GREENHOUSE GAS INVENTORY FOR THE YUKON

Researchers:

Jennifer Jones
Sue Moodie

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Yukon Conservation Society

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GREENHOUSE GAS INVENTORY FOR THE YUKON

1.0 INTRODUCTION

The Yukon government has made a commitment to reducing greenhouse gas emissions within the Yukon. In order to achieve this goal, it is first necessary to garner a picture of the current situation within the territory.

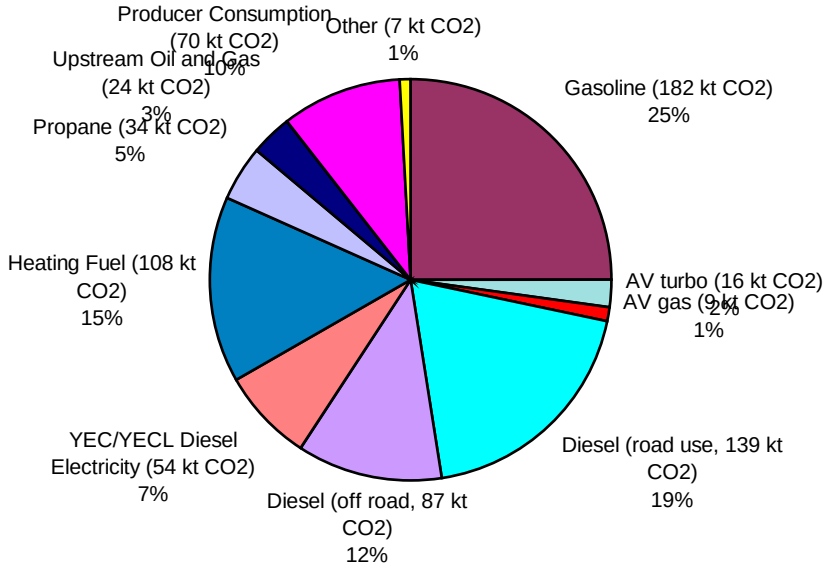
An inventory of Yukon-generated emissions provides an important first step towards the development of a greenhouse gas reduction strategy. This report provides an outline of sources and sinks of emissions appropriate for a more comprehensive inventory of greenhouse gases in the Yukon. The most detailed and accurate analysis in this greenhouse gas inventory for the Yukon focuses primarily on sources from energy and transportation.

Prior to commencing this inventory, jurisdictions outside the Yukon were examined (See *Appendix I Literature Review*). Existing sources of data, as well as approaches to assessing and converting data to carbon dioxide, were identified and evaluated for accuracy, accessibility and appropriateness for this inventory. The two most common sources cited for greenhouse gas emissions in the Yukon are *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Jaques et. al., 1997) and *Yukon State of the Environment Interim Report 1997* (Marshall and McIntyre , 1998).

A preliminary gap analysis investigating data for a detailed Yukon greenhouse gas inventory was initially undertaken. This analysis provided direction and scoping for this Yukon-based greenhouse gas inventory . Emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane(CH_4) have been calculated for transportation and energy fuel combustion sources. *Pie Chart of CO_2 Emissions in the Yukon for 1995* (page 6) is comprised primarily of the CO_2 emissions calculated in this greenhouse gas inventory for the Yukon (See note below pie chart for further explanation). Section *3.0 Inventory* of this report provides a detailed analysis and explanation of the CO_2 emissions presented in this chart. Note that all CO_2 emissions calculated for this report include conversions to CO_2 equivalents for both N_2O and CH_4 .

The examination of these sources provides a baseline for future reduction of greenhouse gas emissions within the Yukon territory. In order to set appropriate priorities, details pertaining to end-use must be discussed. This inventory has initiated a broader interpretation of factors to be considered, for example working towards a better understanding of primary uses of vehicles and electricity to focus attention for reducing the need to consume fossil fuels. The information and analysis in this report will be useful to the development of planning tools for a multiple accounts evaluation of greenhouse gases, to consider both sources and sinks, forecast future emissions, examine emerging trends; as well as inform the implementation of effective policies to reduce greenhouse gas emissions.

Pie Chart of CO2 Emissions in the Yukon for 1995



Data for heating, electricity and transportation are compiled in this report, more detailed figures and explanation of sources are presented in Section 3.0 and in Appendix III. Data for Upstream Oil and Gas, Producer Consumption and Other were derived from the Yukon information presented in Appendix B of *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (there is no 1990 data for Yukon available in Trend's).
Other pie charts and inventory lists are available for greenhouse gases generated in the Yukon for 1995. Appendix B of *Trends in Canada's Greenhouse Gas Emissions 1990-1995* provides data which has not been analysed with a high accuracy of Yukon specific data. The *Yukon State of the Environment Interim Report 1997* uses national data from the Trends book. See Section 3.0 for a fuller explanation.

2.0 METHODS

The research for this greenhouse gas inventory focused on collecting data from the years 1990, 1995 and 1997/98. The year 1990 was chosen because that is the baseline year from which data will be compared to chart success or failure in reducing greenhouse gas emissions (as defined in the Rio Summit and Kyoto Protocol). In 1995, Canada's Environment and Energy Ministers developed the *National Action Program on Climate Change* (1995). The attempt was made to collect the most current data available, however, many of the 1998 records are not yet available. Therefore, data was compiled from both 1997 and 1998 where applicable.

2.1 Yukon Approach

The examination of inventories compiled by other jurisdictions, regulations and reports on climate change provided direction for a Yukon-specific approach to compiling a greenhouse gas inventory. Sources researched were government, university and public libraries, as well as internet websites. This review investigated other approaches to compiling greenhouse gas inventories, reviewed methods and conversion factors used in a variety of documents and determined the degree to which these compared to Yukon specific reports and Yukon specific concerns. Details on this review are discussed in a literature review which is provided in Appendix I. An overview of resources is provided with a rating that depicts the relevancy of each report to the Yukon and the study of greenhouse gases.

2.2 Consultation

Communication with contacts from government, industry, academia and non-governmental organizations, provided specific information and data. An extensive list of contacts is provided in Appendix III. This, in conjunction with the literature review, provided direction for both locations of information and approaches for analysis. The relevance of this information to the Yukon and accuracy of the sources was assessed. For example, much of the federally-compiled data does not differentiate between Yukon, British Columbia and Northwest Territories. This project sought to find Yukon specific data pertinent to greenhouse gas emissions. This search determined what information was easily accessible, available but difficult to access for various reasons, and unavailable. In conjunction with data compilation and analysis, Section *3.0 Inventory* describes the types of data available, the differences of sources, and estimates the ease and availability of data for the compilation of a Yukon inventory.

2.3 Gap Analysis

The gap analysis searched out a wider breadth of information than is compiled in the inventory. Sinks are not analysed in the inventory, but are discussed to some extent in the section *3.0 Inventory* to provide some direction for sources of information and approaches to analysis.

The inventory focuses on the largest sources of greenhouse gas emissions in the Yukon, energy and transportation. Accurate data was compiled for these sectors in a large scale approach that calculated Yukon wide consumption of fuels for transportation and energy. Direction has been provided to move towards a smaller scale of detail for planning purposes, for example to better determine the specifics of end use by sector. Due to the limited scope of this inventory and lack of easily accessible data, detail on the specifics of sector use of fuel and electricity is minimal.

Many factors influence the amount of greenhouse gases that are produced from any given source. Behaviour, fuel type and mechanical efficiency factors all affect the ratios of each specific greenhouse gas that is emitted for a given quantity of fuel consumed. For example, cold weather or the type of catalytic converter will influence the total amount of greenhouse gases generated. This inventory does not attempt to account for this scale of detail, average emission conversion factors were chosen where there is a range provided and details of assumptions are described with each chart and graph.

2.4 Greenhouse Gases

Of the radiative gases, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), carbon tetrafluoride (CF_4), carbon hexafluoride (C_2F_6) and the hydrofluorocarbons (HFC's), only the first three are researched in this report. Since the Yukon industrial and population base is not as large as in other jurisdictions, this results in distinct differences between northern and southern Canada. Yukon emissions of greenhouse gases are primarily from energy and transportation rather than from industrial sources. Consequently, CO_2, CH_4 and N_2O are of greatest concern and are the primary foci of the inventory.

Conversions of fuel and energy to CO_2 and have been accomplished where possible. All CO_2 conversion calculations completed in this inventory have included CO_2 equivalents of CH_4 and N_2O.

The data analyzed for this report has been rated based on quality of data and relevance to the Yukon. This rating is defined and presented in Appendix II. This data rating chart gives an indication of availability and accuracy of data. It also defines what data is not presently being compiled, yet would be required for a more accurate analysis in the future.

3.0 INVENTORY

In order to compile a greenhouse gas inventory for the Yukon, sources of data have been researched and reviewed for analytical accuracy and for degree of direct relevance to the Yukon. This inventory provides an analysis of the gap between information currently available to analyze sources of greenhouse gas emissions and information further desired for the compilation of a more comprehensive greenhouse gas inventory. Sinks for greenhouse gases were considered in the preliminary data and resource search, however, there has been no significant attempt in this report to analyze such information. It is important to consider the relationship between sinks and sources of greenhouse gases, particularly for planning an overall reduction of CO_2 . However, this type of analysis was considered too detailed for the broad scope approach of this project .

The inventory is discussed in the following broad categories: Transportation; Energy Production; Waste; Industry; Mining; Agriculture; and Forestry. This report focuses primarily on providing greater detail on these sources through an analysis of the types and quantities of fossil fuels burned and the greenhouse gases emitted through the burning of these fuels for each inventory category. Consequently, methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) are the main concern for contributing to the greenhouse effect. Conversions of fuel and energy, to CO_2 and CO_2 equivalents (of CH_4 and N_2O), have been accomplished where possible.

In the Yukon, transportation and energy are the largest sources for producing greenhouse gas emissions. The discussion for each of these two main inventory categories, transportation and energy, is divided into two sections each which describe the following: 1. credible sources of data and conversion factors relevant to a Yukon-based analysis of CO_2 emissions (including a summation of CO_2, and equivalencies for CH_4 and N_2O); and 2. topics where data was found to be insufficient, lacking detail for accurate conversion to CO_2, or cases where analysis was beyond the scope of this inventory and are instead described as future considerations for greenhouse gas analysis and investigations.

Emission conversion factors, assumptions made in analysis and data chosen for analysis in this report are explained in each section and under each chart. Emission calculations have been based on average CO_2 conversion factors (for example, in terms of the effectiveness of a vehicle's catalytic converter to reduce greenhouse gas emissions). Analysis in this inventory could not provide sufficient detail to accurately predict the impact of individual behavior (eg driving speeds) or mechanical efficiency factors though these factors are important in the amount of greenhouse gases which are produced from vehicles, generators etc.

This inventory is a first step towards a better understanding of sources of greenhouse gas emissions in the Yukon. This provides some direction for analysis and breakdown of contributions of greenhouse gases by end use and sector in order to focus on priorities and plan for reductions in the overall Yukon contribution of emissions which can influence climate change.

3.1 Transportation

The *Yukon State of Environment Report (1995), Yukon State of the Environment Interim Report 1997* and *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Environment Canada, 1997) describe the percentage of total Yukon greenhouse gas emission that are produced by transportation as the largest contribution of all the inventory categories, at 49% for the State of the Environment Reports and 54% for Trends. The pie chart compiled through this inventory indicates that transportation is only 47% of the total Yukon emissions, see *Pie Chart of CO_2 Emissions in the Yukon for 1995* (page 6).

There are discrepancies between data provided by *Yukon State of Environment Report (1995), Yukon State of the Environment Interim Report 1997* and *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Environment Canada, 1997). The data reported in these three documents are essentially derived from the same source *(ie. Trends in Canada's Greenhouse Gas Emissions 1990-1995* from Environment Canada, 1997), yet do not always concur. Differences are attributed to data manipulation methods, choice of emission factors used and/or the assumptions made to interpret the meaning of the data used. These differences impact greenhouse gas emission calculations and are of concern in the determination of source accuracy. Emission factors continue to change over time as they are better and better refined (email, Liu, 1999).

This division of data between current information known on *Fuels and CO2 Emissions* (Section 3.1.1) and that information which has been relegated to *Future Considerations for Transportation* (Section 3.1.2) was established as this report is unable to link the two sources of information. The transportation data provided is important in greenhouse gas considerations and should be better integrated. However, it is difficult to determine the relationship of total fuels consumed by types and sizes of vehicles given the current information gathered in the Yukon. To accomplish this analysis and predict CO_2 emissions with finer resolution would require a level of detail not currently available for this report. This type of analysis would require a fuller understanding of habitual use of vehicles in the Yukon (for example driving behavior, distances driven, speeds etc.) and specific implications of factors such as cold weather driving.

3.1.1 Fuels and CO_2 Emissions

DATA QUALITY	MED

Information was compiled to provide CO_2 conversions for fuels consumed in the Yukon during 1990, 1995 and 1998.The following sources of were used to determine the types and quantities of fuel used.

Gasoline gross fuel sales were compiled by YTG Finance. These are calculated to include sales of gas which are tax exempt. The term “Gross sales” is defined by Statistics Canada as “all grades of gasoline including farm, construction, or other off road uses, as well as net sales.” This is a more accurate depiction of total sales in the Yukon than the numbers used in Statistics Canada reports and the *Trends in Canada’s Greenhouse Gas Emissions 1990-1995*.

Information on diesel fuel is collected as tax exempt fuel sales and taxable fuel sales by YTG Finance. Taxable fuel sales represent diesel sold at Yukon wide gas stations and used in the Yukon for motive purposes. Tax exempt fuel sales represent sales to permit holders. It is assumed in these charts and graphs that tax exempt diesel fuel sales are primarily used for stationary purposes (for example, generators). YTG issues these permits to placer miners, logging companies, outfitters, federal and territorial departments and others. Presently permitting information is not up to date. There has been a 8% increase in the number of diesel vehicles registered in the Yukon since 1995.

In 1992, Environment Canada conducted a study to determine the quantity of hazardous substances in to the Yukon (Godin, 1999). Under the Transportation of Hazardous Goods Act, information was requested for the records of cargo for all fuel importation. Due to concerns about proprietary information and competition between companies, this information was difficult to accurately compile but data is available in the report *An Inventory of Hazardous Chemicals Transported into the Yukon 1992 and 1993 Database* (Jacobsen et. al., 1994).

Data on fuel sales in the Yukon is collected by YTG finance department and published by Statistics Canada. The most accurate numbers for the consumption of motor gasoline in the Yukon is published in *Road Motor Vehicle Catalogue #53-218* (Statistics Canada) which gives gross sales gasoline. In contrast, the Yukon Bureau of Statistics publishes statistics on quantity of gasoline (in litres) calculated by sales of gasoline which excludes tax exempt sales of gasoline. Therefore, the Yukon Bureau of Statistics is providing an incomplete portrayal of the amount of motor gasoline used in the Territory.

Diesel statistics are also collected by the department of finance and given to Statistics Canada (Larkin, 1999). Statistics Canada also collects information on diesel sales directly through the distributors. Information is not uniformly collected nor stated. This leads to questionable data on end use of diesel fuel. For the purpose of analysis and for calculation of emissions generated from motor diesel fuel, this report uses Statistics

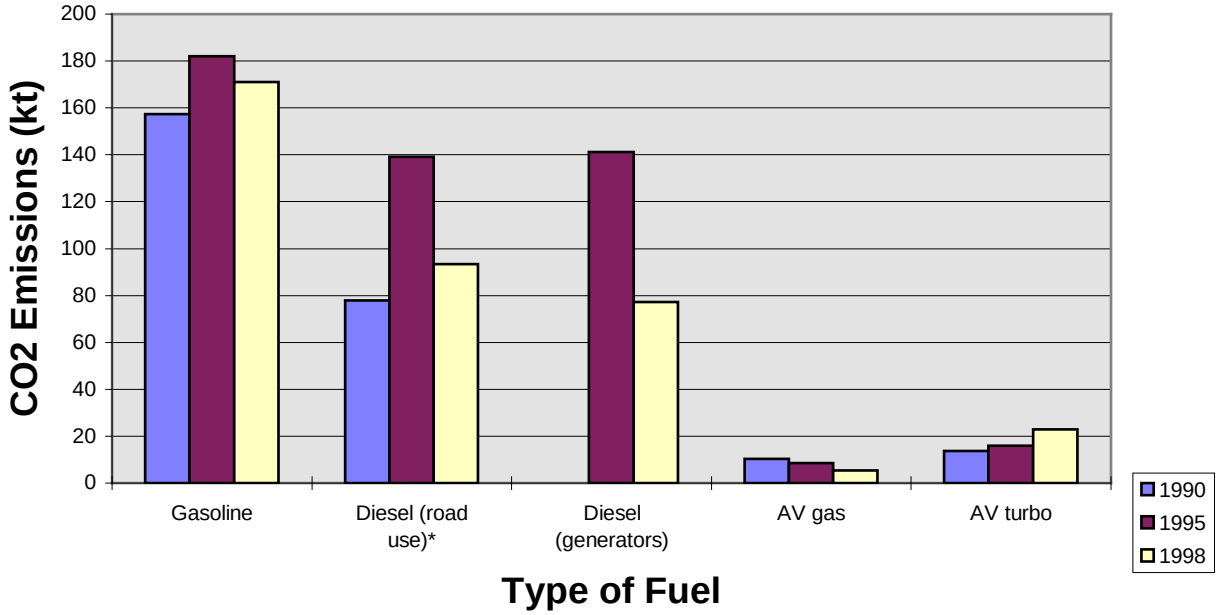
Canada definition of diesel fuel “diesel sold for diesel engine use, for the purposes of diesel consumption analysis concerning transportation” (Statistics Canada 1998). Diesel sales reported in taxable sales will be used.

YTG Finance collects data on diesel from distributors. This information is not uniformly documented and it is therefore difficult to accurately analyze the data in specific terms such as fuel use. Numbers used in the charts and graphs for diesel (generators) is based on these assumptions.

The only information from which to deduce airline or aviation emissions is from the sales of aviation gas and aviation turbo fuel in the Yukon. This information is only referent to planes flying within the Yukon or fueling in the Yukon before departing. These statistics are collected by the YTG Department of Finance. These numbers are also found in *Refined Petroleum Products Statistics Canada* (Statistics Canada).

Figure 1 is a *Graph of CO_2 Emissions (kt per annum) by Fuel Type Based on Gross Fuel Sales in the Yukon for 1990, 1995 and 1998.* This graph is based on the fuel conversion calculations outlined in Appendix III, Figures AIII-1 (*Gross Fuel Sales (in mega-tonnes per annum) in the Yukon by Fuel Type for 1990, 1995 and 1998*) and AIII-2 (*Gross Fuel Sales (litres per annum) and CO_2 Emissions in the Yukon, by Fuel Type for 1990, 1995 and 1998*).

Figure 1: CO2 Emissions (kt per annum) by Fuel Type Based on Gross Sales in the Yukon for 1990, 1995 and 1998



Data Source: YTG Department of Finance

CO_2 conversion factors for gas and diesel were recommended by Jerome McIntyre as follows:

- gas, 2.5 kg of CO_2 per litre; and
- diesel, 2.9 kg of CO_2 per litre.

CO_2 conversion factors for Aviation gas were derived from *Trends in Canada's Greenhouse Gas Emissions 1990-1995* as follows:

- for Av gas, 2.33 kg of CO_2, plus 2.19g of CH_4 (x 21 GWP multiplier), plus 0.23 g N_2O (x310 GWP multiplier) per litre of Av gas; and

for Aviation Turbo gas, 2.55 kg of CO_2, plus 0.08g of CH_4 (x 21 GWP multiplier), plus 0.25 g N_2O (x310 GWP multiplier) per litre aviation turbo gas

3.1.2 Future Considerations For Transportation

For the purposes of this report, *Future Considerations for Transportation* will be broken down into the following: Fuel Statisitics; Aviation; Motor Vehicles; Highways; and Weigh Scale.

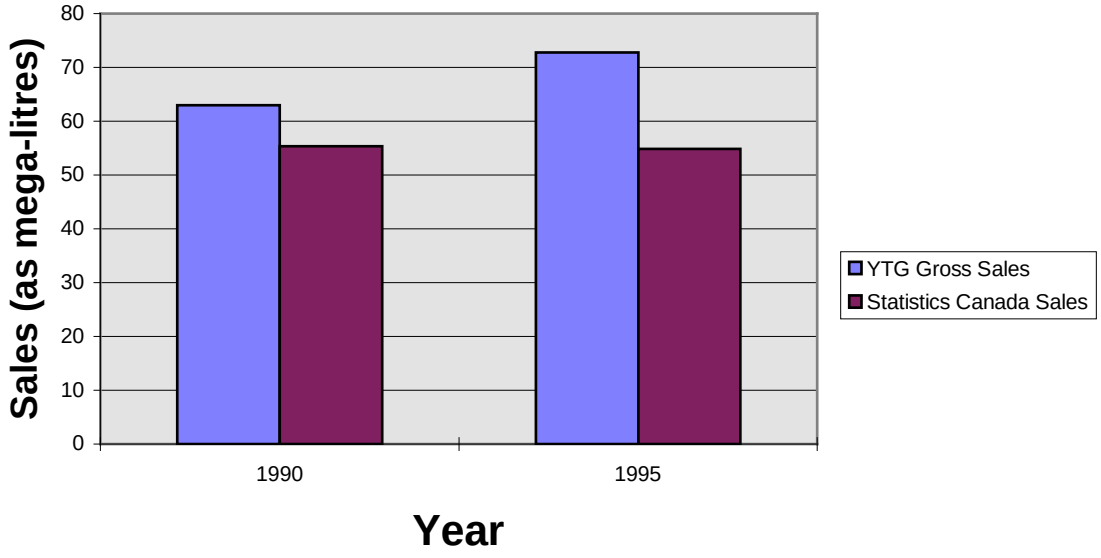
3.1.2.1 Fuel Statistics

DATA QUALITY	***HIGH***

Figure 2 is a *Graph of Gross Sales of Gasoline (from YTG Finance) Compared to Sales Published by Statistics Canada (Sales in mega-litres).* This figure is based on the summation of monthly totals provided in Appendix III, Figure AIII-4 (C*hart of Monthly Gross Sales of Gasoline in the Yukon*) and on Statistics Canada data. See also in Appendix III, Figure AIII-3 (*Chart of Monthly Gasoline Consumption as Taxable Sales for 1990, 1995 and 1998*).

Statistics Canada collects information on domestic sales of refined petroleum products (including diesel) at a provincial level. The Statistics Canada numbers do not concur with numbers published by YTG Finance because Statistics Canada does not publish a Yukon volume (email, Harding, 1999). Furthermore, data is collected by both Statistics Canada and YTG Finance through distributors. In this scenario, information collected by the two differing approaches of these agencies is not uniformly documented.

Figure 2: Gross Sales of Gasoline (from YTG Finance) Compared to Sales Published by Statistics Canada (sales in mega-litres)



3.1.2.2 Aviation

DATA QUALITY	MED

At present data compiled for aviation does not allow for differentiation between the end use of the fuel, whether it be helicopter, small plane or large aircraft. Individual distributors and companies may record fuel quantities with respect to end use but this information is not centrally collected. Information relevant to understanding use of aircraft for different sectors (for example, mining as compared to tourism) and their contribution to greenhouse gas emissions is not maintained in an easily accessible manner.

Environment Canada states that “aircraft emissions are only the emissions from fuels sold to Canadian registered planes. Foreign planes flying in Canadian airspace are considered bunkers if the fuel was sold in Canada. In this scenario the emissions should be allocated to the country of origin” (email, Olsen, 1999). This provides for interesting discussion when dealing with foreign flights flying over and into the Yukon airspace.

Figure 3 is a *Chart of Fire Management Efforts in Forest Fighting for 1998 Aviation Fuel Expenditures and Flight Durations.*

Information on aircraft, fuel consumption and flight times for fire management efforts in 1998 were provided by Rose Putland, Fire Management Clerk, Yukon Forest Fire Centre, DIAND. This statistic was not readily available from Air Operations for past years. Flight times and fuel consumption for forest fire fighting were at an all time high for 1998. There are also statistics available on the area of forest burned in Yukon per year based on general cause, ie human versus lightning. The statistics on hectares burned as a result of lightning versus human cause were: 168,475 ha and 1,139 ha respectively in 1990; 286,487 ha and 578 ha in 1995; and 322,808 ha and 64,971 ha in 1998.

Figure 3: Fire Management Efforts in Forest Fighting (1998) Aviation Fuel Expenditures and Flight Durations			
Air Craft and Gas Type	***Gas (litres)***	***Hours***	***CO2 (tonnes)***
Jet B Helicopter	1,466,028	7,912	3,854
Air Tanker-100 LL Av Gas	659,423	997	1,614
Bird Dogs-100 LL Av Gas	49,089	430	120
Patrol Planes- 100 LL- Av Gas	21,840	312	53
TOTAL	***2,196,380***	***9,651***	***5,642***

Source: Yukon Fire Fighting Centre, DIAND

CO_2 conversion factors for Aviation gas were derived from *Trends in Canada's Greenhouse Gas Emissions 1990-1995* as follows:

- for Av gas, 2.33 kg of CO_2, plus 2.19g of CH_4 (x 21 GWP multiplier), plus 0.23 g N_2O (x310 GWP multiplier) per litre of Av gas
- for Aviation Turbo gas, 2.55 kg of CO_2, plus 0.08g of CH_4 (x 21 GWP multiplier), plus 0.25 g N_2O (x310 GWP multiplier) per litre aviation turbo gas

For the purpose of this chart it is assumed that conversion factors for CO_2, CH_3 and N_2O from Jet Fuel B used for helicopters is the same as for Jet Fuel Turbo conversions.

3.1.2.3 Motor Vehicles

DATA QUALITY	***HIGH***

Data on the number of vehicles registered in the Yukon is collected through the Yukon Motor Vehicles Registration office. This information is broken down into vehicle type; bus, motorcycle, off-highway vehicles by type, cars, trucks under 11,000 kg and trucks over 11,000 kg. Information prior to 1995 is no longer available as the data collection system was purged and all information was lost. The purge was a result of a data system breakdown in 1990. Corresponding data is available through Statistics Canada but is based on national averages, not Yukon specific data. Information for 1995 and 1998 was available yet required substantial efforts by Motor Vehicles Registration staff to compile into a useable form. Prior to this inquiry, data on fuel type had neither been examined nor compiled. Fuel data is now a system parameter at Motor Vehicles Registration, information regarding this documentation is now on file at the department of Motor Vehicles Registration as file #0350-35-04 (S. Belisle, 1999).

Data at the Motor Vehicles Registration is reported in two ways: first by year-end data; and second, by force totals. "Year end data" includes only vehicles registered on December 31 of the given year and is used by Statistics Canada. A "force total" analysis refers to the total number of vehicles registered in the Yukon any day throughout the given year. For the purpose of understanding the effects of transportation on greenhouse gas emissions it is preferable to use force totals. Data is available on the number of vehicles registered as a force total per annum by fuel type.

Figure 4 is a *Chart of Total Number of Vehicles Registered Listed by Weight and Fuel Type for 1995 and 1998*. Information provided by Motor Vehicles Branch, YTG. Data from 1990 was not available due to the purging of the computer system due to technical failure.

Figure 4:
Total Number of Vehicles Registered,
Listed by Weight and Fuel Type for 1995 and 1998

under 11,000 kg (light duty vehicles)		
	1995	***1998***
diesel	1,234	1,519
gasoline	30,035	30,730
propane	104	101
electric	2	2
gas/propane	34	26
over 11,000kg (heavy duty vehicles)		
	1995	***1998***
diesel	1,627	1,576
gasoline	212	181
propane	11	11

Source: Motor Vehicles Branch, YTG
Data was compiled as “force totals”. This refers to the total number of vehicles registered in the Yukon on any day throughout the given year.

Figure 5 is a *Chart of Number of Vehicles by Vehicle and Fuel Type for 1995 and 1998*. Information provided by Motor Vehicles Branch, YTG. Data from 1990 was not available due to the purging of the computer system due to technical failure.

Figure 5:

Number of Vehicles by Vehicle and Fuel Type for 1995				
vehicle type	***diesel***	***electric***	***gasoline***	***propane***
bus	134		88	11
motocycle	1		702	
car	92	2	10,911	5
truck <11,00kg	1,013		17,267	88
snowmobile	1		892	
truck> 11,00kg	1,624		212	

Number of Vehicles by Vehicle and Fuel Type for 1998					
vehicle type	***diesel***	***electric***	***gasoline***	***propane***	
bus	170		124	13	
motorcycle			707		
car	89	2	10,714	6	
truck < 11,000kg	1,265		18,122	82	
snowmobile			860		
truck> 11,000kg	1,574		181	11	

Source: Motor Vehicles Branch, YTG
Data was compiled as “force totals”. This refers to the total number of vehicles registered in the Yukon on any day throughout the given year.

3.1.2.4 Highways

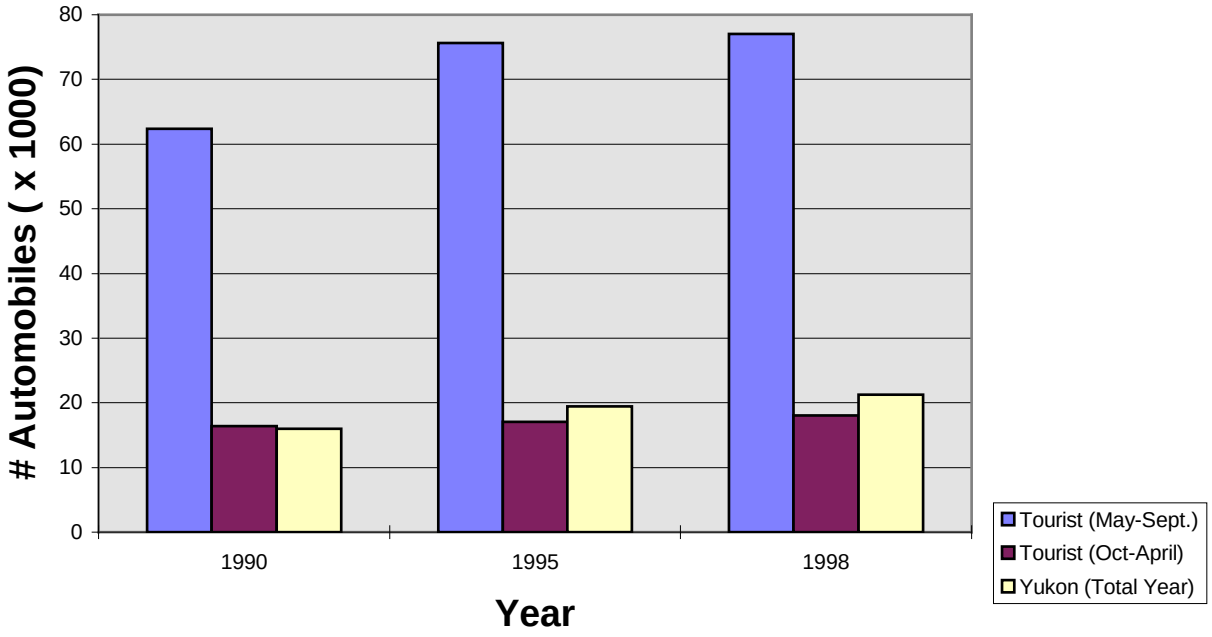
DATA QUALITY	MED

Data collected by the Traffic Count Program indicates the number of vehicles on the road at designated locations and is published annually in the *Yukon Traffic Count Summary* (Yukon Government). There are 27 permanent traffic counters and 22 mechanical counters, although data was inconsistently collected due to mechanical failure of the counters. The data has been collected sporadically since 1990. This information is useful for greenhouse gas analysis in that we are able to track a definite increase in traffic on Yukon highways,(ie- a 3% growth rate on the average annual daily traffic volume on the Klondike highway since 1987) (Yukon Traffic Count Summary, 1997).

Data on the number of vehicles crossing border controls is collected. Tourism collects this data from the border register as a manual count and differentiates Yukon plates from visitor plates. This provides information on tourist vehicle contribution to emissions from transportation sources.

Figure 6 is a *Chart of Border Crossings, Number of Automobiles (x1000) Crossing in 1990, 1995 and 1998*. Information provided by Pierre Germaine from the Department of Tourism, YTG. This data was compiled at Canadian Customs as Yukon license plates versus non-Yukon plates crossing the border into Canada from Alaska.

Figure 6: Border Crossings, Number of Automobiles (x 1000) Crossing in 1990, 1995 and 1998



Source:Department of Tourism, YTG

3.1.2.5 Weigh Scale

DATA QUALITY	MED

Motor Vehicle Registration collects data on vehicles over 11,000 kg, yet it does not categorize trucks by type of commodity being hauled. This data is collected by weigh scale operators and includes data on all trucks traveling along Yukon highways. Included in data collected is vehicle weight, origin and destination, commodity hauled and axle count. As well, data can be derived to determine the number of vehicles traveling through to Alaska. Although, the weigh scale keeps monthly records, numbers compiled for annual calculations are not yet available since they are calculated through a company in Alberta. This data is relevant to greenhouse gas emissions inventory as analysis can be made on the effects of mine openings and closures and the number of trucks on the highway.

Figure 7 is a *Graph of Weigh Scale Information for 1998, on Trucks Entering and Leaving the Yukon by % Commodity Shipped.* Information provided by Wally Hindinger from Transportation Engineering Branch, YTG. Data was provided on a monthly basis and summed for the total year 1998 categorized by commodity.

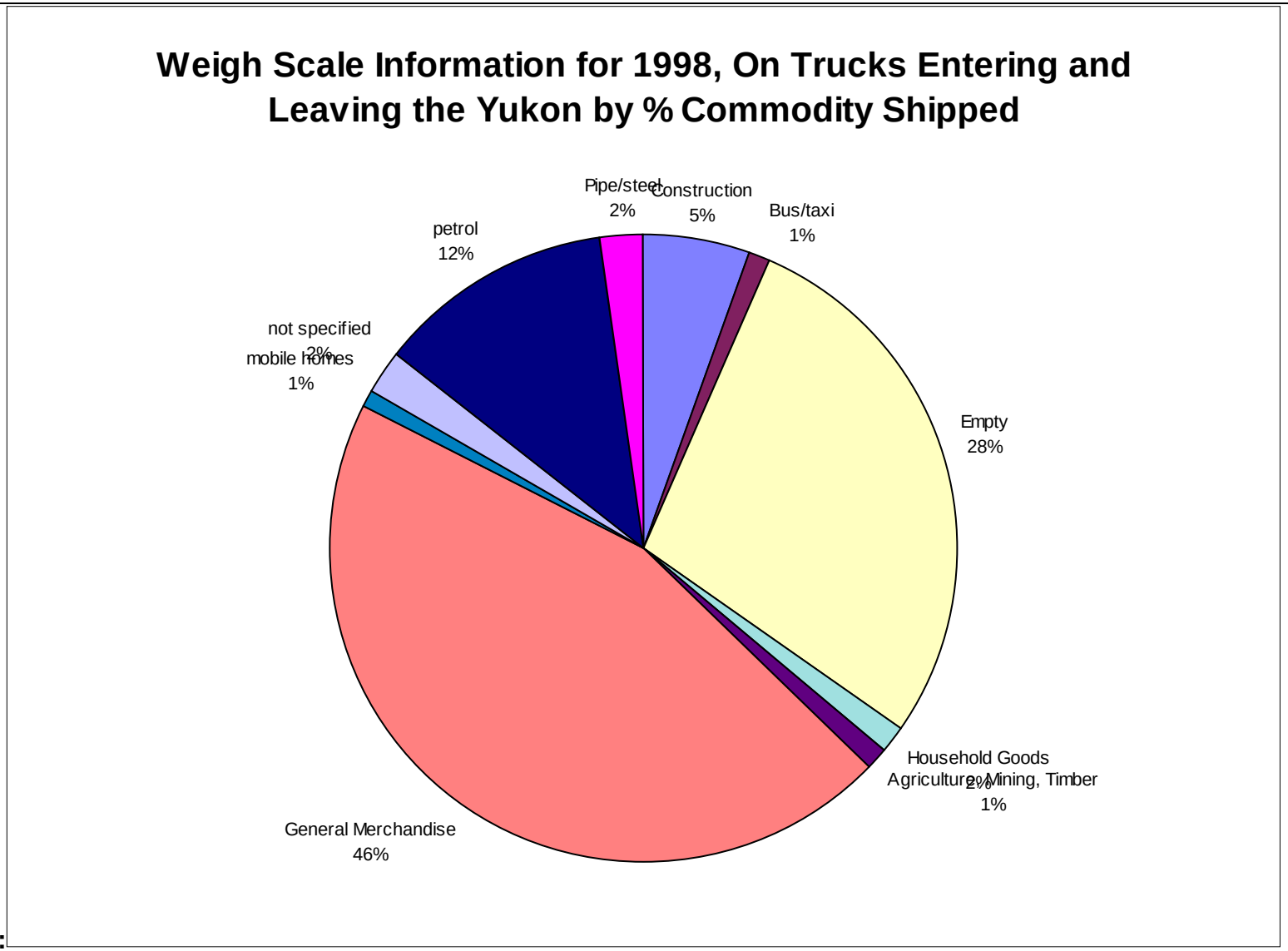


Figure 7:

Source: Transportation Engineering Branch, YTG

3.2 Energy

For the purpose of the analysis of greenhouse gas emissions generated in the production of energy, data is readily accessible in the Yukon. Summaries from both YEC and YECL provide information on the production of diesel generated power. This can be easily converted into CO_2 emissions. Statistics are kept on electricity generated by diesel, hydro and wind generation. Data for energy production for 1998 has been collected from both YEC and YECL. YECL keeps statistics through the Standard Industrial Coding (SIC) system which is able to analyse customer use and end use of energy (Savage, 1999).
Due to changes in information on billing, YECL is unable to easily provide energy end use data. This data is available but at a financial cost.

Information is available to determine the amount of diesel fuel used in the production of electricity (B. Collins Jan. 1999). The amount of diesel fuel burned to produce electricity directly determines the amount of CO_2 produced. There are differences in energy efficiency at each power generation site and the resulting CO_2 production will vary in relation to these mechanical differences. Similarly, it is unclear what constitutes the impact of extreme temperatures and differences of efficiencies of each power producing system on emissions of greenhouse gases. There is no sampling or analysis of greenhouse gas or related emissions conducted on power plants in the Yukon (with the exception of particulate data). For the purpose of calculating emissions in this inventory, a general conversion of fuel to CO_2 emissions was adopted and assumptions are detailed with each chart and graph.

End use of energy is collected by Statistics Canada and is published by the Yukon Bureau of Statistics.

3.2.1 Power Generation and CO_2 Emission

DATA QUALITY	HIGH

The following graphs and charts (Figures 12-19) illustrate energy generation and use in the Yukon. Yukon Electrical Company Limited (YECL) and Yukon Energy Corporation (YEC) provide the majority of the data for this section of the inventory. Figure 8 is a chart of *YECL and YEC Electricity (in M.W.h.) in the Yukon Generated by Hydro, Diesel and Wind*, and calculates the CO_2 emissions from the diesel consumed in generating electricity.

Figure 8:

YECL and YEC Electricity (in MW.h.) in the Yukon Generated by Hydro, Diesel and Wind								
	YECL		***YEC***			**Total Electricity**	**Total Diesel**	**CO2 Emissions for Diesel**
	Electricity in MW.h.		Electricity in MW.h.			**Generated**	**Generation**	**Generation**
	hydro	diesel	hydro	diesel	wind	MW.h.	MW.h.	Kilo Tonnes
1990	9,753	17,923	413,056	44,170	-	484,902	62,093	50.09
1995	7,077	17,943	310,128	52,373	272	387,793	70,316	54.48
1998	5,561	20,013	264,450	21,802	259	312,085	41,815	31.07

Source: YEC and YECL

Conversion factor provided by *Trends in Canada's Greenhouse Gas Emissions 1990-1995*. The conversion factor for CO_2 is 2,730g/l, CH_4 is 0.26g/l and N_20 is 0.40 g/l and is calculated on the amount of fossil fuel used to generate power. Quantity of diesel fuel consumed to produce the electricity in the above chart was provided by Hector Campbell (YEC) and is listed in Appendix III, Figure AIII-7, *Diesel Consumed (in litres) to Produce Electricity for 1990, 1995 and 1998*.

There are no direct CO_2 emissions resulting from hydro power production. A full life cycle analysis is compiled by reviewing all CO_2 emissions which result in direct connection to the production of hydro power. For example, CO_2 emissions resulting from the construction of hydro plants (eg. from concrete production) can be attributed to the CO_2 emissions tally. Similarly, if a reservoir is created and floods, organics will generate CO_2 through decomposition contributing to the total emissions.

Appendix III includes the following graphs and charts which provide detail on data and calculation used in this section to calculateCO_2 emissions from power generation in the Yukon. Figure AIII-5*, Graph of Electricity Generation (in GW.h.) for 1990, 1995 and 1998* (Information provided by YEC and YECL). Figure AIII-6, *Graph of Diesel Fuel (in m^3) Consumed to Produce Electricity for 1990, 1995 and 1998*. Figure AIII-7*, Chart of Diesel Consumed (in litres) to Produce Electricity for 1990, 1995 and 1998* (Information provided by Hector Campbell, YEC).

3.2.2 Future Considerations for Energy

This section provides direction and some analysis to break down information on energy use in terms of end use and sector.

Figure 9: Breakdown of Electrical Sales (in GW.h.) by Sector

DATA QUALITY	*MED*

Breakdown of Electrical Sales (in GW.h.) by Sector			
Sector	***1990*** **GW.h.**	***1995*** **GW.h.**	***1998*** **GW.h.**
Residential	13.4	11.5	
Commercial	12.7	12.5	
Industrial (Mining)	181.9	94.5	
Lighting	0.2	0.3	
Sales to YECL	206.5	216.9	
Total Generated	457.3	362.6	

Information provided by Hector Campbell (YEC) and Wendy Scramsted (YECL). Sector breakdown is collected through "customer rate class" billing information. This data indicates by code who is purchasing electricity. Note that this breakdown of information is not to be confused with end use. The Standard Industrial Classification system denotes end use. Howevere, it is timely and expensive to extrapolate data from this system.

Information from YECL for 1990 is not available.

YECL purchases power from YEC to supply electricity to Whitehorse. Electricity generated by YECL is primarily consumed in Watson Lake.

It is currently difficult to provide a clear picture pertaining to energy use within the various economic sectors. For example, information on diesel generated power at the numerous lodges, mining, forestry and outfitting camps around the territory is near impossible to gather. This situation arises, in part, because the current permitting system is not enforced and this information is not collected elsewhere.

Appendix III lists Figure AIII-8, *Diesel Generated Power in each Community in the Yukon for 1998 Converted into CO_2 Emissions* (Information provided by both YECL and YEC).

Further discussion for future considerations in energy has been divided into sections as follows: Power Generation; Propane; Kotaneelee; and Heating Fuel.

3.2.2.1 Mining

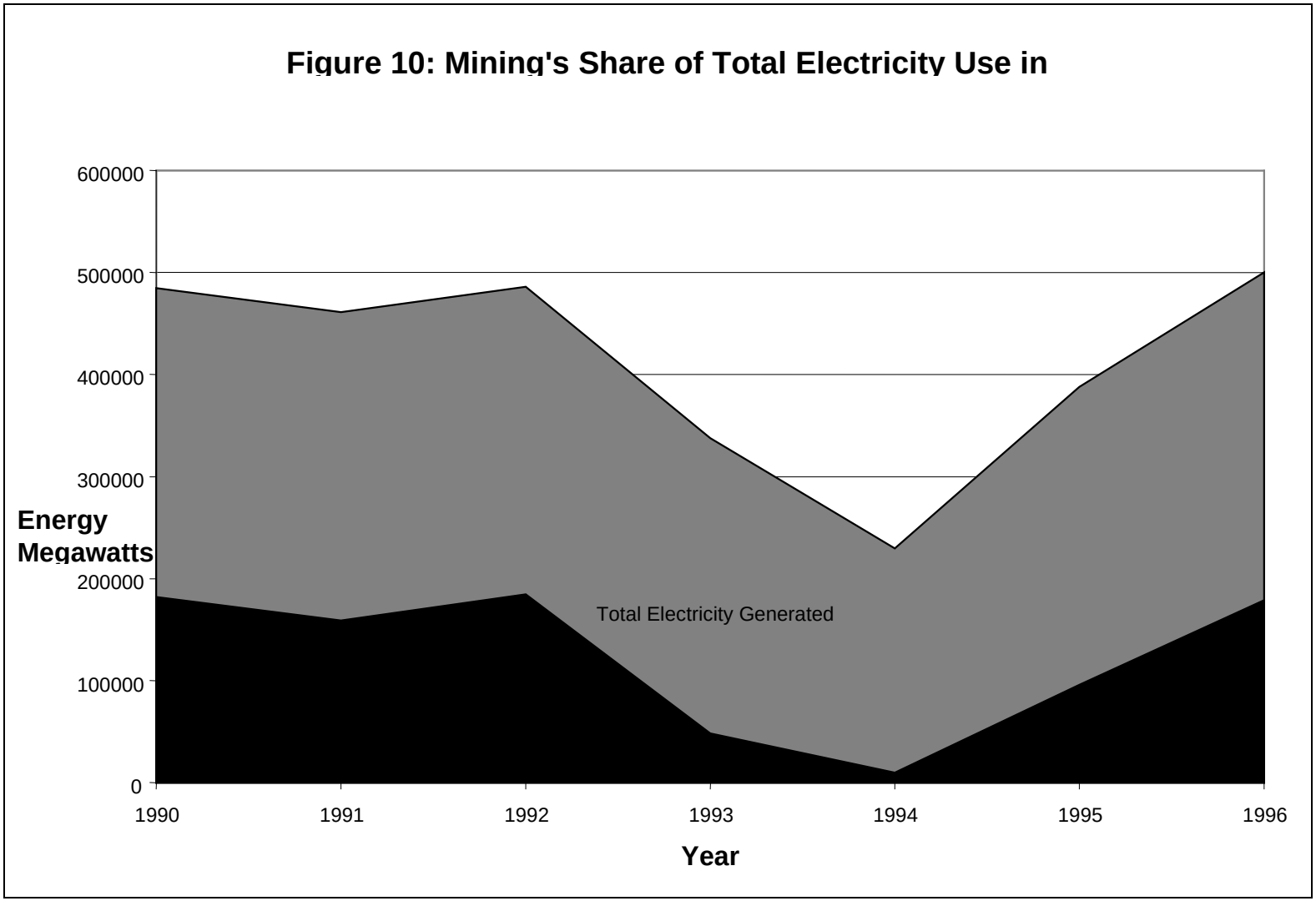


Figure 10: Mining's Share of Total Electricity Use in
600000
500000
400000
300000
200000
100000
0
Energy Megawatts
Total Electricity Generated
1990
1991
1992
1993
1994
1995
1996
Year

Information for Figure 10 was from Statistics Canada Catalogue #57-202. 1997 and 1998 data has not yet been published by Statistics Canada.

The Faro mine was open January 1990 – April 1993
closed May 1993 – August 1995
open September 1995 – March 1997
close April 1997 – October 1997
open November 1997 – January 1998
closed January 1998 –

DATA QUALITY	***MED***

3.2.2.2 Propane

DATA QUALITY	LOW

Propane data is difficult to access in the Yukon due to competition concerns between ICG and Superior Propane, the two companies currently operating in the Yukon.

3.2.2.3 Kotaneelee

DATA QUALITY	LOW

The CO_2 emissions listed in Figure 11 do not represent greenhouse gases emitted in the Yukon. Although greenhouse gases are emitted from the Kotaneelee gas field, at this point it is indeterminable how *Trends in Canada's Greenhouse Gas Emissions 1990-1995* estimates their figures. The conversion factors designed by *Trends in Canada's Greenhouse Gas Emissions 1990-1995* provide an accurate national estimate and not a field specific estimate.

The following information is needed in order to accurately determine CO_2 emissions for Kotaneelee, or other natural gas producers:

- total amount of the produced gas that is combusted on site (producer consumption);
- the CO_2 concentration of the raw gas; and
- a field estimate of gas leakage provided systematically from equipment on site.

Figure 11: Gas Production at Kotaneelee Gas Field

DATA QUALITY	MED

	Volume in (,000 m3)	Energy in (PJ)	CO2 (kt)	CH4 (kt)	CH4 (kt CO2)	N2O (kt)	N2O (kt CO2)	Total Gas (kt)
1995	345,137	12.8	636	0.009	0.188	0.008	2.46	639
1998	337,000	12.5	621	0.009	0.184	0.008	2.4	624

Data on gas production at the Kotaneelee Gas Field provided by John Masterson through Bob Collins. The CO_2 conversion calculations are based on NRCan publication *Canada's Energy Outlook 1996-2000.* The conversion factors are as follows:

49.68 tonnes CO_2/TJ
0.07 kg/TJ CH_4 (x21 GWP multiplier)
0.62 kg/TJ N_2O (x310 GWP multiplier)

The GWP multipliers convert CH_4 and N_2O to CO_2 equivalents and are from *Trends in Canada's Greenhouse Gas Emissions (1990-1995).*
The Yukon does not burn natural gas; this needs to be taken into consideration in using the above numbers. Only a small percentage is used to move gas out of the territory (Collins, 1999).

3.2.2.4 Heating Fuel

DATA QUALITY	*MED*

Figure 12: Monthly Heating Fuel Consumption in the Yukon as Gross Sales (in litres) and CO_2 Emissions (kt)

Monthly Heating Fuel Consumption in the Yukon Gross Sales (in litres)				**CO2 Conversion (in Kilo Tonnes)**		
Month	***1990***	***1995***	***1998***	***1990***	***1995***	***1998***
Jan	4,650,887	5,685,598	8,693,299	13.15	16.07	24.57
Feb	6,436,798	4,696,727	4,655,843	18.19	13.28	13.16
Mar	4,495,448	4,594,466	5,099,382	12.71	12.99	14.41
April	2,006,067	2,763,222	2,828,077	5.67	7.81	7.99
May	1,877,837	1,656,192	2,129,029	5.31	4.68	6.02
June	1,015,700	855,077	1,683,259	2.87	2.42	4.76
July	929,746	941,293	2,021,650	2.63	2.66	5.71
August	1,329,364	1,886,730	1,657,630	3.76	5.33	4.69
Sept	2,104,301	1,991,368	3,268,519	5.95	5.63	9.24
Oct	3,169,730	2,928,431	3,716,876	8.96	8.28	10.51
Nov	4,599,935	4,408,054	4,426,051	13.00	12.46	12.51
Dec	4,965,030	5,758,948	6,221,251	14.03	16.28	17.58
Total	37,580,843	38,166,106	46,400,866	106.22	107.87	131.15

Information provided by YTG Department of Finance.
Information collected through distributor reports.
YTG does not separate heating fuel by type, Statistics Canada collects their own data through distributor reports.
The conversion factor is from *Trends in Canada's Greenhouse Gas Emissions (1990-1995)*.

CO_2 = 2,830g/l fuel
CH_4 = 0.214 (x21 GWP multiplier)
N_2O = 0.006 (x310 GWP multiplier)

3.3 Waste

DATA QUALITY	*LOW*

Waste disposal is of concern in the determination of sources of greenhouse gas emissions for an inventory because the choice of disposal method can alter the overall contribution of emissions generated form wastes. For example, an alternative to the burning of waste oil (which will generate carbon dioxide, methane and nitrous oxide) is to ship it out for recycling. A primary concern with landfill waste is to consider options which can minimize methane produced, such as the disposal method for organics, or the compaction and layering of the landfill itself.

The collection and disposal of waste remains essentially unregulated (conversation, Paslawski, 1999). Records kept to date are incomplete and vague as to the total number of dumps (the term "dump" is used because most have not been engineered and managed as the term "landfill" would imply) in the Yukon, as well as their location, size and use (Gates, 1999). It is estimated that there are over 400 dumps in the Yukon of varying levels of size and use. This includes those located within hamlets, subdivisions, municipalities, mines, maintenance camps, private operations and federal dumps. Under current legislation, dumps are not required to register or provide any information to the Yukon Government on tonnage, number of burn days or hazardous waste disposal.

No central collection of waste data occurs at this time. The *Solid Waste Regulations* (January 1999) are currently under public review. Upon implementation, these regulations may change current practices to better maintain waste records. In addition, the *Air Emissions Regulations* (Yukon Government) will affect the collection of data concerning dumps (for example, burning records).

Personal contact with each municipality revealed a wide range of approaches to collecting, compiling and reporting information on dumps. All municipalities differ in the level of attention given to waste management, for example, some have a site attendant on staff to monitor waste diversion whereas others burn waste oil in 45 gallon drums (Spink, 1999). The number of burn days and what is burned is also relevant for greenhouse gas emissions calculations.

Only the City of Whitehorse keeps records on tonnage and this is calculated through a temporary scale set up at the dump (Heath, 1999). Information on methane emissions are not currently collected at any of the dumps in the Yukon Territory.

The *State of the Environment Report 1995* compiled information on the type of dump for each municipality but is it not extensive. Information is categorized in terms of factors which affect the amount of greenhouse gas emissions generated in the following manner: i) by waste tipped in a natural depression, then burned covered; ii) waste tipped

in a trench, burned, compacted then back filled; and iii) wasted tipped in a trench compacted and back filled but not burned. This data not comprehensive (Gates, 1999).

3.4 Industry

DATA QUALITY	***LOW***

The *Yukon State of the Environment Interim Report 1997* (Marshall & McIntyre, 1998) states that emissions of CO_2 from the burning of fossil fuels by commercial industries is 13%. Both the *State of Environment 1995* (Renewable Resources) and the *State of Environment Interim Report 1997* (Marshall & McIntyre, 1998) attribute 12% to producer consumption. Producer consumption represents emissions from the combustion of fuels manufactured by the producer (email, Olsen, 1999). Consequently, the Kotaneelee gas field is solely represented by this number of 12%.

Industries contribution to greenhouse gases is discussed in the following sections; Emissions control, Kotaneelee Gas Field, Mining

3.4.1 Emission Controls

Until recently no emissions monitoring has been done on industries in the Yukon. Recently the *Air Emission Regulation* was passed. Data collected will provide a base line from which emissions from industry will be measured. Emission monitoring is conducted by a certified company at the cost of the company (P. Paslwski, Feb 1999) and reported to Renewable Resources.

Unlike other jurisdictions in Canada, Yukon does not have stack emission regulations for industries.

3.4.2 Kotanelee Gas Field

The Yukon has 50.6 km of gas pipeline (Statistic Canada Cat No. 57-205-XPB) Data has been collected on production of natural gas since 1979. From 1982 to 1991 there was no production of natural gas at this gas field. Data can be found on production in joules per cubic metre. CO_2 conversion factors for emissions from the Kotaneelee Gas Field are in question as the following information is needed in order to determine CO_2 emissions:

- CO_2 concentration of the raw gas
- Schedule of equipment at the field to estimate gas leakages

Trends in Canada's Greenhouse Gas Emissions 1990-1995 (Jaques et. al., 1997) provides a conversion factor for a national estimate and not to be used for a specific field estimation (email, Olsen, 1999). Currently a suitable conversion factor has not been sourced.

3.5 Agriculture

DATA QUALITY	*MED*

Agriculture is generally small scale in the Yukon and are estimated to contribute only 1% of the total greenhouse gas emissions Yukon wide. Agriculture practices contribute to greenhouse gases through the burning of fuels for machinery, vehicles and power generation. Livestock generation of gases by enteric fermentation and from animal wastes, and soils contribution enhanced by fertilizer applications contribute to greenhouse gas emissions. Additionally, clearing of forest lands for agricultural purposes may decrease the potential for reduction of CO_2 through the carbon sink of photosynthesis . This section discusses agricultural contribution to greenhouse gases in the following sections: Farms, Agricultural Land Cleared, and Power and Fuel Use.

3.5.1 Farms

Statistics on agricultural practices in the Yukon are tracked through the Agriculture Department of Renewable Resources of the Yukon Territorial Government. Numbers of farms, livestock, hectares in use for agriculture and types of crops produced are charted in the *Yukon Agriculture, State of the Industry, 1996-1997* report (Smyth et. al., 1998), and the *Yukon Agriculture, State of the Industry, 1994-1995* report (Renewable Resources, 1996. These reports are compiled every two years. Information prior to 1992 was not collected and reported in this type of systematic format, but some data is readily available. More data can be found in *the Yukon Agriculture Branch Quarterly Newsletter* and the *1996 Census of Agricultural Data for the Yukon and Northwest Territories* (May 1997).

The federal publication *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Environment Canada, 1997) records agricultural contribution to greenhouse gases from livestock manure, fertilizer use and soils as zero, presumably because the agriculture in the Yukon is minimal or difficult to quantify with such low-intensity agricultural practices.

3.5.2 Agricultural Land Cleared

Understanding the amount of land cleared can provide information on the balance of CO_2 sinks, ie through the loss of productive forest as compared to the gain of crop lands and the implications for overall CO_2 balances (see forestry section for further discussion on forest uptake of CO_2). Statistics on land disposition for agricultural purposes is available at the Lands Disposal office of the Agriculture Department of Renewable Resources of the YTG. The Yukon Policy for Agricultural Development started in the early 1980's. This policy directed the process and requirements of agricultural land disposition and required that land be cleared, cultivated and seeded at a rate of 2/3 of 80% of the total land area (53% of the total land area) defined in the "agreement for sale". The proponent has a time frame of five years in which to accomplish the terms of

the agreement for sale, including development such as clearing the required area of land. Once the requirements are met title for the land is granted in a transfer of lands.

In 1991 the old policy was revised to allow for site specific definition of agreements for sale through a farm development plan, but on average, each farm maintains the same rate for clearing of agricultural land (Edward Lee, 1999). These new regulations, *Agriculture for the 90's: A Yukon Policy* (YTG, 1991) are currently under revision.

Information on 1990 disposition of agricultural land would require an in-depth investigation to determine accurately, but there is adequate information available on the number and area of Land Agreements issued. Although records were more accurately kept for 1995 and 1997, data is not yet available for 1998 since reporting is completed every two years. An in-depth search would be required to determine precisely the total area of land cleared per annum for the purposes of agricultural development. Yet an estimate can be made based on the known land areas given out each year in agreements for sale and in completed land titles.

3.5.3 Power and Fuel Use for Agriculture

The *Yukon State of the Environment Report 1995* reported that 1% of fossil fuels emissions in the Yukon was for agricultural purposes (Renewable Resources, 1996, p 6) This estimation is based only on electrical uses as collected by the Yukon Energy Corporation and Yukon Electrical Company Ltd.

Of particular note, YTG Finance records are not up to date for tax exempt fuel permits which can denote consumption of fuel by sector (ie. mining, agriculture, personal heating). A general discussion on diesel consumption was presented under the transportation section, but does not provide detailed analysis by sector.

The report *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Environment Canada, 1997) provides statistics for 1995 (not for 1990) on the CO_2 emissions from agriculture as a result of stationary fuel consumption. There are discrepancies in data on fuel consumed for agricultural purposes derived for 1993 between the *Yukon State of the Environment Report 1995* (Renewable Resources, 1996), *Yukon State of the Environment Interim Report 1997* (Renewable Resources, 1998) and the *Trends in Canada's Greenhouse Gas Emissions 1990-1995* (Environment Canada, 1997), and for 1995 for the last two references (see discussion in the Transportation section for possible reasons contributing to these differences).

3.6 Mining

DATA QUALITY	*LOW*

Data collected on the effects of mining on greenhouse gas production is sporadic. Transportation figures can distinguish data for B-trains used to haul ore, as well as energy consumption figures. Data collected by end use can determine the amount of electricity consumed by the mine. See 3.2.2.1 and Figure 10 which *describe Mining and Total Yukon Use of Electricity from 1990-1996*.

Information relating to placer mining is much less conclusive. Presently, the Government of Yukon collects information on fuel consumption by placer miners through tax exempt permits. Data collection has not been enforced but this process is undergoing some changes (Larkin, 1999). Through fuel permitting, data can be collected and analyzed for the contribution of mining to greenhouse gas emissions from fossil fuels. However, this reporting of data is not a reliable source of information due to sporadic compilation of information and different methods of interpreting reporting forms.

Statistics Canada collects information pertaining to diesel products through the Refined Petroleum Products survey. This survey includes information on the production, receipts and deliveries of 17 different refined petroleum products at a provincial or territorial level. However, they do not publish a Yukon volume (email, Harding, 1999). This information if accessible would be useful in determining mining's use of diesel fuel. There is no data collection occurring on land cleared for quartz and placer claims.

Through calculating transportation of ores to smelters and refineries it would be possible to find tonnage from each mine and determine the number of trucks in conjunction with the distance hauled for processing. It is uncertain where contributions of mineral processing to greenhouse gas emissions would be accounted for. A full accounting of greenhouse gases related to mineral production would require information from both local and associated sources.

3.7 Forestry

DATA QUALITY	*MED*

Forestry practices contribute to greenhouse gases through fuel consumption for logging camp power, machinery and transportation. This is caught in the general totals of fuel consumption but not specifically analyzed in terms of Forestry. Combustion of wood for fuel or in the event of forest fires contributes a variety of greenhouse gases including carbon monoxide, particulates, nitrogen oxides and organics to the atmosphere. Additionally, the loss of metabolically productive forest land disrupts a potential sink for carbon dioxide. This analysis considers logging practices both in terms of area cut and area revegetated. This section discusses greenhouse gas concerns in relation to forestry in four sections: Logging, Reforestation, Fuel Wood Combustion and Forest Fires.

3.7.1 Logging

Statistics on timber volumes cut are available on an annual basis in *Timber Year Harvest Studies* from Forest Resources, DIAND (Skaalid, 1998), the *Timber Supply Analysis* and from the *National Compendium of Forest Statistics*. Clarity on the end use of timber cut is available in these reports defined as fuelwood, sawlogs, roundwood, salvage and posts and rails.

Transportation of logs can be determined based on the number of trucks required to export the annual volume of logs compared to the domestic volumes. Associated fuel consumption can be calculated from knowledge of the distances traveled for certain mills and Weigh Scale records on origin, destination and type of trucks (see section on transportation for more detail).

There is a new lumber mill near Watson Lake which will process 100,000 cubic meters, accounting for a quarter of the annual cut in the Yukon (Baltgailis, 1999). This mill will be producing greenhouse gases through combustion of a scrap wood burner.

3.7.2 Reforestation

The Elijah Smith Reforestation project (ESRP) has planted seedlings and kept records of area replanted (Forest Resources, DIAND,1999). Silviculture fees are currently paid to ESRP by loggers at a rate of $5 per cubic meter of sawlogs harvested. Until the logged areas have been planted or site prepared, or information from a regeneration survey is available, the area is to be considered “not sufficiently restocked” or “NSR” (Whortley, 1999). Information on regenerative success of planted seedling is not collected (Forest Resources, DIAND,1999).

The Timber Supply Analysis For the Southern Yukon (Forest Resources, 1998) reports on a regional basis the area of forest impacted as a result of unsalvaged loss such as fire, blowdown, spruce bark beetle and root rot. This report also comments on NSR areas and regeneration potentials (Forest Resources, 1998).

3.7.3 Fuel Wood Combustion

To estimate the wood burned for home heating use in Whitehorse, the *Yukon State of the Environment Report 1995* (Renewable Resources, 1996) assumes 5 cords of wood for each wood burning appliance. Records on the number of new wood stoves installed in Whitehorse have been kept since March 1, 1997, however any stove in use prior to that date will not be on record. Insurance records keep track of home wood stoves but the data is not compiled or accessible. Precise data on both number of home wood stoves in use and consumption rates would be difficult to determine. Additionally, estimates of greenhouse gas emissions based on number of cords burned would be very difficult due to differences in air space of the cord stack and burning characteristics (ie, wet compared to dry wood) (Collins, 1999).

Statistics on fuel wood cutting are available from *Timber Year Harvest Studies* from Forest Resources, DIAND (Skaalid, 1998), the *Timber Supply Analysis* and from the *National Compendium of Forest Statistics* which are compiled annually. The statistics compiled on personal fuel wood cutting are not accurate due to the difficulty in attaining realistic records of small scale cutting. Commercial permits are more effectively tracked (Baltgailis, 1999).

Wood smoke monitoring was conducted by the City of Whitehorse Bylaws Inspection until the end of 1997 when the city council stopped the program. Data was collected on wood smoke in terms of particulates. In January 1997, the City of Whitehorse by-law was amended to include standards for wood stoves. More information is forthcoming from the City of Whitehorse Environmental Coordinator (Heath, February 1999).

Renewable Resources collects data once per week for the National Air Pollution Monitoring System (NAPS) program which is a national network of ambient air quality monitoring stations. There is one station in the Yukon located on top of the Law Office in Whitehorse, which measures particulates, carbon monoxide and nitrogen oxide. Data from this monitoring station is site specific, infrequently sampled and located above a parking lot, and therefore should not be viewed as representative of Whitehorse air quality (Paslawski, 1999).

The Yukon Bureau of Statistics compiled and reported statistics on air quality from both the City of Whitehorse and the NAPS sampling programs, but no longer collects this data.

3.7.4 Forest Fires

Forest Resources (DIAND, 1999) has a map of Yukon Territory areas affected by fire. Human-caused fires follow the access routes (roads primarily, and rivers) accounting for 50% of fires. These fires tend to be smaller and more quickly extinguished due to their close proximity to human activity. Forest Protection, DIAND, compiles and reports area burned as a result of human versus naturally-caused forest fires (Putland, 1999*). The Timber Supply Analysis For the Southern Yukon* (Forest Resources, 1998) reports on a regional basis the area of forest impacted as a result of fire.

Information on aircraft, fuel consumption and flight times for fire management efforts in 1998 were provided by Rose Putland, Fire Management Clerk, Yukon Forest Fire Centre, DIAND. These statistics were not readily available from Air Operations for the years prior to 1998. See section *3.1.2.2 Aviation* for a discussion on consumption of aviation fuel in the fighting of forest fires.

Forest fire contribution to the generation of greenhouse gas is difficult to predict because there are many factors such as moisture content, ground cover, duff layer, thickness of organic layer and completeness of the burn. These factors all contribute to specific characteristics of fire emissions. Forest Resources, DIAND, is compiling information on a regional basis that defines special characteristics of fire regimes from which an estimate of carbon loss per annum could be inferred, albeit with some effort (Burges, 1999).

4.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations have been divided into three categories: i) Data Considerations discusses recommendations specific to data gaps identified in this report; ii) Next Steps discusses priorities for further research; and iii) General Planning outlines an approach to developing future policy and planning.

4.1 Data Considerations

This report has compiled data to provide a greenhouse gas emissions inventory for the Yukon. Sources have been researched and data obtained to begin an investigation into calculating the production of greenhouse gases in the Yukon. More detailed and precise data needs to be collected in order to have a more accurate picture of CO_2 emissions. A general division of inventory has been established for the purposes of this report. Section 3.0 provides an in-depth explanation of data which should be made more easily accessible, as well as data which could be better understood with a great deal of additional effort and interpretation.

This report focuses on the transportation and energy sectors. In this inventory, data is not complete and therefore does not fully illustrate CO_2 emissions contributed in the Yukon.

Energy: End use of fuels needs to be better determined through data collection. There is insufficient data on the contribution of CO_2 from mining. For example consumption of diesel fuel by placer mining operations is not recorded. These tax-exempt fuels are not adequately tracked, this gives inconclusive information on CO_2 emissions and calculations.

Transportation: Diesel for motive purposes is not accurately tracked.

4.2 Next Steps

The study of greenhouse gases is far from complete in the Yukon. This report provides a view into a small area of possible research on greenhouse gas emissions. Detailed compilation and analysis of data is needed to continue understanding greenhouse gases and their effects within the Yukon. The following are suggestions for future consideration.

An area of great importance is understanding the role of sinks. Land cleared for agricultural, mining or forestry purposes, forests cleared by fire and dead trees at

Kotaneelee all destroy sinks for CO_2 gases. Management of human practices related to clearing lands, or in instigating forest fires must be reviewed. Although waste disposal was superficially discussed in this report, a greater understanding of how the Yukon deals with waste and waste oil is necessary. There is also a need for understanding the contribution of waste to greenhouse gases. Loki Gold ships waste oil into the territory for processing. Data is not presently unavailable on emissions from this plant.

Of particular interest for the Yukon is investigation into stack emissions. Currently the Yukon does not have stack emission regulations. An understanding of approaches taken by other jurisdictions and companies can provide a starting point for policy development and implementation of future regulations. Companies in Alberta have initiated green programs and emission controls. Their achievements and pitfalls can provide a starting point for a better understanding for the creation and implementation of standards for Yukon industrial emissions.

Similar to emission data, effects of greenhouse gases are place specific especially in the Yukon. Research is currently being carried out to investigate the contribution of peat to CO_2 emissions. Much of the Yukon has discontinuous permafrost covered with peat. These conditions, coupled with a continued increase in temperature will significantly increase Yukon's CO_2 gas emissions.

4.3 General Planning

Knowledge of the baseline inventory of greenhouse gases for the Yukon should inform the development of a multiple accounts evaluation, which would incorporate both sources and sinks of greenhouse gases. Once gaps in the understanding of the baseline data are better understood, a greenhouse gas management strategy should be developed. This strategy could include the following actions:

- itemize greenhouse gas commitments and actions to date
- examine optional actions to determine likely costs, benefits and expected results
- analyze options to decide priorities
- develop an overall vision including future goals and commitments
- implement early-action measures that already make sense in environmental and economic terms, "no regrets" methods
- develop methods of implementation and transition
- create criteria for measuring the effectiveness of the strategy

A successful strategy would be developed with public as well as private involvement. It would include all sectors mentioned in this report, residential, commercial, industrial, mining, forestry, agriculture and waste. The strategy should include measures for:

- decreasing energy demand
- improving energy efficiency
- switching to renewable fuels with fewergreenhouse gas emissions
- reducing greenhouse gases

- adaptation to climate change

APPENDIX I: LITERATURE REVIEW

The following is a summary of some periodicals, articles and reports pertaining to climate change and greenhouse gas emissions. These reports provide varying degrees of information, usefulness and analysis for a Yukon greenhouse gas inventory. Inventories collected from NWT, Manitoba, British Columbia and Ontario will be examined for their relevance to the Yukon. Reports on conversion factors have been analyzed and are discussed as to their relevancy and application. Reports published by various agencies in the Yukon were examined for usefulness in designing this inventory. Reports that are a non-inventory type of document yet provide interesting comments, information or approaches are included in this literature review but not extensively discussed. The following sections are: Greenhouse Gas Inventories; Conversion Factor Reports; Yukon Reports; and Other Materials.

Literature Review Ratings

□Not useful to the Yukon
□□ Useful aspects but not wholly applicable
□□□ Highly relevant

AI.1 Greenhouse Gas Inventories

Greenhouse Gas Emission Forecast for the Northwest Territories (Ferguson Simek Clark, 1998) □□□

This report is relevant for application to the Yukon. Much of the report is focused on long range forecasting, business as usual scenario, rapid growth scenario and enhanced measure scenario which is not relevant for this project, as the focus here is looking at three specific years. The information collected in this report and how it is organized are of particular interest due to the specifically northern content.

The potential impact analysis table is applicable to the Yukon and this project. The breakdown of emissions is also useful in analysis of emissions in the Yukon.

An Inventory of Greenhouse Gas and SO_2 Emissions for Manitoba (1990) (Manitoba Environment and Manitoba Mines and Energy) □□

Based on 1990, this report is a joint venture between the Manitoba Environment Department who coordinated the non-energy greenhouse gas emission while the Manitoba Energy Department looked after energy related greenhouse gas

emissions (email, Bezak, 1990). The "objective of the report was to provide a baseline inventory of anthropogenic greenhouse gas sources and sinks specific to Manitoba" (p.1). This report provides twenty-seven pages of detailed spreadsheets and graphs representing greenhouse emissions in Manitoba. The inventory deals with the six greenhouse gases along with sulphur dioxide (SO_2) which was included due to zinc/copper/nickel smelter operations in the province.
Detailed spreadsheets provide a breakdown by type of emissions, fuel type and sector. Very detailed in its approach and extensive in the breakdowns of emissions, this approach demands a larger baseline data inventory than the we are able to provide at this point in time. The report provides useful guidelines for determining what information should be investigated for future greenhouse gas inventories and the relevance of that data. It also indicates sources for large amounts of greenhouse gases, sources which could potentially be developed in the Yukon and might require attention in the future.

A Call to Action City of Ottawa's Task Force on the Atmosphere Action Plan (McDonald & Robinson, 1995)

This report is a municipality's response to climate change and greenhouse gas emissions. This study is broad based and focuses on how on individuals can cut down on their own contribution to greenhouse gases. Its emissions inventory for the City of Ottawa is not as thorough as other papers and reports that issues of jurisdiction complicated the task. The report does provide a good commentary on CO_2 coefficients for electricity. It also provides a fairly in depth plan of action, objectives, responsibility, and implementation plan which is useful for a municipalities when dealing with the issue of CO_2 emissions and city/territorial growth.

Greenhouse Gas Inventory and Management Options: A Summary Report for British Columbia (British Columbia Environment (1992)
The report is a summary of four in-depth studies carried out by private consultants in British Columbia. The four reports were:

- *Evaluation of CO_2 Management Measures*
- *Inventory and Analysis of Control for Methane (CH_4) for British Columbia*
- *Ozone-Depleting Greenhouse Gases*
- *Nitrogen Oxides, Volatile Organic Compounds and Ozone as Greenhouse Gases*

Published in 1992, much of the data is outdated and does not pertain to the Yukon. In addition, much of the subject matter deals with a more developed industrial based economy, CFC's and other issues not pertinent to the Yukon . The report on *Inventory and Analysis of Control for Methane (CH_4) for British Columbia* provides some discussion on the collection and analysis of methane which is relevant for investigating dumps in the Yukon. There is also an interesting approach to

implementing policy instruments for CO_2 management measurements in the first paper which is of some interest.

AI.2 Conversion Factor Reports

Trends in Canada's Greenhouse Gas Emissions 1990-1995 (Environment Canada, 1997)

It is general protocol in Canada to use this publication as a standard for information on greenhouse gas emission. Complete inventories of greenhouse gas emissions, sources, analysis and estimates of emissions for Canada are described. Information provided in this report was used for T*he Yukon State of Environment Interim Report 1997*. Relevancy to the Yukon has been determined to be somewhat skeptical as the sources of information have not been traced. It does provide global warming potential (GWP) values which can be used in conversion of CH_4 and N_2O to CO_2.. *Trends* also provides the most up to date conversion factors.

Canada's Energy Outlook 1996-2020 (Natural Resources Canada, 1997)

This report primarily provided detailed charts on energy generations and the conversion into greenhouse gas emissions. As well, emission conversion factors are determined for CO_2, CH_4 and N_2O. There is some dispute between the conversion factors used in this report and those used by Environment Canada. This can be attributed to the fact that emission factors are changing over time and are better and better refined, the Environment Canada report is more reliable (email, Liu, 1999). This document does not distinguish Yukon from NWT.

Taking Charge: Personal Initiatives (David Suzuki Foundation, 1997)

Appendices in this document provide emission factors. Electricity CO_2 conversion factors are given for the Yukon but are in question to their accuracy. The rest of the paper is a discussion on different levels of government participating in lowering greenhouse gases.

AI.3 Yukon Reports

Yukon State of the Environment Report (Renewable Resources, 1995)

A comprehensive study that provides baseline data and information relevant to greenhouse gas emissions. Information in this report is provided by Environment Canada and often too generic for the purposes of a more in depth inventory analysis.

State of the Environment Interim Report 1997, A Focus on Air Quality and Climate Change (Marshall & McIntyre, 1998)

Provides a good analysis of air quality and emission factors in the Yukon. It also provides background information on greenhouse gas emissions and an understanding of where information is located. This report provides a starting point for analysis.

Yukon Annual Statistical Review 1995 &1997 (Bureau of Statistics)

A comprehensive compilation of statistics collected through Statistics Canada and private sources in the Yukon. All data is relevant to the Yukon. The review provides a starting base in order to determine the source and accuracy of data to be used for a greenhouse gas inventory, and the relevance of certain data to this study.

Yukon Agriculture, State of the Industry, 1994-1995 (Smyth, Beckman, Hill & Smith)

A completion of statistics dealing with agriculture which could be used for calculating an estimate of greenhouse gases from agriculture.

AI.4 Other Materials

Mackenzie Basin Impact Study, Final Report (Cohen, 1997)

This report is a study on the impact resulting from climate change and not on greenhouse gases themselves and focuses on the . Yet it is an important paper in that it deals primarily with the effects of climate change on northern regions. It provides an interesting approach and discussion on climate change and its relevance to traditional lifestyles, land, vegetation, wildlife and water. The executive summary provides a list of agencies and specialists who deal with climate change and its effects in different areas.

This report discusses concerns specific to the northern environment. Since many other reports do not have northern content, this study is important material for an analysis of climate change and the Yukon. This report primarily provides references and questions to be answered by other analysis.

Peterborough Green Up Paper

A short discussion paper on transportation which provides some interesting proposals and recommendations to decrease emissions attributed to greenhouse gases. A discussion on alternative transportation fuels looks at Ontario's initiatives to support alternative fuels through the use of tax exempt policies. Although this does not fall within the scope of this project, the paper does provide some interesting discussion and ideas for recommendations.

The series of publications by the David Suzuki Foundation for **Climate for Change** provide discussions on greenhouse gases that are beyond the scope of this paper. They are policy oriented and provide some considerations on proactive approaches to reducing greenhouse gases. **The Carbon Bomb** (Greenpeace International, 1994) is another paper that provides an interesting analysis of approaches to reducing greenhouse gas emissions, and contextualizes information in terms of the boreal forest and carbon balances.

APPENDIX II: DATA SOURCE RATING

Data Analysed	Quality of Data
Transportation	
Motor Vehicle Data	high
Weigh Scale Data	medium
Diesel Fuel Data	medium
Gasoline Fuel Data	medium
Av Turbo Data	low
Av Gas Data	low
Conversions Factors	medium
Propane Fuel Data	low
Electricity	
Electricity Generated	high
Diesel Consumption	high
Consumption Breakdown	low
Breakdown by Sector	medium
Propane Consumption	low
Conversion Factors	medium
Industry	
Stack Emissions	low
Electricity consumption	medium
Diesel Fuel Use	low
Natural Gas	medium
Conversion Factors	low

Rating Of Data by Quality and Relevance

Quality of Data

Low	Data missing or many assumptions made
Medium	Data from a reputable source, many assumptions are made
High	Data collected from reputable sources, few assumptions made

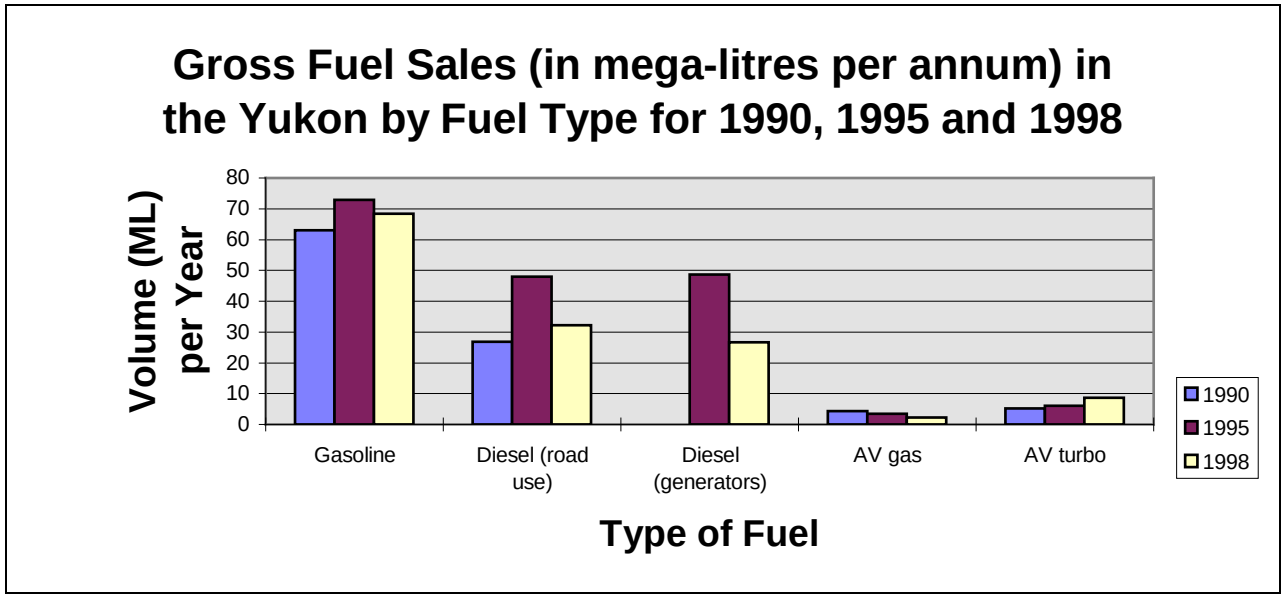
Relevance to the Yukon

Note: all the data sources for this inventory were considered to be “high” relevance to the Yukon

APPENDIX III: FIGURES

A. Transportation

Figure AIII-1



Source: YTG Finance
1990 Diesel Generator fuel quantities were not available from YTG Finance.
Gross diesel figures are broken down in this chart as mobile (ie road use) and stationary (ie generators).

Figure AIII-2

Gross Fuel Sales (litres per annum) and CO2 Emmissions in the Yukon, By Fuel Type for 1990, 1995 and 1998						
	1990	***1990***	***1995***	***1995***	***1998***	***1998***
	(litres)	***(kt CO2)***	***(litres)***	***(kt CO2)***	***(litres)***	***(kt CO2)***
Gasoline	62,967,423	157.4	72,815,330	182.0	68,445,640	171.1
Diesel (road use)*	26,876,111	77.9	48,013,098	139.2	32,191,622	93.4
Diesel (generator)	Not Available	Not Available	48,656,753	141.1	26,663,532	77.3
AV gas	4,246,138	10.4	3,522,006	8.6	2,219,190	5.4
AV turbo	5,170,232	13.6	6,061,960	15.9	8,712,553	22.9
Total	***99,259,904***	***259.3***	***179,069,147***	***486.9***	***138,232,537***	***370.1***

Source: YTG Finance

CO_2 conversion factors for gas and diesel were recommended by Jerome McIntyre as follows:

- gas, 2.5 kg of CO2 per litre; and
- diesel, 2.9 kg of CO2 per litre.

CO_2 conversion factors for Aviation gas were derived from *Trends in Canada's Greenhouse Gas Emissions 1990-1995* as follows:

- for Av gas, 2.33 kg of CO_2, plus 2.19g of CH_4 (x 21 GWP multiplier), plus 0.23 g N_2O (x310 GWP multiplier) per litre of Av gas; and
- for Aviation Turbo gas, 2.55 kg of CO_2, plus 0.08g of CH_4 (x 21 GWP multiplier), plus 0.25 g N_2O (x310 GWP multiplier) per litre aviation turbo gas

Figure AIII-3: Chart of Monthly Gasoline Consumption in Litres as Taxable Sales in the Yukon for 1990, 1995 and 1998.

	1990	1995	1998
Jan	3,095,240	3,591,902	3,699,161
Feb	3,033,017	3,602,726	3,545,531
Mar	3,574,767	4,012,024	4,228,744
Apr	3,306,897	4,016,610	3,914,774
May	5,163,326	6,925,929	5,707,330
Jun	6,266,138	7,461,055	9,103,211
July	8,630,966	10,543,509	9,636,072
Aug	8,747,565	8,955,462	7,921,226
Sept	5,665,783	6,059,343	5,959,747
Oct	4,298,760	5,038,566	4,551,524
Nov	3,273,700	4,052,702	3,659,598
Dec	2,875,456	4,271,160	3,508,519
TOTAL	**57,931,615**	**68,530,988**	**65,435,437**

Information provided by YTG Department of Finance.

Figure AIII-4: Chart of Monthly Gross Sales of Gasoline in Litres in the Yukon for 1990, 1995 and 1998

	1990	1995	1998
Jan	3,484,937	3,772,820	3,903,788
Feb	3,382,889	3,845,011	3,700,264
Mar	4,030,081	4,270,044	4,488,147
Apr	3,705,808	4,247,975	4,148,578
May	5,569,635	7,240,752	5,953,146
Jun	6,769,648	7,976,331	9,445,692
July	9,168,516	11,188,795	10,095,570
Aug	9,006,872	9,561,452	8,184,120
Sept	6,231,802	6,493,480	6,231,554
Oct	4,825,926	5,379,878	4,744,043
Nov	3,522,500	4,289,007	3,842,066
Dec	3,268,809	4,549,785	3,708,672
TOTAL	**62,967,423**	**72,815,330**	**68,445,640**

Information provided by YTG Department of Finance.

B. ENERGY

Figure AIII-5 Electricity Generation (in GW.h.) for 1990, 1995 and 1998

Notes:
Information provided by YEC and YECL.
Production of electricity from wind is negligible.

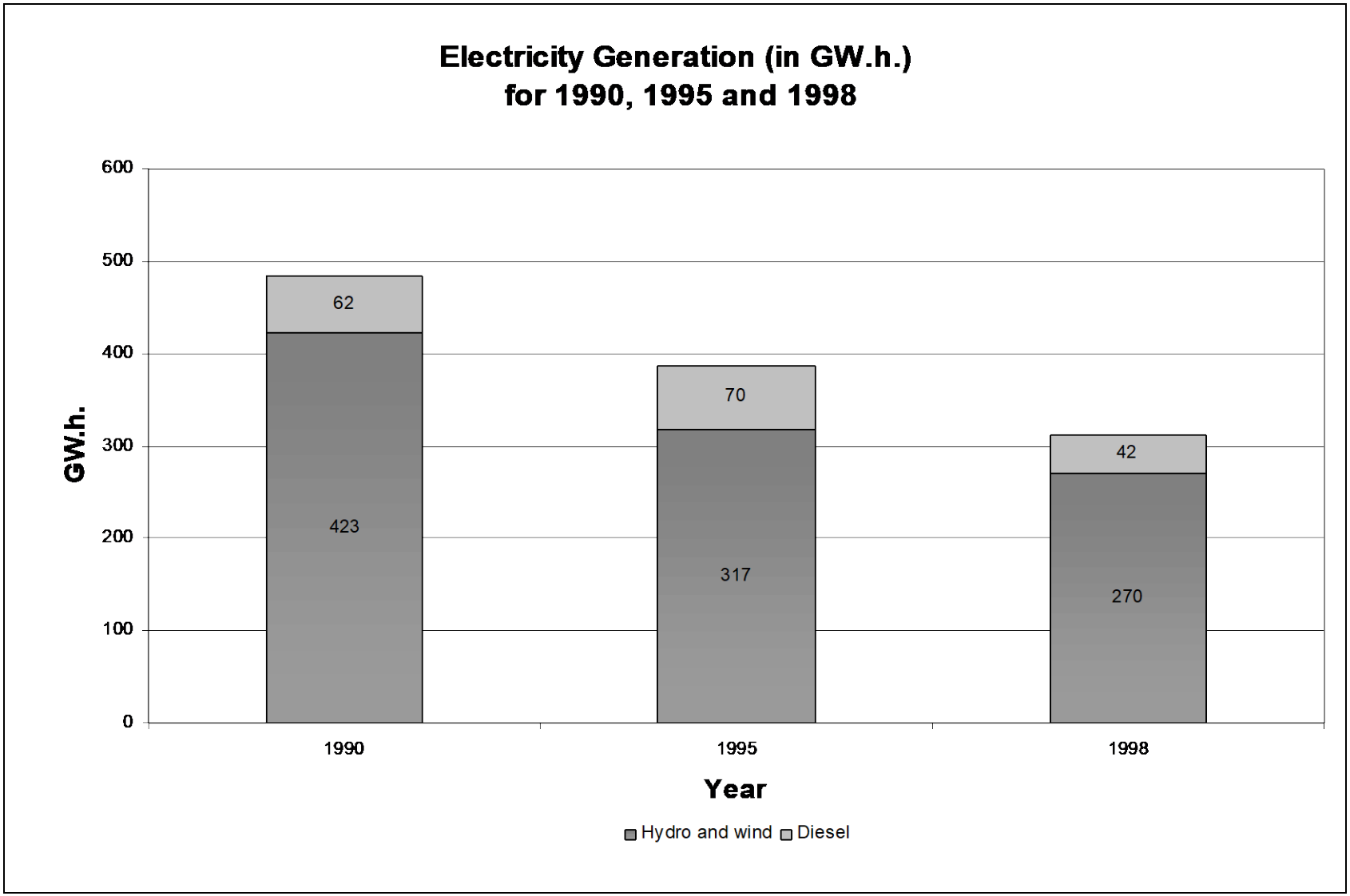

Electricity Generation (in GW.h.)
for 1990, 1995 and 1998
600
500
400
300
200
100
0
GW.h.
62
423
70
317
42
270
1990
1995
1998
Year
Hydro and wind
Diesel

Figure AIII-6 Diesel Fuel (in cubic metres) Consumed to Produce Electricity for 1990, 1995 and 1998

Notes:
Information is based on information provided in Figure 15.
Graph provides a information of amount of diesel fuel consumed to produce electricity in the Yukon.

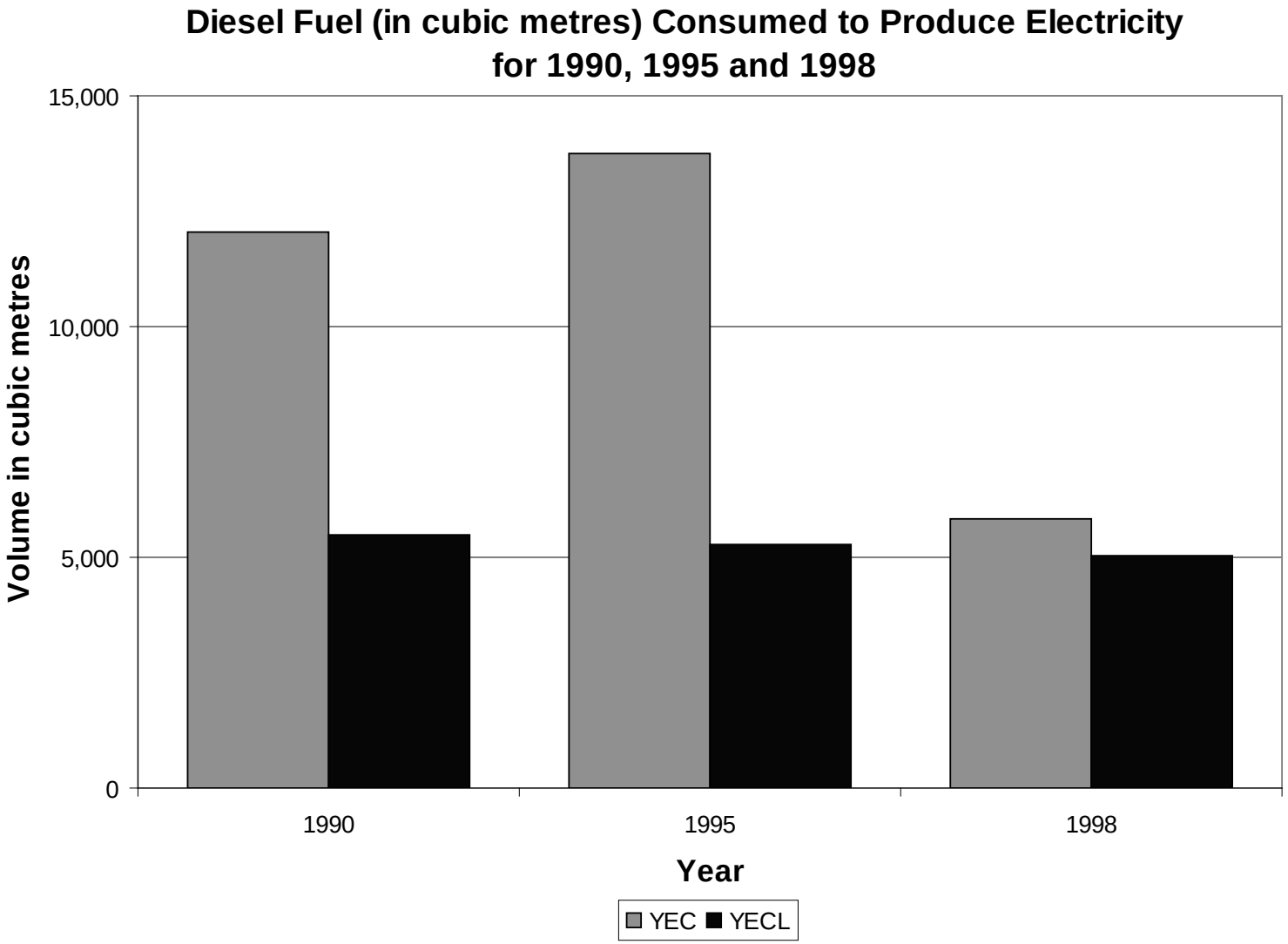

Diesel Fuel (in cubic metres) Consumed to Produce Electricity for 1990, 1995 and 1998
15,000
10,000
5,000
0
Volume in cubic metres
1990
1995
1998
Year
YEC
YECL

Figure AIII-7

Diesel Consumed (in litres) to Produce Electricity for 1990, 1995 and 1998		
	Total Diesel Used in litres	***Total Diesel Electricity Generated in MW.h.***
1990	17,516,000	62,093
1995	19,052,000	70,316
1998	10,867,000	41,815

Information provided by Hector Campbell (YEC)

Figure AIII-8

Diesel Generated Power in each Community in the Yukon for 1998 Converted into CO2 Emissions		
Community	***Energy (MW.h.) (x 1000)***	***CO2 Conversion (kt CO2)***
Watson Lake	12.9	10.3
Beaver Creek	1.8	1.4
Destruction Bay	1.4	1.1
Old Crow	1.7	1.4
Stewart Crossing	0.4	0.3
Pelly Crossing	1.5	1.2
Swift River	0.2	0.2
Whitehorse	3.0	2.4
Faro	4.5	3.6
Mayo	0	0.2
Dawson	14.6	12.0

Information provided by both YECL and YEC. The CO_2 conversion factor from diesel generated power was recommended by John Maisson (YEC) as 0.8 kilo tonnes of CO_2 for every MW.h. of diesel energy produced. Conversion directly from the amount of diesel used in electricity generation to CO_2 could not be used because the diesel consumption by community was not available at this time.

APPENDIX IV: CONTACTS

Name of Contact	Company Description	Contact Number	Comments
Joe Ballantyne	Director, Renewable Resources	667-8177	
Karen Baltgailis	Forestry Researcher, Yukon Conservation Society	668-5678	
Al Beaver	FIre Ecologist, Fire Protection Office	667-3383	
David Beckman	Agriculture Branch, Renewable Resources YTG	667-5838	
Greg Belisle	Engineering YTG	667-5452	
Sharon Belisle	Motor Vehicles Branch, C&TS, YTG	667-3638	Has file #0350-35-04 (info on vehicle and fuel type)
Dave Bezak	Energy & Mines Manitoba Government	email	
David Binks	Statistics Canada, Ottawa, Ontario	(613)951-0521	Information on fuel data
Jack Bower	Manager of Operation, Village of Faro		
Carl Burges	Forestry, DIAND	667-3350 ext 210	
Barbara Campbell	Sooke B.C		
Hector Campbell	Yukon Energy Corporation	667-8380	Information on energy generation
Norm Carlson	Municipal Services, Dawon City	993-7400	
Bob Collins	Economic Development YTG	667-5015	
Louise Comeau	Sierra Club		
Colin Dean	Village of Haines Junction		
Eric Denholm	Environmental Manager, Faro		
Joan Emer	Envirnoment Canada, Whitehorse, Yukon		
Vic Enns	Envirnoment Canada, Whitehorse, Yukon		
Ken Fleet		393-3961	
Bob Gates	Engineering & Development Branch, YTG	667-5197	Information on dumps around the territory
Mike Gill	Wildlife Services		

Beniot Godin	Environment Canada	667-3402	
Eleonore Harding	Statistics Canada, Ottawa, Ontario	hardele@statscan.ca	Information on statistics gathered on RRP
Jackie Heath	Environment Coordinator, City of Whitehorse	668-8312	
Art Jaques	Environment Canada Hull Canada	(819) 994-3098	
Fred Jennex	Transport Services, C&TS, YTG	667-5313	
Grainne Larkin	Finance Department, YTG	667-5334	
Stan Liu	Environment Canada	stan.liu@ec.gc.ca	Has conversion factors and tables applicable to the Yukon
Rob Legare	Forestry Inventory Technician, Forest Resources, DIAND	667-3550 ext206	
Edward Lee	Agriculture Branch, Renewable Resources YTG	667-3022	
John Maisson	Yukon Energy Corporation	667-8119	Information on diesel electricity factors
Jerome McIntyre	Renewable Resources, YTG	667-5803	Coordinator of *State of the Environment Interim Repor*t has information on file
Janine McJannet	Renewable Resources, YTG	667-5456	
Jeff Monty	Senior Forest Advisor, Renewable Resources, YTG	667-8685	
Guy Morgan	Yukon Energy Corporation	633-7096	
David Murray	Agriculture Branch, Renewable Resources YTG	667-3699	
Ken Olsen	Project Engineer, Pollution Data Branch	(819)997-5106	Good contact Kenneth.Olsen@ec.gc.ca
	Environment Canada		
Sue Olsen	Forestry, DIAND		
Pat Paslawski	Environmental Protection and Assesement Branch, Renewable Resources, YTG	667-5934	
Juri Peepre	Canadian Parks and Wilderness Society		
Peter Pool	Canadian Parks and Wilderness Society		
Laura Prentice	YTG	667-5423	Alternative energy expertise

Rose Putland	Forest Protection, DIAND	667-3375	
Mike Richards	VIllage of Carmacks	863-6271	
Lewis Rifkind	Raven Recycling Center	667-7269	
Margo Santry	Maps, DIAND (Jesse, assistant)		
Steve Savage	Yukon Electrical Company Ltd	633-7034	
Joy Schneider	Raven Recycling Center	667-7269	
Sabina Schweiger	City of Whitehorse	667-6312	
Wendy Scramsted	Yukon Electrical Company Ltd	633-7027	In charge of customer service
Susan Skaalid	Forest Resources Technician, DIANS	667-3350 ext269	
Don Spink	Village of Teslin		
Bob van Dijken	Yukon Salmon Committee	668-7172	
Debra Whortly	Silviculture Forester, Forest Resources, DIAND	667-3350 ext308	
Xiang Xeng	University of Alberta		

APPENDIX V: BIBLIOGRAPHY

Agriculture Census. May 1997. **1996 Census of Agricultural Data for the Yukon and Northwest Territories.**

ARA Consulting Group Inc. February 1997. **Economic Models for Climate Change Mitigation Policy Analysis.**

Baker, J. T. and L. H. Allen Jr. 1994. **Assessment of the Impact of Rising Carbon Dioxide and Other Potential Climate Changes On Vegetation.** Environ. Pollut. **83**(1-2), p223-235.

British Columbia Energy Council. November 1994**. Planning Today for Tomorrow's Energy**. Prepared for the Ministry of Energy, Mines and Petroleum Resources.

British Columbia Environment. May 1992. **Greenhouse Gas Inventory and Management Options: A Summary Report For British Columbia.** Ministry of Environment, Lands and Parks.

Canada's National Action Program on Climate Change, 1995. Prepared for the Energy and Environment Ministers for the Framework Convention on Climate Change.

Cohen, Stewart (editor). 1997. **Mackenzie Basin Impact Study, Final Report**. Prepared for Environment Canada.

Curren, T. April 1991. **Forests and Global Warming.** Research Branch of the Library of Parliament.

Economic Development, Yukon Government. September 1997. **Yukon Energy Resources, Oil and Gas.**

Ferguson Simek Clark and Clearstone Engineering Ltd. June 1998. **Greenhouse Gas Emission Forecast for the Northwest Territories.** Prepared for Environmental Protection Service, Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories.

Forest Resources. 1998. **Preliminary Timber Supply Analysis For The Southern Yukon.**

Forest Resouces. Annual. **National Forest Database.**

Greenpeace International. 1994. **The Carbon Bomb, Climate Change and the Fate of the Northern Boreal Forests.** Published by Stichting Greenpeace Council, Amsterdam, The Netherlands.

Haeberli, W and M. Beniston. June 1998. **Climate Change and Its Impacts on Glaciers and Permafrost in the Alps.** Ambio, Vol **27**:4, p258-265.

Hodge, R. A. and L. Ehrlich. January 1983**. Northern Energy, A Soft Path Analysis of the Yukon and Northwest Territories**. Prepared for the Friends of the Earth and Yukon Conservation Society.

Howatson, A., B. Guthrie, D. Bruchet and M. McRae. March 1998**. The Feasibility of a National "Climate Change Economic Analysis Forum".** Prepared by the Conference Board of Canada and the Canadian Energy Research Institute.

Howatson, A. October 1998. **The "Reasonable Relationship" Principle, Weighing the Costs and Benefits of Reducing Environmental Risks.** For the Conference Board of Canada.

Jacobsen, N.A., S. P. Withers and Laberge Environmental Services. May 1994. **An Inventory of Hazardous Chemicals Transported into the Yukon, 1992 and 1993 Database.** Prepared for Environmental Protection, Whitehorse.

Jaques, A., F. Nietzert and P. Boileau. April 1997. **Trends in Canada's Greenhouse Gas Emissions 1990-1995.** Prepared for Environment Canada.

Kurz, W.A., M.J. Apps, S.J. Beukema and T. Lekstrum. 1995. **20th Century Carbon Budget of Canadian Forests.** Tellus, **47B**, p170-177.

Kurz, W. A. 1994. **The Carbon Budget of Canadian Forests: A Sensitivity Analysis of Changes in Disturbance Regimes, Growth Rates, and Decomposition Rates.**Environ. Pollut. 83(1-2), p55-61.

Last, J., K. Trouton and D. Pengelly. October 1998. **Climate of Change, Taking Our Breath Away, The Health Effects of Air Pollution and Climate Change.** Prepared for the David Suzuki Foundation.

Manitoba Energy and Mines, Manitoba Environment. 1990**. An Inventory of Greenhouse Gas and SO_2 Emissions for Manitoba (1990).**

Margolick, M. and A. Pape. October 1997. **Climate of Change, The Role of Government, A Briefing Paper to the Honourable Paul Martin, September 29, 1997.** Prepared for the David Suzuki Foundation.

Marshall, Jane and Jerome McIntyre. May 1998**. Yukon State of the Environment Interim Report 1997, A Focus on Air Quality and Climate Change**. Prepared for the Yukon Department of Renewable Resources Policy and Planning Branch.

McDonald, P and E. W. Robinson. October 1995. **City of Ottawa's Task Force on the Atmosphere Action Plan.** Prepared for the Department of Engineering and Works, Ottawa.

Natural Resources Canada website - Climate Change. http//climatechange.nrcan.gc.ca

Natural Resources Canada. June 1998. **Energy Efficiency Trends in Canada, 1990 to 1996, A Review of Indicators of Energy Use, Energy Efficiency and Emissions.** Prepared by the Office of Energy Efficiency.

Pembina Institue website - www.piad.ab.ca

Pembina Institute for Appropriate Development. October 1998**. Climate of Change, Canadian Solutions, Practical and Affordable Steps to Fight Climate Change**. Prepared for the David Suzuki Foundation.

Pembina Institute for Appropriate Development. December 1997**. Climate of Change, Taking Charge: Personal Initiatives**. Prepared for the David Suzuki Foundation.

Press, M., T. Callaghan and J. Lee. June 1998. **How Will European Arctic Ecosystems Respond to Projected Global Environmental Change?** Ambio, Vol 27:4, p306-311

Renewable Resources, Yukon Government and Environment Canada. 1996**. Yukon State of the Environment Report, 1995.**

Renewable Resources. 1998**. Air Emissions Regulations.** Queen's Printer, Yukon Government.

Renewable Resources. 1998**. Solid Waste Regulations.** Queen's Printer, Yukon Government.

Russel, D. October 1997**. Climate of Change, Keeping Canada Competitive, Comparing Canada's Climate Change Performance to other Countries**. Prepared for the David Suzuki Foundation.

Smyth, S., D. Beckman and C Smith. June 1998. **Yukon Agriculture, State of the Industry, 1996-1997.** Prepared for the Department of Renewable Resources, YTG and Agriculture and Agri-Food Canada, Research Branch.

Smyth, S., D. Beckman, A. Hill and C Smith. March 1996. **Yukon Agriculture, State of the Industry, 1994-1995.** Prepared for the Department of Renewable Resources, YTG.

Smyth, S., D. Beckman and M. Ames. October 1994. **Yukon Agriculture, State of the Industry, 1992-1993.** Prepared for the Department of Renewable Resources, YTG.

Sollid, J. and L. Sorbel. June 1998. **Palsa Bogs as a Climate Indicator-Examples from Dovrefjell, Southern Norway.** Ambio, Vol **27**:4, p287-291.

The Yukon Government Executive Council Office Bureau of Statistics. July, 1998**. Yukon Statistical Review, 1997 Annual Report.**

Yukon Government. 1991. **Agriculture for the 90's: A Yukon Policy.**

APPENDIX VI: CONVERSION FACTORS

CONVERSION	CONVERSION FACTOR	REPORT SECTION	SOURCE
GWP Multipliers:			
CH_4 to CO_2 equivalent	GWP multiplier = 21	section 3.0, AIII	*Trends**, Table page xvi
N_2O to CO_2 equivalent	GWP multiplier = 310	section 3.0, AIII	*Trends**, Table page xvi
Transportation Mobile Combustion:			
gasoline fuel (L) for road vehicles to CO_2 (kg)	2.5 kg CO_2 per litre gasoline	figure 1, AIII-1&2	Jerome McIntyre
diesel fuel (L) for road vehicles to CO_2 (kg)	2.9 kg CO_2 per litre diesel	figure 1, AIII-1&2	Jerome McIntyre
Aviation gasoline (L) to CO_2 (kg)	2.33 kg CO_2 per litre AV gas	figure 1&3, AIII-1&2	*Trends**, Table 6 (I-5)
Aviation gasoline (L) to CH4 (g)	2.19 g CH_4 per litre AV gas	figure 1&3, AIII-1&2	*Trends**, Table 6 (I-5)
Aviation gasoline (L) to N_2O (g)	0.23 g N_2O per litre AV gas	figure 1&3, AIII-1&2	*Trends**, Table 6 (I-5)
Aviation Turbo fuel to CO_2 (kg)	2.55 kg CO_2 per litre turbo fuel	figure 1&3, AIII-1&2	*Trends**, Table 7 (I-6)
Aviation Turbo fuel (L) to CH4 (g)	0.08 g CH_4 per litre turbo fuel	figure 1&3, AIII-1&2	*Trends**, Table 7 (I-6)
Aviation turbo fuel (L) to N_2O (g)	0.25 g N_2O per litre turbo fuel	figure 1&3, AIII-1&2	*Trends**, Table 7 (I-6)
Energy Stationary Combustion:			
Diesel fuel (L) to CO_2 (kg)	2.73 kg CO_2 per litre diesel fuel	figure 8, AIII-8	*Trends**, Table 2 (I-3)
Diesel fuel (L) to CH_4 (g)	0.26 g CH_4 per litre diesel fuel	figure 8, AIII-8	*Trends**, Table 2 (I-3)
Diesel fuel (L) to N_2O (g)	0.40 g N_2O per litre diesel fuel	figure 8, AIII-8	*Trends**, Table 2 (I-3)
Diesel fuel energy (MW.h.) to CO_2 (kt)	0.8 kilo tonnes CO_2 per MW.h.	figure AIII-8	John Maissan (YEC)
Gas fuel energy (TJ) to CO_2 (tonnes)	49.68 tonnes CO_2 per TJ Energy	figure 11	*NRCan***
Gas fuel energy (TJ) to CH4 (kg)	0.07 kg CH_4 per TJ Energy	figure 11	*NRCan***
Gas fuel energy (TJ) to N_2O (kg)	0.62 kg N_2O per TJ Energy	figure 11	*NRCan***

Heating fuel for residential furnace (L) to CO_2 (g)	2,830 g CO_2 per litre fuel	figure 12	*Trends**, Table 2 (I-3)
Heating fuel for residential furnace (L) to CH_4 (g)	0.214 g CH_4 per litre fuel	figure 12	*Trends**, Table 2 (I-3)
Heating fuel for residential furnace (L) to N_2O (g)	0.006 g N_2O per litre fuel	figure 12	*Trends**, Table 2 (I-3)

Jaques, A. , F. Nietzert and P. Boileau. April 1997. Trends in Canada's Greenhouse Gas Emissions 1990-1995.* Prepared for Environment Canada.
**Natural Resources Canada. June 1998. *Energy Efficiency Trends in Canada, 1990-1996*. Prepared by the Office of Energy Efficiency.

SAMPLE CALCULATIONS

GWP Multiplier
To convert mass of CH_4 to CO_2 equivalent use the GWP multiplier as follows:

1 kg of CH_4 x 21 kg CO_2 per kg CH_4 = 21 kg CO_2

Fuel Conversion to CO_2:

The conversion factor provided by Jerome Mc'Intyre is an average conversion which sums all the greenhouse gases emitted during the combustion of fuel in transportation, ie. the CO_2,aswell as the CH_4 and N_2O as CO_2 equivalents. To convert litres of gasoline burned in transportation to an all gas total CO_2 equivalent, calculation is carried out as follows:

1 L of gasoline x 2.5 kg CO_2 per litre gasoline = 2.5 kg CO_2 are produced in the burning of one litre gasoline

Other calculations for fuel conversion to CO_2 may use the Trends charts (Table 6 & 7) and GWP multipliers to calculate the all gas CO_2 equivalent as follows:

1 litre Aviation gasoline x 2.33kg CO_2 per litre gasoline= 2.33kg CO_2

1 litre of Aviation gasoline x 2.19g CH_4 per litre gasoline x GWP multiplier (21 g CO_2 per g CH_4) = 46 g x 0.001 kg per g = 0.05 kg CO_2

1 litre of Aviation gasoline x 0.23g N_2O per litre gasoline x GWP multiplier (310 g CO_2 per g N_2O) = 71g x 0.001 kg per g = 0.07 kg CO_2

Total CO_2 equivalent for the burning of 1 litre of aviation gasoline = 2.33kg CO_2 + 0.05kg CO_2 + 0.07kg CO_2 =2.45kg CO_2

APPENDIX VII: GLOSSARY

ACAP	Annex 1 Countries of Asia-Pacific
AIJ	Activities Implemented Jointly. This refers to the pilot phase of JI, and is open to voluntary participation by all parties. No credits are allocated against current (pre-2000) targets. It is slightly different from JI in that it involves GHG reductions in non-Annex 1 countries.
Annex 1	Developed Countries (under Kyoto agreement), largely the OECD
AOSIS	Association of Small Island States (opposite of oasis). AOSIS countries support vigorous reductions in GHG emissions since they stand to lose major portions of their land if sea levels rise.
Banking credits	Refers to credit for GHG emissions reduction that is ahead of targeted reductions
Borrowing credits	Refers to future commitments to exceed GHG emission reduction targets to make up for current reduction shortfalls.
Budgets	Budgets specify a total amount of emissions to be reduced over a fixed period of time.
CCME	Council of Canadian Ministers of the Environment
CDM	Clean Development Mechanism — to enable the financing of emissions reduction projects carried out by developed countries in developing countries and the earning of credit for doing so.
CEAA	Canadian Environmental Assessment Act, under which environmental impacts of projects are to be reviewed, beginning in 1995.
CEPA	Canadian Environmental Protection Act
CFC	Chlorofluorocarbons, frequently referred to by their trade name of “Freon”. CFCs are responsible for the depletion of the ozone layer in the stratosphere and also are a potent greenhouse gas. The production and use of these substances is now controlled as a result of the Montreal Protocol.
CO_2	Carbon dioxide, the chief greenhouse gas in the atmosphere (after water vapour), which is released from burning fossil fuels.
CoP	Conference of the Parties. Kyoto represents the third such conference.
CoP4	The fourth international conference of the parties held in Buenos Aires in November 1998.
DAP	Development Assessment Process

Differentiation	Individual country targets as opposed to on flat rate target for all countries. It reflects the fact that different national circumstances result in disproportional costs and opportunities to reduce GHG emissions. Eight countries (Australia, Norway, Japan, Switzerland, Iceland, Poland, Russia and Iran) have differentiation proposals. Although differentiation represents complex negotiations and the US opposes it for that reason, the Canadian position is that it should remain on the table since studies indicate that Canada would suffer a greater economic burden in reaching a uniform target than a number of other OECD countries.
Emissions Trading	With respect to GHGs this refers to tradable emissions credits between corporations or countries from Annex 1.
FCCC	Framework Convention on Climate Change
FEARO	Federal Environmental Assessment Review Office
Flexibility	Flexibility elements refer to multi-year baselines, banking, borrowing, and budgets.
G77 Nations	Developing Countries
GHG	Greenhouse gas. The greenhouse effect, which is scientifically accepted, causes the earth's average temperature to be approximately 20 degrees warmer than it would be otherwise, and makes life possible. It is widely believed that an increase in the concentration of greenhouse gases in the atmosphere will be responsible for global climate change, and was the subject of the international agreements signed at Rio in June 1992. The chief greenhouse gases addressed by the CoP are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Chlorofluorocarbons or CFCs are also potent GHGs but are already addressed under the Montréal protocol on ozone depleting substances (ODSs)
IPCC	International Panel on Climate Change - a body that addresses the scientific issues surrounding climate change.
IRP	Integrated Resource Planning – an approach to utility planning to incorporate social and environmental costs into the planning of least-cost power resources.
JI	Joint Implementation. This refers to international projects which result in a measurable long-term reduction in GHG emissions. The EU wishes to limit JI to Annex 1 parties while the US, Norway, Japan, Australia, Canada and New Zealand support credits for JI with developing countries. See also AIJ
JUSCANZ	Pronounced “juice cans” The non-EU OECD countries: Japan, the US, Canada, Australia, New Zealand
Multi-year baselines	Instead of a single year (1990) to define baseline emissions, a multi-year baseline would average emissions over a three to ten year period.
NO_x	Oxides of nitrogen. NO_x emissions are a leading component of acid precipitation.

ODS Ozone Depleting Substance - see CFCs

OECD Organization for Economic Cooperation and Development, comprised of Canada, the USA, Japan, and most of the developed European countries, i.e. Canada's major trading partners

SO_2 Sulphur dioxide

SO_x Sulphur oxides, mainly sulphur dioxide. This is an irritant and a prime ingredient in acid rain. SO_x may be controlled through the use of limestone in a fluidized bed or through exhaust scrubbers.

TOMA Tropospheric Ozone Management Area. Tropospheric ozone is formed in the lower atmosphere by the interaction of nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. Ozone is a lung irritant, and is an important constituent of urban smog. Tropospheric ozone is distinct from stratospheric ozone, which is destroyed by chloroflurocarbons (CFCs), and which protects the earth from solar ultraviolet radiation.

UFA Umbrella Final Agreement (on Yukon First Nation Land Claims)

UNCED United Nations Conference on Environment and Development, which took place in Rio de Janeiro in June 1992 and from which came the Climate Change Convention

VCR Voluntary Challenge and Registry

VOC Volatile Organic Compound - VOCs together with nitrogen oxides in the presence of sunlight are responsible for the production of ground level ozone, a major constituent of smog.

Units of Measure

BTU	British Thermal Unit, the amount of energy it takes to heat one pound of water by one Fahrenheit degree. 1 kWh = 3412 BTU (approximately)
GWh	Gigawatt hour (one million kWh)
joule (J)	a unit of energy (metric). One kilowatt hour equals 3.6 million joules. Raising a sandwich from your plate to your mouth requires approximately one joule of energy. Note that because a bite of sandwich can contain approximately 100 kilojoules of food energy (1 kJ = 1,000 joules), excessive repetitions of this action can result in jowls.
Kg	kilogram, one thousand grams, approximately 2.2 pounds
kt	kilotonne, one thousand metric tonnes
kV	kilovolt - the transmission line to Faro is at 138 kV
kWh	kilowatt hour, a unit of energy, the product of power and time. A person can work steadily at an output of approximately 100 watts, and therefore a day's hard labour would result in one kilowatt hour of work. At a wage of $10 per hour, human powered energy would cost approximately $100/kWh.
Mg	milligram, one thousandth of a gram
Mt	megatonne, or one million metric tonnes
MW	megawatt, one million watts or one thousand kilowatts
ng	nanogram, one billionth of a gram
t	a metric tonne, 1,000 kg, approximately 2,200 pounds