of kilometres driven annually
 - frequency of filter changes, in kilometres

4.1.1.2 Oil consumer data

The following information was noted during the telephone interviews:

- ▶ Oil changes performed internally or not
- ▶ The amount of virgin oil purchased annually, if possible by type
- ▶ The total quantity of used oil, because we were unable to obtain information on quantities of the various types of oil, since the used oil was all stored in one tank.
- ▶ Type and number of equipment, vehicles and machinery that used oil
- ▶ Average age of equipment
- ▶ Equipment's average oil capacity
- ▶ Maintenance habits: frequency of oil changes
- ▶ Average number of hours or kilometres per year
- ▶ Estimated top-up volumes

We also used this data to estimate how the oil market was segmented by sector in Section 2.3.2.

4.1.2 Data acquisition bias correction

Depending on the method, some items can skew the data and require corrective action. The results are presented in Table 17.

Table 17 – Factors that may bias data

METHOD	POSSIBLE BIAS	CORRECTIVE ACTION
Field surveys	Inaccurate volume measurements	Use a scale to measure weight and convert it to a volume using a 0.89 density factor, which industry members all agree to.
	Measurement errors	Accuracy of the scale. Calibration.
	Oil remaining in filters	Weigh the new and used filters to calculate the oil contained in the used filters.
	Subjective responses regarding top-ups	Cross-check with the annual purchase reports, taking top-ups into account.
Analysis	Presence of contaminants	Ask if the used oil is contaminated with other substances, especially water.
	Consumed in use oil included in purchases	Indicate that they need to be excluded and ask for a detailed list to be sure.
	Purchases not representative of total consumption	Ask if any virgin oil included in purchases has been resold but not used.
		Ask if any other oil purchases are included in those purchases. Ask if the oil changes are performed internally. If not, the purchases are for top-ups.
	Recovery records not representative of the generation of used oil	Ask if there are other internal uses or other uses that have not been reported.
	Inventory changes	Ask for the initial and final inventory report for virgin oil and used oil, and if they are not available, ask for the data over several years to minimize inventory variations.
No separate information on used oil	Request the unit data for oil change frequency.	
Expert opinions	Not representative of the situation in Quebec	To be used as a last resort, when a value could not be established using the two other methods.

4.1.3 Target sample size

To achieve the objective of determining the most accurate possible overall percentage of recoverable oil, we needed to maximize the number of samples in the major segments, since a large margin of error in these segments would decrease the accuracy of the overall result.

4.1.3.1 *Passenger car motor oil*

Since there was no known data on the variability of the recovery rate for used oil, it was not possible *a priori* to determine the sample size needed to achieve a specific margin of error.

To determine the number of samples desired, a table of the accuracy of estimators of a proportion was used to obtain an order of magnitude. This table showed the proportion sought and a number of samples, the accuracy of the results, 19 times out of 20.

In the case of passenger car motor oil, the BCUOMA study produced a 92% recovery rate for used oil. For a rate ranging between 80% and 90%, and a sample of 500 measurements, statistical tests indicated a margin of error of $\pm 3.6\%$.

4.1.3.2 *Other oils*

Given the small field sample size that we could have for the other applications, we focused on telephoning users in the various sectors to acquire annual monitoring data. There was no way of knowing the number of samples required beforehand.

4.2 **OTHER PARAMETERS THAT MAY AFFECT THE CALCULATION OF THE RECOVERY RATE FOR USED OIL**

4.2.1 **Oil in vehicles, machinery and products marketed in Quebec (B)**

4.2.1.1 *Definition*

Oil in vehicles, machinery and products sold in Quebec.

4.2.1.2 *Quantification parameters*

SOGHU and the four non-members did not quantify this oil.

We were looking for the number of new vehicles, equipment and machinery sold in Quebec and the net number of used vehicles, equipment and machines sold in Quebec and the average volumes for the various types of oil and the various types of vehicles or equipment.

The data came from the statistics reported by SAAQ and Statistics Canada, who track new vehicles, machinery and products sold, as well as the net balance of imported used vehicles, machinery and products sold in Quebec. We also used the “Chevron 2010 Professional Installer Lubrication Recommendation Guide” to estimate average volumes for the various types of oil and the various types of vehicles or equipment.

4.2.2 **Oil contained in new vehicles, machinery and products sold outside Quebec (C)**

4.2.2.1 *Definition*

Oil contained in new vehicles, machinery and products sold outside Quebec.

4.2.2.2 *Quantification parameters*

SOGHU and the four non-members did not report any data on these types of oil. As a result, they were not included in the oil volumes marketed in Quebec published by RECYC-QUÉBEC. However, they were included in the Lubricants Profile database because they were purchased in Quebec.

We estimated the number of vehicles involved by contacting some of the manufacturers. We then used the average volumes for the vehicles that had been evaluated to estimate the oil from the imported vehicles and machinery described in Section 4.2.1.

4.2.3 **Oil remaining in containers (J)**

4.2.3.1 *Definition*

Oil remaining in containers is defined as the small quantity of virgin oil remaining in containers after they have been emptied.

4.2.3.2 *Quantification parameters*

Sales by type of packaging

SOGHU had statistics on the number of containers with less than a 20-litre capacity, subject to the program. Data on 60- and 205-litre containers and bulk oil throughout Canada was available in the Lubricants Profile.

Quantity of oil remaining by type of packaging

Companies that recycled containers with less than a 20-litre capacity had data on the quantity of oil recovered when the containers were compressed and recycled.

The 205-litre containers were often reconditioned. Specialized companies also had data on the quantity of oil remaining in this type of container.

4.2.4 **Oil in end-of-life vehicles and machinery (G)**

4.2.4.1 *Definition*

The recycling of end-of-life vehicles and machinery includes a decontamination process. The oil contained in the wrecks is recovered during this process.

4.2.4.2 *Quantification parameters*

We used statistics from the SAAQ and professional associations to estimate the number of used vehicles and machines sent to the scrapyard and decontaminated every year. We also used data from recyclers that engaged in good environmental practices to estimate average volumes of oil from the various types of vehicles or machinery that were decontaminated.

4.2.5 Oil in filters (I)

4.2.5.1 Definition

Some oil remains in filters during oil changes. It is released when the filters are compressed and recycled.

4.2.5.2 Quantification parameters

Recyclers monitored the tonnage of the filters that they received and the quantity of oil extracted. They estimated that used oil accounted for 32.9% of the total weight of filters, including the used oil remaining in the filters they collected.

4.3 Sampling plan implementation

4.3.1 Sampling passenger car motor oil in garages

4.3.1.1 Planning and implementation

Selection of garages

The first step in organizing an oil sampling program involved finding partners interested in collaborating in the study. We agreed to find partners that owned many outlets in order to spend less time on solicitation and to optimize sampling. With SOGHU's, five major companies agreed to participate:

- ▶ two new cars dealer through their Toyota and GM dealership network;
- ▶ two mechanical maintenance companies, Carquest and Mr Muffler;
- ▶ an oil change company, Mr Lube.

As mentioned in Section 4.1.3.1, it was estimated that a total of 500 oil changes would be needed to obtain a margin of error $\pm 3.6\%$. To ensure geographical diversity, it was agreed that 18 municipalities would be randomly selected in the province of Quebec, in proportion to the population, and information would be gathered on about 30 oil changes in each municipality.

In addition, to ensure the representativeness of the Quebec car fleet, it was agreed that different brands of cars of all ages would be sampled. Dealers therefore targeted newer (Japanese and American) cars while mechanical maintenance garages targeted older cars of all brands.

Sampling logistics

After the municipalities were selected, the garages to be sampled were selected among the companies' various outlets. Subsequently, each service manager was contacted to schedule the sampling day. For most companies, the head office contacted the managers involved to tell them about the study and ask them for their cooperation.

Before the first appointment, Dessau-NI visited a Toyota dealership garage to validate the methodology that had been developed beforehand. This step helped to enhance the methodology and made it more effective.

On site, the Dessau-NI technician weighed the drained oil, and recorded the amount of new oil added. The work proceeded as follows:

- ▶ Firstly, the container used to collect the drained oil was weighed to determine the tare weight. The mechanic removed the drain plug from the oil pan and the drained oil was collected in the container. The container was weighed and the weight was recorded. The difference between empty and full weight indicated the quantity of oil removed from the oil pan.
- ▶ The oil was then poured back into the used oil barrel and the empty container was weighed for the next sample. The technician also recorded the weight of the used and new oil filters, and how the used filter was disposed of. For example, he noted whether the mechanic emptied the excess oil from the filter into the used oil barrel.
- ▶ The owners of the vehicles being sampled were asked questions about the vehicle (model, year, kilometrage) and their oil change habits. The questions covered oil top-ups and the distance travelled since last oil change and the percentage of oil changes performed by the owner.

The data gathered in the data collection form was then re-entered in a spreadsheet for further analysis.

4.3.1.2 *Sampling plan results*

The number of samples per garage was lower than expected, since between 12 and 13 oil changes were sampled per the garage, which took several visits. In all, 21 garages were sampled and a total of 270 samples of passenger car motor oil changes were taken. However the $\pm 1.7\%$ margin of error that we obtained was better than expected.

Only two transmission oil changes and four heavy duty engine oil changes were sampled. This confirmed the difficulties anticipated for the other types of oil.

Vehicle age could influence the results. We therefore recorded it when the data was being collected. Table 18 compares the characteristics of our sample with those of the car fleet, which were based on SAAQ statistics.

Table 18 – Age classes in the sample versus those in the Quebec car fleet

AGE	DESSAU-NI SAMPLE	SAAQ – CAR FLEET
2 years old or less	38.5%	27.7%
3 – 5 years old	25.2%	21.3%
6 – 8 years old	21.1%	20.8%
9 years old or more	15.2%	30.2%

The results will therefore be prorated according to the breakdown of the SAAQ car fleet.

All the details of the sample are presented in Appendix 4.

4.3.2 Sampling heavy duty motor oil in garages

The method used to sample heavy duty engine oil in the trucking industry involved targeting some major players and sample their fleet of trucks.

However, it was very difficult to find companies that performed many oil changes per day. A total of four companies were sampled and a total of nine samples were taken. In addition, the participants were unable to provide information on oil top-up quantities between oil changes. This data was not usable. This confirmed the difficulties that we had anticipated.

4.3.3 Telephone interviews with oil users

To overcome this difficulty, we contacted about 560 companies from all sectors. However, it was difficult to obtain data because the participants did not have time or the data was not available.

Table 19 presents the results.

Table 19 – Data collected from companies by sector

	NUMBER OF COMPANIES CONTACTED	NUMBER OF QUESTIONNAIRES RETURNED	NUMBER OF USABLE QUESTIONNAIRES	VOLUME OF VIRGIN OIL CONSUMED (IN LITRES)	SECTOR PERCENTAGE
Agriculture	52	7	6	7,351	0.11%
Construction	124	12	9	444,652	4.82%
Forestry	70	3	3	48,623	0.93%
Manufacturing	44	12	6	318,565	3.00%
Marine	67	4	0	-	-
Mining	26	6	6	2,075,066	35.86%
Rail	30	3	2	1,020,583	35.38%
Trucking	72	22	16	881,190	5.63%
Utilities	74	33	23	852,623	25.51%
Other sectors	Not surveyed	Not surveyed	-	-	-
TOTAL	559	102	71	5,648,653	5.0%

We had to telephone the participants repeatedly. The final response rate was about 18%. In all, the quantities of virgin oil marketed by the companies surveyed represented more than 5% of the oil marketed.

5 DATA ACQUISITION RESULTS

5.1 GARAGE SAMPLING PROGRAM

The average rate for passenger car motor oil was 86.4%, but vehicle age and kilometrage had to be taken into account, so we calculated a weighted average rate, which is presented in Table 20.

Table 20 – Weighted rate calculation for passenger car motor oil

AGE	NI-DESSAU SAMPLE		NUMBER		KM TRAVELLED		
	AVERAGE RATE	MARGIN OF ERROR	NUMBER ¹³	%	AVERAGE KM PER YEAR ¹⁴	TOTAL KM	%
2 years old or less	90.1%	±2.0%	1,285,903	27.7%	21,635	27,820,948,282	33.7%
3 – 5 years old	87.6%	±2.6%	986,937	21.3%	17,414	17,186,366,021	20.8%
6 – 8 years old	82.6%	±4.3%	962,579	20.8%	18,023	17,348,493,773	21.0%
9 years old or more	80.3%	±5.9%	1,402,537	30.2%	14,484	20,314,364,037	24.6%
RATE	86.4%	±1.7%	85.1%		85.6%		

Given the margin of error, the difference attributable to the method was not significant. We therefore agreed to use the rate based on the breakdown by number (85.1%), which had the advantage of involving fewer calculations and values, and therefore being more reliable. It should be noted that the newer vehicles travelled greater distances and therefore used more oil.

¹³ SAAQ, 2009

¹⁴ Sample averages

5.2 BUSINESS SURVEY

Because all types of oil were mixed together in the storage tank before it was collected by the oil recycler, we conducted interviews with the companies to calculate the overall rate of used oil per company. We then calculated the average rate. The results are presented in Table 21.

Table 21 – Overall recovery rate for used oil by sector

	PERCENTAGE OF RECOVERABLE USED OIL	ACCURACY	BCUOMA STUDY'S RATE FOR BRITISH COLUMBIA ¹⁵
Agriculture	77.7%	±13.1%	78.1%
Construction	66.5%	±13.7%	73.6%
Forestry	44.3%	±27.3%	64.8%
Manufacturing	80.1%	±11.3%	N/A
Marine	N/A	-	40.6%
Mining	55.0%	±10.1%	67.1%
Rail	36.7%	±48.5%	34.8%
Trucking	72.2%	±5.3%	84.0%
Utilities	76.6%	±7.4%	63.8%
Other sectors	Not surveyed	-	79.5%
Average values	70.4%	±4.5%	-

The overall accuracy was 4.5%, and the trucking industry had an acceptable accuracy of about 5%. The accuracy for the other sectors was about 10%. However, we must keep in mind that these values represented a significant number of oil changes, estimated at more than 161,000¹⁶, and were therefore already averages that accounted for variability.

Three sectors were problematic:

- ▶ The forestry sector had a significant margin of error;
- ▶ The marine sector, for which we were unable to obtain comprehensive data to calculate a rate;
- ▶ Regarding the rail sector, the number of firms that responded was low, but at least one represented nearly half of sales. Given this parameter, the margin of error was certainly better than the statistical calculation.

¹⁵ Weighted average quantities, calculated from the rates by type of oil and sector

¹⁶ By dividing the total volume of oil (113,799,566 litres) minus the volume for cars (44,520,911 litres) by 35 litres per average oil change

5.3 ESTIMATED RATES FOR EACH APPLICATION

We used the overall rate for each sector to calculate a rate by type of oil for each sector. We used some rates from the BCUOMA and ADEME studies and adjusted the rates for hydraulic fluid or heavy duty engine oil to match the overall rate of the sector for which the rate was being calculated. The entire process leading to the estimated rate per application is described in Appendix 3.

Table 22 includes all the data on the rates and presents an overall rate of 73.5% of recoverable used oil.

Table 22 – Recovery rate for used oil by type of oil and sector

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	OVERALL RATE	
Automotive	85.1%				78.1%			80.0%		95.0%	84.8%	
Agriculture		71.8%		81.0%						90.0%	77.7%	
Construction		59.0%	67.0%	81.0%	75.5%			80.0%		90.0%	66.5%	
Forestry		43.0%	29.9%	81.0%	75.5%			80.0%		80.0%	44.3%	
Manufacturing		59.0%	67.1%		78.1%			80.0%	90%	90.0%	80.1%	
Marine								40.0%				40.0%
Mining		55.5%	36.2%	81.0%	75.5%			91.2%		80.0%	55.0%	
Rail							36.7%					36.7%
Trucking		71.6%	70.0%		77.6%			80.0%		80.0%	72.2%	
Utilities		78.0%	70.0%		77.6%			80.0%		80.0%	76.6%	
Other sectors		64.2%	70.0%									69.6%
OVERALL		85.1%	66.9%	56.4%	81.0%	77.1%	36.7%	40.0%	81.0%	90.0%	88.9%	73.5%

We multiplied the total quantity of oil sold (113,799,566 litres) calculated in Table 8 by the 73.5% rate in Table 22 and obtained a total volume of 83,672,792 litres of recoverable used oil.

However, several additional parameters had to be considered. They are presented in the following sections.

5.4 OIL IN VEHICLES, MACHINERY AND PRODUCTS SOLD IN QUEBEC (B)

These volumes of oil are currently not taken into account, but still represent nearly 8% of the oil marketed in Quebec.

Table 23 summarizes the data and results.

Table 23 – Estimated quantity of oil (in litres) in imported vehicles or machines marketed in Quebec

	CARS	TRUCKS AND BUSES	MACHINERY
Vehicles and machinery			
New units sold in Quebec	411,421 ¹⁷	11,877 ¹⁸	27,931 ¹⁸
Imported used units sold in Quebec	58,784 ¹⁹	3,404 ¹⁹	N/A
Imported used units sold outside Quebec	35,968 ¹⁹	2,135 ¹⁹	N/A
NET TOTAL	434,238	13,146	27,931
Oil ratios			
Volume of oil by unit (l)	13 ²⁰	67 ²⁰	84 ²¹
Total volume of oil	5,645,092	880,804	2,346,204
GRAND TOTAL		8,872,101	

5.5 OIL IN NEW VEHICLES, MACHINERY AND PRODUCTS SOLD OUTSIDE QUEBEC (C)

There are many truck assembly plants in Quebec, but the trucks are already filled with oil when they are assembled. The original manufacturers, who manufacture trucks and buses, put the oil in the trucks, but few of these manufacturers operate in Quebec. We contacted these manufacturers and found that approximately 6,000 vehicles per year were made in Canada, but sold outside Quebec. However, this figure fluctuated significantly every year depending on the economic situation.

We used a ratio of 67 litres per vehicle to estimate this flow at about 402,000 litres of oil purchased on the Quebec market, which is less than 0.4% of oil sales.

Since this was such a small percentage, we decided not to include this value in the calculation of the overall rate. We therefore considered that all the oil marketed in Quebec was used in Quebec.

5.6 OIL REMAINING IN CONTAINERS (J)

We estimated the quantity of oil remaining in containers after use, as shown in Table 24.

To simplify the process, the ratios obtained for containers with a capacity of less than 20 litres were applied to 250- and 60-litre containers.

¹⁷ Statcan, 2005–2009 average

¹⁸ SAAQ, average for 1 year age class 2005–2008

¹⁹ Statcan, 2004–2009 average

²⁰ Average estimated using data from the Chevron 2010 Professional Installer – Lubrication Recommendation Guide

²¹ 80% of trucks and buses + 30 l of hydraulic fluid (orders of magnitude, arbitrarily set for evaluation purposes)

Table 24 – Estimated quantity of oil (in litres) remaining in containers after use

	CONTAINERS <20 L	205 L – 60 L	BULK	TOTAL
Types of oil marketed (in l) ²²	40,547,077	12,218,084	52,748,418	105,513,579
Weight of container per litre of capacity	0.051	0.051	-	-
Containers marketed (kg)	2,080,384	626,884	-	2,729,426
Volume of oil remaining (l) per kg of container ²³	0.109	0.109	-	0.109
Remaining oil (l)	227,027	68,410	-	295,437
Percentage of recoverable oil remaining in the containers	0.56%	0.56%	-	0.28%

The percentage of oil from all oil sales remaining in containers is approximately 0.28%, which is well below the margin of error. We therefore decided not to take this amount into account.

5.7 OIL IN END-OF-LIFE VEHICLES AND MACHINERY (G)

We contacted several auto recyclers and obtained data on nearly 32,000 processed vehicles. The average volume of oil per car was 8.9 litres. We compared this ratio to that of new cars in Section 5.4, and found that the percentage of recoverable oil was 68.5%.

We then extrapolated this figure to other categories, in proportion to the average for passenger car motor oil (85.1%) and heavy duty engine oil used in the road transportation industry (71.3%) for trucks and buses, and in the construction industry (59%) for machinery.

²² Breakdown based on SOGHU 2008 and Lubricants Profile Packaging 2004

²³ Average data from container recyclers

Table 25 summarizes the data and results.

Table 25 – Estimated quantity of oil contained in end-of-life vehicles and machinery

2008	CARS	TRUCKS – BUSES	MACHINERY
Decontaminated units	473,176 ²⁴	11,877 ²⁵	27,931 ²⁵
Volume of oil by unit (l)	8.9	38.5	39.9
Volume of oil by new unit (l) ²⁶	13	67	84
Percentage of recoverable oil	68.5%	57.4% ²⁷	47.5% ²⁸
Total volume of oil (l)	4,216,626	457,026	1,115,032
Grand total (l)	5,788,684		

This represented almost 7% of the amount of recoverable oil²⁹.

These volumes will have to be added to the volumes calculated from the rate per application to obtain the overall percentage of recoverable oil in Quebec.

5.8 OIL IN FILTERS (I)

We used data from SOGHU and recyclers to estimate the quantities involved, which are summarized in Table 26.

Table 26 – Estimated quantity of recoverable oil remaining in used filters

2008	FILTERS <203 MM	FILTERS ≥ 203 MM	TOTAL
Filters on the market (units)	8,599,104	681,117	9,280,221
Filters on the market (kg)	2,707,600	756,401	3,464,001
Percentage of oil remaining in used filters	32.9%	32.9%	32.9%
Recoverable used oil (kg)	1,327,571	370,873	1,698,445
Recoverable used oil (l)	1,491,653	416,711	1,908,365

²⁴ RECYC-QUÉBEC and ISQ

²⁵ Number of vehicles and machinery on the market. Given that the fleet is stable, the number of vehicle scrapped was nearly identical.

²⁶ Section 5.4 estimates

²⁷ Extrapolation of value for automobiles in proportion to the average rate of heavy duty engine oil used in the road transportation industry

²⁸ Extrapolation of value for automobiles in proportion to the average rate of heavy duty engine oil used in the construction industry

²⁹ 83,672,792 litres – Section 5.3

The total quantity of oil represented more than 2% of the amount of recoverable oil³⁰. However, the rate obtained for passenger car motor oil already took into account the oil remaining in the filters. The quantities from filters greater 203 mm accounted for less than 0.5% of the amount of recoverable oil. We agreed to consider this volume to be insignificant.

6 CALCULATION OF THE PERCENTAGE OF RECOVERABLE OIL

6.1 PERCENTAGE CALCULATION

We compared the percentage of recoverable oil for each application to the sales breakdown and obtained a total quantity of recoverable used oil from vehicle and machinery maintenance operations.

Based on the data obtained, the formula presented in Section 3.4 can be adjusted as follows:

$$\frac{\text{Volume of used oil for each application} + \text{volume of oil in end-of-life vehicles and machinery}}{\text{Total volume of oil marketed} + \text{volume of oil in vehicles, machinery and products sold in Quebec}}$$

Table 27 presents the results of the calculation and the overall percentage of theoretically recoverable oil, i.e., the percentage which takes into account all oil entering Quebec.

Table 27 – Calculation of the overall percentage of recoverable oil based on the total volume of oil marketed in Quebec

2008 VALUES	VOLUME (L)
Virgin oil marketed in Quebec	113,799,566
Virgin oil contained in vehicles, machinery and products marketed in Quebec	8,872,101
Oil used in the applications	83,672,792
Used oil in end-of-life vehicles and machinery	5,788,684
OVERALL RATE	72.9%

The quantity of recoverable used oil was estimated at 89,461,476 litres in 2008.

³⁰ 83,672,792 litres – Section 5.3

6.2 DISCUSSION

6.2.1 Accuracy of the result and sensitive parameters

The study results were based on rigorous methodology and a similar approach used in two previous studies. Readers will be able to assess the accuracy of each variable quantified in the study. We systematically focused on parameters that had the greatest impact on the final result to ensure that it reflected reality as closely as possible.

To identify sensitive parameters, i.e. those that had greater influence on the result, the various basic values used to calculate the results were changed at the extremes of the confidence intervals. The variation in the percentage of recoverable oil can be used to determine which variables should be examined in future studies. Appendix describes the tests and presents the results.

In summary, some parameters showed significant sensitivity when the margin of error for each segment was applied to the result of that segment. A parameter was considered sensitive if it caused the percentage of recoverable oil to change by more than 5%.

1- *Sales breakdown*

Maximum variation of the overall rate was $\pm 0.1\%$, therefore no significant impact on the result.

2- *Percentage of recoverable passenger car motor oil*

Maximum variation of the overall rate was $\pm 1.8\%$, therefore no significant impact on the result.

3- *Percentage of recoverable oil for the various sectors*

Maximum variation of the overall rate was $\pm 9.2\%$, therefore significant impact on the result.

4- *Volume of used oil from end-of-life vehicles and machinery*

Maximum variation of the overall rate was $\pm 1.3\%$, therefore no significant impact on the result.

5- *Volume of virgin oil in vehicles, machinery and products marketed in Quebec*

Maximum variation of the overall rate was $\pm 1.5\%$, therefore no significant impact on the result.

7 RECOMMENDATIONS CONCERNING USE OF THE RATES AND FREQUENCY OF UPDATES

DESSAU-NI makes a few recommendations herein that ultimately seek to increase the accuracy of the percentage of recoverable oil in Quebec.

Keep collecting data to improve accuracy

Collecting sufficient quantities of high quality of data was the most challenging aspect of this study. For the most part, we overcame these difficulties and achieved our objectives. In particular, the major industries and types of oil, such as the trucking and utilities industries and passenger car motor oil, were well sampled to achieve an absolute error margin of about $\pm 5\%$ or less, or slightly higher for utilities.

However, we could not obtain usable data for certain sectors or types of oil or we did not obtain enough data to achieve a satisfactory margin of error. These sectors were forestry, the marine sector and rail transportation. It was very difficult to obtain data for the marine and forestry sectors. We would need the cooperation of members of these sectors to conduct more in-depth studies. It would also be helpful to obtain responses from two more major consumers and some small consumers in the rail sector.

Midway between these two extremes, the margins of error for the farming, construction, manufacturing and mining industries were about $\pm 12\%$. Additional sampling would reduce the margin of error. In particular, the manufacturing sector includes a very wide range of activities. It might be helpful to separate them: the iron and steel, lumber, chemical, cement, metalworking, paper industries.

It would be interesting to keep collecting reliable, representative data in these sectors order to increase sample size and accuracy.

Monitoring oil users in various in various sectors

This would involve monitoring a group of users over several years to collect additional accurate data and document trends in certain parameters. This type of approach would enable us to gather information on every aspect of *oil consumption and disposal habits* in certain sectors.

In particular, we are thinking about diffuse sectors such as the agricultural and automotive sectors. But it would be interesting to study the feasibility of monitoring representatives from various sectors, and ask the users for their cooperation. We could monitor data on top-ups, oil changes and vehicle characteristics, for example.

Estimating quantities of used oils, by disposal method

The oil flow diagram clearly indicates that there are various methods of oil disposal: oil is recovered and upgraded under the program, but it is also disposed of in landfill sites or used in unconventional ways that are not reported to SOGHU (boiler fuel, lubricants, wood preservatives, etc.). These quantities may be assessed in a future study to confirm estimated recoverable amounts.

Updating the overall recovery rate for used oil

To ensure that we are always using the most current possible recovery rate for used oil, it is recommended that the rate be recalculated every year as a function of annual sales data, based on rates by types of oil and number of decontaminated used vehicles in Quebec.

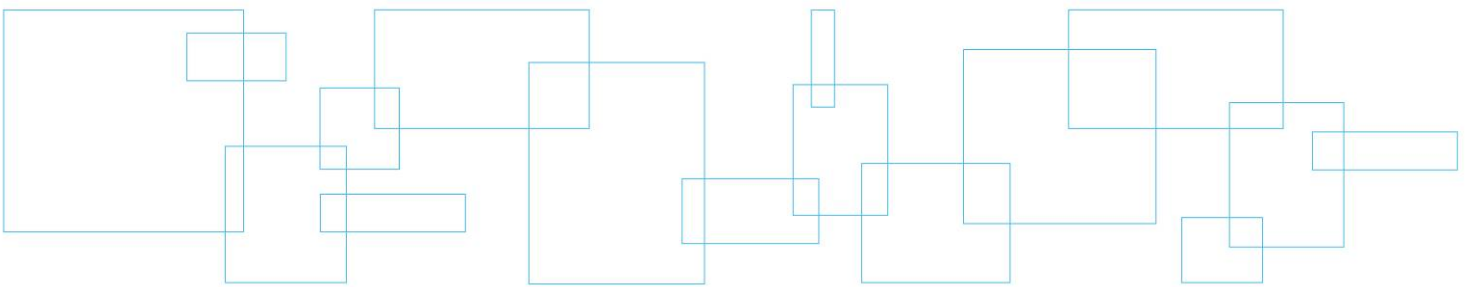
Sales segmentation and rates for each application to be reviewed every five years

There will be some changes in the coming years, such as:

- ▶ Changes in maintenance behaviour and the dissemination of good environmental practices;
- ▶ Technological developments leading to the production of mechanical equipment that uses significantly less oil, and the introduction of higher performance oil;
- ▶ The advent of technological breakthroughs initially involving hybrid vehicles, followed by electric vehicles, which will gradually become more popular and change the type of oil consumed and the rate of oil consumed in use.

To take these developments into account, it is recommended that sales segmentation and rates for each application be reviewed every five years.

Appendix 1
Oil sales



APPENDIX 1: OIL SALES DETAILS

The table below shows 2008 oil sales in Quebec and British Columbia.

Table 1 – 2008 oil sales – 1,000s of litres (Lubricants Profile)

TYPE OF OIL	QUEBEC	BC
Passenger car motor oil	43,250	21,749
Automatic transmission fluid	4,403	3,684
Differential gear oil	2,684	1,867
Two-stroke motor oil	775	280
Heavy duty engine oil	25,438	20,983
Other automobile oil	758	43
Natural gas sector	114	4,763
Aviation sector	79	76
Rail sector	2,802	2,764
Marine sector	5,350	2,034
Hydraulic fluid	13,964	14,237
Tractor hydraulic fluid	5,523	5,254
Circulating oil	1,035	1,125
Industrial gear oil	2,588	2,104
Metalworking fluid	962	90
Rustproofing oil	31	10
Compressor oil	513	1,627
Saw guide oil	155	2,121
Paper machine oil (paper mills)	1,281	888
Chain saw oil	1,813	955
Oil for pneumatic drills and tools	373	325
Grease	1,755	2,389
Other industrial oils	769	1,122
Process oil	13,535	3,749
TOTAL	129,950	94,239

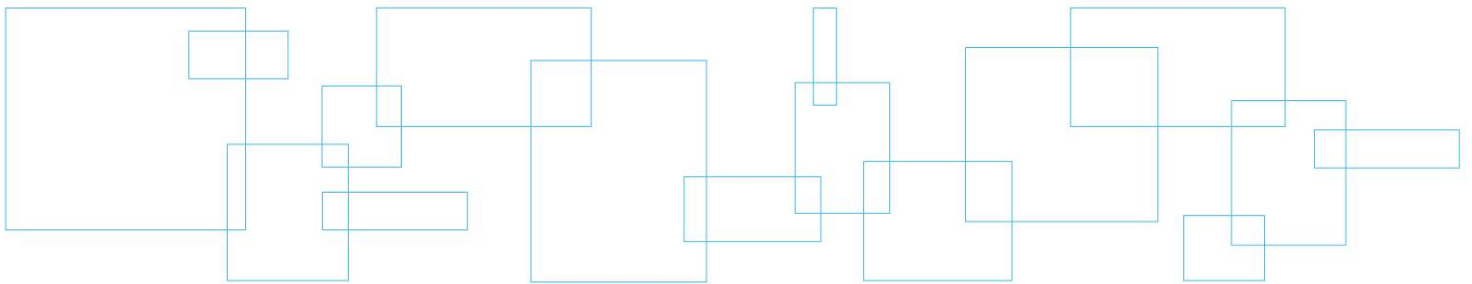
However, this table includes consumed in use oil which does not produce used oil, such as: two-stroke engine oil, metalworking fluid, rustproofing oil, saw guide oil, chain saw oil, oil for pneumatic drills and tools, grease, and process oil.

The table below compares the sales of oil not consumed in use in Quebec and British Columbia.

Table 2 – Sales of oil not consumed in use in Quebec and British Columbia in 2008 – 1,000s of litres (Lubricants Profile)

TYPE OF OIL	QUEBEC	B.C.
Passenger car motor oil	43,250	21,749
Automatic transmission fluid	4,403	3,684
Differential gear oil	2,684	1,867
Heavy duty engine oil	25,438	20,983
Other automobile oil	758	43
Natural gas sector	114	4,763
Aviation sector	79	76
Rail sector	2,802	2,764
Marine sector	5,350	2,034
Hydraulic fluid	13,964	14,237
Tractor hydraulic fluid	5,523	5,254
Circulating oil	1,035	1,125
Industrial gear oil	2,588	2,104
Compressor oil	513	1,627
Paper machine oil (paper mills)	1,281	888
Other industrial oils	769	1,122
TOTAL	110,551	84,320

Appendix 2
Detailed approach leading
to segmentation



APPENDIX 2 – ESTIMATING OIL SALES BREAKDOWN

Although the sales data was listed by types of oil, there was no information on sales by sector. Very many players were involved in oil sales, as was the case with the more than 250 members who belonged to SOGHU. Since major producers sold to major consumers or intermediaries who each had their specialty, it was very difficult to track oil sales by sector.

However, the calculation process used in this study involved distinguishing recovery rates for used oil by sector.

Estimating sales segmentation was a complex task involving a series of calculations and adjustments.

The process involved 11 steps:

- 12- Selecting the applications;
- 13- Summary classification of the oils used by one sector;
- 14- Estimating oil consumption ratios for each type of oil, per unit depending on the sectors: per machine, per company, per capita, etc.;
- 15- Determining total values for each parameter;
- 16- Extrapolating the unit values by multiplying them by the total units for the sector;
- 17- Determining the quantities by sector using the British Columbia data presented in the Spence study, based on GDP;
- 18- Adjusting the results of the extrapolation of field data based GDP values;
- 19- Determining segmentation in the “tractor hydraulic fluid” category;
- 20- Determining segmentation in the “transmission oil” and “differential gear oil” categories;
- 21- Determining segmentation in the “other oils” category;
- 22- Applying the final results to the total published by RECYC-QUÉBEC.

The following sections provide a detailed explanation of the procedure.

1 - Selecting the applications;

The BCUOMA study was one of the few studies on determining the recovery rate for used oil. It was also the most recent study and the only one conducted in Canada. It was based on surveys of major vendors, which could not be conducted in Quebec, because there were more intermediaries in the Quebec market. Given these factors, we used the segmentation presented in the BCUOMA study and adapted it to the Quebec context, based on Quebec's economic data and data from oil user surveys.

The following adjustments were made:

- ▶ The manufacturing sector was added because of its importance in Quebec. Conversely, the oil and gas industry was placed in the “other sectors” category;
- ▶ Because of the very small quantities involved, the “oil used in the natural gas industry” was placed in the “other oils” category. However, we created specific categories for “differential gear oil” and “industrial gear oil”;
- ▶ Some simplifications were made where no data was available and to streamline the study, but small amounts of oil were involved in these cases. The “marine” and “rail” sectors consumed other types of oil, such as heavy-duty motor oil or hydraulic fluid, but we did not select these applications. The “agricultural” sector also probably consumed hydraulic fluid, transmission fluid or differential gear oil, but we considered all these types of oil to be tractor hydraulic fluid.
- ▶ We expanded hydraulic fluid sales in the trucking and utilities sectors, “tractor hydraulic fluid” sales in the construction, forestry and mining sectors, but we removed hydraulic fluid from the “other sectors.” Similarly, we expanded sales of “automatic transmission fluid” sales in the manufacturing, mining, trucking and utilities sectors and the “other sectors”;
- ▶ Many sectors used passenger car motor oil, but in order to simplify the study, we agreed to group all passenger car motor in the automotive sector. The BCUOMA study demonstrated that there was no difference in the results for these sectors, and the data obtained from the various companies that were surveyed excluded automobiles, either because the maintenance was conducted at another location or the amount of oil involved in their maintenance had been subtracted.

We are proposing the segmentation presented in table below. The data for an application is to be entered in the white boxes. The volume of oil sold and the percentage of recoverable used oil will have to be determined for each of the 46 applications.

Table 1 – Various proposed applications

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS*
Automotive										
Agriculture										
Construction										
Forestry										
Manufacturing										
Marine										
Mining										
Rail										
Trucking										
Utilities										
Other sectors†										

2 - Summary classification of the oils used by one sector

Some oils were used only in one sector, such locomotive engine oil, marine engine oil, oil used in the natural gas industry, aviation oil and paper machine oil. To make things simpler, we also assumed that gear oil and circulating oil were also used exclusively in the manufacturing sector.

* Other motor oils, natural gas sector, aviation sector, circulating oil, compressor oil, paper machine oil, other industrial oils

† Aviation, oil and gas drilling and coal mining, all services, trade

Table 2 – Distribution single-sector oils

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS*
Automotive	100 %									Details shown in the following table
Agriculture										
Construction										
Forestry										
Manufacturing									100 %	
Marine								100 %		
Mining										
Rail							100 %			
Trucking										
Utilities										
Other sectors										

Table 3 – Detailed information on the “other oils” category

	OTHER AUTOMOBILES	NATURAL GAS	AVIATION OIL	CIRCULATING OIL	COMPRESSOR OIL	PAPER MACHINE OIL	OTHER INDUSTRIAL OILS	TOTAL
Automotive								
Agriculture								
Construction								
Forestry								
Manufacturing				100 %		100 %		
Marine								
Mining								
Rail								
Trucking								
Utilities								
Other sectors		100 %	100 %					

* Other motor oils, Natural gas sector, Aviation sector, Circulating oil, Compressor oil, Paper machine oil, Other industrial oils

3 – Estimated oil consumption ratios

Using data acquired from oil consumers in all sectors, we evaluated annual consumption ratios per specific unit for several types of oil and for each sector, shown in Table below.

Table 4 – Oil consumption ratios (in litres per year per unit)

	UNITS	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	DIFFERENTIAL GEAR OIL
Agriculture	Tractors	38.73		57.67		
Construction	Machinery	97.71	69.68	0.00	23.21	11.42
Forestry	Machinery	147.80	347.31	3.23	2.44	5.81
Manufacturing	Employees	7.86	21.05		4.36	0.68
Mining	Machinery	1601.02	695.97	0.00	224.93	104.39
Road transportation – trucking	Trucks	133.80	0.00		6.14	4.36
Road transportation – people	Bus	95.98	7.61		9.37	5.48
Utilities	Inhabitants	0.2851	0.0809		0.0387	0.0182

4 – Determining total values for each parameter

To estimate the total amount of oil per application, we needed to determine the total values per parameter for each sector. The table below shows the values that were selected.

Table 5 – Total value of the parameters

SECTORS	UNITS	TOTAL VALUE	SOURCE
Agriculture	Number of tractors	70,874	SAAQ, 2009
Construction	Number of machines	32,108	Calculation details shown below
Forestry	Number of machines	4,875	Avenir Québec 2007*
Manufacturing	Number of employees	124,217	Statistics Canada 2008†
Mining	Number of machines	2,369	Calculation details shown below
Road transportation – trucking	Number of trucks	101,193	Calculation details shown below
Road transportation – people	Number of buses	17,744	SAAQ, 2008
Utilities	Population	7,546,131	ISQ, 2006

Some values required an additional calculation, such as the number of machines in the construction and mining industries and the number of trucks.

To estimate the number of machines in the construction industry, the ratio—the number of machines per hour reported—taken from the industry survey was multiplied by the total number of hours of civil engineering (23,527,000 hours) reported to the Quebec Construction Commission in 2007, which accounted for the vast majority of oil-consuming machinery.

The number of machines in the mining industry was estimated by multiplying the average number of machines per mine, taken from the industry survey by the total number of mines in Quebec (36, Mining Association of Canada, 2009).

Finally, the number of trucks used in the trucking industry was estimated as follows: we subtracted the number of trucks being assembled (13,549, value calculated by extrapolating data from the companies surveyed) and the number of trucks operated by utilities (4,784, value calculated by extrapolating data from the municipalities and companies surveyed) from the total number of licenced trucks (119,526 – SAAQ, 2008).

* Avenir Québec 2007 estimated that there were 6,500 of the following types of jobs: 8241 – Mining machine operators (3,300) and 8421 – Chain saw and skidder operators (3,200). We selected 75% of the jobs to estimate the number of machines.

† Only heavy industry: Wood product manufacturing [321] Paper production [322] Petroleum and coal production [324] Plastic and rubber product manufacturing [326] Nonmetallic mineral product manufacturing [327] Primary metal production [331] Metal product manufacturing [332]

All trucks in other industries such as the manufacturing industry were included in the road transportation industry. There was no data on the use of trucks in the oil consumption statistics provided in the manufacturing company surveys.

5 – Extrapolating the unit values by multiplying them by the total units for the sector;

Table 6 – Extrapolated oil consumption figures (in thousands of litres per year)

	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	DIFFERENTIAL GEAR OIL
Agriculture	2,745		4,087		
Construction	3,137	2,237	0	745	367
Forestry	721	1,693	16	12	28
Manufacturing	976	2,615		542	84
Mining	3,793	1,649	0	533	247
Road transportation – freight	13,539	0		621	442
Road transportation – people	1,703	135		166	97
Utilities	2,151	611		292	138
TOTAL	28,765	8,940	4,103	2,911	1,403
TOTAL Lubricant Profile 2008	25,438	13,964	5,523	4,403	2,684

The totals differed from those presented in the Lubricant Profile: The quantities of heavy duty engine oil were overestimated; however the quantities of hydraulic fluid, tractor hydraulic fluid, transmission fluid and differential gear oil were underestimated. As a result, some adjustments were needed.

6 – Determining quantities per sector based on British Columbia data

This alternative approach was used to compare and adjust the values obtained for heavy duty engine oil and hydraulic fluid in step 5.

The BCUOMA study presented the volumes of the various types of oil marketed in the various sectors. We extrapolated the volumes of heavy duty engine oil and hydraulic fluid used in British Columbia in proportion to the GDP of both provinces, to estimate quantities for Quebec.

The table below shows the GDP of the various sectors for both provinces.

Table 7 – BC and Quebec GDPs (millions of \$) – Statistics Canada, 2006

SECTORS	BC	QUEBEC
Agriculture	1,162	2,752
Construction	8,432	15,003
Forestry	2,841	1,247
Manufacturing	15,574	48,019
Marine	4,018	5,350
Mining	1,135	2,279
Rail	2,780	2,802
Trucking	2,532	5,130
Utilities	2,842	10,431
Oil and gas	5,160	2
Other sectors	96,915	171,588

The table below presents the extrapolated results for Quebec.

Table 8 –Quantities of oil (1,000s of litres) used in BC extrapolated for Quebec, based on GDPs

	HEAVY DUTY		HYDRAULIC FLUID	
	BRITISH COLUMBIA	QUEBEC	BRITISH COLUMBIA	QUEBEC
Agriculture	1,214	2,875	805	1905
Construction	2,429	4,321	3,219	5,727
Forestry	4,857	2,133	8,047	3,533
Marine	2,429	3,234		
Mining	1,214	2,439	805	1616
Rail	486	490		
Trucking	7,286	14,761		
Utilities	729	2,674		
Oil and gas	2,429	0.80	1,609	0.53
Other sectors	1,214	2,371	1,609	3,142
Including manufacturing*	N/A	1,778	N/A	2,356
TOTAL	24,287	35,299	16,093	15,923
TOTAL Lubricant Profile†	24,287	25,438	16,093	13,965

* The BCUOMA study did not provide data for the manufacturing sector. We assumed that 75% of the oil included in “other sectors” was used in the manufacturing sector.

† 2004 for British Columbia and 2008 for Quebec

As shown by the comparison with the Quebec data from the 2008 Lubricant Profile, the quantities were over-estimated. The Quebec economy seemed to be consuming less oil per dollar of GDP.

To use the same segmentation as the one we proposed in part one, we removed the quantities of heavy duty engine oil from the marine and rail sectors and the quantities of hydraulic fluid from the agricultural sector, and determined the percentage distribution, which we then applied to the total quantities reported by Lubricant Profile. The results are presented in the table below.

Table 9 – Adjusted quantities of oils (1,000s of litres) for Quebec

	HEAVY DUTY	HYDRAULIC FLUID
Agriculture	2,317	-
Construction	3,481	5,705
Forestry	1,718	3,519
Manufacturing	1,432	2,347
Marine	-	-
Mining	1,965	1,610
Rail	-	-
Trucking	11,892	-
Utilities	2,155	-
Other sectors	477	782
TOTAL	25,437	13,964

7 - Using data from Step 6 to adjust the results of Step 5

In Step 5, we estimated the quantities of oil by sector, based on the unit ratios obtained from the users through telephone surveys. In Step 6, we estimated the quantities of heavy duty engine oil and hydraulic fluid based on the breakdown presented in the BCUOMA study, and the British Columbia and Quebec GDPs.

The table below compares the values obtained in Step 5 with those obtained in Step 6.

Table 10 – Extrapolated oil consumption figures (in thousands of litres per year)

	HEAVY DUTY		HYDRAULIC FLUID	
	STEP 5 – RATIOS	STEP 6 – GDP	STEP 5 – RATIOS	STEP 6 – GDP
Agriculture	2,745	2,317		
Construction	3,137	3,481	2,237	5,705
Forestry	721	1,718	1,693	3,519
Manufacturing	976	1,432	2,615	2,347
Mining	3,793	1,965	1,649	1,610
Road transportation – freight	13,539	11,892	0	0
Road transportation – people	1,703	Included	135	0
Utilities	2,151	2,155	611	0
Other sectors	N/A	477	N/A	782
TOTAL	28,765	25,437	8,940	13,964

The following adjustments were made for heavy duty engine oil:

- ▶ Since no data was available on the “other sectors”, we used the data from Step 6;
- ▶ Because the BCUOMA study did not provide any data on bus transportation, we used the data from Step 5;
- ▶ For the remaining sectors, the Step 5 and 6 values were averaged;
- ▶ Finally, since the total quantities were not equal to the value reported by the Lubricant Profile (27,112,000 litres versus 25,438,000 litres), all the quantities were adjusted to maintain the same percentage distribution.

The following adjustments were made for hydraulic fluid:

- ▶ Since no data was available on the “other sectors”, we used the data from Step 6;
- ▶ Because the BCUOMA study did not provide any data on bus transportation, we used the data from Step 5;
- ▶ Because the BCUOMA study did not provide any data on the utilities sector, we used the data from Step 5;
- ▶ The value for truck freight was obtained by using the same motor oil to hydraulic fluid ratio that we used for bus transportation;
- ▶ For the remaining sectors, the Step 5 and 6 values were averaged;
- ▶ Finally, since the total quantities were not equal to the value reported by the Lubricant Profile (13,157,000 litres versus 13,964,000 litres), all the quantities were adjusted to maintain the same percentage distribution.

The results are presented in the table below.

Table 11 – Adjustment results (in thousands of litres per year)

	HEAVY DUTY		HYDRAULIC FLUID	
	INITIAL VALUES – STEP 5	ADJUSTED VALUES	INITIAL VALUES – STEP 5	ADJUSTED VALUES
Agriculture	2,745	2,355		
Construction	3,137	3,079	2,237	4,215
Forestry	721	1,135	1,693	2,766
Manufacturing	976	1,121	2,615	2,633
Mining	3,793	2,678	1,649	1,729
Road transportation – freight	13,539	11,039	0	999
Road transportation – people	1,703	1,585	135	143
Utilities	2,151	2,003	611	648
Other sectors	N/A	444	N/A	830
TOTAL	28,765	25,438	8,940	13,964

8 – Determining segmentation in the “tractor hydraulic fluid” category

The values for this category were determined as follows:

- ▶ We used the value for the agricultural sector obtained in Step 5, which was 4,087,000 litres;
- ▶ We allocated 20% of the remaining tractor hydraulic fluid to the mining industry, 30% to the construction industry and 50% to the forestry industry. Where no data was available, these percentages were assigned arbitrarily.

9 – Determining segmentation in the “transmission fluid” and “differential gear oil” categories

The values for these categories were determined as follows:

- ▶ The values obtained in Step 5 for the forestry industry seemed very low compared to those for the other sectors (12,000 litres of transmission fluid and 28,000 litres of differential gear oil versus 745,000 litres and 367,000 litres respectively for the construction industry). The values were therefore adjusted, based on values for motor oil, to bring them into line with those of the construction industry;
- ▶ We used the values obtained in Step 5 for the other sectors;
- ▶ We allocated the remaining difference and the total reported by Lubricant Profile to the automotive sector.

10 – Determining segmentation in the “other oils” category

The values for this category were determined as follows:

- ▶ Other passenger car motor oils were broken down by sector as a percentage of the total quantities of motor oil, hydraulic fluid, tractor hydraulic fluid, transmission fluid and differential gear oil;
- ▶ The other industrial oils were arbitrarily split between the manufacturing (95%) and utilities sector (5%);
- ▶ Compressor oils were arbitrarily divided as follows: 50% in manufacturing, 20% in utilities, 20% in mining and 10% in construction.

The table below presents the results.

Table 12 – Detailed information on the amount of oil (in thousands of litres per year) in the “other oils” category

	OTHER AUTOMOBILES	NATURAL GAS	AVIATION OIL	CIRCULATING OIL	COMPRESSOR OIL	PAPER MACHINE OIL	OTHER INDUSTRIAL OILS	TOTAL
Automotive	364							364
Agriculture	51							51
Construction	70				51			122
Forestry	39							39
Manufacturing	35			1,035	257	1,281	731	3,338
Marine								0
Mining	44				103			146
Rail								0
Road transportation – freight	104							104
Road transportation – people	16							16
Utilities	25				103		38	166
Other sectors	10	114	79					203
TOTAL	758	114	79	1,035	513	1,281	769	4,549

11 – Applying the final results to the total published by RECYC-QUÉBEC

We integrated the results of the previous steps to obtain the breakdown presented in the table below.

Table 13 – Oil sales broken down by industry and type of oil (thousands of litres per year)

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS
Automotive	43,250				1,229			1,174		363
Agriculture		2,355		4,087	0			0		51
Construction		3,079	4,215	431	745			367		122
Forestry		1,135	2,766	718	275			135		40
Manufacturing		1,121	2,633		542			84	2,588	3,338
Marine								5,350		
Mining		2,678	1,729	287	533			247		146
Rail							2,802			
Trucking		12,623	1,142		787			539		120
Utilities		2,003	648		292			138		166
Other sectors		444	830							203
TOTAL		43,250	25,438	13,964	5,523	4,403	2,802	5,350	2,684	2,588

The table below presents the total and percentage broken down by sector.

Table 14 – Oil sales broken down by sector, volume and percentage

	TOTAL VOLUME (1,000 LITRES)	%
Automotive	46,016	41.6%
Agriculture	6,493	5.9%
Construction	8,958	8.1%
Forestry	5,068	4.6%
Manufacturing	10,306	9.3%
Marine	5,350	4.8%
Mining	5,621	5.1%
Rail	2,802	2.5%
Trucking	15,211	13.8%
Utilities	3,247	2.9%
Other sectors	1,478	1.3%
TOTAL	110,551	100%

Finally, the percentage breakdown by sector and type of oil.

Table 15 – Annual oil sales (%) by sector and type of oil

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS
Automotive	100%				27.9%			43.7%		8.0%
Agriculture		9.3%		74.0%						1.1%
Construction		12.1%	30.2%	7.8%	16.9%			13.7%		2.7%
Forestry		4.5%	19.8%	13.0%	6.2%			5.0%		0.9%
Manufacturing		4.4%	18.9%		12.3%			3.1%	100%	73.4%
Marine								100%		
Mining		10.5%	12.4%	5.2%	12.1%			9.2%		3.2%
Rail							100%			
Trucking		49.6%	8.2%			17.9%		20.1%		2.6%
Utilities		7.9%	4.6%			6.6%		5.1%		3.6%
Other sectors		1.7%	5.9%							4.5%
TOTAL		100%	100%	100%	100%	100%	100%	100%	100%	100%

And the percentage breakdown by type of oil.

Table 16 – Annual oil sales (%) by type of oil

SECTORS	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	TOTAL
Percentage of oil sales	39.1%	23.0%	12.6%	5.0%	4.0%	2.5%	4.8%	2.4%	2.3%	4.1%	100%

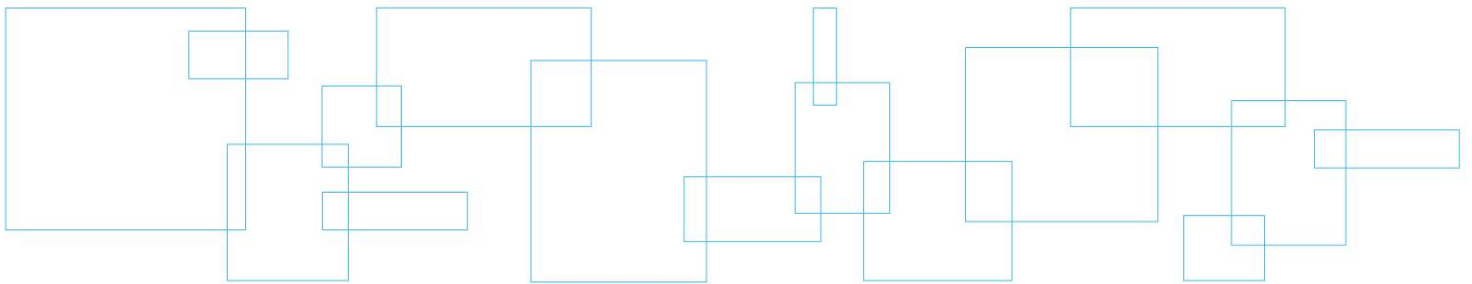
Every year, RECYC-QUÉBEC publishes the quantities of virgin oil marketed and reported by members of SOGHU and the four non-members companies. In 2008, 113,799,566 litres were marketed.

The table below multiplies this figure by the percentages in Table 16 to show the numbers of litres sold (in thousands of litres) by type of oil. This data will be used in the following steps to determine the percentages of recoverable used oil.

Table 17 – Oil sales by sector and type of oil (thousands of litres per year) based on the total quantity published by RECYC-QUÉBEC

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	TOTAL VOLUME (1,000S OF LITRES)	
Automotive	44,521				1,265			1,209		374	47,369	
Agriculture		2,424		4,207						53	6,684	
Construction		3,170	4,339	443	767			378		125	9,222	
Forestry		1,168	2,847	739	283			139		41	5,217	
Manufacturing		1,153	2,711		558			87	2,664	3,436	10,609	
Marine								5,507				5,507
Mining		2,757	1,780	296	548			255		150	5,786	
Rail							2,884					2,884
Trucking		12,994	1,175		810			555		124	15,658	
Utilities		2,062	667		301			142		170	3,342	
Other sectors		457	855							209	1,521	
TOTAL		44,521	26,186	14,374	5,685	4,532	2,884	5,507	2,763	2,664	4,683	113,800

Appendix 3
Estimated recovery rate
for used oil per application



APPENDIX 3 – ESTIMATED RECOVERY RATE FOR USED OIL PER APPLICATION

Estimating the recovery rates for used oil was a complex task involving a series of calculations and adjustments.

The procedure involved six steps:

- 23- Data acquisition;
- 24- Determining a sector's overall rate based on the companies' survey data;
- 25- Determining the rates by type of oil based on the companies' survey data when available, and data from the BCUOMA and ADEME studies;
- 26- Adjusting the rates for heavy duty engine oil or hydraulic fluid, in order to meet the sector's overall rate indicated in step 2;
- 27- Determining the rates in certain sectors: automotive and marine;
- 28- Calculating the rates by type of oil and calculating the overall rate.

The following sections provide a detailed explanation of the procedure.

1 – Data acquisition

We used several data sources:

- ▶ We took direct measurements: 264 samples of passenger car motor oil in 25 different garages. The number of samples taken in one day was well below our expectations and we had to return to several garages to increase the sample size. The sample characteristics are presented in Appendix 4.
- ▶ We surveyed companies in various sectors. It was difficult to obtain data from the companies either because the participants did not have time or the data was not available. Appendix 6 presents the details.
- ▶ We surveyed automatic transmission repair shops. Appendix 5 presents the details.
- ▶ We used data from other studies when we could not obtain usable data. This was the case for the "Marine" sector or "other sectors."

2 – Determining a sector's overall rate based on the companies' survey data

We averaged all of the rates obtained through company surveys.

The table below presents the results.

Table 1 – Overall recovery rate for used oil by sector

	PERCENTAGE OF RECOVERABLE USED OIL	SPENCE RATE FOR BRITISH COLUMBIA*
Agriculture	77.7 %	78.1 %
Construction	66.5 %	73.6 %
Forestry	44.3 %	64.8 %
Manufacturing	80.1 %	N/A
Mining	55.0 %	67.1 %
Trucking	72.2 %	84.0 %
Utilities	76.6 %	63.8 %

3 – Calculating the rates by type of oil and sector

We were unable to obtain detailed data by type of oil for the agricultural and mining sectors. We obtained an overall rate per company for the other sectors. Depending on the type of oil, we used some rates from the other sectors, others from the BCUOMA or ADEME studies for less important oils, and finally, we adjusted the rates for hydraulic fluid or heavy duty engine oil to comply with the overall rate from the company surveys. The values obtained are detailed in the following tables for all sectors.

Table 2 – Percentage of recoverable oil by type of oil for the agricultural sector

TYPE OF OIL	RATES USED	BCUOMA STUDY	COMMENTS
Heavy duty	71.8 %	66%	Value from the surveys
Tractor hydraulic fluid	81.0%	80%	Value adjusted using the overall rate (Step 2)
Other oils	90.0%	90%	Value from the BCUOMA study

Table 3 – Percentage of recoverable oil by type of oil for the construction sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	59.0%	59%	Value from the BCUOMA study
Hydraulic fluid	67.0%	80%	Value adjusted using the overall rate (Step 2)
Tractor hydraulic fluid	81.0%	80%	Value for the agriculture sector
Automatic transmission fluid	75.5%	96%	Value for the mining sector
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	90.0%	90%	Value from the BCUOMA study

* Weighted average quantities, calculated from the rates by type of oil and sector

Table 4 – Percentage of recoverable oil by type of oil for the forestry sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	43.0%	43%	Value from the BCUOMA study
Hydraulic fluid	29.9%	70%	Value adjusted using the overall rate (Step 2)
Tractor hydraulic fluid	81.0%	N/A	Value for the agriculture sector
Automatic transmission fluid	75.5%	96%	Value for the mining sector
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	80.0%	80%	Value from the BCUOMA study

Table 5 – Percentage of recoverable oil by type oil for the manufacturing sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	59.0%	N/A	Value for construction taken from the BCUOMA study
Hydraulic fluid	67.1%	N/A	Value adjusted using the overall rate (Step 2)
Automatic transmission fluid	78.1%	N/A	Average of the value from the transmission repair shop surveys (Table 2) and the rate presented for the construction industry in the BCUOMA study (96%)
Differential gear oil	80.0%	N/A	Value from the ADEME study
Industrial gear oil	90.0%	N/A	Value from the ADEME study
Other oils	90.0%	N/A	Value for construction taken from the BCUOMA study

Table 6 – Percentage of recoverable oil by type of oil for the mining sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	55.5%	61%	Average of the values from the surveys and the BCUOMA study
Hydraulic fluid	36.2%	70%	Value adjusted using the overall rate (Step 2)
Tractor hydraulic fluid	81.0%	N/A	Value for the agricultural sector
Automatic transmission fluid	75.5%	N/A	Average value from the companies surveyed
Differential gear oil	91.2%	N/A	Average value from the companies surveyed
Other oils	80.0%	80%	Value from the BCUOMA study

Table 7 – Percentage of recoverable oil by type of oil for the rail sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Locomotive engine oil	36.7%	34.8%	Average data provided by the companies surveyed

Table 8 – Percentage of recoverable oil by type of oil for the trucking sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	70.9%	83%	Value adjusted using the overall rate (Step 2)
Hydraulic fluid	70.0%	N/A	Value for the other sectors taken from the BCUOMA study
Automatic transmission fluid	77.6%	95%	Average of the value from the transmission repair shop surveys (Table 2) and the rate presented in the BCUOMA study (95%)
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	80.0%	80%	Value from the BCUOMA study

Table 9 – Percentage of recoverable oil by type of oil for the road transportation – passenger sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	76.5%	83%	Value adjusted using the overall rate (Step 2)
Hydraulic fluid	70.0%	N/A	Value for the other sectors taken from the BCUOMA study
Automatic transmission fluid	77.6%	95%	Average of the value from surveys of transmission repair shops (Table 2) and the rate presented in the BCUOMA study (95%)
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	80.0%	80%	Value from the BCUOMA study

To obtain the overall rate for road transportation, the average rates were pro-rate according to the quantities consumed in freight and passenger transportation. The results are presented in the table below.

Table 10 – Percentage of recoverable oil by type of oil for the road transportation sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	71.6%	83%	Value adjusted using the overall rate (Step 2)
Hydraulic fluid	70.0%	N/A	Value for the other sectors taken from the BCUOMA study
Automatic transmission fluid	77.6%	95%	Average of the value from the transmission repair shop surveys (Table 2) and the rate presented in the BCUOMA study (95%)
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	80.0%	80%	Value from the BCUOMA study

Table 11 – Percentage of recoverable oil by type of oil for the utilities sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	78.0%	55%	Value adjusted using the overall rate (Step 2)
Hydraulic fluid	70.0%	N/A	Value for the other sectors taken from the BCUOMA study
Automatic transmission fluid	77.6%	N/A	Value for the road transportation sector
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	80.0%	80%	Value from the BCUOMA study

Table 12 – Percentage of recoverable oil by type of oil for the other sectors

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Heavy duty	64.2%	80%	Average values for the previous sectors
Hydraulic fluid	70.0%	70%	Value from the BCUOMA study
Other oils	80.0%	80%	Value from the BCUOMA study

4 – Determining the rates in certain sectors: the automotive, marine and other sectors

We took 270 samples of passenger car motor oil in garages. The average rate was 86.4%, but the age of the vehicles had to be taken into account. So we calculated a weighted average rate, which is presented in the following table.

Table 13 – Weighted rate calculation for passenger car motor oil

	SAMPLE	NUMBER		KM TRAVELLED		
AGE	AVERAGE RATE	NUMBER	%	AVERAGE KM PER YEAR	TOTAL KM	%
2 years old or less	90.1%	1,285,903	27.7%	21,635	27,820,948,282	33.7%
3 – 5 years old	87.6%	986,937	21.3%	17,414	17,186,366,021	20.8%
6 – 8 years old	82.6%	962,579	20.8%	18,023	17,348,493,773	21.0%
9 years old or more	80.3%	1,402,537	30.2%	14,484	20,314,364,037	24.6%
RATE	86.4%	85.1%		85.6%		

Given the degree of accuracy, the difference attributable to the method was not significant. We therefore agreed to use the rate based on the breakdown by number, which had the advantage of involving fewer calculations and values, and therefore being more reliable. It should be noted that the newer vehicles travelled greater distances and therefore used more oil.

The following table presents the rates used for the automotive sector.

Table 14 – Percentage of recoverable oil by type of oil for the automotive sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Passenger car motor oil	85.1%	92%	Garage sampling value
Automatic transmission fluid	78.1%	96%	Average of the value from the transmission repair shop surveys (Table 2) and the rate presented in the BCUOMA study (96%)
Differential gear oil	80.0%	N/A	Value from the ADEME study
Other oils	95.0%	95%	Value from the BCUOMA study

We did not obtain any usable data for the marine sector. We therefore used the 40% value presented in the BCUOMA study.

Table 15 – Percentage of recoverable oil by type of oil for the marine sector

TYPE OF OIL	RATES USED	SPENCE STUDY	COMMENTS
Marine engine	40.0%	40%	Garage sampling value

5 – Calculating the rates by type of oil and calculating the overall rate

The following table includes all the data on the rates and presents an overall rate of 73.5% of recoverable used oil.

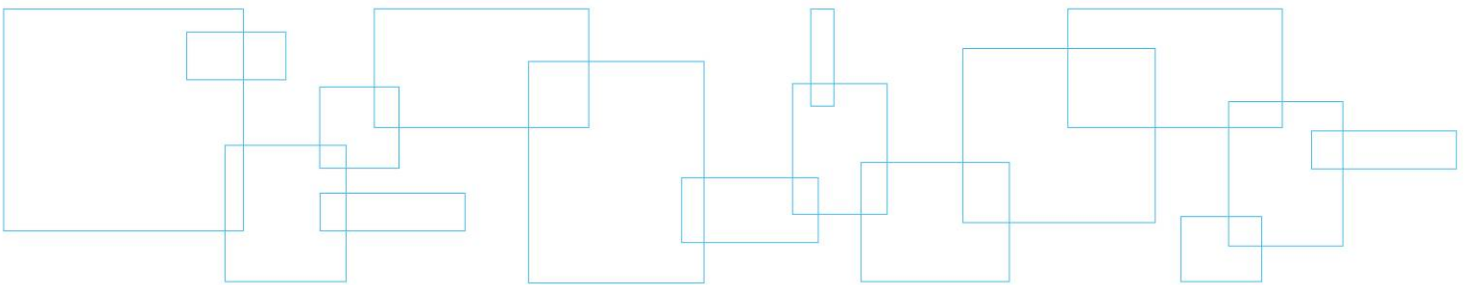
Table 16 – Recovery rate for used oil by type of oil and sector

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	OVERALL RATE
Automotive	85.1%				78.1%			80.0%		95.0%	84.8%
Agriculture		71.8%		81.0%						90.0%	77.7%
Construction		59.0%	67.0%	81.0%	75.5%			80.0%		90.0%	66.5%
Forestry		43.0%	29.9%	81.0%	75.5%			80.0%		80.0%	44.3%
Manufacturing		59.0%	67.1%		78.1%			80.0%	90%	90.0%	80.1%
Marine								40.0%			40.0%
Mining		55.5%	36.2%	81.0%	75.5%			91.2%		80.0%	55.0%
Rail							36.7%				36.7%
Trucking		71.6%	70.0%		77.6%			80.0%		80.0%	72.2%
Utilities		78.0%	70.0%		77.6%			80.0%		80.0%	76.6%
Other sectors		64.2%	70.0%								69.6%
OVERALL		85.1%	66.9%	56.4%	81.0%	77.1%	36.7%	40.0%	81.0%	90.0%	88.9%

Table 17 – Volumes of recoverable used oil by type of oil and sector (thousands of litres per year)

	PASSENGER CAR MOTOR OIL	HEAVY DUTY	HYDRAULIC FLUID	TRACTOR HYDRAULIC FLUID	AUTOMATIC TRANSMISSION FLUID	LOCOMOTIVE ENGINE OIL	MARINE ENGINE OIL	DIFFERENTIAL GEAR OIL	INDUSTRIAL GEAR OIL	OTHER OILS	TOTAL
Automotive	37,878				989			967		355	40,188
Agriculture		1,741		3,407						47	5,195
Construction		1,870	2,905	359	579			302		113	6,128
Forestry		502	851	599	213			111		33	2,309
Manufacturing		681	1,818		436			69	2,398	3,092	8,494
Marine								2,203			2,203
Mining		1,530	644	239	414			232		120	3,180
Rail							1,057				1,057
Trucking		9,305	823		629			444		99	11,299
Utilities		1,608	467		233			113		136	2,559
Other sectors		294	598							167	1,059
TOTAL		37,878	17,530	8,107	4,604	3,493	1,057	2,203	2,239	2,398	4,164

Appendix 4
Garage sampling
campaign



APPENDIX 4 – RESULTS OF PASSENGER CAR MOTOR OIL SAMPLING IN GARAGES

A direct sampling approach was used to determine the percentage of recoverable passenger car motor oil. It involved weighing the oil drained from the vehicles, and recording the volume of oil added to the vehicle (including top-ups between oil changes).

Overall, 270 oil changes involving a total of 1,000 litres of used oil were documented. The samples were broken down as follows:

Table 1 – 270 samples of passenger car motor oil by region, type of garage, type of vehicle and vehicle age

REGION	TYPE OF GARAGE	TYPE OF VEHICLE	VEHICLE AGE
- 103 in Montreal (38%) - 49 in Quebec City (18%) - 118 in the other regions (44%)	- 177 at dealerships (65%) - 53 at general maintenance garages (20%) - 40 in oil change facilities (15%)	- 226 automobiles (84%) - 44 minivans and pick-ups (16%)	- 104 from 2008 to 2010 (39%) - 68 from 2005 to 2007 (25 %) - 57 from 2002 to 2004 (21 %) - 41 in 2001 and earlier (15 %)

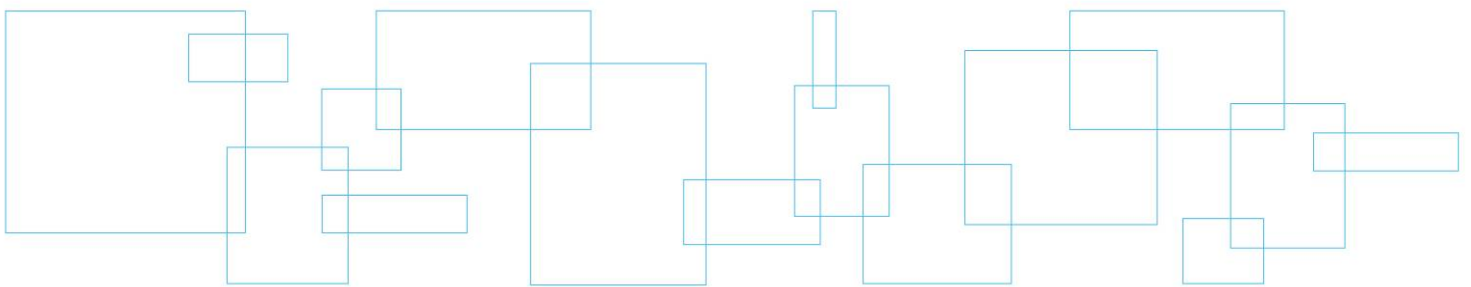
Number of samples taken by vehicle brand:

Table 2 – 270 samples of passenger car motor oil by vehicle brand

BRAND	NUMBER OF SAMPLES	BRAND	NUMBER OF SAMPLES
Acura	1	Isuzu	1
Audi	1	Jeep	1
Buick	5	Lexus	1
Cadillac	1	Mazda	9
Chevrolet	18	Mitsubishi	1
Chrysler	3	Nissan	9
Dodge	8	Oldsmobile	1
Ford	17	Pontiac	20
GMC	6	Saturn	4
Honda	8	Subaru	1
Hyundai	6	Toyota	145
Infinity	1	Volkswagen	2

Toyotas were well represented because the dealers we contacted were very cooperative.

Appendix 5
Transmission repair shop
survey



APPENDIX 5 – AUTOMOBILE TRANSMISSION FLUID RECOVERY SURVEY

Visits to automobile transmission repair shops:

We visited 42 professionals to document the quantity of transmission fluid purchased and recovered in automobile transmission repair shops.

The shops were pre-screened to make sure they repaired only automobile transmissions.

The purpose of the visits was to determine the number of transmission (removed from the vehicle before arrival at the garage) repairs as a percentage of the total number of vehicle repairs. The participants were asked if the transmissions arrived at the shop empty or full of oil, and whether they left the shop empty or full of oil.

The data provided by a shop had to meet the following criteria to be used in the study:

- the shop only performed transmission repairs on cars and if other repairs were performed, the oils could not be mixed;
- transmissions removed from the vehicle could not arrive at the shop empty and leave full, and vice versa.

If the shops met these criteria were met, the participants were asked questions regarding the quantities of oil involved. In most cases, data on the quantities of oil recovered were provided by the recyclers, not the mechanics.

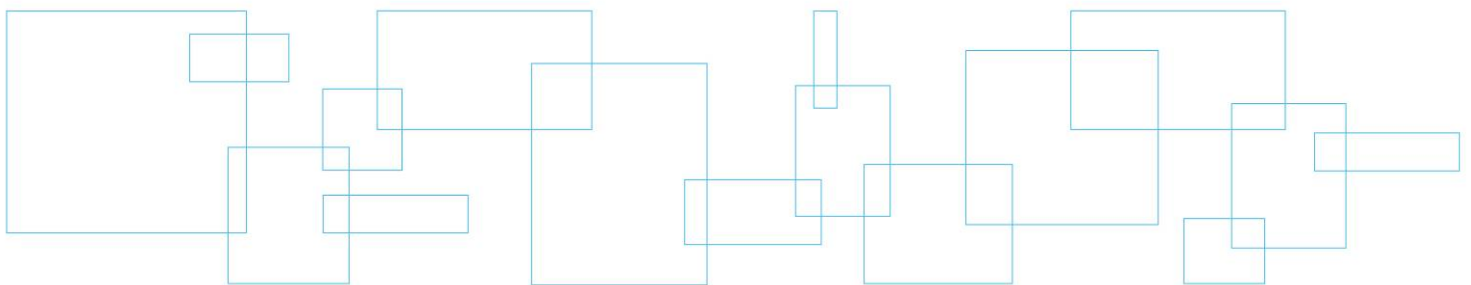
The answers provided by shops were broken down as follows:

- Two (2) shops did not wish to participate in the survey.
- At six (6) shops, the person in charge was not there at the time of the visits.
- Twenty-three (23) garages performed transmission repairs and other repairs and the oils were mixed.
- Four (4) met the criteria but did not wish to provide data on the quantities of used oil or the name of the company that recycled their oil.
- Seven (7) garages sent all the information requested.

Table 1 – Transmission repair shop survey responses

	NUMBER OF COMPANIES CONTACTED	NUMBER OF RESPONSES	NUMBER OF USABLE QUESTIONNAIRES	AVERAGE PERCENTAGE OF RECOVERABLE OIL	ACCURACY
Transmission fluid	42	7	4	60.3%	± 20.5

Appendix 6
User sector survey



APPENDIX 6 – USER SECTOR SURVEY

Since it was not possible or not appropriate to conduct sampling in all sectors and all regions of Quebec, we surveyed users in various sectors.

It was difficult to obtain data from the companies either because the participants did not have time or the data was not available.

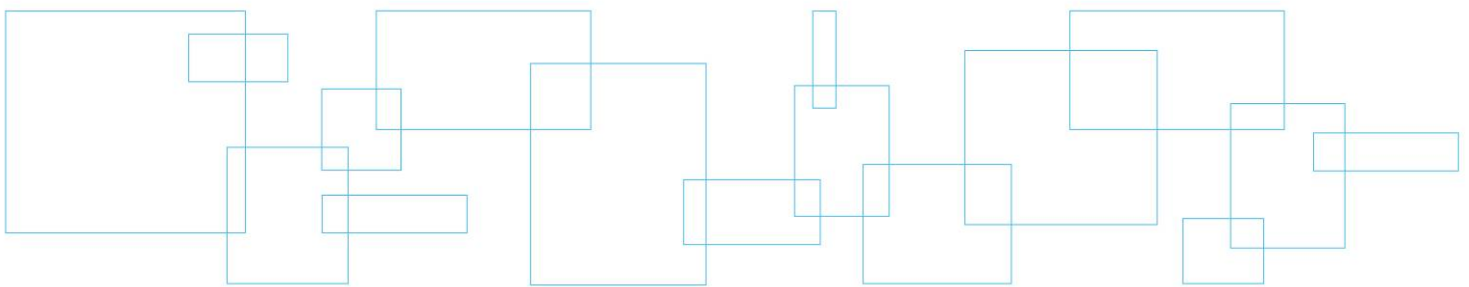
The table below presents the details.

Table 1 – Company survey responses

	NUMBER OF COMPANIES CONTACTED	NUMBER OF QUESTIONNAIRES RETURNED	NUMBER OF USABLE QUESTIONNAIRES	VOLUME OF VIRGIN OIL CONSUMED (IN LITRES)	SECTOR PERCENTAGE
Agriculture	52	7	6	7,351	0.11%
Construction	124	12	9	444,652	4.82%
Forestry	70	3	3	48,623	0.93%
Manufacturing	44	12	6	318,565	3.00%
Marine	67	4	0	-	-
Mining	26	6	6	2,075,066	35.86%
Rail	30	3	2	1,020,583	35.38%
Trucking	72	22	16	881,190	5.63%
Utilities	74	33	23	852,623	25.51%
Other sectors	Not surveyed	Not surveyed	-	-	-
TOTAL	559	102	71	5,648,653	5.0%

We had to telephone the participants repeatedly. The final response rate was about 18%. In all, the quantities of virgin oil marketed by the companies surveyed represented more than 5% of the oil marketed.

Appendix 7
Data collection forms,
questionnaires and
documents



Data collection form

Dealer:		
City:	Date:	Page___

Container weight: kg before = _____ kg = after _____ kg
Quantity of virgin oil poured into the vehicle: _____ litres
Vehicle (make and model): _____
Vehicle year _____ Kilometrage: _____
Reported quantity of oil added since the last oil change: _____
Kilometrage reported since last oil change: _____
Reported percentage of oil changes performed by the vehicle owner: _____%
Vehicle owner contact information, if required: _____

Container weight: kg before = _____ kg = after _____ kg
Quantity of virgin oil poured into the vehicle: _____ litres
Vehicle (make and model): _____
Vehicle year _____ Kilometrage: _____
Reported quantity of oil added since the last oil change: _____
Kilometrage reported since last oil change: _____
Reported percentage of oil changes performed by the vehicle owner: _____%
Vehicle owner contact information, if required: _____

Container weight: kg before = _____ kg = after _____ kg
Quantity of virgin oil poured into the vehicle: _____ litres
Vehicle (make and model): _____
Vehicle year _____ Kilometrage: _____ Reported quantity
of oil added since the last oil change: _____
Kilometrage reported since last oil change: _____ Reported percentage of oil
changes performed by the vehicle owner: _____%
Vehicle owner contact information, if required: _____

Study of the percentage of recoverable oil – motor vehicles

In preparation for the possible enactment of the Regulation respecting the recovery and reclamation of products by companies, which specifically involves oil, RECYC-QUÉBEC and SOGHU have retained the services of NI Environment and Dessau.

The mandate's **objective** is to determine the quantity of recoverable oil as accurately as possible and express it as a percentage of annual sales. This percentage has a significant impact on Quebec's current oil recovery program.

To fulfill the mandate, the study protocol requires that the party dealing with passenger car motor oil, document the quantity of oil removed from a vehicle relative to the total quantity of oil poured into the crankcase since the previous oil change (including top-ups).

About 500 measurements must be taken to achieve an adequate level of accuracy (i.e. the quantity of oil drained from 500 motor vehicles must be measured).

To ensure representativeness, the study protocol requires that samples be taken at different locations: dealers (dominance of one brand and newer cars), general maintenance garages (a wide variety of brands and many older vehicles on average), etc.

The site work will proceed as follows:

- 1) If the site had a mechanic pit:
 - a. the morning the samples are to be taken, the tanks placed under the vehicles will be emptied;
 - b. the oil from an initial oil change will be drained into each tank. Then the tank valve will be opened in the mechanic pit to drain the oil above the level of the outlet pipe into our sampling tank, by gravity. This is how *we determine the tank's zero point*;
 - c. the same procedure is used for the second and subsequent oil changes—all the oil drained by gravity is assumed to be equal to the quantity of oil drained from the vehicle;
 - d. we will weigh the tank before and after filling, to determine the weight of the oil;
 - e. the weighed oil will then be emptied into a recovery tank provided by the facility;
 - f. meanwhile, we will ask the vehicle owner how much oil had been added and how many kilometres the vehicle has travelled since the last oil change.
- 2) If the site uses jacks to lift the vehicles:
 - a. we will place a plastic container (which we will bring) on the funnel normally used to collect the oil;
 - b. we will weigh the plastic container before and after filling to determine the weight of the oil;
 - c. the weighed oil will be drained into the usual tank;
 - d. meanwhile, we will ask the vehicle owner how much oil had been added and how many kilometres the vehicle has travelled since the last oil change.

Data collection form

Company: _____

City: _____

Date: _____

Page ____

Container weight: kg before = _____ kg = after _____ kg

Quantity of virgin oil poured into the vehicle: _____ litres

Weight of the used filter: _____ kg new: _____ kg

Is the excess oil in the filters poured into the same container as the oil from the oil pan?

Or is the used filter simply placed in a container?

Vehicle (make and model): _____

Vehicle year _____ Kilometrage: _____

Reported quantity of oil added since the last oil change: _____

Kilometrage travelled since last oil change: _____

Container weight: kg before = _____ kg = after _____ kg

Quantity of virgin oil poured into the vehicle: _____ litres

Weight of the used filter: _____ kg new: _____ kg

Is the excess oil in the filters poured into the same container as the oil from the oil pan?

Or is the used filter simply placed in a container?

Vehicle (make and model): _____

Vehicle year _____ Kilometrage: _____

Reported quantity of oil added since the last oil change: _____

Kilometrage travelled since last oil change: _____

Container weight: kg before = _____ kg = after _____ kg

Quantity of virgin oil poured into the vehicle: _____ litres

Weight of the used filter: _____ kg new: _____ kg

Is the excess oil in the filters poured into the same container as the oil from the oil pan?

Or is the used filter simply placed in a container?

Vehicle (make and model): _____

Vehicle year _____ Kilometrage: _____

Reported quantity of oil added since the last oil change: _____

Kilometrage travelled since last oil change: _____

Study of the percentage of recoverable oil – road transport

In preparation for the possible enactment of the Regulation respecting the recovery and reclamation of products by companies, which specifically involves oil, RECYC-QUÉBEC and SOGHU have retained the services of NI Environment and Dessau.

The mandate's **objective** is to determine the quantity of recoverable oil as accurately as possible and express it as a percentage of annual sales. This percentage has a significant impact on Quebec's current oil recovery program.

To fulfill the mandate, the study protocol requires that the party dealing with passenger car motor oil, document the quantity of oil removed from a vehicle relative to the total quantity of oil poured into the crankcase since the previous oil change (including top-ups).

About 75 measurements must be taken to achieve an adequate level of accuracy (i.e. the quantity of oil drained from 75 motor vehicles must be measured).

The site work will proceed as follows:

The site work will proceed as follows:

- 1) If the site had a mechanic pit:
 - a. the morning the samples are to be taken, the tanks placed under the vehicles will be emptied;
 - b. the oil from an initial oil change will be drained into each tank. Then the tank valve will be opened in the mechanic pit to drain the oil above the level of the outlet pipe into our sampling tank, by gravity. This is how *we determine the tank's zero point*;
 - c. the same procedure is used for the second and subsequent oil changes—all the oil drained by gravity is assumed to be equal to the quantity of oil drained from the vehicle;
 - d. we will weigh the tank before and after filling, to determine the weight of the oil;
 - e. the weighed oil will then be emptied into a recovery tank provided by the facility;
 - f. meanwhile, we will ask the vehicle owner how much oil had been added and how many kilometres the vehicle has travelled since the last oil change.
- 2) If the site uses jacks to lift the vehicles:
 - a. we will place a plastic container (which we will bring) on the funnel normally used to collect the oil;
 - b. we will weigh the plastic container before and after filling to determine the weight of the oil;
 - c. the weighed oil will be drained into the usual tank;
 - d. meanwhile, we will ask the vehicle owner how much oil had been added and how many kilometres the vehicle has travelled since the last oil change.

If you have any questions, call 1-800-694-1216, Joanie Paradis (ext. 302) or Charles Drouin-Racine (ext. 204).

Number:

Construction company questionnaire

RECYC-QUÉBEC and SOGHU has hired NI Environnement and Dessau to calculate the quantity of recoverable oil and express it as a percentage of annual sales. The study protocol requires that data be gathered from companies in the construction industry.

Your involvement is limited to recording information on various types of oil and answering a few questions. Here is the information we need.

Question	Answers		
What is your line of business and what region do you operate in? Number of employees or hours worked			
Do you perform the maintenance and oil changes in-house?			
Frequency of oil changes (in kilometres or number of changes per year)	- motor oil: - transmission fluid: - differential gear oil: - hydraulic fluid: - other:		
Vehicles and machines used	Number	Average number of kilometres driven per year or average number of hours worked per year	Average vehicle age
Car / Pickup			
Trucks -Class?			
Loaders			
Power shovels			
Other:			
Other:			
Other:			

Number:

<p>Quantities purchased in litres per year (over several years, check whether there were any direct sales, if so, find out how many litres.)</p>	<ul style="list-style-type: none"> - motor oil: - transmission fluid: - differential gear oil: - hydraulic fluid: - other: 					
<p>Quantities recovered in litres per year (over several years, check whether any oil was used internally, as a mixture with diesel or for lubrication. If so, find out how many litres.)</p>	<ul style="list-style-type: none"> - used oil: - (details?) : 					
<p>Approximately how many litres of oil were used for top-ups between two oil changes</p>	<ul style="list-style-type: none"> - motor oil: - transmission fluid: - differential gear oil: - hydraulic fluid: - other: 					
<p>Average volumes of virgin oil for each oil change in litres, by type of equipment or vehicle</p>		Truck Class	Loader	Shovel	Other	Other
	- motor oil:					
	- transmission fluid:					
	- hydraulic fluid:					
	- other:					
<p>What factors may influence oil consumption?</p>						
<p>Comments:</p>						



Dear Sir or Madam:

In preparation for the possible enactment of the Regulation respecting the recovery and reclamation of products by companies, which specifically involves oil, RECYC-QUÉBEC and SOGHU have retained the services of *NI Environment* and *Dessau*.

They have been commissioned to determine the quantity of recoverable oil as accurately as possible and express it as a percentage of annual sales. This item has a major impact on the amounts required.

The term of the mandate is limited and we want to fully cooperate with the consultants, *NI Environment* and *Dessau*, to speed up their work and enable them to focus on obtaining reliable data.

For this reason, RECYC-QUÉBEC and SOGHU have authorized *NI Environment* and *Dessau* representatives to contact you to obtain information or request your cooperation.

We would appreciate your responding to their requests to the extent possible.

Please feel free to contact the undersigned if you have any questions.

Thank you for your cooperation.

Gilles Goddard
CEO
SOGHU

Claude Bourque, P. Eng.
Research and Planning Officer
RECYC-QUEBEC

Appendix 8
Test for identifying
sensitive parameters

APPENDIX 8 – TEST FOR IDENTIFYING SENSITIVE PARAMETERS

Test methodology

To determine which calculation variables had a major impact on the 78.6% rate of recoverable oil, the values of these variables could be changed to the extreme values indicated by the confidence interval.

In the following paragraphs, each variable is presented and analyzed in light of its impact on the percentage of recoverable oil. For purposes of interpretation, a change greater than $\pm 5\%$ is considered significant.

Interpretation of parameter sensitivity

1- *Sales breakdown*

Description

Appendix 2 provides a detailed description of the process leading to sales segmentation. It presents a table showing the percentage of sales for each application.

The sales breakdown by type of oil is considered reliable.

Sensitivity test

The method used to obtain this data, which is explained in Appendix 2, did not allow the margins of error to be calculated. However, the percentages could be varied to test sensitivity.

We used this process for heavy duty engine oil and hydraulic fluid, whose percentage of recoverable oil varied the most between sectors. To account for this variability, we increased or decreased the weight of the various sectors between 1% and 10%, while of course maintaining a total of 100%.

Table 1 – Variation in sales of heavy duty engine oils and hydraulic fluid

	HEAVY DUTY		HYDRAULIC FLUID	
	INITIAL	MODIFIED	HYDRAULIC FLUID	HYDRAULIC FLUID
Automotive				
Agriculture	9.3%	9.3%		
Construction	12.1%	12.1%	30.2%	25.2%
Forestry	4.5%	4.5%	19.8%	24.8%
Manufacturing	4.4%	4.4%	18.9%	13.9%
Marine				
Mining	10.5%	10.5%	12.4%	17.4%
Rail				
Trucking	49.6%	49.6%	8.2%	5.2%
Utilities	7.9%	7.9%	4.6%	2.0%
Other sectors	1.7%	1.7%	5.9%	5.6%
TOTAL	100%	100%	100%	100%
Rate	78.6%	78.7%	78.6%	78.6%

This corresponded to a relative variation of $\pm 0.1\%$. The results did not show significant sensitivity to these parameters.

2- *Percentage of recoverable passenger car motor oil*

Description

This is the rate from the garage sampling program adjusted to the automobile fleet's age distribution. The value obtained was 85.1%. Its absolute accuracy, based on the accuracy of each age class was ± 3.8 .

Sensitivity test

Using the lower confidence interval value, the percentage of recoverable oil decreased to 77.2%, which corresponded to a relative variation of $\pm 1.8\%$.

The results did not show significant sensitivity to this parameter.

3- *Percentage of recoverable oil for the various sectors*

Description

These percentages were taken from the user surveys conducted in the various sectors.

Sensitivity test

Table 2 – Variation in the overall percentage of recoverable used oil by sector

	PERCENTAGE OF RECOVERABLE USED OIL	ABSOLUTE ACCURACY UTILIZED	PERCENTAGE OBTAINED WITH THE LOWER VALUE
Agriculture	77.7%	±13.1	64.0%
Construction	66.5%	±13.7	52.8%
Forestry	44.3%	±27.3	17.0%
Manufacturing	80.1%	±11.3	68.8%
Marine	40.0%	±20.0*	30.0%
Mining	55.0%	±10.1	44.9%
Rail	36.7%	±20.0†	26.7%
Trucking	72.2%	±5.3	66.9%
Utilities	76.6%	±7.4	69.2%
Other sectors	67.3%	±6.8	60.5%

By integrating all these lower values, the rate of recoverable oil decreased to 71.3%, which corresponded to a relative variation of ±9.2%. The results showed significant sensitivity to this parameter.

However, this was a maximum relative variation and it was unlikely that the parameters of all segments were offset in the same direction (upward or downward), which would suggest a bias. It was more likely that some segments were overestimated while others were underestimated.

4- *Volume of used oil from end-of-life vehicles and machinery*

Description

These were the estimated volumes of oil from the decontamination of end-of-life vehicles and machinery.

Sensitivity test

The method used to obtain this data, which is described in the report, did not allow the margins of error to be calculated. We arbitrarily set the margin of error to 20%, which was significant.

Using the lower confidence interval value, the percentage of recoverable oil decreased to 77.6%, which corresponded to a relative variation of ±1.3%.

The results did not show significant sensitivity to this parameter.

* Where no data was available, we set the accuracy at ±20.

† The accuracy of the values obtained was ±48.5, but since one participant represented 50% of purchases, we decreased the accuracy to ±20.

5- *Volume of virgin oil in vehicles, machinery and products sold in Quebec*

Description

These were the estimated volumes of virgin oil in imported vehicles and machinery marketed in Quebec.

Sensitivity test

The method used to obtain this data, which is described in the report, did not allow the margins of error to be calculated. We arbitrarily set the margin of error to 20%, which was significant.

Using the lower confidence interval value, the percentage of recoverable oil that was integrated this parameter increased from 72.9% to 74.0%, which corresponded to a relative variation of $\pm 1.5\%$.

The results did not show significant sensitivity to this parameter.