# Creating an Ecological Footprint Assessment: Using Component and Compound Economic Input Output Methods

## Natural Step and Life Cycle Assessments

Case Study: BCIT's Burnaby Campus – 2006/2007

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# Executive Summary

"*…universities[/colleges]…have a particular responsibility in being role models for best environmental practice due to their significant influence on societal development.*"[1]

Ecological footprint studies, or environmental assessment studies, of universities/ colleges demonstrate the need for integrating environmental/sustainability management systems into these institutions to effectively and efficiently monitor their impacts on the environment.[2] BCIT's first Ecological Footprint Assessment (EFA) demonstrates the need for centralizing this type of environmental information and making this data accessible to many different users. For BCIT to make sustainability part of its values, sustainability must be integrated into BCIT's operations and educational mandate.

This assessment demonstrates how to create a framework and a set of indicators to measure an organization's ecological sustainability. Two major concepts are explored the hybrid Ecological Footprint and the Natural Step's sustainability principles[3](TN). The hybrid Ecological Footprint[4] is derived by a combination of the component and compound economic input output methods to calculate the footprint. The component method uses Life Cycle Assessment (LCA) data to derive the footprint. The compound economic input-output method is a top down approach which takes aggregated data and divvies it up into smaller pieces to calculate the footprint of each component. The TN principles are over arching indicators to include aspects that may not be accounted for in the ecological footprint, such as products that are not easily assimilated by the biosphere. The assessment was done for BCIT's Burnaby campus for the fiscal year 2006/2007.

This assessment considers energy and material flow through the campus from direct energy, water, food, food packaging, staff travel, student travel, consumables, built form and green space, and solid waste. The total ecological footprint for BCIT's Burnaby Campus is 16,590 global hectares (gha). A global hectare is defined as the unit of area that encompasses the bioproduction capacity, including waste assimilation, of ecosystems appropriated for use by BCIT operations.

**(1) Direct Energy**
Direct energy refers to the use of electrical and heat energy on the Burnaby campus. The assumption is that raw materials or extraction of resources should not be included in the calculation; only the energy for delivery and use of the resource in the form of KWh and GJ is considered. The total footprint of the Direct Energy component is 3,001gha. This means that one-third of the city of Burnaby would have to be covered in trees to

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[1] Wood, R. and Lenzen M., 2003, "An Application of a Modified Ecological Footprint Method and Structural Path Analysis in a Comparative Institutional Study", Carfax Publishing, Local Environment, Vol 8, No. 4, 365-386.
[2] Ibid.
[3] Holmberg, J. and Robert, K.H. "Backcasting From Non-Overlapping Sustainability Principles: A Framework for Strategic Planning." International Journal of Sustainable Development and World Ecology 7 (2000): 1-18.
[4] Wackernagel M. and Rees W. E., 1996, Our Ecological Footprint: Reducing human impact on the earth. New Society Publishers, Gabriola Island, BC, Canada
Global Footprint Network and the University of Sydney, 2005, "The Ecological Footprint of Victoria Assessing Victoria's Demand on Nature", Prepared for EPA Victoria, pp. 10-11.

sequester the emissions generated from the consumption of Direct Energy on the Burnaby campus. Furthermore, natural gas makes up 86% of the total footprint, even though the amount of energy consumed by natural gas is on par with the amount of electricity consumed.

**(2) Water**

The footprint associated with water use is calculated based on the energy to extract the water from the reservoir or watershed and then pump it to the consumer, as well as subsequent pumping to the sewage treatment plants. The total ecological footprint for water is 2.04 gha, very small in comparison to the other components.

**(3) Food & Drink**

The assumption for the food and drink component considers only the energy to create the product and the transport of goods to the end user. The associated labour is not included in the calculation because this data was not readily available at the time when the study was done. The total Food and Drink ecological footprint is 4654 gha, somewhat larger than the Direct Energy footprint. The Drink portion represents the largest contributor to the Food & Drink component, on account of the embodied energy in the containers of the drinks such as glass, plastic, and aluminum bottles.

**(4) Food Packaging**

Energy and matter are required to make packaging materials to ship food, and disposable tableware to serve food to customers on the Burnaby campus. The food packaging component includes the packaging material for shipment and disposable tableware. The plastic bottles, glass, and aluminum cans for beverages are accounted for in the total Food & Drink component. These containers are not separated into the food packaging calculation. The total ecological footprint for Food Packaging is 147 gha.

**(5) Staff Travel**

The ecological footprint for Staff Travel consists of travel to and from work and business air travel. The assumptions are that vehicle wear and tear is not included in this calculation, nor is the energy and labour for maintenance of the roadway. Only the fuel usage of vehicles to and from the Burnaby campus and staff homes is considered. No car pooling is considered. The number of parking passes sold to staff is considered the number of staff that would drive to work regularly. The air travel considered the maintenance of the airplane and fuel usage from take-off to landing. Energy for the manufacturing of the airplane is not considered, nor is the decommissioning of the airplane. The impact of staff driving to work is estimated to be almost equal to the air travel of staff. The total ecological footprint for staff travel is 1284 gha.

**(6) Student Travel**

Student Travel is the second largest footprint component, slightly smaller than the Food & Drink footprint. A 2007 survey was conducted on student mode of travel, with a sample size of 1,090. As with staff, most students drive to the Burnaby campus, which is the mode of transportation that has the biggest impact. The same assumptions are made as for Staff Travel in calculating student travel. The total ecological footprint for Student Travel is 4446 gha.

**(7) Consumables**

The ecological footprint for the Consumables component is calculated using the economic input-output method, since the only available data at the time this study was conducted was in monetary value. The consumables are organized into 15 categories as described by the North American Industry Classification System (NAICS). The largest contributor to the Consumables footprint is wood products. And wood is the item purchased the most at BCIT compared to any other item. The assumptions are that the impacts of transportation of goods between sectors and the associated labour, and the use phase and end-of-life phases, are not included in the results. The total ecological footprint for Consumables is 2958 gha.

**(8) Built Form and Green Space**

For this assessment, the built form consists of buildings and parking lot spaces. The buildings are further classified into classrooms, offices, lodgings, and office/educational use. The total green space, or vegetated area, is not considered to have an environmental impact; however, the biocapacity can be calculated from the green space. The total green space for the Burnaby campus is 30.6 ha which accounts just for the physical area; the biocapacity of the green space is not considered for this study. The total ecological footprint of the built form is 95 gha.

**(9) Solid Waste**

The environmental impact of solid waste comes from the actual space that waste takes in a landfill and the decomposition process. Since BCIT exported its solid waste to a Metro Vancouver landfill, this waste then became an issue for Metro Vancouver. For this assessment the boundaries are set to account for all incoming mass products, emissions generated on site, and products leaving the campus such as waste and sewage. However, the treatment of waste and sewage are considered to be outside the boundary of this study. That is why the ecological footprint for this study only accounted for the delivery of solid waste to the landfill, which is 0.34 gha. For future assessments, the ecological footprint can be calculated for the recycled materials and compost that is generated on site. The compost generated on site is used on the surrounding vegetated landscape; hence, the compost does not leave the campus.

Other indicators are generated from the same data that is collected for calculating the ecological footprint. Included in this study are the total greenhouse gas emissions generated for each of the components listed above, to provide another perspective for monitoring environmental impacts.

# Table of Contents

# 1 Measuring an Organization's Sustainability

## 1.1 Purpose

The purpose of this report is to demonstrate how to create a framework and a set of indicators to measure an organization's ecological sustainability. Two major concepts are explored the hybrid Ecological Footprint and the Natural Step's (TN) sustainability principles.[5] The hybrid Ecological Footprint[6] is derived by a combination of the component and compound economic input output methods to calculate the footprint. The component method uses Life Cycle Assessment (LCA) data to derive the footprint. The compound economic input-output method is a top down approach which takes aggregated data and divvies it up into smaller pieces to calculate the footprint of each component. The TN principles are over-arching indicators to include aspects that may not be accounted for in the ecological footprint, such as products that are not easily assimilated by the biosphere.

A case study is used to demonstrate the process of creating and measuring an organization's ecological sustainability. The British Columbia Institute of Technology's (BCIT) main Burnaby Campus (BBY) was used for this 2006/2007 case study.

## 1.2 Introduction

No longer are the days of unlimited resources: we have fished certain species to extinction and drilled more oil than can be replaced in our lifetime. The reality is that there are limits to the resources that provide us with our basic needs for survival (food, water, air and shelter). Companies and institutions are feeling this limit as prices increase due to resource scarcity; they are hitting a wall of limited or no options. Organizations will continue to hit the wall until they fail or the system (biosphere) they exist in fails, as demonstrated by the funnel analogy below.

[5] Holmberg, J. and Robert, K.H. "Backcasting From Non-Overlapping Sustainability Principles: A Framework for Strategic Planning." International Journal of Sustainable Development and World Ecology 7 (2000): 1-18.

[6] Wackernagel M. and Rees W. E., 1996, Our Ecological Footprint: Reducing human impact on the earth. New Society Publishers, Gabriola Island, BC, Canada
Global Footprint Network and the University of Sydney, 2005, "The Ecological Footprint of Victoria Assessing Victoria's Demand on Nature", Prepared for EPA Victoria, pp. 10-11.

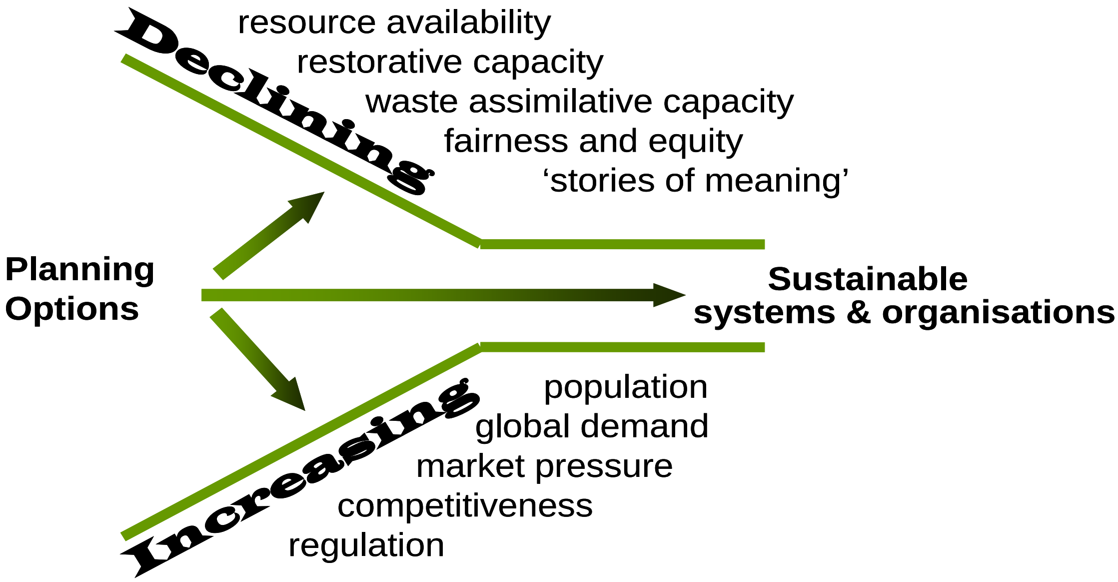


**Figure 1: Funnel Analogy**

*Source: Holmberg, J. and Robert, K.H. "Backcasting from Non-Overlapping Sustainability Principles: A Framework for Strategic Planning." International Journal of Sustainable Development and World Ecology 7 (2000): 1-18.*

The walls of the funnel demonstrate the biosphere's or the surrounding ecological system's limits, and the 45 degree angled arrows pointing to the walls of the funnel demonstrate the direction most organizations move when they are not acting sustainably within the biosphere/system. Once organizations can identify the system's constraints or limits, they are better equipped to strategically plan for the future and aim for long-term success, avoiding smashing into the walls. This is where indicators reflecting an organization's sustainability within the system become significant, in informing strategic moves for an organization to avoid hitting the wall.

The Natural Step's sustainability principles describe the constraints of the system, and the Ecological Footprint[7] demonstrates the limited bioproductive capacity by measuring the unsustainability of current consumption levels of the system. The combination of these concepts creates a framework to construct a holistic picture of an organization's environmental impact due to its operations. The data required to generate the aforementioned indicators is extensive, and the same data can be used to generate other indicators such as carbon dioxide equivalents ($CO_2e$), energy intensity, total non-renewable mass flow, and total waste. Using only one indicator, for example, $CO_2e$, ignores the long-term hazardous effects on the environment from practices such as the use of nuclear power. Hence, the combination of sustainability principles and indicators needs to be used to make a more informed decision.

The ecological footprint is considered a primary indicator because it reflects the level at which we consume available resources upon which we depend. The ecological footprint indicator is a quantification of the amount we demand from the biosphere. This amount can be compared to the availability of resources and the ability of the biosphere to

[7] Wackernagel M. and Rees W. E., 1996, Our Ecological Footprint: Reducing human impact on the earth. New Society Publishers, Gabriola Island, BC, Canada.

assimilate the waste generated from our actions. The indicator is represented in global hectares that average bioproductive capacity of different land types. For example, crop land refers to fertile land available for growing fruits and vegetables, and energy land refers to forested areas that can absorb the carbon dioxide generated from burning different fossil fuels for energy. The land types are described in full in the Methodology section.

Ecological footprints provide a snapshot of current demand for biocapacity.[8] The environmental impact of activities over long time frames, such as the creation and use of plastic bags, cannot be properly expressed in an ecological footprint. The ecological footprint does not demonstrate the long-term (over 50 years) persistent degradation of the environment, e.g., from plastic bags. Nor can the footprint demonstrate the disruption of natural cycles in 50+ years' time, when the plastic bag breaks down into foreign substances.

Using Natural Step's sustainability principles to outline all activities that can impact the environment, regardless of time, broadens the scope and prioritizes what to account for that can impact the environment.

1. *First principle* – deems that the extraction of all substances from under the earth's crust which are mined or drilled, such as heavy metals and oil, are unsustainable activities. Hence, reducing the extraction of such resources will lead towards sustainability.

2. *Second principle* – refers to avoiding all substances created by humans that can't be assimilated by nature, such as chlorofluorocarbons (CFC) and petroleum-based plastics.

3. *Third principle* – accounts for human-induced physical degradation of nature, such as soil erosion and depletion of watersheds.

   The ecological footprint indirectly quantifies the impacts that are not easily assimilated by nature through the available biocapacity. However, the degradation of biocapacity due to current activities will appear in the future. For example, some farming practices which rely heavily on herbicides and pesticides contribute to long-term soil erosion. This type of degradation is not easily captured in the ecological footprint unless the assessment is prepared annually over many years. This is where the results of an LCA demonstrate other impacts and risks associated with an activity in the immediate and long term, such as global warming potentials, acidification, eutrophication, degraded indoor air quality, smog, ozone depletion, and negative effects on human health.

4. *Fourth principle* – is the idea of not creating barriers for people in meeting their basic needs for food, water and shelter.

   For example, the Nile Perch fish was introduced into Lake Victoria, Tanzania in the mid 1960s to be exported to Europe. Since there were no natural enemies for the perch, they have overtaken other fish populations, changing the ecology of the lake to be unsustainable. In addition to devastating Lake Victoria, there are some thousands of local people suffering from malnourishment because they

[8] Global Footprint Network and the University of Sydney, 2005, "The Ecological Footprint of Victoria Assessing Victoria's Demand on Nature", Prepared for EPA Victoria, pp.10-11.

cannot afford to pay for this type of fish.[9] In this globalized economy, many products can be made in one country and sold in another. However, without full cost accounting of the ecosystem, the people in these countries, like Tanzania, often face increasing barriers to attain food and clean water easily. The ecological footprint can demonstrate the footprint of resources required in one country and/or organization, but doesn't necessarily demonstrate from where these resources will come and which peoples will be affected by the resource extraction. Inter-regional ecology is a new tool that is being developed to address this issue. It is designed to be used in tandem with ecological footprint assessments.[10]

For the purposes of this report, the Ecological Footprint Assessment (EFA) refers to the combination of the use of the Ecological Footprint methodologies and the Natural Step's sustainability principles. The process to create an EFA is systematic and consists of five components similar to the ISO 1997 reference document to organize an approach for an LCA study.[11]

1. *Goal Definition and Scoping* – establishes the context in which the assessment is to be made and identifies the boundaries and key environmental effects from the assessment.

2. *Data Collection* – encompasses the creation of a flow diagram of the system being evaluated, a collection plan, documentation of data collected, and evaluation of data collection.

3. *Methodology and Calculation Procedures* – outlines the theory and reasoning for calculating the results.

4. *Interpretation* – of results, while clearly stating associated assumptions, limitations and quality of data related to the assessment.

5. *Critical Review* – a peer review of the assessment of scope, system boundaries, methodology, data collection, validity of results, and communication of results.

To demonstrate the process of creating an EFA in this report, BCIT's Burnaby campus (BBY) is used as a case study. An EFA is created for BBY for the fiscal year 2006/2007.

# 2 Goal Defining and Scoping

Defining the goals and scope of an EFA should provide a framework to answer the questions and concerns of decision-makers or stakeholders. The goals and scope need to provide stakeholders relevant information, in an accurate, meaningful and usable form, about how the evaluated system impacts the environment. The following six decisions should be made at the beginning of the EFA to begin to create the framework and determine the time and resources required for the EFA.

[9] Darwin's Nightmare, 2004, documentary. Director: Hubert Sauper
[10] Kissinger M., 2008,"Inter-regional Ecology: Resource Flows and Sustainability in a Globalizing World", Dissertation. Vancouver: University of British Columbia.
[11] International Standards Organization, 1997, "Environmental Management – Life Cycle Assessment – Principles and Framework, ISO 14040.

1. Define the goals of the project.
2. Identify the decision-makers/stakeholders and the information they are seeking from the EFA.
3. Determine the level of specificity.
4. Determine how the data will be organized and results will be displayed.
5. Define the scope of the assessment.
6. Determine the ground rules for performing the work.

## 2.1 Define the Goals of the Project

The primary goal is to choose activities, products, and/or services that are ecologically sustainable. Conducting an EFA can help guide the development of new procurement processes, business models, and actions towards reduction of harmful or unsustainable consumption of resources. There are also secondary goals such as establishing a baseline, creating a ranking system, identifying data gaps, identifying possible risks, supporting policy, providing direction to decision-makers, and guiding the process for the development of an environmental management system.

### 2.1.1 BCIT's BBY Goals

The primary goals are: i) to complete an ecological footprint assessment of the Institute's Burnaby campus and ii) develop the means and methods to minimize the ecological footprint while achieving economies and adding value to the Institute and industry clients. These goals are articulated in the Memorandum of Understanding (MOU) between BCIT's Administrative Services and BCIT's School of Construction and the Environment regarding: *Environmental Stewardship and Sustainability Practices*.

This agreement clearly defined BCIT's primary goal for the BBY EFA. The secondary goals were derived by interviewing the School of Construction Director of Sustainable Development and Environmental Stewardship, Jennie Moore. After a meeting, the following secondary goals were created:

- Develop a strategy for developing the Ecological Footprint for BCIT's Burnaby campus based on the component and compound economic input-output methods which include:
  - An overview of available data and data gaps
  - Options for how to attain missing data
  - Estimates of resource and time requirements to access data and complete assessments
  - Identification of key individuals who should be involved
- Identify challenges pertaining to the storage and access of data and develop options for consideration to facilitate completion of future assessments
- Present the strategy for developing the Ecological Footprint to the MOU Implementation Committee for ratification and formation of a steering committee to oversee implementation

- Develop a communication and engagement strategy for the project to inform people about how they can either participate or find out more about calculating their individual ecological footprints
- Develop a work program for implementing the approved strategies.

## 2.2 Information for Decision-Makers

Having a good understanding of the stakeholders or decision-makers and their needs for a specific organization is a prerequisite when creating a management system that fulfills the requirements of ISO 9000:2000. The first step is to identify stakeholders and external factors that influence the success of an organization and its ability to meet its sustainability/environmental goals. Each stakeholder will be interested in the impacts that mostly relate to their area of involvement within the organization. Some questions the stakeholder may have are listed below:

What are the data confidentiality protocols?

How will the changes in the processes/activities be reflected in the indicators?

What is the most damaging process/activity?

How can the process/activity be changed to reduce the environmental impact?

What are the time and resources required?

### 2.2.1 Case Study: BCIT's BBY Stakeholders

BCIT's BBY stakeholders can range from the students and staff to the general public, as BCIT is a public institute. The primary decision-makers using the results from the EFA are staff. The outcomes had to be communicated to various groups within BCIT; this is identified in earlier discussions with different departments. The diversity of groups made the footprint more attractive as an indicator, since it simplifies complex and numerous data points about demands for biocapcity and the need to deal with the environmental impacts to one unit value (global hectares). Global hectares can be created as an easy visual. A committee comprising the Director of Sustainable Development, Associate Director of Facilities, and Faculty Researcher formed to oversee the development of the EFA and represent the interests of staff. The major concern of the committee is how much time and resources would be required to conduct this EFA.

## 2.3 Determine the Specificity of Data

The level of specificity may be obvious from the goals of the project, or the intended use of the information. The level of specificity must be clearly defined and communicated so that readers are able to understand the context of the results. The analyst of the EFA must determine if the data collected is to be specific to the organization or represent common industry sector practices. If the intent of information is meant to be used for a public forum or regulator, then a high level of specificity of data will be needed. If the intent is to use the information for internal decision-making, then estimates and best engineering judgement may be applied more frequently. This may reduce the overall cost and time of collecting and analyzing the data. The extent of representation depends on the quality and coverage of available data, which is why the analyst will need to revisit the specificity question during the process of data collection to determine if the available data remains valid for the intended use.

#### 2.3.1 Case Study: BCIT's BBY Specificity

The original desire from the committee overseeing the EFA for BBY is to collect and use as much specific data as possible in calculating the BBY footprint. Checking the specificity level of the available data was an iterative process during data collection. Essentially 80% of the BBY specific data is collected. Since this is the first time BCIT is conducting such a study, one of the expected outcomes is to determine the resources and time required to attain the entire data specific to BBY.

### 2.4 Determine the Organization of Data and Results Displayed

The analyst preparing the EFA needs to determine the functional unit to compare the data and display the analyzed data. Some examples of functional units in comparative studies are: volumes, weights, kilowatt hours (kWh), and carbon dioxide equivalents ($CO_2e$).

When considering the functional unit to compare results, the analyst must consider the audience's level of familiarity and understanding of the functional unit. This will determine how the results will be displayed.

#### 2.4.1 Case Study: BCIT's BBY Functional Unit

Since the BBY EFA uses an ecological footprint as a means to compare the data, the functional unit is in global hectares. A global hectare is the unit of area that encompasses the amount of biologically productive land required to supply the energy and materials and absorption of wastes when averaged for all land across the world. This is distinct from a hectare which is simply a measure of land area. Other functional units could be displayed from the same data that was collected, such as $CO_2e$ and energy intensity measured in gigajoules per square metre ($GJ/m^2$).

### 2.5 Determine the Scope of the Assessment

The following must be assessed: the goal of the study, the required accuracy of the results, and the available time and resources. Clearly identifying the boundaries of a study can be the most challenging step because of the availability of accurate LCA data. This task alone can be onerous. In setting system boundaries, the analyst must decide where the analysis will be limited and be very clear about the reasons for decisions. The following questions are useful in setting and outlining system boundaries for an organization:

Does the organization want to track the entire life cycle of each product and/or process flowing through the organization?

How will the results be used? Can equivalent-use ratios be developed? Is the assessment meant to compare similar industry practices? Can the inputs and outputs of the organization be clearly delineated?

What are the ancillary materials and chemicals used to make the products and/or run the processes? Will they be included in the assessment?

### 2.5.1 Case Study: BCIT's BBY Scope

The main objective of BCIT's BBY EFA is to calculate the ecological footprint for the baseline fiscal year 2006/2007. This is done by estimating the consumption of components for the baseline year. The components are listed as:

- direct energy, and water
- food, food packaging
- staff travel, student travel
- consumables
- built form and green space
- solid waste, recycling, and compost.

Each of these components has subcomponents (see Appendix 2 for details of subcategories). These components demand different resources and/or land categories to be produced and assimilated back into the biosphere. The list is derived based on previous studies demonstrated in *Sharing Nature's Interest*.[12]

Each component listed above is considered as a main input and output of the system (i.e., Burnaby Campus). A mass flow analysis (MFA) was utilized to track and quantify the embodied energy of materials in and out the system over the fiscal period 2006/2007. The MFA measures the direct consumption, whereas the conversion to an ecological footprint measures the efficiency of consumption and amount of ecological land required to absorb and neutralize pollution. The system conditions define the boundaries that the mass travels within, and the ecological footprint defines ecological demands of the mass flow from the system.

The consumables component was analyzed using an input-output monetary based hybrid approach.[13] This approach is still as holistic as the MFA, in the aspect that this hybrid method looks at all the industries downstream which contribute to the manufacturing and delivery of the product. Further discussions of the differences are listed in the Methodology section of this paper.

## 2.6 Determine the Ground Rules for Conducting Work

At the time this research was initiated, there was no set procedure to conduct an organizational EFA. However, the Global Footprint Network now publishes standards to guide organizational EFA and these standards should be consulted.[14] Setting limitations on the available data should also be considered in the beginning to determine the total time and resources required for conducting an assessment.

1. *Document Assumptions* – all assumptions and/or choices made throughout the entire assessment should be documented alongside the final results. If assumptions are omitted, the final results may easily be taken out of context.

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[12] Chambers, Simmons, and Wackernagel. 2000. "Sharing Nature's Interest: ecological footprint as an indicator of sustainability", London: Earthscan.

[13] Suh, S., Lenzen, M. et al. 2004. System Boundary Selection in Life-Cycle Inventories Using Hybrid Approaches", *Journal of Environmental Science & Technology*, Vol. 38, No. 3.

[14] Global Footprint Network. 2009. Ecological Footprint Standards 2009. Oakland CA: Global Footprint Network. (www.footprintstandards.org)

2. *Quality Assurance of Procedures* – assurance procedures are meant to ensure that the goal and purpose for performing the assessment are met. The level of quality depends on whether the results will be made public or are for internal use. If the results are made public, a formal review process is typically required (external auditor). For internal use, the person(s) reviewing the EFA should be familiar with the procedures and methodologies applied, and preferably not associated with the EFA project in order to be objective.

3. *Reporting Requirements* – Defining what should be in the final report ensures the final product meets the stakeholder's expectations. The report should define the systems that were analyzed and the boundaries that were set. The basis for comparison among systems and all assumptions made in performing the work should be clearly explained.

### 2.6.1 Case Study: BCIT's BBY EFA Assumptions, Review, and Report

There are assumptions made on the boundaries of the mass flows of the BBY EFA, which are stated for each component and discussed in the Methodology section of this paper and reiterated in the Results section. There are assumptions in the use of the LCA data which are listed in the Methodology section. All data sources which are used in the calculations are documented, and the method in which this is done can be seen in the Data Collection section of this paper.

The quality assurance of this assessment is done internally, because the results are used for internal planning. The analyst met with the committee members throughout the project to update them on the data collection process and issues arising out of the project. This served to check that the goals are continuously reviewed, and the analyst did not stray from the intended goals. Final results are reviewed by the committee and then presented to a larger group of different department heads and managers representing Facilities, Schools, and IT. Again, this worked as a review of the assessment. The final review of the assessment is done by reviewing this document.

For the first year of this assessment the reporting requirement has been done in the form of a guideline to demonstrate how to conduct a similar assessment. For future reporting, simple summaries of each component can be demonstrated in tables and graphs, since staff will have become familiar with the concepts and methods behind assessments.

# 3 Data Collection

First, taking inventory of the available data within an organization is a large task that requires a plan. Once an inventory is created and documented, determining the gaps becomes obvious. The next step then becomes finding how to supplement missing data, if it is possible. Second, collecting and organizing data that is not specific to the organization but part of the overall calculation is another large inventory. An example is emission factors required to estimate the emissions generated from the combustion of fuels consumed by vehicles. These factors are not specific to a make or model of a particular vehicle and can be applied in different regions of Canada.

**Table 1: Vehicle Emission Factors, 2005**

| Fuel | CO2 (g/L) | CH4 (g/L) | N2O (g/L) |
|---|---|---|---|
| Natural Gas Vehicles | 1.893 | 0.009 | 6E-05 |
| Propane Vehicles | 1510 | 0.642 | 0.0282 |
| Light-Duty Gasoline Trucks (LDGTs) | 23601 | 0.134 | 0.254 |
| Light-Duty Diesel Trucks (LDDTs) | 27301 | 0.0682 | 0.222 |

(Environment Canada, 1990-2005)[15]

To help in creating these inventories and assessing the quality of data, the following are actions the analyst can take:

1. Develop a flow diagram of the system being evaluated.
2. Develop a data collection plan.
3. Develop documentation templates for data storage.
4. Create a method to evaluate the quality of data.

## 3.1 Develop a Flow Diagram

A flow diagram is a tool to map the inputs and outputs of a system. The goals and scoping of the project define the initial boundaries. The flow diagram demonstrates the inputs of materials and energy in the system and each subsystem. The outputs from the system are demonstrated in the flow diagram as emissions, recyclables, and waste.

[15] Environment Canada. (1990-2005). *Information on Greenhouse Gases Sources and Sinks.* Retrieved January 19, 2008, from NATIONAL INVENTORY REPORT, 1990-2005:GREENHOUSE GAS SOURCES AND SINKS: http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm

### 3.1.1 Case Study: BCIT's BBY Flow Diagram

**Input flows to BBY:**

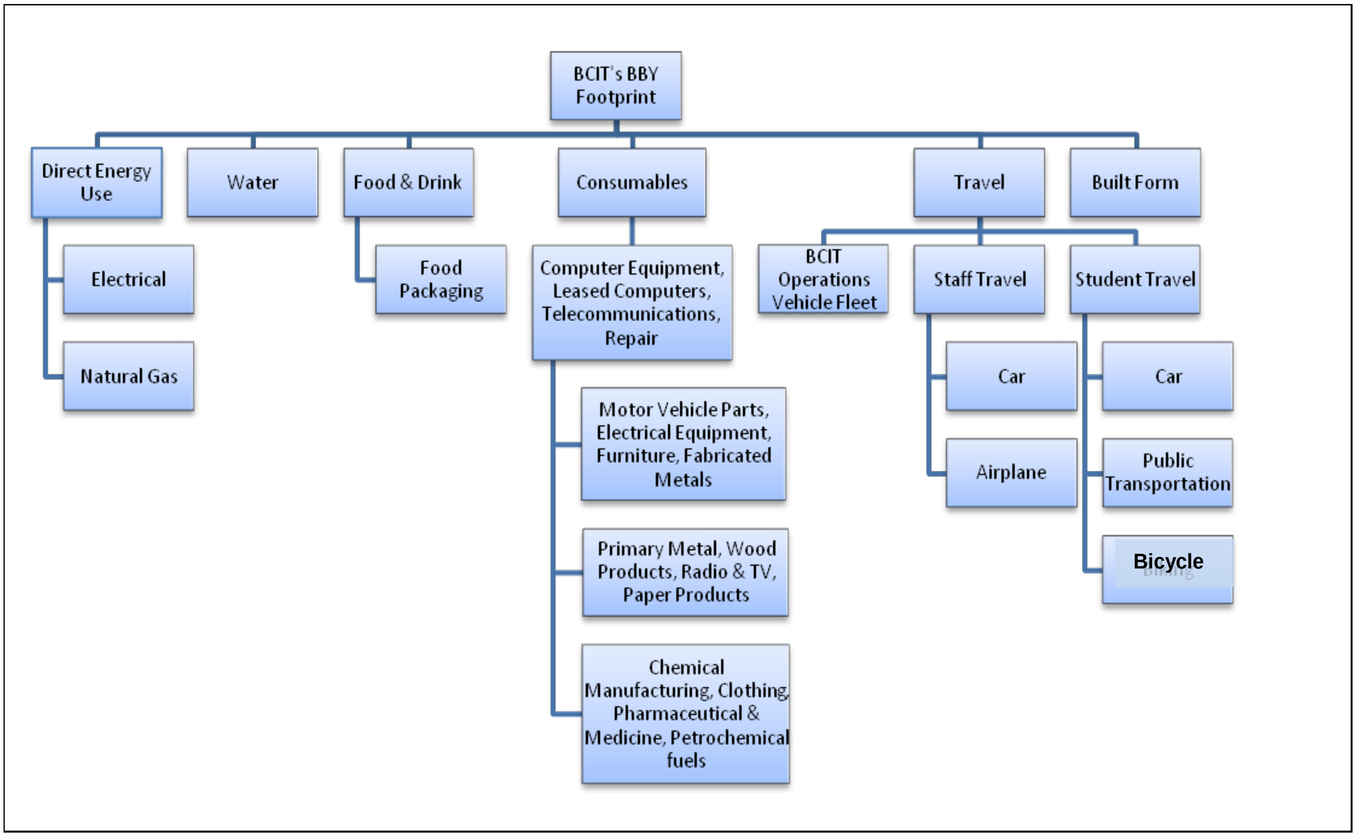


Figure 2: Flow Diagram: Inputs to the System

**Output flows from Burnaby:**

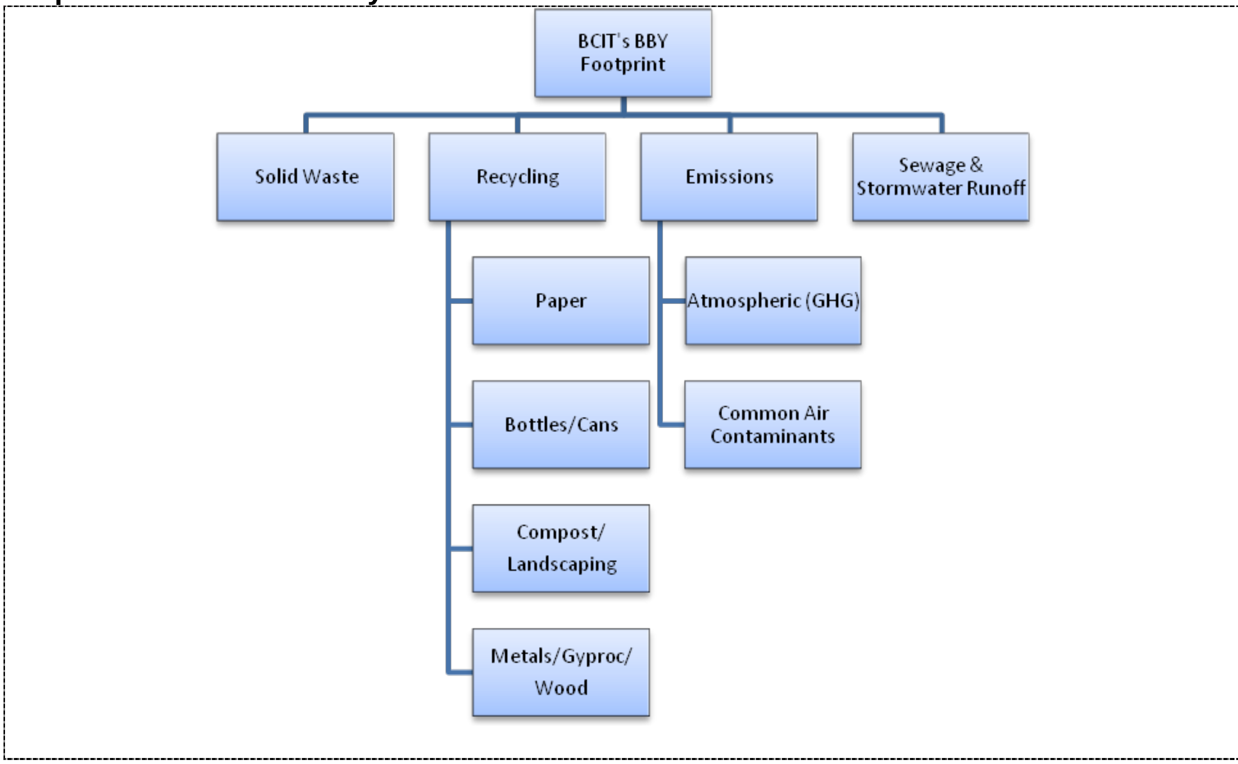


**Figure 3: Flow Diagram: Outputs from the System**

## 3.2 Data Collection Plan

A data collection plan is required to source data and determine the time for collection. A plan can ensure the quality and accuracy of data meeting the expectations of the decision-makers. A collection plan includes the following key elements:

1. Identify the data source/location, type, and people responsible for the data.
2. Develop a collection worksheet.
3. Develop a timeline.

The scope and boundary of the data collection help the analyst determine the level or type of information required.

Data collection efforts involve a combination of research, site visits, and direct contact with experts. In addition to site-specific data, if external data is required for process and products, the analyst may want to consider buying commercially available LCA software packages and ecological footprint data sets to save time.

### 3.2.1 Case Study: BCIT's BBY Collection Plan

In order to identify the availability of data, the analyst interviewed various departments within BCIT. A letter introducing the project was sent to each group outlining the goals of the assessment and the steps for investigating data availability, location, and resources. Since this was the first EFA being done at BBY, the committee helped the analyst to identify the groups that would be contacted and a process for how to approach each group. Below is a sample of the letter sent to the group's directors to introduce the analyst, the project, and the data collection goals.

*"As a preliminary step in preparing for the Ecological Footprint Assessment a review of available data will be undertaken with the aim of evaluating the resources required to mine that data. Should the project proceed, appropriate resources will be provided by the research group. Working collaboratively and with concern for resource and privacy implications, [the analyst] will be seeking to interview directors (or their designates) in order to determine the availability and accessibility of information on campus, and where that data is stored (for example, in an electronic database or on paper).*

*The aim of this meeting is to determine how information is stored, evaluate confidentiality of the information, and review methods for mining data. We understand that some data may be confidential in nature. Please note that it will be used only for the purpose of the Ecological Footprint Assessment, and only with your permission. Should the project move to the next phase of implementation, we will contact you about how to mine the data so as not to impact your department."*

The site-specific data sources are identified from the meetings with the various groups within BCIT. Most of the data is housed in three databases, in electronic format. The staff business vehicle travel is only in paper format, and this data is not collected for the first assessment. A status report is created to summarize the data collection process and gaps; see sample below:

"*Status Report 1*

| | |
|---|---|
| ***Project Name*** | *Ecological Footprint Assessment BCIT Burnaby Campus* |
| ***Author(s) of Report*** | *Analyst Name* |
| ***Date*** | *January 30, 2008* |

***D e s c r i p t i o n***

*To review status of Ecological Footprint assessment since it started in October 1, 2007, using the project charter's objective and deliverables as a guide to discussion of status…*

***The first identifiable data gaps*** *are the energy from the solar energy panels and the hidden flows of energy requirements for electricity generation from hydro and heating from natural gas. The project owners of the solar panels will need to be identified to determine how the energy from the solar panel is being used and/or stored. The hidden flows related to hydro-generation and natural gas can be done in consultation with Global Footprint Network.*

***The second identifiable data gap*** *is the Food packing and Food component. The committee has identified that most of this information will come from Chartwells, a private company that supplies most of the food to the Burnaby campus. The Student Association will also have some of this information and a meeting should be coordinated to determine the possible collaboration with BCIT and the Student Association…"*

Data work sheets are created for each group that is interviewed to fill out and submit to the analyst; see sample below:

| GROUP NAME | Name/ Financing | | Estimate Time | 8 hrs |
|---|---|---|---|---|
| Data Range | Fiscal Year | 2006/2007 | | |

| Component | Material | Unit | |
|---|---|---|---|
| Travel | **By Air** | **Passenger-Km** | |
| | By Car | **Passenger-Km** | claimed business travel |

**Location of Data:**

Banner Database, will need to work with COGNOS to extract data

Most of the coordination and planning is required for the site-specific data. The external data, such as LCAs and Economic Input-Output tables, requires research and contact with experts to find the most relevant data sets. After the initial review of the project, the analyst creates the timeline and schedules to complete the project. The timeline needs to be revisited monthly and updated to reflect the actual completion of data collection. (See Appendix 3 for sample timeline.)

## 3.3 Documentation of Data

Documenting site-specific data is a key step in tracking who is involved in delivering the data, the date of arrival, and any conditions/assumptions with the data. When documenting site-specific data, the analyst must ensure the company/organization's trade secrets and competitive technologies are protected during collection and reporting results. The level of protection of confidential business information needs to be made clear for all the data that is gathered.

Surveys from end-users can provide data on user practices from which inputs and outputs can be derived. Generally, the end-user can be the source of related information from which the energy, materials, and pollutant release inventory can be derived.

External sources from which to document data are often:

- Industry average: data derived from a representative sample of locations and believed to statistically describe the typical operation across technologies.
- Generic: data that is not specific for any one company but representative of trends and is quantitatively descriptive of a process or technology/product. For example vehicle emission rate.

External data comes from journals, government documents, industry reports, and technical books. All sources should be documented within the vicinity of where data is being stored. All assessments should note the age of the data used.

### 3.3.1 Case Study: BCIT's BBY Documentation

The site-specific data reflecting BBY's raw data is stored in Excel files. The date of arrival and the contact person are recorded next to the data, as shown below.

| Components | Material/Product | Unit | Location/Dept. of Data | Contact Person | Data Made Available |
|---|---|---|---|---|---|
| Direct Energy | Electricity ( each building) | GWh | Facilities/PDF report from Prism Engineering | Joe Smith | Yes |
| | Gas (each building) | GWh | Facilities/PDF report from Prism Engineering | Joe Smith | Yes |
| | Solar (each building) | GWh | Tech Centre/ not being recorded | John Bell | No |

This table is linked to the raw data of each component/subcomponent.

The student mode of travel survey, which is conducted internally, is used to estimate the student travel footprint.

External LCA data sets for food and food packaging are from journals and Canadian and American government reports. External Consumable LCA data sets are from a free LCA online software program provided by Carnegie Mellon: http://www.eiolca.net/. Experts contacted as reference sources, and methodology inputs are listed as follows:

- Prof. Manfred Lenzen, ISA- Centre for Integrated Sustainability Analysis, University of Sydney, Australia
- Uta Krogman Ph.D., Associate Professor Extension, Specialist in Solid Waste Management, Rutgers University, NJ, USA
- Ullika Lundgren, Environmental Coordinator, Göteborgs University, Sweden
- Mark Anielski & Jeff Wilson, Anielski Management Inc., Edmonton, AB
- Jan Minx, Stockholm Environment Institute, Future Sustainability Group, UK
- Jørgen Vos, Principal, Sustainability Planning Partners, CA, USA
- Patrick Inglis and Susan Hayduk, Ecological Footprint Team, Environment & Safety Management, The city Of Calgary
- Brad Ewing, Global Footprint Network, CA,USA
- Meidad Kissinger, Ph.D., UBC Planning
- Bud Fraser, Senior Engineer, Holland Barrs Planning Group Inc., Vancouver, BC
- Aviva Savelson, Stantec (formerly The Sheltair Group), Vancouver, BC

BCIT became partners with the Global Footprint Network (GFN) to attain Canadian ecological footprint data, which is used to calculate BCIT's BBY footprint: http://www.footprintnetwork.org/en/index.php/GFN/

## 3.4 Evaluation of Quality of Data Collected

Evaluate data based on reputable source, precision, completeness, representativeness, consistency, and reproducibility.

### 3.4.1 Case Study: BCIT's BBY Evaluation of Data

*Reputable Source* – All site-specific data came from within BCIT and direct suppliers, which would increase its accuracy in depicting BCIT's actual impact.

*Precision* – Calculating the percent error of the data is not included in this footprint analysis. Once the data collection and analysis become automated, this may be easier to determine.

*Completeness* – 80% of the site-specific data was collected. Most of the LCA data is Canadian-specific. All the footprint data from the GFN is Canadian-specific.

*Representativeness* – Most of the site-specific data is possible to attain, and when data was not available there is survey data which is used.

*Consistency and Reproducibility* – These will be seen when the assessment is repeated year after year.

# 4 Methodology & Calculation Procedures

## 4.1 Hybrid Ecological Footprint Assessment

The ecological footprint developed by Wackernagel and Rees (1996) is intended to serve as an indicator of unsustainable consumption by considering the bio-productivity and bio-assimilation capacity of land types to meet a certain population's demand for natural resources and waste disposal. There are five land types, which consist of arable land, pasture, forest, built-up land, and sea space. Productive land is diminishing due to desertification, erosion, sea level rise, and increase in the world's population[16]. For example, the GFN calculated in 2003 that the global average per-capita ecological footprint was 2.2 gha/person and there was only 1.8 gha/person of biocapacity, thus demonstrating we are already consuming more resources than are available.

There are two distinct methods to calculate the ecological footprint. One method is called the component[17] method, which is a bottom-up approach. This method accounts for the resources a population consumes based on the physical quantities of each component. In order to achieve such detailed information, LCA data is used to determine quantitative values. However, the accuracy of the LCA data is limited by the completeness and reliability of the assessment for each identified component. Even though it is difficult to ascertain specific, accurate, and complete LCA data for this assessment, it is still worthwhile to use existing available data for heuristic encouragement of holistic assessment practices.

The Compound Footprinting method is a top-down approach which starts with the whole and then divides into sub-components. This approach, which is based on the work of Wassily Leontief[18], combines LCA data and economic input-output (EIO) assessment methods***.*** Economic input-output models are used to study changes in the demands or structure of the economy. The traditional economic input-output model uses a matrix that indicates economic transactions between industries. It can be appended with information on emissions to the environment. In effect, this creates an additional column representing "the environment sector", and the additional value represents the pollutant "output" from an industry sector that is "input" to "the environment" sector. Since increased demand of output from one sector influences the output of other sectors, with an appended model one can also model how increased demand for output from one sector influences the output of pollutants to the environment. This EIO-LCA approach eliminates the two major issues of boundary definition and circularity effects of process-based models or bottom-up approaches. However, this methodology does not account for impacts of transportation of goods between sectors or the associated labour. Also, the use phase and end-of-life phases are not directly included in the results.

For this study, the use of both methods increases the data that is available in different forms. For example, in the case study of BCIT's Burnaby campus, the food data was available in mass quantities, whereas data for the amount of wood used on campus was

[16] UN-Habitat, 2008, "State of the World's Cities 2008/9: Harmonious Cities", United Nations Human Settlements Programme, ISBN: 9781844076963
[17] Simmons, C., Lewis, K. and Barrett, J., 2000, "Two feet – two approaches: a component-based model of Ecological Footprinting, Ecological Economics, 32(3), p. 375-380.
[18] Carnegie Mellon University Green Design Institute (2008), Economic Input-Output Life Cycle Assessment (EIO-LCA), US 1997 Industry Benchmark model [Internet], Available from: http://www.eiolca.net, Accessed 1 January, 2008.

only available in dollars based on the amount spent. According to the jointly authored paper produced by the GFN, and the University of Sydney (2005),[19] where the results of both methods are compared, the derived footprint quantities from both methods are fairly similar.

### 4.1.1 Methodological Variations

The Natural Step Principles are used to guide a holistic perspective in organizing mass flow components. Because the ecological footprint is limited to accounting for the impacts of consumption and waste generation that can be assimilated by nature, some materials not included in the ecological footprint are the hazardous materials that do not break down easily, such as plastics, PCBs, and asbestos. These components will be monitored in the future. The other impacts that are not accounted for in the ecological footprint, but that can be monitored, are the degradation of nature and some of the social sustainability aspects. These impacts are beyond the scope of this study.

Similar to John Barrett et al (2002),[20] the energy calculations for this study adopt the following approaches:

- The embodied energy of goods considers the amount of energy required in producing all goods consumed by a given population. This embodied energy can be accounted for using life cycle energy information for a given item, as opposed to using the raw materials of the given item to determine its footprint and embodied energy. The life cycle energy use covers the energy required for production and disposal of the item purchased, which is calculated over its whole life cycle and expressed as primary energy. This energy is then converted into an energy land equivalent and, hence, into an ecological footprint.
- Where possible, BCIT-specific data is used.
- Other greenhouse gas emissions in addition to $CO_2$ are taken into account for this study.

### 4.1.2 Material Inputs and Energetic Flows through a Sustainability Lens

Typically, material inputs are classified into four categories:[21]

1. Abiotic – fossil fuels, minerals, ores
2. Biotic – cork, fibres, plant, rubber, wood
3. Water
4. Secondary – ashes, gypsum, slags

These four categories are further organized within the aforementioned system conditions or Natural Step principles.

- System Condition 1: (related to the extraction of resources from the earth's crust)

[19] Global Footprint Network and the University of Sydney, 2005, "The Ecological Footprint of Victoria Assessing Victoria's Demand on Nature", Prepared for EPA Victoria.
[20] Barrett, J., Vallack, H., Jones, A. and Haq, G., 2002, A Material Flow Analysis and Ecological Footprint of York, Stockholm Environment Institute.
[21] Ibid.

    - Abiotic materials would fall under this category
- System Condition 2: (related to creating human-made materials)
    - Secondary material inputs would fall into this category
- System Condition 3: (relates to the degradation of nature)
    - Biotic materials and water would most affect this condition

These material inputs are the primary sources in making any products, which are typically tertiary items or that have been processed to produce the final product. Some raw materials are used as is, such as wood, but all these materials have hidden flows to extract and deliver the raw material to the consumer.

The energy flow includes the amount of fossil fuels (energy carriers) required to provide the goods and services consumed by BCIT employees and students. In other words each item or product has an embodied energy value which accounts for the extraction of raw materials, the processing to produce the item, and the delivery to the end consumer. This embodied energy is converted into equivalent tonnage of fossil fuels.

#### 4.1.3 Material Stocks

Material stocks typically refer to man-made fixed assets. For the purpose of this study, two categories will be considered related to infrastructure and they are buildings and roads/parkades. Other stock items such as machinery and durable goods that are already on campus will not be included in this study, but may be revisited in subsequent studies. According to past research, infrastructure can account for at least 90% of the total physical stock measured in tonnes.[22]

#### 4.1.4 Material Outputs through a Sustainability Lens

Material outputs from the Burnaby campus are predominantly human-made compounds, which would be categorized under the third system condition. The material output items include solid waste going to the landfill, sewage, and air emissions. There are air emissions generated off campus (embodied in the production and disposal of an item, and travel outside of the campus) and point source air emissions generated on campus. All air emissions generated outside and on the Burnaby campus are converted to carbon dioxide equivalents ($CO_2e$).

#### 4.1.5 Calculating the Impact of BBY Consumption of Food, Packaging

The energy used for each stage of the life cycle of a food item from gathering raw materials, processing, packaging, and transporting the final product to a wholesaler is used to estimate the energy footprint of the food production of 55 items. This life cycle data is mostly derived from European sources.[23] This embodied energy data from the year 2000 may be dated, but the exercise of calculating the footprint with these values can provide a conservative baseline. Table 2 presents the food categories and embodied energy with associated $CO_2e$.

[22] Barrett J. et al, 2002, p. 14; also Berkhout F., 1999, Industrial Metabolism – Concept and Implications for Statistics, EUROSTAT Working Papers 2/1999/B/4.
[23] Barrett J., Vallack H., Jones A. and Haq G., 2002, A Material Flow Analysis and Ecological Footprint of York, Stockholm Environment Institute; also Energy Analysis Program, Centre for Energy and Environmental Studies, University of Groningen, The Netherlands.

**Table 2: 55 Major Food Products within BCIT and Embodied Energy**

| Name of Product | Embodied Energy MJ/t | GWP tCO2e/t |
|---|---|---|
| **Milk, cream and cheese** | | |
| Whole milk | 17.6 | 3.52 |
| Skimmed milk | 16.85 | 3.77 |
| Yoghurt and fromage frais | 48.88 | 7.21 |
| Other milks and dairy products | 48.89 | 7.21 |
| Cream | 42.12 | 12.17 |
| Cheese (natural & processed) | 91.67 | 13.86 |
| **Meat, fish and eggs** | | |
| Beef and veal | 67.9 | 19.3 |
| Mutton and lamb | 54.7 | 13.09 |
| Pork/ham/bacon | 59.99 | 13.89 |
| Poultry (uncooked) | 43.02 | 10.63 |
| Poultry (cooked) | 170.73 | 26.76 |
| All other meats | 85.48 | 17.17 |
| Total fish | 209.47 | 17.23 |
| Eggs | 21.8 | 5.48 |
| **Fats** | | |
| Butter | 82.2 | 17.36 |
| Margarine | 25.97 | 3.02 |
| Low-fat and dairy spreads | 37.35 | 4.41 |
| Vegetable and salad oils | 25.79 | 3 |
| Other fats (animal) | 46.01 | 5.59 |
| **Sugar and preserves** | | |
| Sugar | 14.36 | 1.67 |
| Honey, preserves, syrup & | 34.66 | 4.01 |
| **Vegetables** | | |
| Fresh potatoes | 19.17 | 1.88 |
| Fresh green vegetables | 8.8 | 1.67 |
| Other fresh vegetables | 21.1 | 2.33 |
| Processed vegetables | 39.44 | 3.72 |
| **Fruit** | | |
| Fresh fruit | 17.59 | 3.4 |
| Other fruit (e.g. tinned) | 27.02 | 3.32 |
| Fruit juices | 32.21 | 2.43 |
| **Cereals** | | |
| Bread | 14.05 | 1.49 |
| Flour | 9.73 | 1.15 |
| Cakes | 56.04 | 5.93 |
| Biscuits | 26.35 | 2.72 |
| All other cereals | 18.59 | 4.07 |
| **Beverages** | | |
| Tea | 55.16 | 6.01 |
| Coffee | 128.92 | 13.62 |
| Cocoa/drinking chocolate | 60.51 | 7.31 |
| Branded food drinks (e.g. | 73.94 | 8.81 |

| Name of Product | Embodied Energy MJ/t | GWP tCO2e/t |
|---|---|---|
| **Miscellaneous** | | |
| Soups | 21 | 10.71 |
| Mineral water | 7.77 | 0.83 |
| Ice-cream & other frozen dairy | 38.15 | 7.26 |
| **Soft drinks** | | |
| Soft drinks (concentrated) | 8.91 | 0.92 |
| Soft drinks (ready to drink) | 10.45 | 0.93 |
| Soft drinks (low cal, | 11.17 | 1.01 |
| Soft drinks (low cal, ready to | 11.19 | 1.15 |
| **Confectionery** | | |
| Chocolate confectionery | 36.05 | 6.58 |
| Non-choc confectionery | 38.06 | 4.64 |

*****MJ/t – Mega Joules per metric tonne

*GWP – Global warming potential normalized to Carbon Dioxide ($CO_2$)

In addition to calculating the energy footprint of each food item, the total area of grazing, or crop, or sea space was also calculated and added to make the total footprint for each food item.

It is difficult to determine where the food products are grown (within Canada or abroad), produced, and the energy used to for the life cycle of the food products. It is assumed that fossil fuels are used in the production of the food items listed on Table 2. Assuming that the supply of fossil fuel is far less limiting than the biosphere's ability to cope with the waste, the methodology[24] to determine the bio-capacity or waste assimilation is calculated using the embodied energy values in Table 2 and the Global Footprint Network's (GFN) 2005 Canadian $CO_2$ sequestration rate of 0.97 $tCO_2$/ha. The perspective of calculating the impact of the waste assimilation is a conservative approach compared to the method calculating the biomass supply.[25] This means that for every hectare of forested land in Canada, 0.97 tonne of $CO_2$ emissions can be absorbed. Once the energy land was calculated, it was then converted to global land average of productivity. The GFN estimated Canada's average forest productivity was 1.33 times the global average.

**Table 3: Equivalence Factors for Converting Different Land Use Areas to Global Average Productivity**

| Footprint Area Type | Equivalence Factor |
|---|---|
| Crop Land | 2.64 |
| Grazing Land | 0.50 |
| Other Wooded Land | 0.50 |
| Forest | 1.33 |
| Marine | 0.40 |
| Inland Water | 0.40 |

[24] Wackernagel M., Monfreda C., et al., 2005,"National Footprint and Biocapacity Accounts 2005: The underlying calculation method.", Global Footprint Network. www.footprintnetwork.org
[25] This waste assimilation method is used to account for the unknown distances some food may travel from.

| | |
|---|---|
| Infrastructure | 2.64 |
| Hydro | 1.00 |

*2005 Canadian Values from GFN

In addition to forested land, other types of land are required for producing food and drink beverages. To determine the area of the other types of land, such as crop and/or grazing, yield factors are needed.

**Table 4: Yield Factors for Major Food Categories**

| Food or Drink Category | Yield Factor ha/t |
|---|---|
| Beef | 9.64 |
| Chicken/Turkey | 2.64 |
| Eggs | 2.33 |
| Pork/Ham | 4.94 |
| Fish/Shrimp | 4.17 |
| Whole Milk | 0.49 |
| Skim Milk | 0.52 |
| Yoghurt | 5.23 |
| Cream | 3.24 |
| Cheese | 3.24 |
| Soy products | 0.41 |
| Potatoes | 0.03 |
| Tomato | 0.01 |

**Source predominantly from GFN 2005 Canadian Ecological Footprint data tables*
*Secondary source: U.S. LCI Database Project - www.nrel.gov/lci*
*Tertiary source: Barrett J. et al, 2002, "A material flow analysis and Ecological footprint of York", SEI p. 29*

Once each type of land area was calculated, these land areas were then converted to global average productivity land area. The conversion meant multiplying the land area with the appropriate equivalence factor; see Table 3.

Examples for beef and muffins are demonstrated below.

The food data was organized into seven major categories which further broke down into 51 subcategories. From the seven major categories, the meat category represented the largest footprint in the Food component.

**Beef**

The amount of energy land area or area for waste assimilation per tonne of beef is derived by assuming the embodied energy for 1 tonne of beef is 67.9 MJ, which would generate 19.3 tonnes of $CO_2$e. For every tonne of $CO_2$e generated, 25% of it would be absorbed by the ocean. The forest would sequester the rest at a rate of 0.97 t$CO_2$e/ha.

Energy land for beef = 19.3 x (1-0.25)/0.97 = 14.92 ha/t

The conversion to global average productivity land is calculated assuming the forest equivalence factor is 1.33.

Energy land for beef (global average) =14.92 x 1.33 = 19.88 gha/t

The yield factor for beef is 9.64 ha/t. To convert the grazing land required for 1 tonne of beef into global average productivity of land is to assume an equivalence factor of 0.5.

Grazing land for beef (global average) = 9.64 x 0.5 = 4.82 gha/t

The total ecological footprint conversion factor is the sum of the energy land and grazing land for beef.

Ecological factor for beef = 19.88 + 4.82 = 24.7 gha/t

The total amount of beef products delivered to BBY for 1 year is 10.69 tonnes.

Ecological Footprint for Beef = 24.7 x 10.69 = 264.29 gha

**Muffins**

Muffins and other baked sweet goods are grouped in one category. It is assumed that most baked sweet products share three predominant ingredients: flour, sugar, and oil. In this example the muffin mix composition ratio is 50% flour, 30% sugar, and 20% oil. This mix ratio is based on a generic online recipe for muffins.[26] Each ingredient has a crop land component. The total embodied energy of muffins and associated $CO_2e$ is used to determine the energy land area required for every tonne of muffins. Energy to mix the raw material and make the end product, such as cookies or muffins, is not accounted for. For every tonne of $CO_2e$ generated, 25% of it would be absorbed by the ocean. The forest would sequester the rest at a rate of 0.97 $tCO_2e/ha$.

From Table 2 it is assumed the embodied energy for making biscuits is equal to making muffins. Hence, the embodied energy used to make muffins is 26.35 MJ/t, which generates 5.93 $tCO_2e/t$ of muffins made.

The energy land area required to sequester emissions generated from making 1 tonne of muffins is calculated as demonstrated below.

Energy land = 5.93 x (1-0.25)/0.97 = 4.58 ha/t

The conversion to global average productivity land is calculated assuming the forest equivalence factor is 1.33.

Energy land (global average) = 4.58 x 1.33 = 6.09 gha/t

The calculation for crop land area to produce flour to make 1 tonne of muffins is done assuming the muffin mix contains 50% flour with a wheat yield factor of 0.396 ha/t.[27]

Crop land (wheat) = 0.5 x 0.396 = 0.198 ha/t

The calculation for crop land area to produce sugar to make 1 tonne of muffins is done assuming the muffin mix contained 30% sugar with a sugar yield factor of 0.045 ha/t.[28]

Crop land (sugar) = 0.3 x 0.045 = 0.013 ha/t

The calculation for crop land area to produce the vegetable oil for making 1 tonne of muffins is done assuming the muffin mix contained 20% oil with a yield factor of 0.226 ha/t.[29]

[26] http://www.muffinrecipes.net/apple-muffins.html, viewed September 20, 2008.
[27] 2005 Canadian Values from GFN, table crop_efi
[28] Ibid.
[29] Ibid.

Crop land (oil) = 0.2 x 0.226 = 0.045 ha/t

The conversion of crop lands required for 1 tonne of muffins into global average productivity of land is done assuming an equivalence factor of 2.64 as listed in Table 3.

Crop land (global) = (0.198+0.013+0.045) x 2.64 = 0.68 gha/t

The ecological footprint (EF) conversion factor for muffins is the sum of the energy land and crop lands.

EF conversion factor = 6.09 + 0.68 = 6.77 gha/t

The total muffin and baked goods consumed on the Burnaby campus in 1 year was 27.33 t. Hence, the total ecological footprint for muffins and baked goods is calculated by multiplying the EF conversion factor and the total mass of muffins.

Total EF of muffins (and baked goods) = 6.77 x 27.33 = 185.61 gha

#### *4.1.5.1 Food Packaging*

Energy and matter are required to make packaging material to ship or serve food to customers on the BBY campus. Table 5 below demonstrates the ecological footprint conversion calculation for cardboard items.

**Table 5: Example of Ecological Footprint Conversion for Cardboard**

| Cardboard 1tonne | GWP/tonne 1$CO_2$e* | Sequestration rate | Yield Factor (ha/t) | Global Equivalence | Ecological Footprint factor (gha/t) |
|---|---|---|---|---|---|
| Energy Land | 2.47 | 0.97 | | 1.33 | 3.40 |
| Forest Land | 2.47 | | 0.58 | 1.33 | 0.77 |
| Total | | | | | 4.17 |

*25% sequestration of $CO_2$e from oceans taken into account in GWP/tonne values

The mass quantity is known for packaging materials such as cardboard and plastics. The plastic bottles, glass, and aluminum cans for beverages are accounted for in the total Food and Drink component. These items are not separated into food packaging. The following table demonstrates the ecological footprint for each type of packaging material considered in this study. Low density polyethylene (LDPE) plastics includes such items as disposable cutlery, cup lids, plates, bowls, and other plastic containers for food.

**Table 6: The Ecological Footprint of Packaging**

| Food Packaging Item | Weight (tonne) | Ecological Conversion Factor (ha/t) | Total Ecological Footprint (gha) |
|---|---|---|---|
| Cardboard | 26.64 | 4.17 | 111.36 |
| LDPE | 14.80 | 2.42* | 35.83 |
| Total | | | 147.20 |

*Source: Barrett J. et al. 2002,"A material flow analysis and Ecological footprint of York", SEI*

### 4.1.6 Calculating the Impact of BBY Consumption of Direct Energy and Water

**Direct Energy**

The energy mix for the BBY campus is electricity and natural gas. The $CO_2$e emissions generated from the energy consumed are converted into the ecological footprint by considering the amount of land required to sequester the emissions. Different fuels/energy sources generate different levels of $CO_2$e emissions. The method for determining energy consumption is based on the calculation of biomass supply as oppose to waste assimilation. All the energy consumed within the observed year for this report is assumed to be local or regional.

The electricity delivered to BCIT's BBY campus comes from one supplier, BC Hydro. BC Hydro primarily generates electricity from hydro-power; however, there are coal power and natural gas plants in BC Hydro's electricity mix. BC Hydro estimated their $CO_2$e emissions generated per kWh of electricity delivered[30] in a Green House Gas Report created in 2005. The values in this report are used to calculate BBY's electricity consumption footprint.

The total $CO_2$e emission from BC Hydro generation of 1 GWh is 46.5 tonnes. This value is converted into the amount of global average land needed to sequester the $CO_2$e emissions: 0.28 gha/ t$CO_2$e. In other words multiply the total $CO_2$ emissions generated per GWh by the land needed to sequester a t$CO_2$ to determine the ecological footprint for direct energy.

46.5 x 0.28 =13.04 gha/GWh

This would indicate that it takes 13.04 gha to sequester 1 GWh of power from BC Hydro. The amount of electricity that is consumed in BBY is 29.1 GWh.[31]

29.1 x 13.04 = 380.74 gha

Therefore it takes 380 gha of forested area to sequester 1 year of electricity consumption from the BBY campus. The consumption of natural gas is a similar calculation but with a different value of $CO_2$e emissions/GWh.

**Water Supply**

The Water Supply footprint calculation is based on the energy to extract the water from the reservoir, which is mostly gravity fed, then pumped to the consumer, as well as pumping the sewage to treatment plants. The energy used at the treatment plants is not included in this study. The GVRD waste and water management engineering department estimated the electrical energy required to supply portable water to the BBY campus is in the range of 370 kWh/megalitre[32].

Since the BBY consumption of water is 208.8 ML, the total energy consumed for water delivery and export is:

370/1000000 x 208.8x2 = 0.14 GWh

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[30] BC Hydro Greenhouse Gas Report, March 2005, viewed March 2008: http://www.bchydro.com/about/our_commitment/sustainability/greenhouse_gases.html

[31] Prism Engineering, 2007, "Utility Reporting: Electricity, Natural Gas, Steam, and Water", Internal Report for BCIT.

[32] This value was confirmed in a phone conversation with GVRD engineer Ed VonEuw on, August 20, 2008.

It is assumed that BC Hydro is the main power supplier to the water plants. From this assumption the energy ecological footprint conversion factor is 13.04 gha/GWh:

0.14 x 13.04 = 2.04 gha

The total ecological footprint for water is very small in comparison to the other components.

### 4.1.7 Calculating the Impact of Staff Travel

#### Automotive Vehicle

The assessment is done to quantify the environmental impact of staff traveling to and from work every day to the BBY campus and business travel by air. The ecological footprint methodology is used to calculate the impact of traveling by car and airplane. Other modes of transportation are not considered. The assumption made of the number of staff driving to work is based on the number of parking passes sold to staff, which equals the number of staff that work at the BBY campus. There are no other sources of information of staff travel mode.

The ecological footprint calculation accounts only for the impact of the fuel consumed for vehicles traveling to and from work.

Another assumption is each employee travels to work and home for 208 days per year. This is a conservative estimate based on average vacation days and sick days when employees would not come into work. BCIT's Human Resources Department provided the first three letters of the employees' home postal code. This allows a general neighbourhood location to be identified. The distance traveled for each employee is then estimated. It is assumed no car pooling occurs. It is also assumed that gasoline is the main fuel used for travel, and a mid-size vehicle would represent the average passenger vehicle for each employee. Below are vehicular emission rates for kilometres traveled.

**Table 7: Vehicle Emission Rates**

| Source | Vehicle Emission Rates ($tCO_2e/Km$) |
|---|---|
| Climate Care (US)[33] | 0.000145 |
| VCACarFuelData (UK)*[34] | 0.000183 |
| Barrett (2002)[35] | 0.00022 |
| Transport Canada (2006)[36] | 0.000171 |

*This represents the average of mid-size American vehicles such as Ford and GM for the year 2006.

The Canadian vehicle emission rate is derived by dividing Canada's average fuel consumption by Canadian fuel emissions for gasoline. Table 7 demonstrates the variability of vehicular emissions relative to country and/or organization calculating the conversion factor. Hence, it is important to try and ascertain data that is specific to the region. The sample calculation for staff travel is in Table 8.

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[33] http://www.jpmorganclimatecare.com/
[34] http://www.vcacarfueldata.org.uk/
[35] Barrett, J. et al, 2002, "A material flow analysis and Ecological footprint of York", SEI.
[36] http://www.tc.gc.ca/programs/environment/fcp/goals.htm, http://www.ec.gc.ca/pdb/ghg/inventory_report/2006_report/a12_eng.cfm#ta12_2

**Table 8: Staff Travel Ecological Footprint Calculation**

| Total Km Traveled x2 | Number of days traveled | Vehicle Emission Rate ($tCO_2e/km$) | Global Ecological Footprint Factor ($gha/tCO_2e$) | Total Ecological Footprint (gha) |
|---|---|---|---|---|
| 64,962 | 208 | 0.000171 | 0.28 | 646.99 |

### Air Travel

The final destinations for BCIT employee business air travel is recorded by travel agency HUME Travel. The distances can then be estimated based on departure and arrival locations provided by HUME. Once the distances are derived, the emission factor is multiplied to calculate the total $CO_2e$ emissions for each trip. Then the global ecological footprint factor is multiplied by the total emissions generated by each trip to provide the ecological footprint.

The aviation emission factors used are from DEFRA,[37] as the methodology included the radiative forcing index (RFI) and the uplift factor, as well as other detail differences related to length of flight, which the Canadian GHG Registry Guide did not include. The DEFRA methodology is supported by another-well known aviation calculator called "atmosfair[38]".

Depending on whether the flight is domestic, short haul, or long haul, the factor would change. See Table 9 below for a list of emission factors.

**Table 9: Aviation Emission Factors**

| Source | Emission Factor ($tCO_2e/Km$) |
|---|---|
| Canadian GHG Registry[39] | 0.000135 |
| DEFRA[40] | |
| Domestic | 0.000175 |
| Short haul | 0.000140 |
| Long haul | 0.000234 |

The results depend on the type of flight: domestic, short haul or long haul. Then the global ecological footprint factor is multiplied to determine the total ecological footprint, as shown in Table 10.

**Table 10: Aviation Ecological Footprint**

| Type of Flight | Total Emissions $tCO_2e$ | Global Ecological Footprint Factor | Total Ecological Footprint (gha) |
|---|---|---|---|
| Domestic | 1114.67 | 0.28 | 149.67 |
| Short Haul | 625.92 | 0.28 | 175.25 |
| Long Haul | 534.55 | 0.28 | 312.13 |
| **Total** | | | **637.06** |

[37] http://www.defra.gov.uk/environment/business/envrp/pdf/passenger-transport.pdf, viewed September 23, 2008.
[38] https://www.atmosfair.de, viewed September 23, 2008.
[39] http://www.ghgregistries.ca/assets/pdf/Challenge_Guide_E.pdf
[40] http://www.defra.gov.uk/environment/business/envrp/pdf/passenger-transport.pdf

### 4.1.8 Calculating the Impact of Student Travel

The student mode of travel to and from the BBY campus is extrapolated from a survey conducted in 2007.[41] The same survey booklet indicated the location from where students are traveling to get to the BBY campus. The population of students both full-time and part-time is confirmed by BCIT's Student Resources office to be 32,479 for the fiscal year 2006/2007of which 13,923 were full-time and 18,556 were part-time. For this analysis, the number of part-time students is halved to account for the reduced time these students would be going to the BBY campus.

Parking passes sold to students for the fiscal year were checked and reflected the survey estimation of the number of students driving to the BBY campus. The following table lists the factors and assumptions made to calculate the ecological footprint for students driving to and from the BBY campus.

**Table 11: Student Travel by Car Variables**

| Variable | Value Used | Notes |
|---|---|---|
| Population | 12,485 | Based on survey |
| Passenger Vehicle Emission Rate | 0.000171 $tCO_2e/km$ | Transport Canada, 2006 |
| Mode Share | 1 person per vehicle | No car pooling was assumed |
| Commuter Distance | 10.4 km – 36.51 km | This was the range of distances students were traveling during the fiscal year 2006/2007 |
| Number of Days Traveled | 145 | Based on Sessions 06/07 excluding holidays |
| Ecological Footprint Factor | 0.28 $gha/tCO_2e$ | GFN Canadian values, 2005 |

**Table 12: Ecological Footprint for Student Travel by Vehicle**

| Where students were traveling from | Ecological Footprint (gha) |
|---|---|
| Vancouver | 598.20 |
| Burnaby | 242.66 |
| Surrey | 772.92 |
| Richmond | 350.95 |
| Coquitlam | 289.31 |
| N. Vancouver | 196.56 |
| Delta | 164.01 |
| Port Coquitlam | 125.37 |
| Langley | 197.79 |
| Maple Ridge | 176.19 |

[41] BCIT, 2007, "2007 Full-Time Student Opinion Survey: Education and Training", Institutional Research and Planning.

Similar assumptions are made for students traveling by public transit. The table below lists the variables considered in the calculation of students taking the bus to the BBY campus.

**Table 13: Student Travel by Bus Variables**

| Variable | Value Used | Notes |
|---|---|---|
| Population | 8537 | Based on 2007 Survey |
| Diesel Bus Vehicular Emission Rate | 0.00181t$CO_2$e/veh-km | Transport Canada website[42] |
| Passenger Load | 40 per bus | Translink report[43] |
| Commuter Distances | 10.4 km – 36.51 km | This was the range of distances students were traveling during the fiscal year 2006/2007 |
| Number of Days Traveled | 145 | Based on Sessions 06/07 excluding holidays |
| Ecological Footprint Factor | 0.28 gha/t$CO_2$e | GFN Canadian values 2005 |

The resulting ecological footprint for students traveling to the BBY campus from their respective homes is listed in Table 14.

**Table 14: Ecological Footprint for Student Travel by Bus**

| Where students are traveling from | Ecological Footprint (ha) |
|---|---|
| Vancouver | 255.89 |
| Burnaby | 103.80 |
| Surrey | 330.63 |
| Richmond | 150.12 |
| Coquitlam | 123.76 |
| N. Vancouver | 84.08 |
| Delta | 70.16 |
| Port Coquitlam | 53.63 |
| Langley | 84.61 |
| Maple Ridge | 75.37 |

There are an estimated 92 students that bike to school. It is assumed that students bike on average 6.14 km based on the fact most cycling trips originated within the city of Burnaby. The ecological footprint per kilometre factor used to determine the bicycle footprint is 0.0000017 ha/km.[44] Hence, the total ecological footprint for students riding their bikes is 0.28 ha.

The environmental impact of walking to school is assumed to be negligible; hence, there is no ecological footprint calculated for the 2,111 students who walk to school.

[42] http://wwwapps.tc.gc.ca/prog/2/UTEC-CETU/Menu.aspx?lang=eng
[43] http://www.translink.bc.ca/files/polls_surveys/regtravel.pdf
[44] Barrett J. et al, 2002, “A material flow analysis and Ecological footprint of “York”, SEI.

#### 4.1.9 Calculating the Impact of Consumables

The method for calculating the ecological footprint of consumables is done differently from all other components. Actual mass values are not available but total dollars spent on consumable items are available. The consumables are defined as items purchased by BCIT employees. Fifteen categories are created based on the 2002 North American Industry Classification System (NAICS). The economic input-output life cycle data came from Carnegie Mellon,[45] which uses NAICS codes in organizing its output files. When the data was extracted from Carnegie Mellon's tool, the website reported values from 2008.[46] The BCIT expenditure values are not adjusted for 2008.

The following table demonstrates the variables involved using the life cycle economic input-output values for telecommunication equipment.

**Table 15: Telecommunications Equipment, NAICS 344210**

| Variable | Value Used | Notes |
|---|---|---|
| Telecommunications Equipment | EIO:334A | EIO refers Carnegie Mellon's shortened labelling of industry sectors |
| Total Economic Activity for Sector per million | $3,220,000 | This is the economic factor in millions for total $tCO_2e$ generated per year of all activities linked to sector |
| Direct Economic Impact | $1,860,000 | Direct economic factor of sector |
| Direct Economic Impact | 57.8% | Percentage of direct economic impact from total economic activity |
| Total GWP Impact | 1.41 $KMtCO_2e$ | Global warming potential (GWP) |
| BCIT Expenditure for Sector for fiscal year | $1,013,587 | |
| Global Ecological Footprint Factor | 0.28 $gha/tCO_2e$ | GFN Canadian 2005 tables |
| **Total Ecological Footprint for Sector** | **124.35 gha** | |

The summary of each category is listed below. There are 9,116 line items sorted into 15 categories. The process of organizing the data into NAICS categories took the most amount of time, as it is a manual process.

**Table 16: Ecological Footprint for Consumables**

| Description | Ecological Footprint (gha) |
|---|---|
| Computer and computer peripheral equipment | 34.53 |

[45] http://www.eiolca.net/, viewed October 1, 2008.
[46] This data is no longer available; only 2002 data is available now

| Description | Ecological Footprint (gha) |
|---|---|
| Leased computers | 0.36 |
| Telecommunications equipment | 124.35 |
| Repair construction | 114.28 |
| Motor vehicle parts manufacturing | 55.01 |
| Electrical equipment, appliance and component manufacturing | 140.14 |
| Furniture | 152.59 |
| Fabricated metal product manufacturing | 610.16 |
| Primary metal | 115.99 |
| Wood products | 1284.58 |
| Radio and television broadcasting | 70.54 |
| Converted paper products manufacturing | 132.46 |
| Chemical manufacturing | 73.36 |
| Clothing manufacturing | 8.25 |
| Pharmaceutical and medicine manufacturing | 5.34 |
| Petrochemical fuels | 36.95 |

### 4.1.10 Calculating Built Area

For this assessment, the built form consists of buildings and parking lot spaces. The buildings are further classified into classrooms, offices, lodgings, and office/educational use. The areas for buildings and parking lots are provided by BCIT's campus planning. For each type of built form, an infrastructure yield factor[47] of 1.14 is multiplied to the total area. Then the crop equivalence factor of 2.64 is multiplied to the total. The example below demonstrates the ecological footprint calculation for the total classroom area of 9.19 ha.

Ecological Footprint (classrooms) = 9.19 x 1.14 x 2.64 = 27.65 gha

The table below summarize the ecological footprint for each type of built form.

**Table 17: Ecological Footprint of the Built Form**

| Type of Built Form | Ecological Footprint (gha) |
|---|---|
| Classrooms | 27.66 |
| Lodging | 2.57 |
| Offices | 9.90 |
| Off/Edu. | 11.16 |
| Parking lot space | 44.57 |

[47] The infrastructure yield factor was provided by GFN for Canada.

The total green space, or vegetated area, is considered to not have an environmental impact. For future analysis, the biocapacity of the green space can be calculated to counter the ecological footprint of the built form. For now the total green space area for the BBY campus is 30.6 ha.

#### 4.1.11 Calculating the Impact of BBY Solid Waste Removal

The environmental impact of solid waste comes from the actual space that waste takes up in a landfill and the decomposition process. Since BCIT exported its solid waste to a Metro Vancouver landfill, this waste then became an issue for Metro Vancouver. For this assessment the boundaries are set to account for all incoming mass products, emissions generated on site, and products leaving the campus such as waste and sewage. However, the treatment of waste and sewage are considered to be outside the boundary of this study. That is why the ecological footprint for this study only accounted for the delivery of solid waste to the landfill.

The table below lists the variables considered to calculate the ecological footprint for delivering the amount of waste generated in one year to the BBY campus.

**Table 18: Ecological Footprint of Waste Transported to Landfill**

| Variables | Values Used | Notes |
|---|---|---|
| Total Waste | 192.68t | From BCIT's Facilities |
| Heavy Duty Vehicle Emission Rate | 0.00018t$CO_2$e/Km | Transport Canada |
| Distance to Closest Landfill in Metro Vancouver | 27.40 Km | Available from Metro Vancouver website |
| Global Ecological Footprint Factor | 0.28 gha/t$CO_2$e | GFN Canadian 2005 tables |
| **Total Ecological Footprint** | **0.34 ha** | |

For future assessments, the ecological footprint can be calculated for the recycled materials and compost that is generated on site. The compost generated on site is used on the surrounding vegetated landscape; hence, the compost doesn't leave the campus.

# 5 Interpretation of Results

1. State assumptions
2. List completeness check
3. Draw conclusions and recommendations

## 5.1 The Total Ecological Footprint for BCIT's BBY

The total ecological footprint for the BBY campus in the fiscal year 2006/2007 is 16,590 hectares.

**Table 19: Summary of Totals of All Components**

| Component | Total EF (ha) | Percentage |
|---|---|---|
| Food & Drink | 4654.41 | 28.06% |
| Energy | 3001.55 | 18.09% |
| Consumables | 2958.38 | 17.83% |
| Staff Travel | 1284.07 | 7.74% |
| Student Travel | 4446.27 | 26.80% |
| Built Form | 95.87 | 0.58% |
| Waste to Landfill | 0.33 | 0.00% |
| Water | 2.04 | 0.01% |
| Food Packaging | 147.20 | 0.89% |

Ecological footprint per capita (staff and students) is 0.49 ha/capita.

**Assumptions:** Total full-time staff and students and part-time students is 34,119, of which 1,640 are staff, 13,923 are full-time students, and 18,556 are part-time students

### Food & Drink

The total Food & Drink ecological footprint is somewhat larger than the energy footprint. As shown below, the Drink portion represents the largest contributor to the Food & Drink component.

**Assumption:** Only the energy to create the product is considered; transport of goods to the end user and associated labour is not included in the calculation.

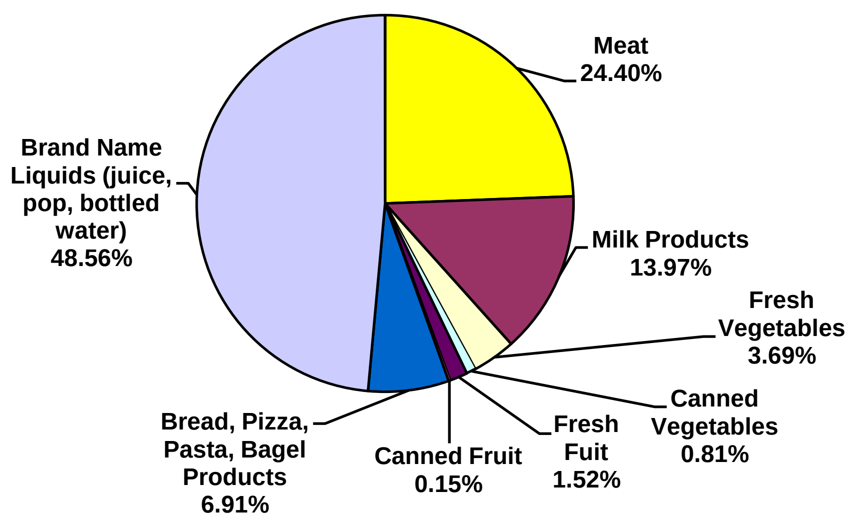


**Figure 4: Food & Drink Footprint**

*Sources: 1) Barrett J., Vallack, H., Jones, A., and Haq, G., 2002, A Material Flow Analysis and Ecological Footprint of York, Stockholm Environment Institute*
*2) Energy Analysis Program, Centre for Energy and Environmental Studies, University of Groningen, the Netherlands*

3) *U.S. LCI Database Project - [www.nrel.gov/lci](www.nrel.gov/lci)*
4) *Global Footprint Network Canadian National Accounts 2005*

**The Direct Energy**

The total footprint of the Energy component is 3,001 hectares. One third of the city of Burnaby would have to be covered in trees to sequester the emissions generated from the BBY campus. Natural gas makes up 86% of the total footprint, even though the amount of energy consumed by natural gas is on par with the amount of electricity consumed.

**Assumption:** Raw materials or extraction of resources are not included in calculation; only the energy for delivery and use of the resource is considered.

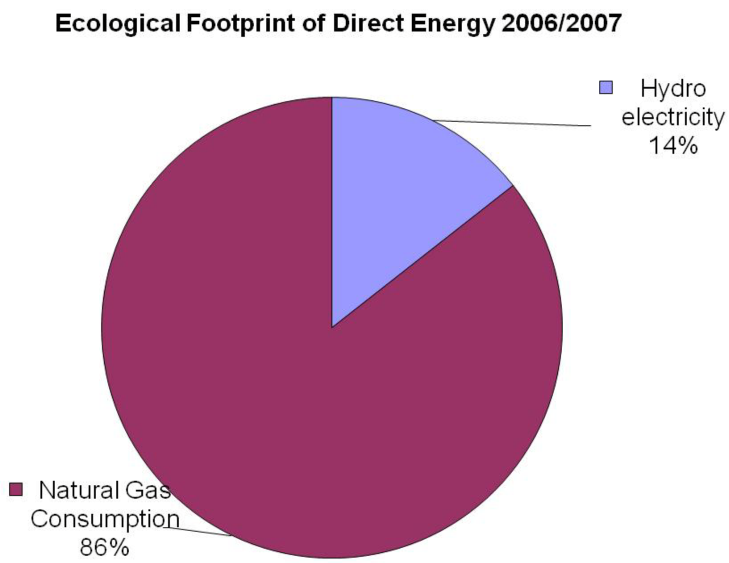


**Figure 5: Direct Energy Footprint**

*Sources: 1) NRCAN energy conversion was used[48].*
*2) Interpolated BC Hydro energy conversion was used[49]*

**Consumables**

The ecological footprint for the Consumables component is calculated using the economic input-output method, since the only available data is in monetary value. The consumables are organized into 15 categories as described by the North American Industry Classification System (NAICS). The largest contributor to the Consumables

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[48] Source: http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/ta9_11_eng.cfm, viewed March 2008.
[49] BC Hydro Greenhouse Gas Report, March 2005: http://www.bchydro.com/about/our_commitment/sustainability/greenhouse_gases.html. Viewed March 2008.

footprint is wood products. And wood is the item purchased the most at BCIT compared to any other item.

**Assumptions:** The calculation does not account for the impact of transportation of goods between sectors and the associated labour. As well, the use phase and end-of-life phases are not directly included in the results.

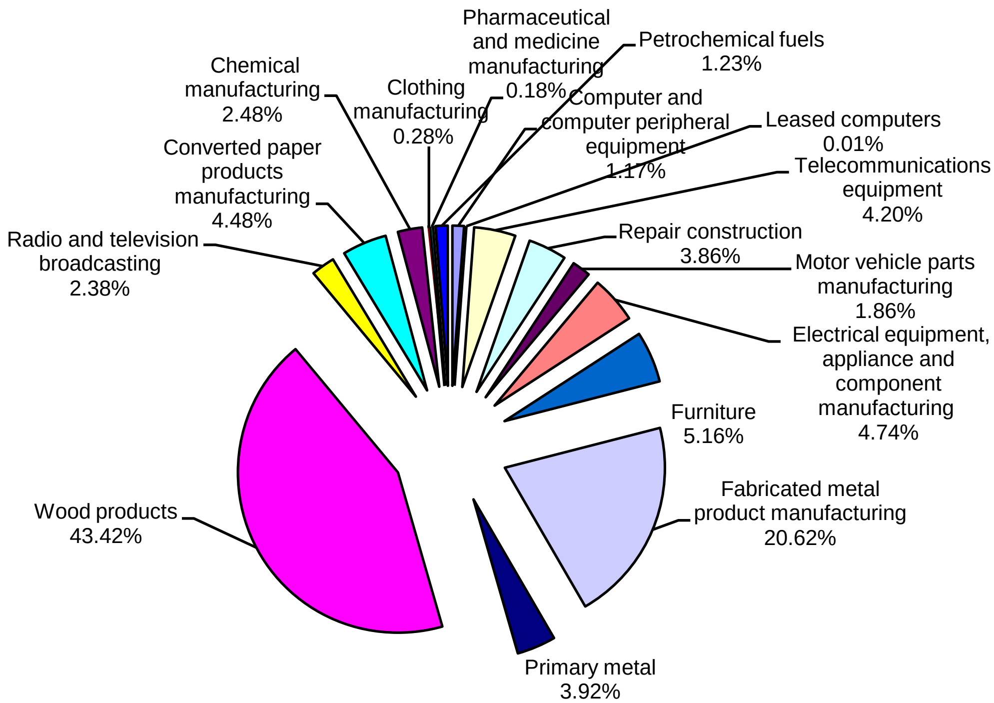


**Figure 6: Consumables Footprint**

*Sources: 1) http://www.eiolca.net/ – The Canadian 2008 stats were used.*
*2) http://www.statcan.ca/english/Subjects/Standard/naics/2002/naics02-menu.htm*

## Staff Travel

The ecological footprint for Staff Travel consisted of travel to and from work during the school year and business air travel. The impact of staff driving to work is estimated to be almost equal to the air travel of staff.

**Assumptions:** The vehicle wear and tear is not included in this calculation, nor is the energy and labour for maintenance of the roadway. Only the fuel usage of vehicles to and from the BBY campus and staff homes is considered. No car pooling is considered. The number of parking passes sold to staff is considered the number of staff that would drive to work regularly. The air travel considered the maintenance of the airplane and fuel usage from take-off to landing. Energy for the manufacturing of the airplane is not considered, nor is the decommissioning of the airplane. Other modes of travel are not considered as the data was not available at the time of this study.

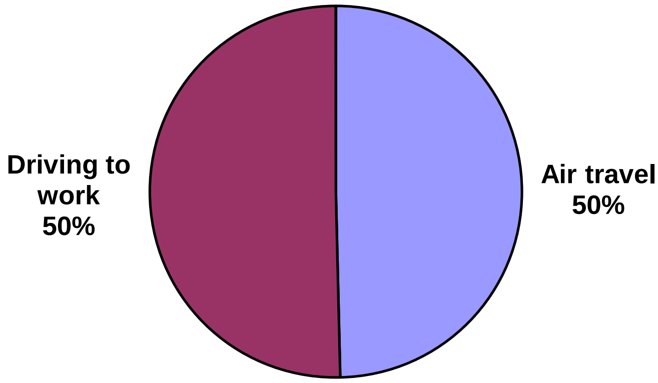


**Figure 7: Staff Travel Footprint**

*Source: 1) http://www.ghgregistries.ca/assets/pdf/Challenge_Guide_E.pdf*
*2) http://www.vcacarfueldata.org.uk//*
*3) www.atmosfair.de*
*4) http://www.defra.gov.uk/environment/climatechange/index.htm*

### Student Travel

Student Travel is the largest footprint, slightly bigger than the Food & Drink footprint. A 2007 survey is conducted on student mode of travel, with a sample size of 1,090. As with Staff Travel, most students are driving to the BBY campus, which is the mode of transportation that has the biggest impact.

**Assumptions:** Part-time students are considered to drive half the amount of full-time registered students. The vehicle wear and tear is not included in this calculation. The energy and labour for maintenance of the roadway is also not considered, just the fuel usage of vehicles to and from the BBY campus and student homes. No car pooling is considered. The number of parking passes sold to students is considered the number that would drive to work regularly.

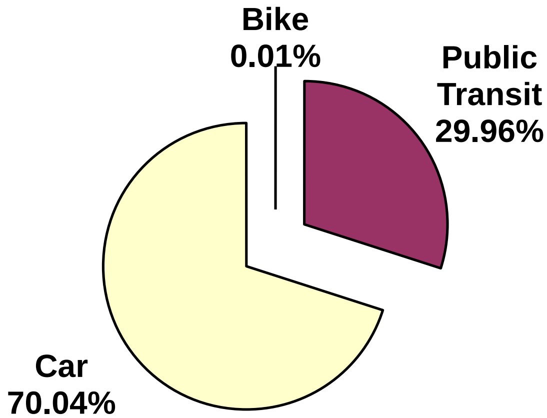


**Figure 8: Student Travel Footprint**

*Source: 1) http://www.ec.gc.ca/pdb/ghg/inventory_report/2006_report/a12_eng.cfm#a12_1_4*
*2) http://wwwapps.tc.gc.ca/prog/2/UTEC-CETU/Menu.aspx?lang=eng*
*3) http://www.vcacarfueldata.org.uk//*

**Built Area, Waste to Landfill, Water and Food Packaging**

Water and Food Packaging components are fairly small impacts compared to the other components. However, they are also "low hanging fruit" or achievable actions with high profile potential. The Built Form and Waste to Landfill would represent larger footprints if a full analysis is completed for each component.

### 5.1.1 Comparative Analysis of EF in Global Hectares with Other Schools

In the literature review for this project, one objective was to find other post-secondary schools that had done an ecological footprint. The findings are summarized in the tables below, which now includes the BBY campus. Table 20 compares the total ecological footprints of the University/Colleges along with the year the study was conducted, the number of staff and students, and the campus area. Table 21 compares the different components each study considered for assessing their overall ecological footprint.

**Table 20: Comparison of Other Post-Secondary Schools' Footprints**

| University/College | Year EF Calculated | Total EF (ha) | No. of Staff | No. of Student | Campus area (ha) | EF/Staff | EF/student |
|---|---|---|---|---|---|---|---|
| Newcastle, Australia | 2001 | 3211 | 2200 | 17000 | 135 | 1.46 | 0.19 |
| Redlands, CA, USA | 2001 | 2375 | 2727 | No data | 133.5 | 0.87 | Unknown |
| University Swansea, Wales | 2002 | 10004 | 2316 | 10314 | 19.66 | 4.32 | 0.97 |
| East Anglia, UK | 2002 | 2499 | 2500 | 13000 | 41.4 | 1 | 0.19 |
| Holme Lacy College, UK | 2001 | 296 | 64 | 460 | 240 | 4.63 | 0.64 |
| Oxford Brookes, UK | 2000 | No data | No data | No data | No data | No data | 0.22 |
| Middlebury College, US | 2005 | 23188 | No data | 5700 | | | 2.97 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dartmouth College, US | 2005 | 17080 | 200 | 2350 | | 7.27 | |
| **BCIT BBY Campus, CA** | **2006/2007** | **16590** | **1640** | **32479** | **52.6** | **7.4*** | **0.65**** |

*This is the ratio of the total EF minus the student travel EF divided by the staff population.
** This is the ratio of the total EF minus the staff travel EF divided by the student FTE and PTE.

**Table 21: Comparison of Components Assessed in Ecological Footprint**

| University/College | Year EF Calculated | Capital Items | Energy for transport | Energy for building | Food | Water | Waste | Toxic waste |
|---|---|---|---|---|---|---|---|---|
| Newcastle, Australia | 2001 | no | yes | yes | yes | yes | yes | Unclear |
| Redlands, CA, USA | 2001 | no | yes | yes | no | yes | yes | No |
| University Swansea, Wales | 2002 | no | yes | yes | yes | yes | Yes, paper only | no |
| East Anglia, UK | 2002 | | | | | | | |
| Holme Lacy College, UK | 2001 | no | yes | yes | yes | yes | yes | no |
| Oxford Brookes, UK | 2000 | | | | | | | |
| Middlebury College, US | 2005 | no | yes | yes | no | no | no | no |
| Dartmouth College, US | 2005 | no | yes | yes | no | no | no | no |
| **BCIT BBY, CA** | **2006/2007** | **Partial** | **Yes** | **Yes** | **Yes** | **Yes** | **Partial** | **no** |

## 5.2 The Total Carbon Footprint

The total carbon footprint for the BBY campus is 15,190 $tCO_2e$. The pie chart below demonstrates the carbon footprint for each component that was evaluated.

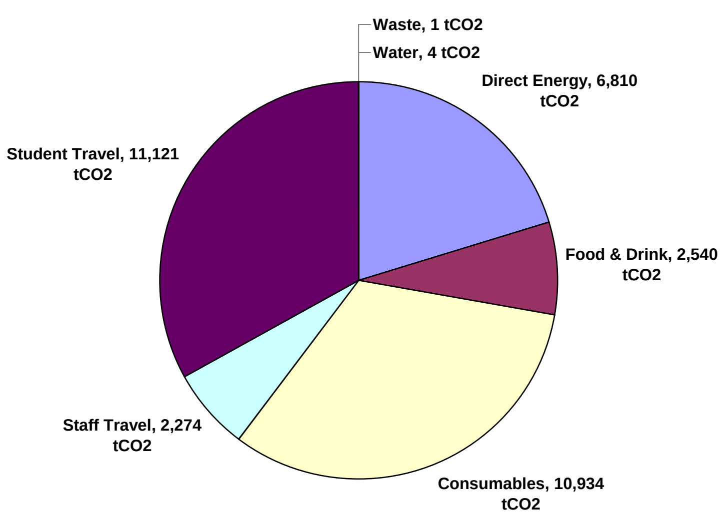


**Figure 9: BCIT's BBY Carbon Footprint 2006/2007**

### 5.2.1 Provincial Carbon Cost

The Province of BC has three scopes or levels for assessing greenhouse gas emissions to calculate the carbon tax. The first level or scope requires BCIT and all other public institutes to report on direct energy consumption, paper use, and fleet fuel. The hatched areas of following pie chart illustrate the amount of $CO_2$e emissions required to be reported for the first scope or level. The hatched areas amount to less than half of the total contributing $CO_2$e emissions.

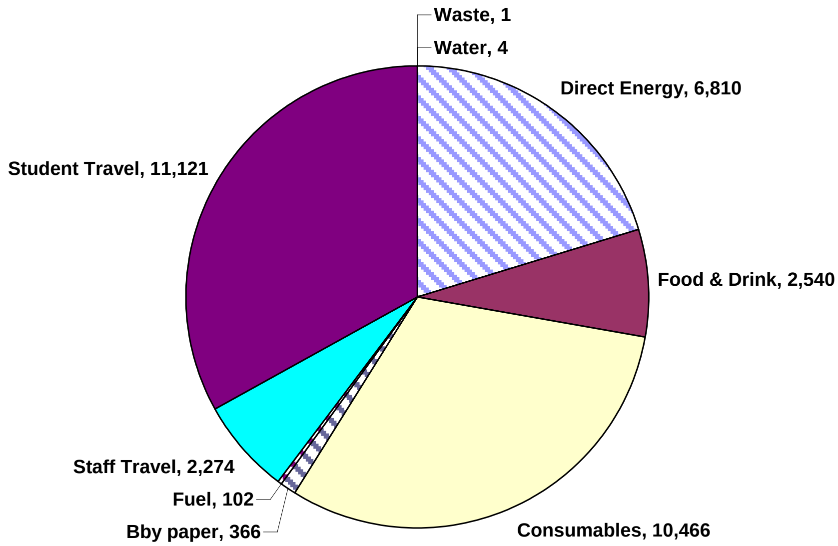


**Figure 10: BC Government's First Scope, GHG Emissions**

# 6 Recommendations

*"A case in point are universities[/colleges]…have a particular responsibility in being role models for best environmental practice due to their significant influence on societal development."*[50]

Ecological footprint studies, or environmental assessment studies, on universities/colleges demonstrate the need for integrating environmental/sustainability management systems into these institutions to effectively and efficiently monitor their impacts on the environment[51]. BCIT's first EFA demonstrated the need for centralizing this type of environmental information and making this data accessible to many different users. For BCIT to make sustainability part of its values, sustainability must be integrated into BCIT's operations and educational mandate.

[50] Wood R., Lenzen M.,2003,"An Application of a Modified Ecological Footprint Method and Structural Path Analysis in a Comparative Institutional Study", Carfax Publishing, Local Environment, Vol 8, No.4, 365-386.
[51] Ibid.

## 6.1 Future Research

- Redo the ecological footprint using the economic input-output method for all the components and compare the results with the first assessment.
- Associate full cost accounting to the ecological footprint calculation assessment.
- Use LCA results of the built form and redo the ecological footprint with new data.
- Integrate all other impacts from the LCA results in the next assessment.
- Account for the impacts of stormwater runoff within the footprint methodology or as another indicator. For example, quantifying the impacts to local watersheds
- Account for waste going to the landfill and its full environmental impacts.
- Use this assessment as a framework to guide the process of implementing an environmental management system which could effectively automate the data collection, analysis, and reporting in an organization.
- In the next assessment, include the biocapacity of BCIT.
- Create a personal footprint calculator or perform surveys to determine staff and student habits related to traveling, food choices, and length of stay at BCIT.

### 6.1.1 Lessons Learned

**Collection of Data**

- Initial meetings need to clearly demonstrate the concepts and the plan for the project.
- Subsequent meetings with groups should outline action to collect and deliver data with set dates
- Create a system to allow for central collection location and accessibility

**Analysis of Data**

- Purchase up-to-date LCA software package at the beginning of assessment.

**Interpretation of Results**

- Demonstrate how results relate to the individual.

### 6.1.2 Future Data Tracking

The chemical compounds of air emissions released on the BBY campus should be monitored and then converted into carbon dioxide equivalents ($CO_2e$) using global warming potentials (GWP). For example, boilers on campus using natural gas not only release $CO_2$ but the combustion process also releases methane $CH_4$ and nitrous oxide $N_2O$.

### 6.1.3 Other Sustainability Indicators

Another indicator, in addition to the ecological footprint and GHG emissions, is energy intensity which is used as a common value to compare building performances across different sectors. See example below:

Average British Columbia College, University Energy Intensity[52]:

1.31 GJ/m^2 – 1.56 GJ/m^2

Burnaby Campus Energy Intensity for 2006/2007:

1.40 GJ/m^2

Non-renewable resources, total mass, total energy, and total solid waste going to the landfill are other indicators that can be easily attained as these values are recorded in the process of collecting data for the ecological footprint.

# 7 Critical Review

The peer reviewer will focus on the following areas of the assessment:

- Scope/boundaries methodology
- Data acquisition/compilation
- Validity of key assumptions and results
- Communication of results

Below is an example of a peer review for this study.

**Peer Review: Creating a Sustainability Assessment: Principles and Practice**
**Jennie Moore**
**December 7, 2009**

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**Introduction**
This report demonstrates an important contribution to the body of literature that documents ecological footprint assessments of educational institutions. In using the compound method for ecological footprint assessment, it provides a reasonably comparable analysis to other institutions that have used a similar approach. This study is the first of its kind completed for a North American academic institution.

**Scope and Methodology**
The scope of this research is comprehensive and lacks only in the inclusion of waste to landfill in the ecological footprint assessment for BCIT's Burnaby Campus. This should be included in the next assessment, as noted in section 6.1 Future Research. An attempt to integrate The Natural Step with Ecological Footprint Assessment to build a sustainability management framework demonstrates a useful approach to using multiple tools to aid in an organizations efforts to: a) become sustainable, and b) track progress towards ecological sustainability. An effort to quantify the participation on campus by

[52] Natural Resources Canada, 2007, "Commercial and Institutional Consumption of Energy Survey: Summary report – June 2007", NRCAN Office of Energy Efficiency, p. 12.

faculty and students in part-time studies activities as distinct from full-time studies should be pursued in future research in an effort to communicate both the total and weighted per-capita ecological footprint of the BCIT community, relative to their consumption activities on campus.

The methodology makes appropriate use of the compound ecological footprint assessment method that includes material flow analysis, lifecycle assessment, and input-output analysis. A suggestion for future research is to compare the ecological footprint assessment methodology used in this study to the greenhouse gas emissions reporting protocols introduced by the Province of British Columbia (BC). An objective is to use the ecological footprint assessments to simultaneously gather the data needed to complete the greenhouse gas emission inventory. Analysis of how the ecological footprint performs in this task and recommendations for adaptation would be a positive step towards improving the methodology for use by BCIT and to gain associate cost-savings through improved efficiency and effectiveness. This could also serve other public sector organizations in BC who may wish to pursue an ecological footprint assessment.

**Data Acquisition and Compilation**

This study attempts to use local data to the extent it was available. Data gaps were filled by relying on data from previous studies and data bases that rely on U.K. and U.S.A. data. Future research could initiate more in-depth studies for the various components in the ecological footprint, especially for food and consumables using BC statistics or an attempt to quantify the embodied energy and materials of these products first-hand using the "inter-regional" ecology approach cited in this study. Engaging students and/or faculty through student projects and applied research activities may enable collection of local data for energy and materials embodied in the products consumed on-campus. Compiling the data in a centralized data-base and developing protocols for the automatic collection of the data that is required for the ecological footprint assessment also represents an important step towards cost-effective completion of an ecological footprint assessment on an annual basis. This approach is noted in section 6.1 Future Research. Implementation of such an initiative could be aided by tying the ecological footprint assessment to the greenhouse gas emission inventory reporting process recently introduced by the Province of BC.

**Validity of Key Assumptions and Results**

I have no concerns with the validity of the report findings. Key assumptions are rationale and aside from the delimitation of solid waste in landfill, I believe this study makes sound use of the methodology prescribed by Barrette et al. 2002 for compilation of an ecological footprint using the component method. This report was conducted using existing data sources and advice from the Global Footprint Network who also reviewed a draft copy of this report and commented on key assumptions and results. This is an excellent approach to verification of key assumptions and results.

**Communication of Results**

Findings from this study have been effectively communicated to BCIT senior management through the BCIT Environmental Stewardship and Sustainability Practices Committee. Findings have also been communicated to those faculty and staff that participated in the study through the data collection process and to the BCIT community generally through a presentation at the BCIT Professional Development Day. A summary of key findings is also posted on the BCIT web site at: www.bcit.ca/sustainability.

This report that documents the methodology of the study will be used both as an aid to teaching the ecological footprint assessment methods as well as to further communicate with the BCIT community and those interested from outside the community.
A summary of this report is also being presented at the 2009 Ecocity conference in Istanbul, Turkey, to an international audience of ecocity practitioners comprising non-government organizations, community grass-roots associations, urban development consultants, municipal staff and public elected officials from cities around the world.
A copy of this report will also be forwarded to the Association for the Advancement of Sustainability in Higher Education for inclusion in their web-based tools and resources.

# Appendix I: Acronyms, Abbreviations & Definitions

## Acronyms and Abbreviations

| | |
|---|---|
| BCIT | British Columbia Institute of Technology |
| CFC | Chlorofluorocarbon |
| $CO_2e$ | Carbon dioxide equivalent |
| EF | Ecological Footprint |
| EIO | Economic input-output |
| ha | hectare |
| gha | global hectare |
| GFN | Global Footprint Network |
| GHG | greenhouse gas |
| GWP | global warming potential |
| HDPE | High density polyethylene |
| LCA | Life Cycle Assessment |
| LDPE | Low density polyethylene |
| MFA | Mass Flow Analysis |
| MJ | mega joule |
| NAICS | North American Industry Classification System |
| t | tonne |

## Definitions

| | |
|---|---|
| **Economic input-output (EIO) models** | Represent the monetary transactions between industry sectors in mathematical form. EIO models indicate what goods or services (or output of an industry) are consumed by other industries (or used as input). As an example, consider the industry sector that produces automobiles. Input to the automobile manufacturing industry sector includes the output from the industry sectors that produce sheet metal, plate glass windshields, tires, carpeting, as well as computers (for designing the cars), electricity (to operate the facilities), etc. In turn, the sheet metal, plate glass windshield tire, etc. industry sectors require inputs for their operations that are outputs of other sectors, and so on. Each of these requirements for goods or services between industry sectors is identified in an EIO model. |

| | |
|---|---|
| **Global hectare** | Global hectare is the unit of area that encompasses the impacts of ecosystems all over the world as opposed to hectares which is simply the measure of area. |
| **Life Cycle Assessment (LCA)** | Ways to investigate, estimate, and evaluate the environmental burdens caused by a material, product, process, or service throughout its life span. Environmental burdens include the materials and energy resources required to create the product, as well as the wastes and emissions generated during the process. By examining the entire life cycle, one gets a more complete picture of the environmental impact created and the trade-offs in impact from one period of the life cycle to another. Results of LCAs can be useful for identifying areas with high environmental impact, and for evaluating and improving product designs. |
| **Bio-productivity** | And bio-assimilation is the Capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies. The bio-capacity of an area is calculated by multiplying the actual physical area by the yield factor and the appropriate equivalence factor. Bio-capacity is expressed in units of global hectares |

# Appendix 2: Categories of Consumption Components

| Components | Material/Product | Unit | Date Delivered |
|---|---|---|---|
| Direct Energy | Electricity (each building) | GWh | 01/11/2007 |
| | Gas (each building) | GWh | 01/11/2007 |
| | Solar (each building) | GWh | |
| | Hidden flows (mine dumping and back filling) | GWh | Global Network |
| Water | Water Usage | L | 01/11/2007 |
| | Rainfall | L | Environment Canada |
| Food Packaging | Liquid, bread, and other | Tonnes | 26/06/2008 |
| Food | Liquid (Juice, pop, products containing milk) | L | 13/05/2008 |
| | Bread | Tonnes | 13/05/2008 |
| | Other (prepared foods, chips..) | Tonnes | 13/05/2008 |
| Office Supplies | Consumables (paper ) | $ | 06/06/2008 |
| | Electrical ( computers, AV equipment, batteries) | $ | John Doe's group |
| | Office Furniture (tables, desks, chairs, shelves..) | $ | John Doe's group |
| Hazardous Materials | Grounds keeping (pesticides, fertilizers | tonnes | 50% |
| | | | 29/11/2007 |
| | Student/Research labs | Tonnes | 50% |
| | | | 29/11/2007 |
| Travel | BCIT owned vehicles (number, kilometres) | #, km | 16/06/2008 |
| | Gasoline, diesel, natural gas ( motor vehicle fuels) | Tonnes | John Doe's group |
| | Maintenance & manufacturing | Tonnes | 26/06/2008 |
| | Road space | Tonnes | 28/02/2008 |
| Travel of staff | By Car | Parking pass | Bob's group, |
| | | Postal Code | 02/07/2008 |
| | By Air | Passenger-Km | Finance |
| Travel of student | By Car | Passenger-Km | 25/02/2008 |
| | By Bus | Passenger-Km | |
| | By Skytrain | Passenger-Km | |

| Components | Material/Product | Unit | Date Delivered |
|---|---|---|---|
| | Walking | Passenger-Km | |
| | Carpool/vanpool | Passenger-Km | |
| | Student home | Postal Codes | Human resources |
| Built Land | Burnaby lot size Campus (Excluding green space) | $m^2$ | 28/02/2008 |
| Green Space | Vegetated areas ( Does not include planters) | $m^2$ | 28/02/2008 |
| Student Material | Timber Wood | t | John Doe's group |
| | PVC-pipes | t | John Doe's group |
| | Chemicals | t | John Doe's group |
| | Sheet metals | t | John Doe's group |
| | Metals | t | John Doe's group |
| Freight Transport of Goods | Food | t-Km | 26/06/2008 |
| | Direct consumables (Chemicals, office supplies) | t-Km | John Doe's group |
| | Electrical equipment | t-Km | John Doe's group |
| | Waste transportation | t-Km | Facility's |

| Component OUT | Material/Product | Unit | Date Provided |
|---|---|---|---|
| Waste | Landfill | t | Facility's |
| Recycling | Paper, Card | t | Facility's |
| | Metals | t | Facility's |
| | Compost | t | Facility's |
| Atmospheric Pollutants GHG | CO2, CFC, HFC, CH4 | Parts per billion | 80% |
| | | | 01/11/2007 |
| Common Air Contaminants | PM2.5, PM10, O3, NOX, SOX, CO, VOC, NH3 | g/km, Parts per billion | 80% |
| | | | 01/11/2007 |

# Appendix 3: Sample Timeline

| ID | | Task Name | Duration | Start | Finish | Predecessors | Resource Names |
|---|---|---|---|---|---|---|---|
| 1 | ✓ | **Strategy to ID data gaps & resource requirments** | **2.19 days** | **Wed 28-11-07** | **Wed 05-12-07** | | **Kerly Acosta** |
| 2 | ✓ | ID Challenges pertaining storage and acces of data | 0.88 days | Wed 28-11-07 | Mon 03-12-07 | | Kerly Acosta |
| 3 | ✓ | Research options | 1.5 days | Wed 28-11-07 | Mon 03-12-07 | | Kerly Acosta |
| 4 | ✓ | Present strategy to committee | 1.5 days | Mon 03-12-07 | Wed 05-12-07 | | Kerly Acosta[50%],Jennie Moore[25%],Marvin F |
| 5 | ✓ | **Develop Communication & engagement strategy** | **1.13 days** | **Wed 05-12-07** | **Wed 12-12-07** | **1** | **Kerly Acosta[80%],Jennie Moore[6%]** |
| 6 | ✓ | Create presentation | 1 day | Wed 05-12-07 | Wed 12-12-07 | | Kerly Acosta |
| 7 | ✓ | Research individual EF calcs for educational tool | 1.13 days | Wed 05-12-07 | Wed 12-12-07 | | Kerly Acosta |
| 8 | ✓ | **Develop work program for implementing approved strategies** | **4 days** | **Mon 17-12-07** | **Mon 14-01-08** | **1** | |
| 9 | ✓ | Present Work Program and communication strategy to steeri | 4 days | Mon 17-12-07 | Mon 14-01-08 | | Kerly Acosta[50%],Jennie Moore[25%],Marvin F |
| 10 | | Coordinate implementation of project under leadership of Steering | 57.75 days | Mon 14-01-08 | Thu 18-09-08 | 8 | Kerly Acosta[37%],Jennie Moore[6%] |
| 11 | | **Resources required for Extraction of data** | **35.95 days?** | **Mon 28-01-08** | **Mon 30-06-08** | | |
| 12 | | Direct Energy and Fresh water resource extraction | 0.2 days | Mon 30-06-08 | Mon 30-06-08 | | Marvin Rogers |
| 13 | | Food Component | 4 days | Mon 28-01-08 | Mon 11-02-08 | | Compass - Chartwell[50%] |
| 14 | | Waste to landfill, Recycled waste | 1.5 days? | Mon 28-01-08 | Wed 30-01-08 | | Kerly Acosta[20%],Cindy Macintosh[80%] |
| 15 | | Student Material, building material, Office supplies consumab | 3 days? | Mon 28-01-08 | Wed 06-02-08 | | Cognos operator[60%],Kerly Acosta[40%] |
| 16 | | Hazardous Chemical compounds | 7.5 days? | Mon 28-01-08 | Wed 05-03-08 | | Kerly Acosta[80%],Interview different reporting |
| 17 | | Travel | 30 days | Mon 04-02-08 | Mon 09-06-08 | | Kerly Acosta[20%],Glen Magel/ Safety & Securi |
| 18 | | GHG & Air Contaminant | 5 days | Mon 28-01-08 | Mon 18-02-08 | | Kerly Acosta[60%],Glen Magel/ Safety & Securi |
| 19 | | Habitat and built environment | 2 days? | Mon 28-01-08 | Mon 04-02-08 | | John Wong[50%],Kerly Acosta[50%] |
| 20 | | Population Data | 4.69 days? | Mon 28-01-08 | Wed 13-02-08 | | Mario Mazzolti[30%],Kerly Acosta[10%],Marnie |
| 21 | | Use Global Network method | 3 days | Mon 28-01-08 | Wed 06-02-08 | | Kerly Acosta |
| 22 | | **Develop actual tool to calculate EF** | **65 days** | **Wed 05-12-07** | **Wed 24-09-08** | **5SS** | |
| 23 | | First Energy component | 16 days | Wed 05-12-07 | Wed 27-02-08 | | Kerly Acosta |
| 24 | | Food Component | 8 days | Wed 27-02-08 | Wed 02-04-08 | 23 | Kerly Acosta |
| 25 | | GHG & Air Contaminants component | 3 days | Wed 02-04-08 | Wed 16-04-08 | 24 | Kerly Acosta |
| 26 | | Travel | 3 days | Wed 16-04-08 | Mon 28-04-08 | 25 | Kerly Acosta |
| 27 | | Waste to landfill | 3 days | Mon 28-04-08 | Mon 12-05-08 | 26 | Kerly Acosta |
| 28 | | Recycled waste | 3 days | Mon 12-05-08 | Mon 26-05-08 | 27 | Kerly Acosta |
| 29 | | Hazardous Chemical Compounds | 3 days | Mon 26-05-08 | Wed 04-06-08 | 28 | Kerly Acosta |
| 30 | | Student Material | 3 days | Wed 04-06-08 | Wed 18-06-08 | 29 | Kerly Acosta |
| 31 | | Office Supplies | 3 days | Wed 18-06-08 | Wed 02-07-08 | 30 | Kerly Acosta |
| 32 | | Building Material | 3 days | Wed 02-07-08 | Mon 14-07-08 | 31 | Kerly Acosta |
| 33 | | Freight Transport of Goods | 3 days | Mon 14-07-08 | Mon 28-07-08 | 32 | Kerly Acosta |
| 34 | | Water Waste | 3 days | Mon 28-07-08 | Mon 11-08-08 | 33 | Kerly Acosta |
| 35 | | Fresh Water | 3 days | Mon 11-08-08 | Wed 20-08-08 | 34 | Kerly Acosta |
| 36 | | habitat | 8 days | Mon 25-08-08 | Wed 24-09-08 | 35 | Kerly Acosta |
| 37 | | **Indicators** | **16 days** | **Wed 24-09-08** | **Wed 03-12-08** | **22** | |
| 38 | | EF | 3 days | Wed 24-09-08 | Wed 08-10-08 | | |
| 39 | | Total Material Requirement | 3 days | Wed 24-09-08 | Wed 08-10-08 | | |
| 40 | | Resource intensity | 3 days | Wed 24-09-08 | Wed 08-10-08 | | |
| 41 | | Energy Consumption | 3 days | Wed 24-09-08 | Wed 08-10-08 | | |
| 42 | | Total CO2equivalent | 3 days | Wed 24-09-08 | Wed 08-10-08 | | |
| 43 | | Social indicators | 16 days | Wed 24-09-08 | Wed 03-12-08 | | |
| 44 | | Regenerative Indicators | 3 days | Wed 24-09-08 | Wed 08-10-08 | | Kerly Acosta |
| 45 | | **Funding research** | **8 days** | **Mon 17-12-07** | **Wed 30-01-08** | **8SS** | **Kerly Acosta[6%]** |
| 46 | | Funding applications | 8 days | Mon 17-12-07 | Wed 30-01-08 | | Kerly Acosta[50%],Jennie Moore[50%] |
| 47 | | Presenting to faculty and Students EF project | 2 days | Wed 07-05-08 | Sat 17-05-08 | 5SS | Kerly Acosta |