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Centre for Sport and Sustainability

Life Cycle Assessment

of the UBC Thunderbirds teams, events, and venues

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UBC ATHLETICS & RECREATION
UBC A&R commissioned this study and supplied the data and logistical support. UBC hosts over 200 high performance and recreational events a year and manages the athletic venues at UBC including fields, stadiums, an aquatic centre, a tennis centre, indoor gymnasiums, fitness facilities, and ice hockey arenas. 71% of UBCs 47,000 students participate in UBC A&R activities with over 3,000,000 annual visits to facilities and programs. Varsity "Thunderbird" teams travel across North America to participate in the Canadian (CIS) and American (NAIA) interuniversity Sport leagues.

QUANTIS INTL
Quantis provided technical LCA and software support for this project. Quantis Intl. is a leading environmental impact assessment company specializing in Life Cycle Assessment (LCA). They were founded in 2009 as a joint venture between a spin-off from the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland and the consulting team of the Canadian Interuniversity Research Center for the Life Cycle of Products, Processes and Services (CIRAIG), located at École Polytechnique of Montréal, Canada.

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UBC CENTRE FOR SPORT AND SUSTAINABILITY
The Centre provided academic guidance and is the publisher of this report. UBC established the Centre for Sport and Sustainability in 2010 with a mission to act as a community resource to capture and transfer knowledge on how sport can create sustainable benefits locally, regionally and internationally.

MITACS
This project was supported by a MITACS-Accelerate accelerate research grant. MITACS is Canada's premiere research internship program. It connects companies to graduate students and postdoctoral fellows at over 50 research-based universities.

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Executive Summary

This study was commissioned by UBC Athletics & Recreation (UBC A&R). The goal was to carry out a Life Cycle Assessment (LCA) and provide UBC A&R with a tool to assess and manage the environmental impacts of their varsity "Thunderbird" teams, venues, and events.

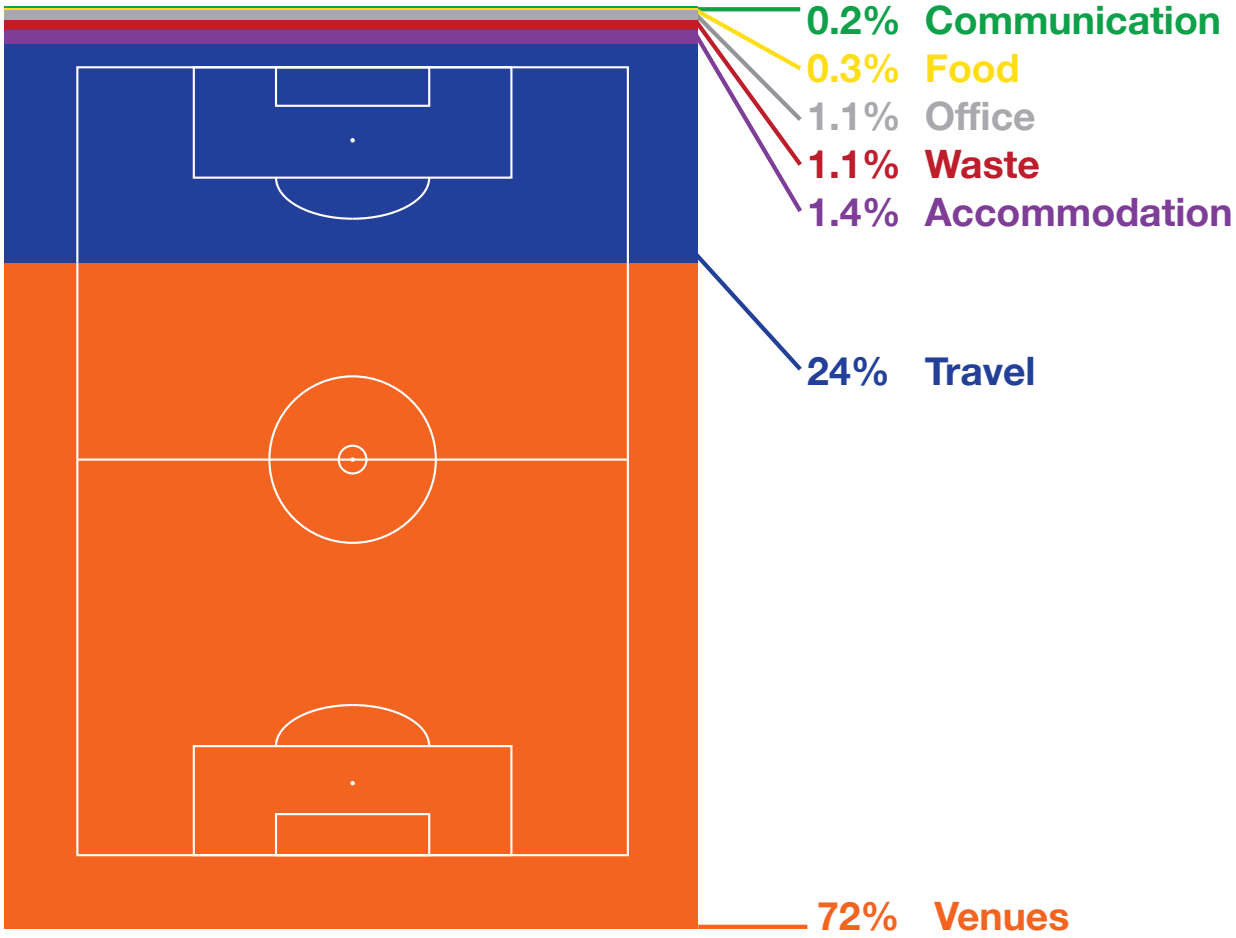
A principal aim of this study was to apply rigorous evaluation methods in a resource-efficient manner to identify major impacts from UBC A&Rs operations, stakeholders, and supply chain.

The study uses the IMPACT 2002+ LCA method to determine cradle–to–grave impacts across the environmental damage categories of *climate change* (Carbon Footprint), *human health*, *water withdrawal*, *ecosystem quality*, and *resource depletion*. The unit of analysis was the provision of an entertainment / athletic experience to participants of the UBC A&R Thunderbird sports events for the 2011/2012 season. The results showed a total annual footprint of 8,300 tonnes of carbon dioxide equivalents. The largest contributors were venues (72%) and travel (24%) — with food, office, waste, communication, and accommodation combining for the remaining 4%.

The results, data, and methodology presented in this report have been incorporated into the Quantis SUITE 2.0 LCA software tool. General recommendations for impact mitigation opportunities and ongoing data collection strategies are also included. UBC A&R will use this to track and report on environmental performance.

This approach represents a new level of sophistication for sustainability management and assessment of the events industry.

Carbon Footprint of UBC Athletics & Recreation Thunderbirds teams, events, and venues for the 2011/12 season.



Contents

Abbreviations

A&R	Athletics & Recreation
BC	British Columbia
CAN	Canada
CO_2-eq	Carbon dioxide equivalents
CH	Switzerland
DALY	Disability adjusted life years
EF	Environmental Factor
GHG	Greenhouse Gas
GLO	Global
GWP	Global warming potential
IPCC	International Panel on Climate Change
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
NA	North America
PDF	Potentially disappeared fraction of species
RER	Europe
UBC	University of British Columbia

1. Introduction

UBC Athletics & Recreation

The University of British Columbia's Athletics & Recreation department (UBC A&R) aims to be a leading sport and recreation program in Canada by delivering diverse, innovative and sustainable programming. This initiative supports UBCs global vision:

> *"As one of the world's leading universities, The University of British Columbia creates an exceptional learning environment that fosters global citizenship, advances a civil and sustainable society, and supports outstanding research to serve the people of British Columbia, Canada and the world."* [UBC Vision 2012]

UBC A&Rs mandate covers two core areas that reach over 3,000,000 participants per year:

Athletics - Organization of the UBC 'Thunderbirds' teams, events, and venues:

- Varsity teams (m=men, w=women): Baseball (m), Basketball (m,w), Cross Country (m,w), Field Hockey (m,w), Football (m), Golf (m,w), Ice Hockey (m,w), Rowing (m,w), Rugby (m,w), Skiing-Alpine (m,w), Skiing-Nordic (m,w), Soccer (m,w), Swimming (m,w), Tennis (m,w), Track (m,w), Volleyball (m,w);
- Club Sports: Cheerleading (m,w), Debating (m,w);
- 200 events hosted at UBC
- Venues: 7 buildings, 12 sports fields, 3 ice hockey rinks, 2 swimming pools, 1 football stadium, 1 indoor gymnasium arena, 12 indoor tennis courts.

Recreation - Delivery of sport and recreation programmes:

- Recreation sport leagues and tournaments;
- Fitness and instructional classes;
- Youth sports camps;
- Special events such as: Day of the Longboat, UBC Triathlon, Great Trek Run, and Storm the Wall;
- Sport facilities rental and operation.

Sustainability at UBC

UBC has made Sustainability an integral part of its mission. The University Sustainability Initiative (USI) was created to implement an ambitious strategy that sets new environmental, social and economic standards for a University. On the environmental front UBC has already set a particularly ambitious goal of achieving greenhouse gas reduction targets: net zero carbon impacts by 2050 [22].

This project represents a way for UBC A&R to contribute to UBCs efforts and fits particularly well under the two cross-cutting sustainability themes identified to achieve this: *UBC as a Living Lab* and *UBC as an Agent of Change* [3].

The Project

UBC A&R contracted the UBC Centre for Sport and Sustainability (CSS) to a develop an environmental impact assessment framework to cover their Athletics activities; specifically the "Thunderbird" varsity sports teams, their associated venues, and the 500+ events the teams participate in annually on and off campus.

The resulting framework will serve as a basis for monitoring and developing new sustainability strategies.

Matt Dolf, a UBC PhD student and CSS Manager, was engaged to carry out the project. Financial support was provided by a 'MITACS Accelerate' grant. Quantis Intl., a leading company in environmental assessment, provided technical support.

This work is an extension of a pilot study carried out in Spring, 2011 by Matt Dolf and a group of interdisciplinary UBC Grad students from the LCA Alliance at UBC. Their report, *Measuring the Climate Change Impacts of a UBC Thunderbirds Men's Basketball Game,* is available at www.css.ubc.ca/projects/ubc-athletics-recreation.

GOAL AND OBJECTIVES

The primary goal of this project is to provide UBC A&R with a tool to estimate and mitigate the impacts of their varsity athletic events. The specific objectives of this study are:

- To develop an LCA framework to assess the major environmental impacts associated with the UBC Thunderbirds events.

- To apply the resulting framework to the UBC Thunderbirds 2011/12 season to serve as a baseline for future years.
- To integrate the results and framework into a user-friendly tool (Quantis SUITE 2.0) that UBC A&R will use to continually monitor the impacts of its activities.

KEY CONSIDERATIONS

- The framework must be applicable to all UBC A&R varsity sport events, teams and venues.
- The tool must be user-friendly for UBC A&R and therefore require minimal ongoing expertise/support.
- Indicators should be specific to UBC covering energy, water, material, transportation, and construction impacts.
- The framework should include both direct (e.g. UBC venue operation) and indirect (e.g. spectator travel) impacts to determine scope of responsibility and influence.
- The framework should make use of existing data and, where required, implement new data collection procedures.
- Methodology and results from this project may be used and published as a part of a Matt Dolf's PhD research.
- Quantis Intl. may use this project to develop a sports event-specific software tool.

Context

Few small to mid-sized sport organizations assess their environmental impacts because of the high cost and the complexity of collecting data, accessing tools, and applying impact assessment methods. The few who do use approaches that vary widely in how they assess, compare and report on impacts [11,18].

The emergence of Life Cycle Assessment (LCA) presents new methods, tools, and databases that can be employed consistently by a large variety of organizations in a credible manner.

Quantis SUITE 2.0 offers a robust LCA framework that can be tailored to specific clients. The system provides an interactive and user-friendly tool to help organizations set strategies and priorities for environmental impact reduction. Where most tools require expert users, a non-expert can use Quantis SUITE 2.0 after minimal training. The software also allows for results to be presented in an interactive and attractive manner.

Format and Contents

This report first outlines the LCA methodology and requirements. Section 3 provides an overview of the specific assessment framework and approach used to assess impacts of UBC Thunderbirds activities. This is followed by an overview of results for the teams/events and individual venues. Some general recommendations and conclusions are provided in the last section.

The following supporting documents contain detailed data, assumptions, impact calculations, and results:

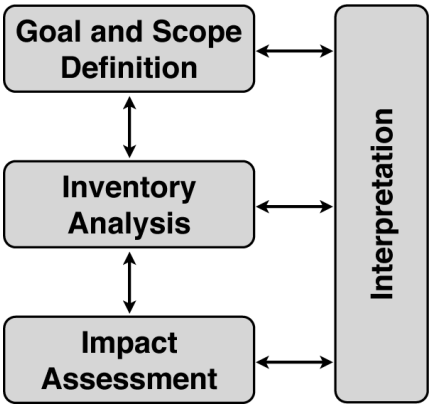
- Quantis SUITE 2.0 software
- UBC A&R Environmental Factors & Assumptions [Excel]
- UBC A&R Event and Team Travel Data [Excel]
- UBC A&R Spectator & Staff Event Travel Survey [Excel]
- UBC A&R Venue Data [Excel]

2. Life Cycle Assessment (LCA)

LCA measures the impact of products and services 'cradle to grave', covering the phases of resource extraction, manufacture, distribution, use, and disposal (see Figure 1).

The LCA method is rapidly becoming the most internationally accepted way of holistically assessing environmental impacts [12]. A strength of the method is that it can assess multiple impact categories such as *land use*, *water*, *smog*, *eutrophication*, *acidification*, *resource depletion*, and *climate change*. The ISO 14044 *Environmental management - Life cycle assessment - Requirements and guidelines* is the most widely agreed standard for carrying out LCA studies [7]. In conformity with this standard, this study applies the four phases shown in Figure 2.

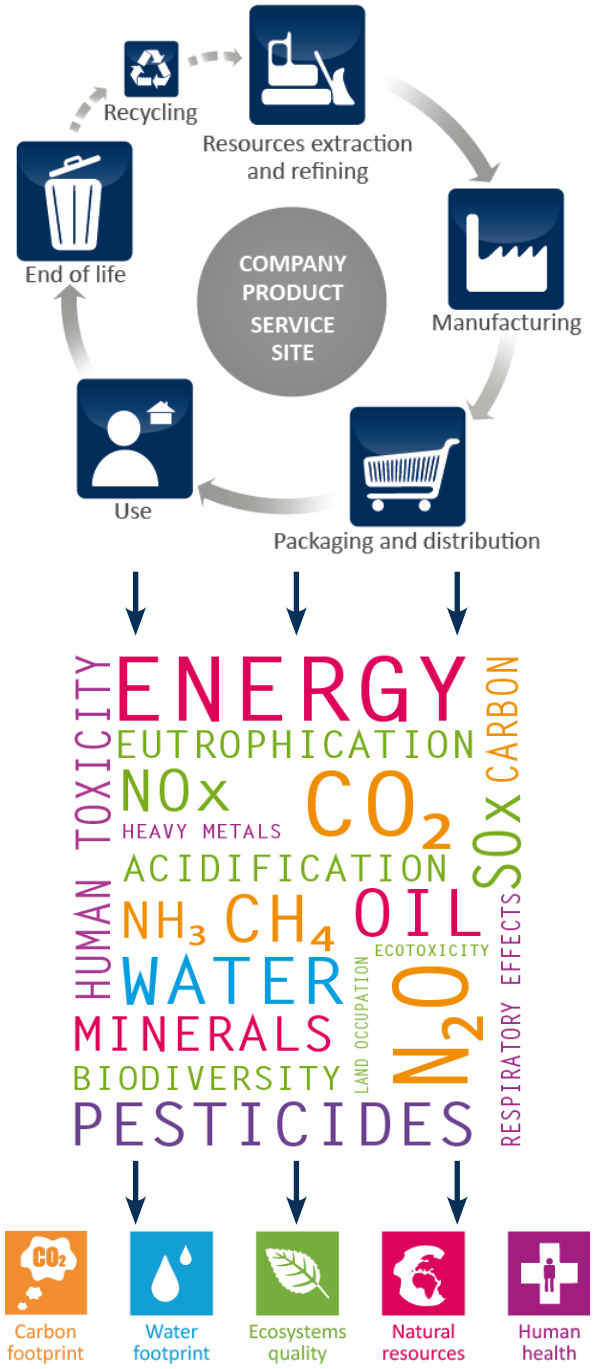
Figure 2: ISO 14044 Phases of an LCA Study



- **Goal and Scope**: Defines the purpose of the study, the system boundaries, and the major assumptions.
- **Inventory Analysis**: Defines the inventory of data, environmental inputs and outputs of the system under study, and the methods for data collection and analysis.
- **Impact Assessment**: Specifies the environmental impacts of the defined input and output flows using a particular LCA assessment method.
- **Interpretation**: Interprets the results of the inventory and environmental impact assessment relative to the goals of the study.

LCA is used for a widening range of applications including business strategy, product and process design, environmental labeling, and product declarations. It has yet to be applied extensively to the sport events industry but this is beginning to change. The City of Lausanne, Switzerland embedded the use

Figure 1: LCA measures impacts from cradle to grave. The IMPACT 2002+ method interprets environmental flows into five damage categories (image credits: Quantis Intl.).



of a multi–indicator LCA into the planning process of the 2011 World Gymnaestrada; an event with 20,000 athletes.

By contrast, a *carbon footprint* is an LCA method that refers to the *single* environmental impact category of *climate change* (also referred to as Global Warming Potential [GWP]) measured in greenhouse gas (GHG) emissions [19]. A growing number of events carry out *carbon footprints*; two pioneering examples were the FIFA 2006 World Cup and the Vancouver 2010 Olympic and Paralympic Winter Games. While the *carbon footprint* method is widely understood and arguably simpler to implement, it does not allow for an understanding of potential trade-offs between various types of impacts, such as between *climate change* and *human health*. We have therefore chosen to apply the IMPACT 2002+ method, which examines 5 impact categories.

LCA Requirements

This section addresses key ISO 14044 requirements. This project adheres as closely as possible to the ISO 14044 process at a "Screening LCA" level — as opposed to a "Full LCA" study. A screening approach was deemed sufficient in order to minimize costs and maximize efficiency to get a first order understanding of major impacts. Quantis Intl. provided methodological support and quality reviews.

GOALS OF THE STUDY

- To carry out a preliminary inventory of major environmental impacts applicable to the UBC Athletics & Recreation Thunderbirds season between September 2011 to August 2012.
- To identify areas with the largest contributions to environmental impacts and recommend options for impact reduction.
- To develop a benchmark against which future performance can be measured.

FUNCTIONAL UNIT

The functional unit quantifies the services and products of the product system into a measurable unit:

> *"The provision of an entertainment / athletic experience to participants of the UBC A&R Thunderbird sports events for the 2011/12 season"*

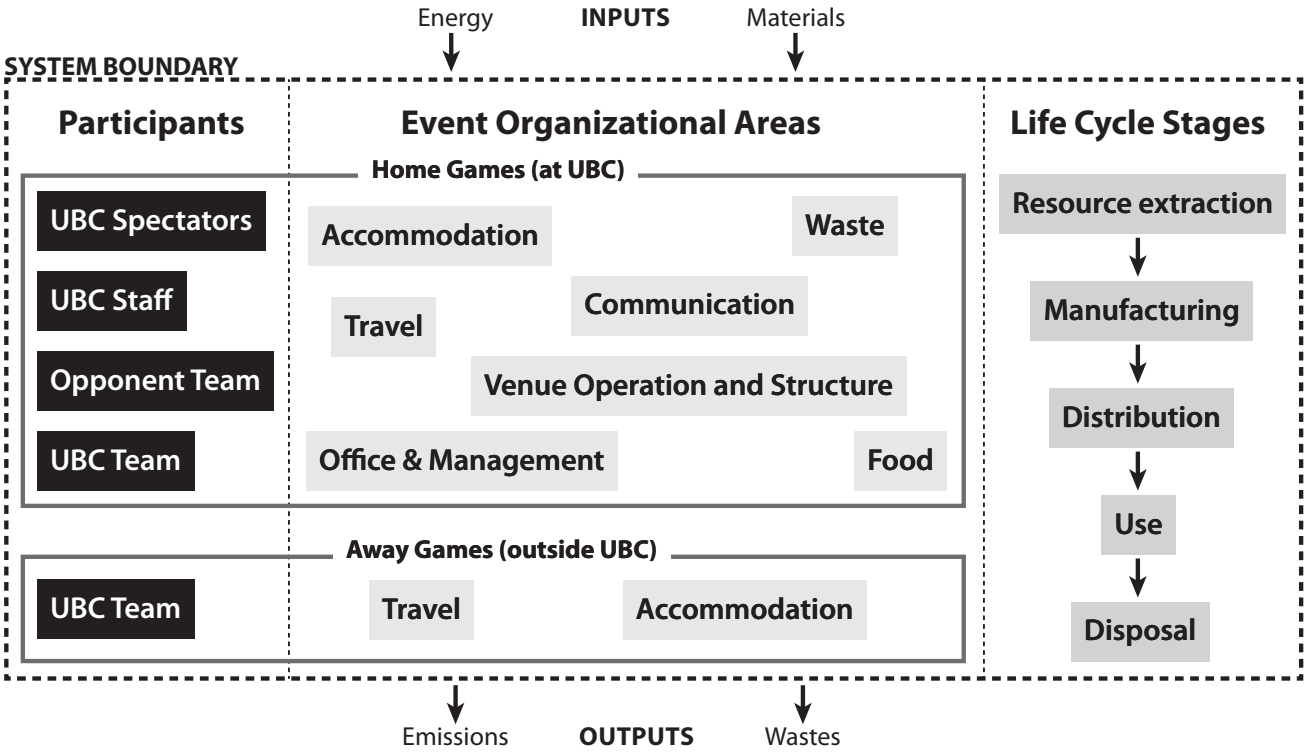
PRODUCT SYSTEM

Figure 3 shows all major direct and indirect environmental impacts associated with the UBC Athletics & Recreation Thunderbirds season occurring September 2011 - August 2012

The specific areas under review include:

- All Thunderbirds events and activities organized by UBC A&R;

Figure 3: System boundary for UBC Thunderbirds teams, venues, and events



- UBC A&R owned and managed sports venues;
- Spectator travel, accommodation, and on-site activities;
- Team travel, accommodation, and on-site activities;
- Sponsor, media, and guest travel, accommodation, and on-site activities.

PRIMARY FUNCTIONS OF THE PRODUCT SYSTEM

The function of this system are two-fold: (a) to provide an entertainment experience to spectators and (b) a competitive athletic experience to athletes. In order to do this, UBC A&R must also ensure a minimum level of comfort and safety, suitable accommodation and transportation options, and offer an excellent event experience to all attendees.

SYSTEM BOUNDARY

The system boundary for this study included all life cycle stages (cradle to grave) for each organizational area of the even (see Figure 3). For home games occurring at UBC, spectators, staff, and teams (both UBC and their opponents) were counted. For away games, only the UBC team travel and accommodation was included. This study applied a 99% cut-off criteria. In other words, all aspects estimated to contribute an impact of 99% to the total impact were included.

LCA TYPE

This study is an "Attributional LCA" type because it describes the environmental aspects of the system under study. A "Consequential LCA", on the other hand, describes the *effects* of changes in a system.

INTENDED AUDIENCE

The detailed results of this study are intended primarily for UBC A&R internal use. Any communication of selected results should be accompanied with a statement that the findings are preliminary. This study is a 'Screening LCA' and therefore may not be fully compliant with all components of ISO 14044.

PUBLICATION OF RESULTS

This study will be primarily used and communicated internally by UBC Athletics & Recreation. Methods and results may also be presented in academic publications or conferences.

UNITS OF COMPARISON

The following units are used in order to compare impacts:

- Impacts for one UBC A&R Thunderbirds season — this includes 100% of venue use and all elements in the system boundary.
- Impacts per venue — 100% of venue use only. The other organizational areas such as accommodation, travel, etc. are excluded in this comparison.
- Impacts per team — Examines only those impacts attributable to the teams. In particular, only the portion of the venues they use are applied to the teams. For example the Men's Basketball team used 5% of the War Memorial Gyms over one year since it shares the venue with three other teams, UBC A&R offices, and other users.

ASSUMPTIONS

Detailed assumptions for each organizational area are provided in Section 3. Results and Discussion.

PRIMARY ACTIVITY DATA BY ORGANIZATIONAL AREA

Data was collected for the event organizational areas of transportation, accommodation, food, waste, venues, office management, and communication. Results and methods for each are outlined further in Section 2 of this report.

LCA INVENTORY DATA SOURCES

Environmental impact factors were applied to activity data with a unit process (individual material impacts) approach [12]. Environmental impact factors were derived from a number of sources including:

- ecoinvent v2.2 LCA database;
- scientific literature and LCA studies; and
- reports, websites, newspapers.

LCA METHOD

This study applied the IMPACT 2002+ method developed by Jolliet et al. (2003) and updated by Humbert et al. (2011) [14, 15]. The following are the endpoint damage categories and associated units of measurement:

Climate Change – *kilograms of carbon dioxide equivalents*

Human Health – *disability adjusted life years*

Ecosystem Quality – *potential disappeared fraction of species per square meter per year*

Resources – *megajoules of primary energy*

Water Withdrawal – *litres of water*

IMPACT 2002+ groups impacts from thousands of material and energy flows into 14 mid-point damage categories, which are then further grouped into 5 end-point, or damage categories. Midpoint categories are defined as "a parameter in a cause-effect chain or network (environmental mechanism) for a particular impact category that is between the inventory data and the category endpoints" [1]. Damage categories reflect stressors at the end of a cause-effect chain and reflect society's understanding of a final effect. For example, high levels of phosphate and nitrate emissions may lead to *eutrophication* (midpoint) on a body of water, which in turn can be represented as an overall reduction in *ecosystem quality* (endpoint). Only

damage categories are communicated in this report in order to simplify interpretation and decision-making.

*For further details on IMPACT 2002+ see Appendix I.

LIMITATIONS

The purpose of this study was to provide an overview of the largest impacts of the 2011/12 Thunderbirds athletic season. The results should not be taken outside of this context.

This study applied a selected set of environmental damage categories and conclusions should not be drawn about impacts not represented here. Many of the environmental factors used are taken from an LCA database for a European context. Where possible, efforts have been made to represent a BC / Canadian context, however in many cases this was not possible. The foreground data was based on samples, averages, or assumptions using available data. For the most significant impacts (travel and venues), every effort has been made to get detailed and specific data. Given the broad scope of this study, some simplifications were made and therefore certain important impacts may have been missed or over/under represented. In some areas no data was available. For example, the construction impacts of natural grass fields were not included as information was not available.

IMPACT 2002+ characterizes results as *potential* impacts rather than *actual* impacts in order for us to better understand how the environment may be damaged by our activities (i.e. the *climate change* category looks at a 100 year time horizon for the environmental impacts of GHG emissions). Results should be interpreted and communicated as such.

Further limitations are also provided in Section 3.1 Event Organizational Areas' and Section 4. Sensitivity Analysis.'

SENSITIVITY ANALYSIS

A sensitivity analysis was undertaken (see Section 4 on page 60) to test alternate assumptions on the following key parameters:

- Electricity grids applied (BC vs. CAN vs. NA)
- Passenger travel occupancy rates
- Venue allocation % to teams

Performing a sensitivity analysis illustrates how assumptions and parameters can influence the results and examines the robustness of recommendations. In this study, the sensitivity analyses have all been performed with respect to *climate change* as it has the least uncertainty of the damage categories.

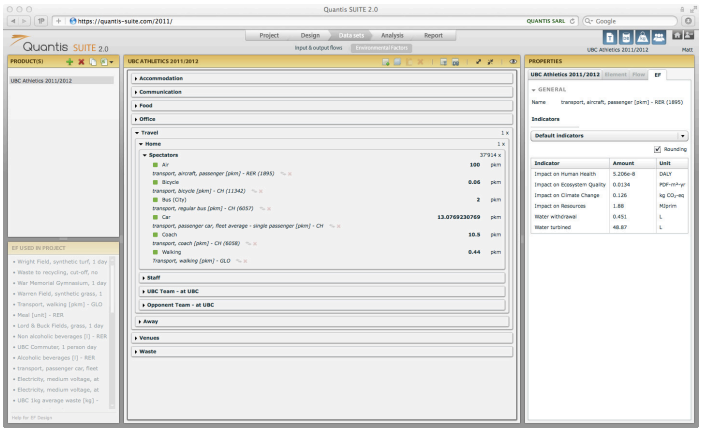
Tool - Quantis SUITE 2.0 LCA Software

Quantis SUITE 2.0 is a client-based software developed by Quantis Intl. to measure environmental impacts and help organizations set strategies and priorities for environmental impact reduction. Its strength compared to other LCA tools is an interface that is user-friendly, intuitive, and visually appealing. A non-expert can use the SUITE after minimal training. Quantis SUITE 2.0 integrates LCA impact assessment databases including ecoinvent, ADEME Bilan Carbone, DEFRA and a number of national Input-Output databases.

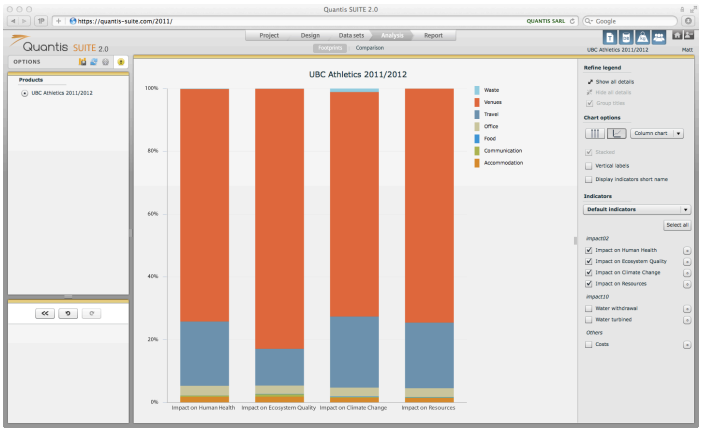
For this project we developed a template applicable to sports events that UBC can use to input activity data and track their environmental impacts. Further details on Quantis SUITE 2.0 along with user instructions are available in Appendix II on page 69).

Image (a) shows an example of the project design and environmental factors used for spectator travel on Quantis SUITE 2.0, and image (b) shows the interactive results overview page.

(a)



(b)



Further user instructions for Quantis SUITE 2.0 are available in 'Appendix II - Quantis SUITE 2.0' on page 69.

3. Results and Discussion

This chapter presents the results of the study for five environmental damage categories: *climate change*, *resources*, *human health*, *ecosystems quality*, and *water withdrawal*. Impacts, assumptions, data sources, and implications are broken down for each of the following:

- 3.1 Event Organizational Areas
- 3.2 Thunderbirds Venues
- 3.3 Thunderbird Teams

Interpreting Results

These results should be used in the context of the functional unit (UBC A&R Thunderbird activities for 2011/12 season), the boundaries and assumptions of this study, and in consideration of this study's limitations (described in Section 2 on page 8).

UNCERTAINTY

The underlying models used to characterize impacts have uncertainties which cannot be quantified using statistical analysis; guidelines have therefore been proposed by the authors of the IMPACT 2002+ method [14]. They provide thresholds of significance for each impact category to assist with interpreting results:

- Any difference in results lower than 10% is not considered significant for *resource depletion* or *climate change* scores.
- A difference lower than 30% is not considered significant for *respiratory inorganics, acidification,* and *eutrophication* (midpoint categories for the *ecosystem quality* indicator).
- Toxicity impacts under *ecosystem quality* and *human health* typically require an order of magnitude (factor of 10) difference to be significant.
- Results in the *water withdrawal* category are highly uncertain as water footprinting methods are relatively new and approaches vary widely [3]. Results presented here should only be interpreted as potential areas of concern and can be used to inform future investigations.

These guidelines depend on the correlation between the options compared. Deviations lower than those described above can be considered significant when the systems being compared are very similar. The interpretation given in this section takes into account these considerations.

LCA studies typically present impacts across multiple damage categories on a 100% scale to avoid weighting the importance of one category over another (e.g. importance of *climate change* over *human health*). According to ISO 14044 requirements, such weighting should only be done internally by the stakeholders.

Overview of UBC A&R Thunderbird Impacts

The total impacts of UBC A&R Thunderbirds venues, teams, and events during the period September 1, 2011 to September 1, 2012 are listed in Table 4 and illustrated in Figure 5. A detailed breakdown of the assumptions and data used to derive impacts for each organizational area are provided in Section '3.1 Event Organizational Areas' on page 15.

Taking into consideration one full year of operation and 100% allocation of impacts to UBC A&R, venues clearly dominate across all damage categories at 72% for *climate change*, 73% for *resources*, 75% for *human health*, 83% for *ecosystem quality*, and 86% for *water withdrawal*. This is mainly due to life cycle impacts of the buildings, particularly the Aquatic Centre, Doug Mitchell Arena, War Memorial Gym, and the Student Recreation Centre. Detailed results for each venue are available in Section '3.2 Thunderbirds Venues' on page 29.

Travel impacts are also significant, primarily for *climate change* at 24%. The major contributors are spectator travel, staff travel, UBC team travel, and opponent team travel.

The combined totaled for the organizational areas of Office, Accommodation, Waste, Food, and Communication is less than 5% for all damage categories; except in terms of water impacts, where food contributed 9%. Material goods consumed per participant were relatively low, in most cases just event brochures, snacks, and merchandise. The areas of travel, waste, communication, and food are most closely tied to participant activities and therefore higher attendance will likely increase impacts. The venues, office and team accommodation areas are less dependent on spectator participation.

Less than 1/3 of events are hosted at UBC since many teams play the majority of games on the road and some teams, such as skiing and golf, don't have venues on campus. A higher proportion of home games would likely increase impacts.

To contextualize results, Figure 6 provides sample benchmarks for each damage category. Further explanation of each category is available in Appendix I - IMPACT 2002+ LCA Method.

Table 4: Total annual impacts for the UBC Thunderbirds 2011/12 season.

ORGANIZATIONAL AREA	CLIMATE CHANGE (kg CO_2–eq)	RESOURCES (MJ prim)	HUMAN HEALTH (DALY)	ECOSYSTEM QUALITY (PDF•m²•yr)	WATER (L)
Venues	6,000,000	100,000,000	3.10	1,700,000	190,000,000
Travel	2,000,000	31,000,000	0.94	270,000	8,600,000
Office	90,000	1,500,000	0.06	22,000	700,000
Accommodation	120,000	1,800,000	0.07	36,000	3,800,000
Waste	93,000	80,000	0.01	1,900	75,000
Food	21,000	270,000	0.00	2,700	21,000,000
Communication	19,000	220,000	0.02	20,000	3,600,000
Total	**8,300,000**	**140,000,000**	**4.20**	**2,100,000**	**230,000,000**

Figure 5: Total annual impacts for the UBC Thunderbirds 2011/12 season on a 100% scale.

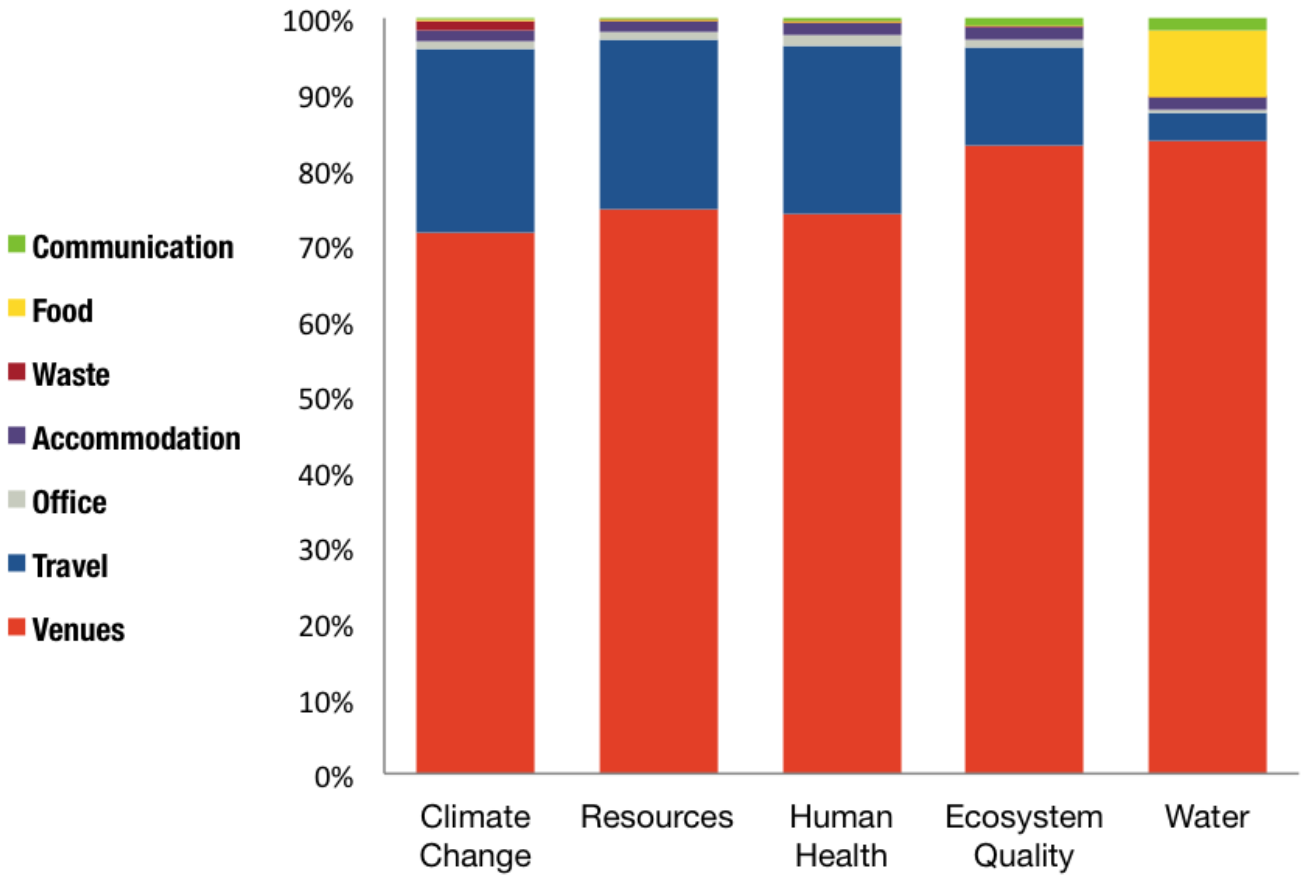


Figure 6: Some reference benchmarks to interpret the overall results for each damage category.

Carbon footprint

8,300,000 kg CO_2–eq =
2,600 return flights from Vancouver to London;
or 1 car driving around the world 730 times [7]

Natural resources

140,000,000 MJ Prim =
Annual resource depletion caused by 330 Canadians [17]

Human health

4.2 DALY =
Human health impact potential of 200,000 cigarettes smoked [20]

Ecosystems quality

2,100,00 PDF•m²•yr =
Loss of 2.1 hectares of forest for 100 years [14]

Water footprint

230,000,000 L =
Annual water consumption of 160 Canadians;
or 770 Europeans [9,14]

[SIDEBAR - Carbon Footprint according to the GHG Protocol]

The *carbon footprint* of UBC A&R Thunderbirds can also be classified according to the Greenhouse Gas (GHG) Protocol, which sets out boundary and scoping guidelines to assess and report publicly on GHG Emissions [28].

GHG emissions are classified into three main scopes: Scope 1 – direct emissions, Scope 2 – indirect emissions due to electricity or heating , and Scope 3 – indirect emissions from the supply chain. Scopes 1 and 2 are required for public reporting of emissions. Scope 3 is currently optional as it may result in double counting due to overlaps with reporting from other organizations in the supply chain.

SCOPE 1 - DIRECT GHG EMISSIONS

From sources owned or controlled by the organization:

- Natural gas for direct heating or steam in UBC A&R venues
- Fuel used by vehicles owned by UBC A&R (primarily maintenance vehicles) and fuel used by vehicles leased by UBC A&R (team travel in buses on the road)

SCOPE 2 - INDIRECT GHG EMISSIONS

Emissions due the generation of purchased electricity:

- Purchased electricity from the grid used by the venues

SCOPE 3 - OTHER INDIRECT GHG EMISSIONS

Covers emissions resulting from all other activities within UBC A&Rs scope of influence including activities in their supply chain and affiliated activities of event attendees:

- Spectator, event staff and team travel in non-owned/leased vehicles such as commercial planes, buses, and cars
- UBC A&R employee commuting in vehicles not owned by the organization such as public transit or private cars
- Production, transport and end of life of materials and resources used by UBC A&R such as sporting goods, office supplies, food, merchandise, etc.

RESULTS

Figure 7 provides a breakdown of the *carbon footprint* color–coded by organizational area.

Results show that 41% of the *carbon footprint* for UBC A&R lie in Scope 1 and come from energy use in the venues, fuel use in UBC A&R owned and operated vehicles, and leased vehicles for team travel. Scope 2 emissions are due to purchased electricity and come to approximately 15%. The remaining 44% of impacts fall under Scope 3 because they are under UBC A&R influence, not control.

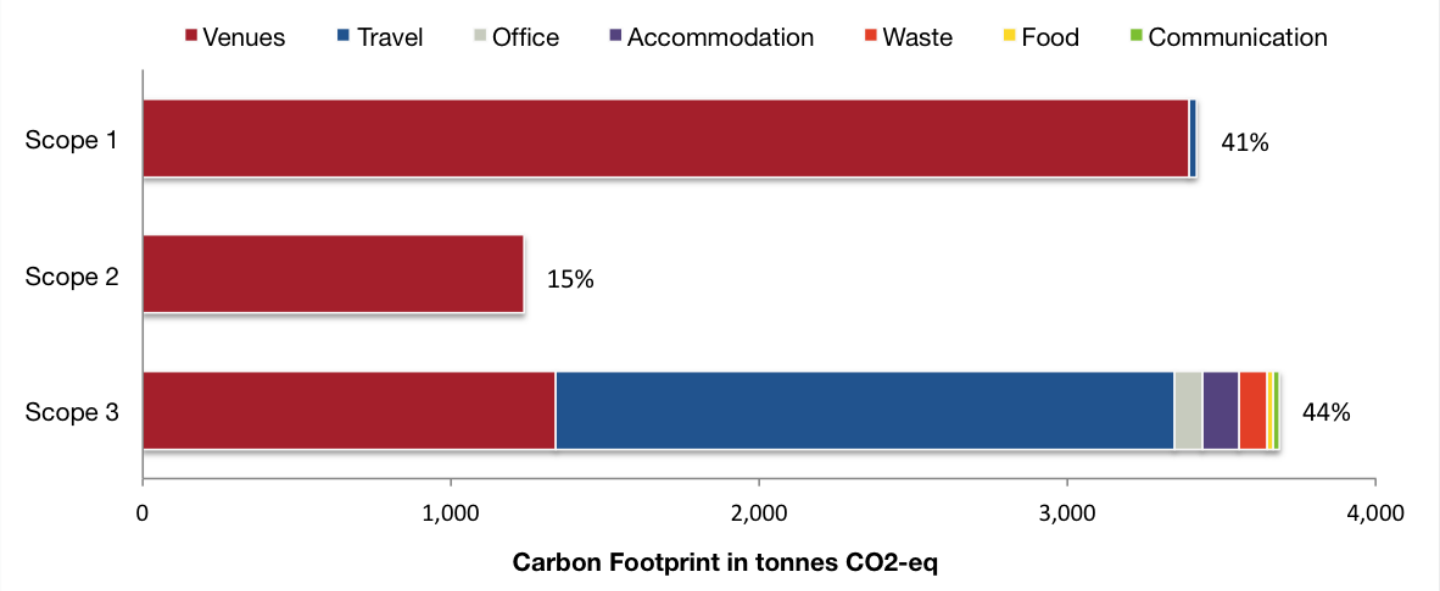
CARBON OFFSETS

UBC currently reports and offsets Scopes 1 and 2. They do not offset Scope 3 [22]. UBC pays carbon taxes and purchases offsets at $30 and $25 per tonne of CO_2-eq respectively for Scopes 1 and 2 under the guidelines of the BC Provincial Carbon Tax and the UBC Carbon Climate Action Plan [4 ,22].

If UBC A&R offsets its Scope 3 emissions, this would cost approximately $85,000 applying the UBC rate of $25 per tonne.

	SCOPE 1	SCOPE 2	SCOPE 3
t CO_2-eq	3,700	1,200	3,400
Tax rate ($30/t)	$111,000	$36,000	–
Offsets ($25/t)	$92,500	$30,000	$85,000

Figure 7: Carbon Footprint broken down by the GHG Protocol scopes for public reporting



3.1 Event Organizational Areas

Organizational Areas

This section outlines the approach taken to determine the environmental impacts of UBC Athletics & Recreations activities. Impacts for the events were broken down into the following seven organizational areas:

- Accommodation
- Communication
- Food
- Office
- Travel
- Venues
- Waste

While impacts are often categorized by life cycle stages, a grouping by organizational area was chosen to represent the typical breakdown of responsibilities common to most events. These areas are also consistent with the Canadian *CSA Z2010 Standard: Requirements and Guidance for Organizers of Sustainable Events (2011)*. As shown in the system boundary (see Figure 3), the cradle to grave impacts have been included.

Sub-Functional Units

For each organizational area, a functional unit (FU) represents a group of impacts. By applying the functional to the event activity data collected, such as the number of participants attending an event, a fairly robust estimate of the environmental impacts can be obtained. The functional units are:

Accommodation: *per person night in a standard North American hotel for participants attending an average UBC Thunderbirds event*

Communication: *per participant attending an average UBC Thunderbirds event*

Food: *per participant attending an average UBC Thunderbirds event*

Waste: *per participant attending an average UBC Thunderbirds event*

Office & Management: *per employee managing UBC Thunderbirds events full–time for 1 year*

Travel: *per participant attending an average UBC Thunderbirds event — broken into spectator / staff / UBC team / opponent team*

Venue: *per UBC Thunderbirds venue operating for 1 year — for each of the 14 game venues.*

INPUT-OUTPUT FLOWS

Each organizational area has a number of material an energy flows entering or leaving the system boundary. Activity data, units of measure, and the corresponding environmental factor (EF) are provided for each along with a brief description of the assumptions and data sources used. More details are available in supporting documents and in the Quantis Suite project file.

ENVIRONMENTAL FACTORS

The environmental factors (EFs) are taken primarily from the ecoinvent 2.2. LCA database. They allow us to characterize the impacts from the inventory data into environmental impacts.

DATA QUALITY

Each impact category has an assigned number between 1 - 4 to represent the quality of the data and assumptions based on the following chart:

DATA QUALITY	RELIABILITY	REPRESENTATIVENESS
1 - High Quality	Specific validated or calculated data	Good geographical and technological representativeness
2 - Acceptable Quality	Validated or calculated data from other source	Geographical or technological lack of representativeness
3 - Low Quality	Qualified estimate	Geographical and technological lack of representativeness
4 - Very Low Quality	Rough estimation	Proxy

Confidence in the results should be interpreted accordingly and efforts should be made in future years to improved the levels of data quality. It should be noted that data collection resources for this project were concentrated on the areas of highest impact: travel and venues.

Accommodation

Accommodation impacts are included for visiting team members both for UBC teams when on the road and for opponent teams at UBC events. The participants making use of accommodation are almost exclusively away team members. Locals are assumed to stay at home and therefore do not represent a change in impacts due to the event. Only a very small percentage of spectators reported being from out of town and among those, few reported staying at a hotel. As they represent significantly less than 1% of accommodation nights, they are excluded.

Due to the large number of different hotels used by travelling teams, an average North American hotel is modelled. The NA energy grid is applied rather than the BC one since most hotels are located outside BC. Electricity is the most significant impact in terms of *climate change* and *resources* and therefore these assumptions should be updated in future to reflect the trend of hotels becoming more energy efficient.

KEY FIGURES

Average number of UBC team nights per event when on the road: 1

Total number of UBC team person nights when on the road: 6,700*

Total number of opponent team person nights at UBC events: 2,400*

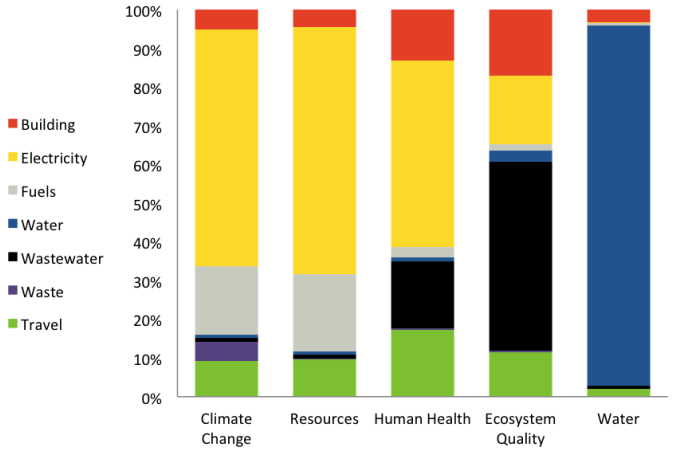
*UBC competes in significantly more away games than home games, hence the higher number of UBC team hotel nights

ACCOMMODATION – FUNCTIONAL UNIT

Per person night in a standard North American hotel for participants attending an average UBC Thunderbirds event.

IMPACTS PER FUNCTIONAL UNIT

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water (L)
11	180	7.0E-06	3.5	370



Data Assumptions and Sources

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Building construction materials	0.002	m^3	20 m^2 per person * 3 m ceiling for a standard multi-story building with 80 yr lifespan	Quantis-Gymnaestrada & TourBench Layman Report	ecoinvent 2.2 - building, multi-storey [m2] - RER (549)	2 - Acc.
Electricity	10	kWh	0.474 kWh/m^2/yr * 20 m^2 per person: 10 kWh per person per night	US EPA (2005) CHP in the Hotel and Casino Sectors	Quantis EF - Electricity, medium voltage, at grid/AmN [kWh] - N-A (N-A Background)	2 - Acc.
Fuels	29	MJ	1.44 kWh/m^2/yr * 20 m^2 per person: 29 MJ per person per night	US EPA (2005) CHP in the Hotel and Casino Sectors	ecoinvent 2.2 - natural gas, burned in boiler condensing modulating <100kW [MJ] - RER (1357)	2 - Acc.
Water	300	L	300 L water per person per night	Quantis-Gymnaestrada 2010 study	ecoinvent 2.2 - tap water, at user [kg] - RER (2288)	2 - Acc.
Wastewater	0.3	m^3	100% of tap water to wastewater		ecoinvent 2.2 - treatment, sewage, to wastewater treatment, class 2 [m3] - CH (2276)	2 - Acc.
Waste	1	kg	1 kg per person per night (100% landfilled)	Quantis-Gymnaestrada 2010 study	ecoinvent 2.2 - disposal, municipal solid waste, 22.9% water, to landfill [kg] - CH (2223)	2 - Acc.
Travel	20	km	10 km travel return from hotel to venue	UBC A&R	ecoinvent 2.2 - transport, coach [pkm] - CH (6058)	2 - Acc.

Communication

Communication impacts are included for all participants at UBC hosted events. Very little communication material are distributed or sold on site other than some paper event brochures and textile merchandise. TV, radio, newspaper, and advertising impacts are not included as they were considered negligible contributors. These can be quite important contributors in larger events however. End of life impacts for paper and merchandise are included in the waste section in order to avoid double counting.

Assumptions for communication data are based on rough estimations by UBC A&R staff. It is strongly recommended that in future the amount of communications materials for each team and/or venue be tracked and reported on an annual basis since they represent the majority of impacts for this category. The transport assumptions are based on industry averages and other studies undertaken by Quantis Intl.

The internet time per person is purely an estimation and more specific web traffic should be included in future.

KEY FIGURES

Total paper in a season: 970 kg

Total merchandise sold in a season: 485 kg

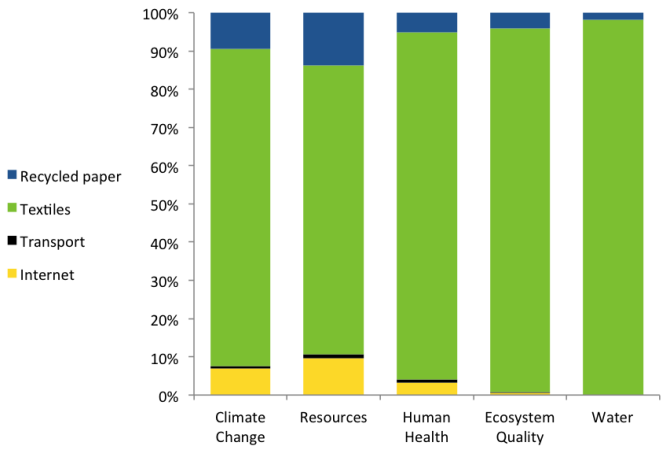
Total internet time: 67 days

COMMUNICATION – FUNCTIONAL UNIT

Per participant attending an average UBC Thunderbirds event.

IMPACTS PER FUNCTIONAL UNIT

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water (L)
0.33	3.8	3.30E-07	0.35	63



Data Assumptions and Sources

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Recycled paper	0.02	kg	One 4-page recycled event program (5 g per page) per participant (with de-inking)	UBC A&R Event Coordinator	ecoinvent 2.2 - paper, recycling, with deinking, at plant [kg] - RER (1714)	3 - Low
Textiles	0.01	kg	1 item (t-shirt/hat/scarf) sold for every 20 participants. Reference unit 1 t-shirt (200 g)	UBC A&R Event Coordinator	ecoinvent 2.2 - textiles, woven cotton, at plant [kg] - GLO (10177)	3 - Low
Transport	21.6	kgkm	Estimate 720 km travel from regional storage to UBC	Quantis guidelines for average transport in NA market	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	3 - Low
Electricity from internet use	0.0033	kWh	Each participant visits the UBC A&R website for 2 mins per event (0.0033 kWh per 2 min)	Internet time is estimated. Quantis guidelines for internet energy use.	Quantis EF - Electricity, medium voltage, at grid [kWh] - NA (NA Background)	3 - Low

Food

This indicator includes all food and beverages consumed at UBC events. Since detailed information on the food ingredients and sources were not available, an estimation based on an average meal three course meal at an event in Switzerland is used (Quantis Comptoir Gruyeren Study, 2009). Based on the estimates from UBC A&R food contractors, an estimate of 1/5 of an average meal is applied to each participant of a UBC event. Alcoholic and non-alcoholic beverages are separated since their relative impacts differ significantly — alcoholic drinks have a *carbon footprint* approximately 3.5 times higher than non-alcoholic drinks. Although total volume of beverages sold was provided by UBC A&R, the breakdown of drink types are also based on the Comptoir Gruyeren event study.

The food and beverage section should be covered in more depth in future both to increase accuracy of results and to highlight the differences in impacts between meats/vegetables, local/foreign sourcing, organic/non-organic, fresh/processed foods.

It should be noted that tap water consumption is not included as this is already covered under stadium usage and would result in double counting. For events with food consumption outside the venue (not the case at UBC events), tap water as beverage should be added. End of life impacts of food are covered in the waste section.

KEY FIGURES

Total meal equivalents served at UBC events: 9,700

Liters of alcohol consumed at UBC events: 1,200

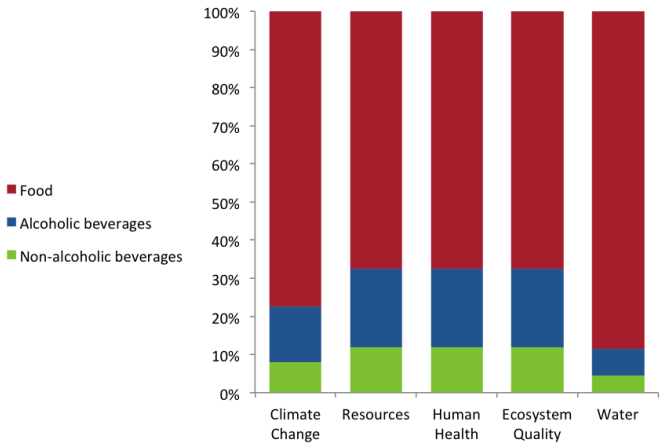
Liters of non-alcoholic beverages at UBC events: 4,850

FOOD – FUNCTIONAL UNIT

Per participant attending an average UBC Thunderbirds event.

IMPACTS PER FUNCTIONAL UNIT

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water (L)
0.47	5.9	5.90E-08	0.059	450



Data Assumptions and Sources

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Food	0.2	meals	0.2 meals per person, includes transport	UBC A&R Food contractor	Quantis-Comptoir Gruyeren 2009 Study	3 - Low
Alcoholic beverages	0.05	L	50 ml per person, 50% beer in glass bottle, 50% wine, includes transport	UBC A&R Food contractor	Quantis-Comptoir Gruyeren 2009 Study	2 - Acc.
Non-alcoholic beverages	0.1	L	100 ml per person, 75% coca-cola, 25% water, includes transport	UBC A&R Food contractor	Quantis-Comptoir Gruyeren 2009 Study	2 - Acc.

*Based on a typical three course meal

Office

Office covers impacts related to UBC Athletics staff that organize the events. Athletics has approximately 100 administration, facilities, and coaching staff that work full-time throughout the year to manage the venues, teams, communication, budgets, administration, etc. Most teams have a full-time coach. Some, such as Football, have additional coaching staff while others, such as tennis, are fully student run.

UBC A&R offices are located in the War Memorial Gym, Thunderbird Stadium, and Doug Mitchell Arena venues. Specific office dimensions and data for energy, water, waste etc. were not available and therefore an estimation is applied based on average British Columbia office building energy use and North American office sizes. Because the offices are within the venues, all impacts except staff commuting are excluded from the overall impact since this would have resulted in double counting. When looking at the impacts of individual teams or events, the full list of office impacts can be applied.

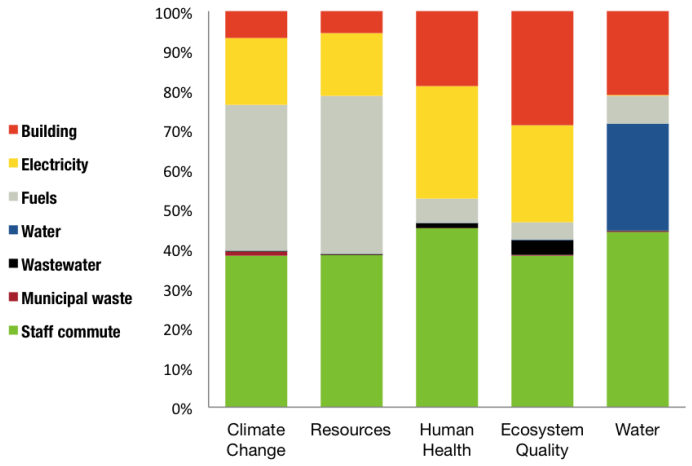
A major impact across all damage categories is employee commuting. Office energy use (fuel and electricity) is significant in all categories. The building material construction impacts are most significant in terms of *human health*, *water withdrawal*, and *ecosystem quality*. It is recommended that more specific office data and travel patterns be obtained to improve the accuracy of these results.

KEY FIGURES
UBC A&R staff: 100

OFFICE – FUNCTIONAL UNIT
Per employee managing UBC Thunderbirds events full–time for 1 year.

IMPACTS PER FUNCTIONAL UNIT

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
2,400	38,000	1.30E-03	570	16,000



Data Assumptions and Sources

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Building construction materials	0.75	m^3	20 m^2 per person * 3 m ceiling for a standard multi-story building with 80 yr lifespan	GSA report for average workspace	ecoinvent 2.2 - building, multi-storey [m3] - RER (549)	3 - Low
Electricity	2600	kWh	130 kWh/m^2/yr * 20 m^2 per person	National Resources Canada - BC office energy	Quantis EF - Electricity, medium voltage, at grid/BC [kWh] - BC (N-A Background)	2 - Acc
Fuels	11800	MJ	590 MJ/m^2/yr * 20 m^2 per person	National Resources Canada - BC office energy average	ecoinvent 2.2 - heat, natural gas, at boiler modulating <100kW, RER, (1349)	2 - Acc
Water	3750	L	15 L per person day x 250 days	Quantis-Gymnaestrada 2010 study	ecoinvent 2.2 - tap water, at user [kg] - RER (2288)	2 - Acc
Wastewater	3.75	m^3	100% of tap water to wastewater		ecoinvent 2.2 - treatment, sewage, to wastewater treatment, class 2 [m3] - CH (2276)	2 - Acc
Waste	80	kg	4 kg waste/m^2/yr to landfill * 20 m^2 per person	UBC Sustainability Office	ecoinvent 2.2 - disposal, municipal solid waste, 22.9% water, to municipal incineration, CH (2103)	2 - Acc
Staff commuting	1	unit	49% car 20 km (1.2 p/v), 49% transit 20 km, 1% walk 2 km, 1% bike 10 km	UBC TREK Transport Survey - travel distance is an estimate from Main St. to UBC (return)	Custom EF - UBC commuter, 1 person day [unit] - UBC	1 - High

Travel

Transportation was anticipated to be a major contributor to environmental impacts and therefore detailed results were collected for each of the following participant types:

- Spectators at UBC home games
- Staff at UBC home games
- UBC team at UBC home games
- Opponent team at UBC home games
- UBC team at away games

Travel data for spectators and staff come from a sample of on-site surveys (detailed on page 21). Travel data for the UBC and opponent teams are calculated by using the Thunderbirds event schedule and UBC A&R travel records.

This study was completed part-way through the season and therefore the exact number of games is unknown since it depends on the success of teams in the playoffs. Estimates are used for teams still in competition. Results should be updated at the end of the season.

Transport modesW

The *carbon footprint* per km travelled for each mode is shown in Figure 8. The key elements included for these calculations are described below.

BIKE — Impacts are based on the manufacture and end-of-life of a standard aluminum bicycle as well as a share of road infrastructure.

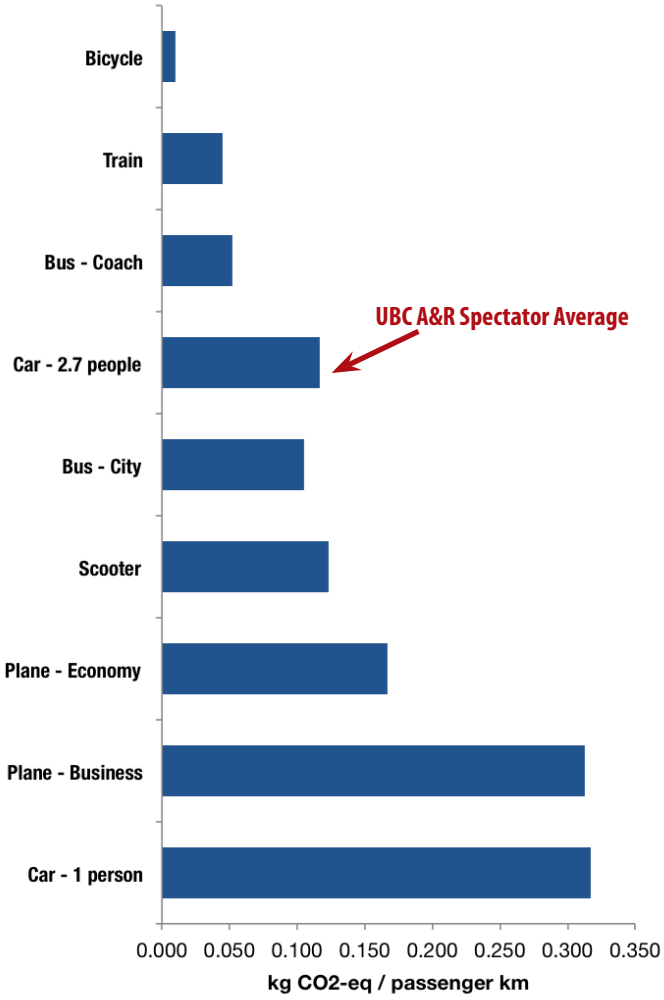
BUS CITY — Impacts are based on construction, road and fuel use of a standard bus used for public transportation. An average European mix of trolley, diesel, and other city bus types are assumed. The bus occupancy rate is also based on a European industry average. In future the UBC specific bus occupancy rate could be applied if information can be made specific to UBC event travel patterns.

BUS COACH — Impacts are based on construction, road infrastructure, and fuel use of a standard coach used either for intercity travel or dedicated to specific trips, e.g. school buses or rented buses for team travel. The bus occupancy rate and technology are based on a European industry average.

CAR — Impacts are based on construction, road infrastructure, and fuel use of a standard small passenger vehicle. A European fleet average technology and fuel mix is used. Occupancy rates for cars, however, are specific to UBC events.

SCOOTER/MOTORCYCLE — Impacts are based on construction, road infrastructure, and fuel use of an average European scooter. Since a very small % of participants (<0.01%) reported using a scooter/motorcycle, these individuals are counted under "Car" as impacts per km are similar at UBC events.

Figure 8: Carbon Footprint per travel mode



PLANE — Impacts are based on average plane, airport construction, and fuel use. Only 2nd class travel impacts are assumed as all UBC A&R teams are booked 2nd class. It is possible that some spectators flew 1st class but this information was not captured. Since impacts can be almost twice as large due to the reduced number of seats available on a flight, this information could be collected in future. An industry average flight occupancy rate was used.

TRAIN — Impacts are based on a European average construction, infrastructure, and energy use of trains. No participants reported using trains in this study and therefore this mode is not included in the results.

WALK — Walking is assumed to be a zero impact activity

Spectator & Staff Travel at UBC Home Games

To determine spectator and staff travel patterns, surveys were carried out at eight separate events over the period of October 15 - November 19, 2011. The following events were selected, representing 7 of the 23 different teams, to include a variety of travel patterns:

- Mens Football (Oct 15, 2011)
- Mens Football (Oct 29, 2011)
- Mens Ice Hockey (Nov 19, 2011)
- Mens Volleyball (Nov 19, 2011)
- Womens Basketball (Oct 28, 2011)
- Womens Field Hockey (Oct 22, 2011)
- Womens Ice Hockey (Oct 29, 2011)
- Womens Soccer (Oct 21, 2011)

These events cover a cross-section of characteristics - indoor/outdoor; weekday/weekend; men/women; local away team/non-local away team; regular season game/playoff game; level of public transport and parking services; variable weather; daytime/evening; ticketed/non-ticketed. It is recommended that more events be surveyed in the future to cover a larger sample size and a wider range of characteristics - particularly for playoff games.

SURVEY METHOD

The anonymous survey of participating spectators and staff obtained the following information:

- mode of travel
- if they came by car, number of people in the vehicle
- first 3 digits of their postal code (to determine distance travelled at a resolution of approximately 1 km)
- whether they travelled to UBC primarily for the game (if not they were excluded)
- participant type (spectator, staff, team)

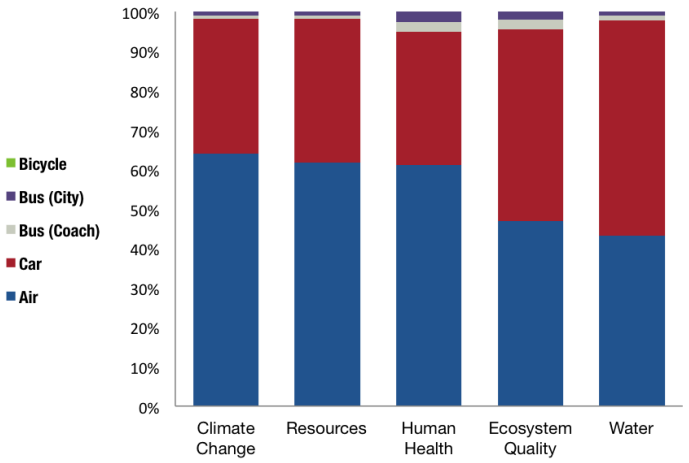
The sample size for spectators was 849 out of a total population of 2,520 at 8 events, a total sample rate of 34%. For staff, the sample size was 82 out of a total population of 100 at 2 events, a sample rate of 82%.

Travel impacts for spectators and staff are determined by applying the average distances travelled for each mode of transport and the % of each transport mode. In the case of cars, a vehicle occupancy rate for UBC home games was captured. For all other modes of transport, an industry average is used (i.e. for transit, planes, and coaches).

FUNCTIONAL UNIT - SPECTATOR TRAVEL

Per spectator attending an average UBC Thunderbirds home event.

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
27	420	1.20E-05	4	140



FUNCTIONAL UNIT – STAFF

Per staff attending an average UBC Thunderbirds home event.

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
2.6	41	2.60E-06	0.75	17

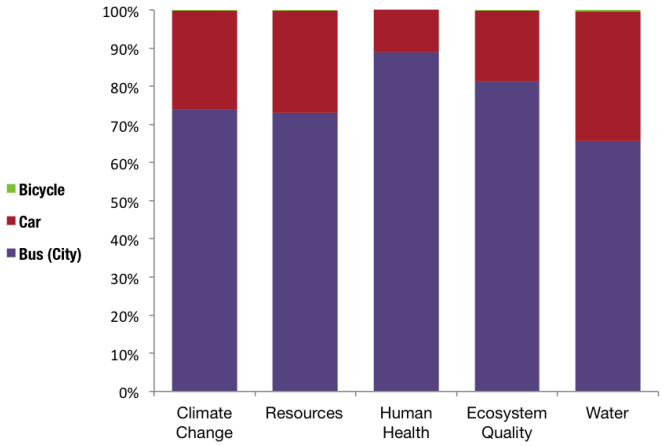


Table 9: Spectator travel modes, distances and vehicle occupancy rates

TRAVEL MODE	TOTAL SPECTATORS	% TRAVEL MODE	TOTAL TRAVEL DISTANCE [KM]	AVERAGE TRAVEL DISTANCE [KM]	AVERAGE VEHICLE OCCUPANCY [P/V]
Bike	21	2.5%	120	6	n/a
Bus City	63	7.4%	2,000	32	n/a
Bus Coach	54	6.4%	4,200	77	n/a
Car	580	68.3%	65,000	110	2.6
Motorbike	1	0.1%	17	17	n/a
Plane	42	4.9%	120,000	2,800	n/a
Walk	88	10.4%	340	4	n/a
Totals	**849**	**100%**	**190,000**	**223**	**n/a**

Table 10: Staff travel modes, distances and vehicle occupancy rates

TRAVEL MODE	TOTAL SPECTATORS	% TRAVEL MODE	TOTAL TRAVEL DISTANCE [KM]	AVERAGE TRAVEL DISTANCE [KM]	AVERAGE VEHICLE OCCUPANCY [P/V]
Bike	8	9.8%	36	5	n/a
Bus City	27	32.9%	880	33	n/a
Car	32	39.0%	1,500	46	3.1
Walk	15	18.3%	40	3	n/a
Totals	**82**	**100%**	**2,400**	**30**	**n/a**

SPECTATOR TRAVEL PATTERNS

As shown in Table 9, the large majority of spectators came by car (68%). The vehicle occupancy rate averaged 2.6 people per vehicle (p/v). This occupancy rate is significantly above the UBC commuting norm of 1.1 p/v [23]; this can likely due to people going to events with friends and families.

Walking was the next most common travel mode at roughly 10%. There were an almost even number of spectators that reported coming by city and coach buses. It should be noted that at one of the events surveyed, a very large school group travelled with charted bus — part of an UBC A&R program for schools.

The number of people taking transit fluctuated significantly between games, likely as a result of a variety of factors including proximity to bus stops, the time of the event (affecting schedule frequency), the day of the event (weekday or weekend), and weather.

Very few people reported biking to the event. The average may actually be lower than 2.5% since the sample included one event where a "bike to the game" initiative was held — leading to a significant number of spectators attending by bike.

A somewhat surprising result was the relatively large percentage of spectators (4%) that flew primarily to attend events. Note that participants that reported flying to Vancouver primarily for other reasons were excluded. As shown in Figure 11, these flights dominate the *carbon footprint* contribution.

Figure 11: Spectator mode share and Carbon Footprint

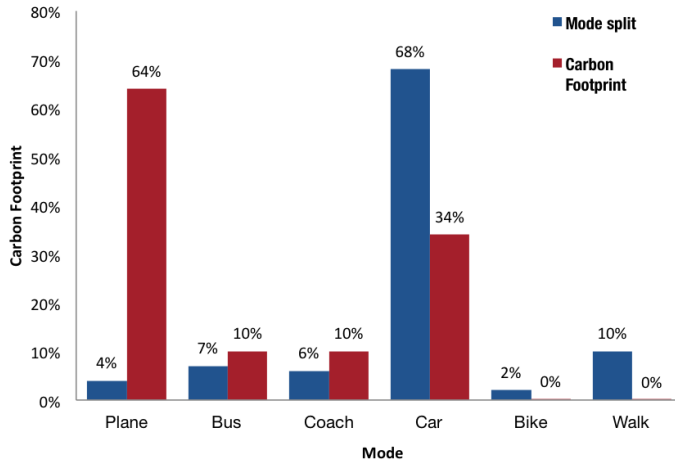
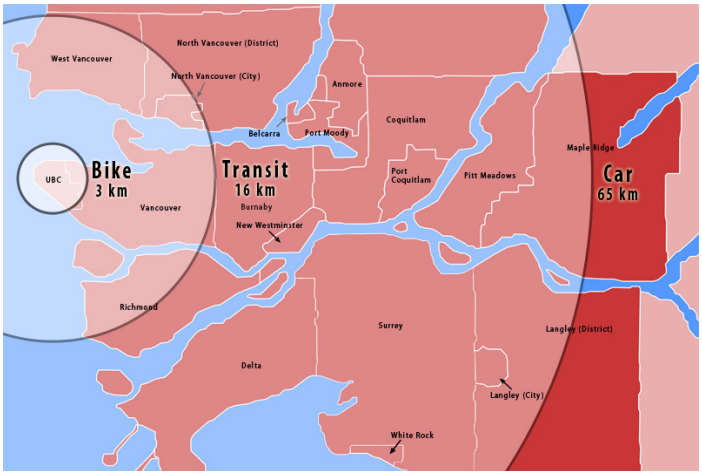


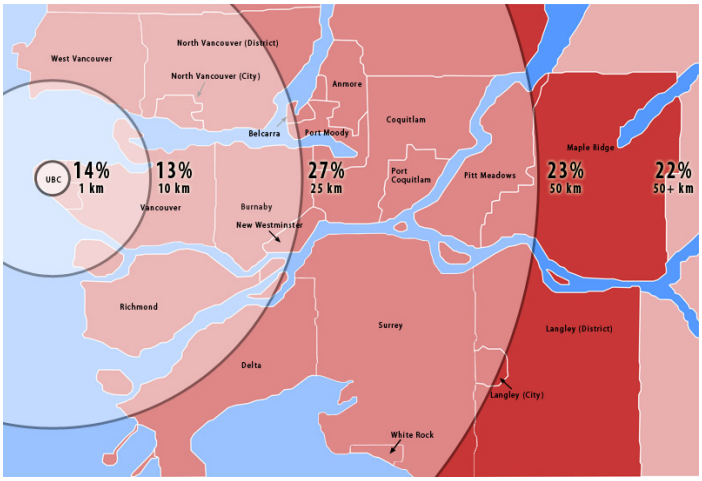
Figure 12: Average spectator travel distance by bike, transit and car modes



The map in Figure 12 shows the average distance travelled for the modes of biking (3 km), transit (16 km), and driving (65 km) across greater Vancouver. The car average distance is likely higher than transit due to the people who favoured car use for long distance travel from out of town.

A breakdown of zones of travel to UBC is shown in Figure 13. Approximately 14% came from within the UBC campus area, 54% from within a 25 km radius. 22% came from a distance of greater than 50 km, showing a significant proportion of out-of-town travel — mostly affiliated with the opposing teams.

Figure 13: Average spectator travel distances by 1, 10, 25, 50, and 50+ km zones



STAFF TRAVEL PATTERNS

It should be reiterated that the staff travel patterns are only based on results from two events and that results varied significantly (see Table 10). Nevertheless, these results indicate that there is likely a more even distribution of travel modes used and that the travel distances are shorter than for spectators, an average distance of 30 km for staff versus 223 km for spectators. This may be due to many event staff members being students and living close to campus. It is recommended that these numbers be measured more extensively in future.

UBC Team Travel Home & Away

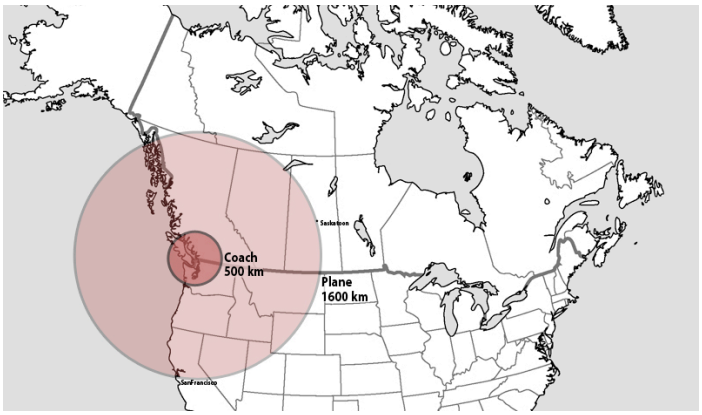
AWAY GAMES

UBC team travel to away games is tracked on an annual basis for most teams by UBC A&R. Where information was missing, coaches were contacted. Detailed travel information was completed for 23 of the 24 teams. Only the Nordic Skiing team information is missing; it is assumed that their impacts are the same as for the Alpine Skiing team. Travel details for the teams are very accurate as they are based on actual schedule data. City to city travel distances are calculated for every trip made and include the mode of travel used.

UBC teams travel across Canada and the US for their away games. For events that take place within a radius of 500 km, they predominantly use rented coach buses or minivans (since the impacts of a coach bus and a minivan are relatively similar, the coach bus process is used to represent both). As shown in Figure 14, the average travel distance for Coach travel is approximately 500 km's, or roughly the distance to Kamloops, BC or Portland, OR.

For events that take place further away, the economy flights are the main mode of travel. On average the teams fly 1,600 km's to an away event, about the distance of Saskatoon, SK or San Francisco, CA.

Figure 14: Average travel distance by coach and plane for UBC team to away games



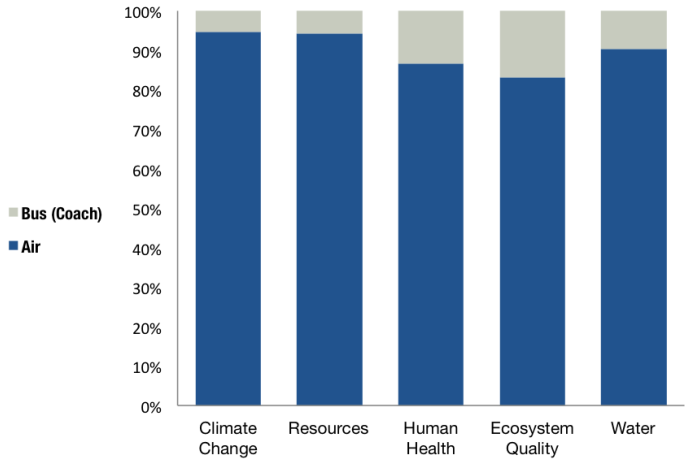
HOME GAMES AND PRACTICES

No specific travel data were gathered for UBC teams traveling to home games and practices. It was assumed that for home games, the UBC team travel patterns would be similar those of event staff since both are predominantly made up of students. It is recommended that UBC A&R include the UBC team members in future travel surveys to test this assumption.

FUNCTIONAL UNIT - UBC TEAM AT AWAY EVENTS

Per UBC team member attending an average UBC Thunderbirds away event.

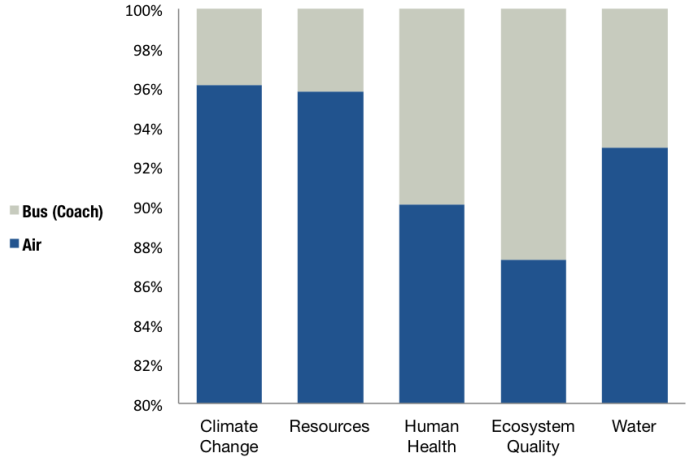
Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
440	6,600	2.00E-04	54	1,700



FUNCTIONAL UNIT - OPPONENT TEAM TRAVEL

Per opponent team member (at home) attending an average UBC Thunderbirds event.

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
370	5,500	1.60E-04	43	1,400



Opponent Team Travel to UBC Games

Opponent travel is derived from the UBC A&R competition schedule and assumptions are made based on UBC team characteristics (i.e. travel modes used for travel distances). For events where the equivalent number of athletes are competing, the assumptions are quite accurate. In some sports — such as in golf, track, and swimming, UBC hosts tournaments where a large number of teams participate. The participation numbers and travel details for these were not available.

Data Assumptions and Sources for Participant Types

SPECTATOR TRAVEL

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Walk distance (return)	0.4	pkm	modal split of 9.8% and average return distance of 4 km	Travel surveys	Zero impact assumed	1 - High
Bike distance (return)	0.1	pkm	modal split of 2.5% and average return distance of 4 km	Travel surveys	ecoinvent 2.2 - transport, bicycle, CH (11342)	1 - High
Car distance (return)	12	pkm	modal split of 67.6% and average return distance of 49 km / vehicle occupancy rate of 2.7	Travel surveys	Custom ecoinvent EF - transport, passenger car, petrol, fleet average, 2010, RER - single passenger	1 - High
Bus-city distance (return)	2.5	pkm	modal split of 8.7% and average return distance of 29 km	Travel surveys	ecoinvent 2.2 - transport, regular bus, CH (6057)	1 - High
Bus- coach distance (return)	17	pkm	modal split of 6.4% and average return distance of 263 km	Travel surveys	ecoinvent 2.2 - transport, coach, CH (6058)	1 - High
Plane (economy) distance (return)	137	pkm	modal split of 4.9% and average return distance of 2795 km	Travel surveys	ecoinvent 2.2 - transport, aircraft, passenger, RER (1895)	1 - High

STAFF TRAVEL

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Walk distance (return)	1	pkm	modal split of 20% and average return distance of 3 km	Travel surveys	Zero impact assumed	2 - Acc
Bike distance (return)	1	pkm	modal split of 5% and average return distance of 5 km	Travel surveys	ecoinvent 2.2 - transport, bicycle, CH (11342)	2 - Acc
Car distance (return)	2	pkm	modal split of 25% and average return distance of 26 km / vehicle occupancy rate of 3.1	Travel surveys	Custom ecoinvent EF - transport, passenger car, petrol, fleet average, 2010, RER - single passenger	2 - Acc
Bus-city distance (return)	18	pkm	modal split of 50% and average return distance of 36 km	Travel surveys	ecoinvent 2.2 - transport, regular bus, CH (6057)	2 - Acc
Bus- coach distance (return)	0	pkm	modal split of 0% and average return distance of 0 km	Travel surveys	ecoinvent 2.2 - transport, coach, CH (6058)	2 - Acc

UBC TEAM TRAVEL AT AWAY GAMES

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Bus- coach distance (return)	450	pkm	modal split of 100% and average return distance of 450 km	UBC A&R	ecoinvent 2.2 - transport, coach - CH (6058)	1 - High
Plane (economy) distance (return)	3,300	pkm	modal split of 100% and average return distance of 3322 km	UBC A&R	ecoinvent 2.2 - transport, aircraft, passenger - RER (1895)	1 - High

UBC TEAM TRAVEL AT UBC HOME GAMES

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Walk distance (return)	1	pkm	modal split of 20% and average return distance of 3 km	Estimate based on staff travel	Zero impact assumed	2 - Acc
Bike distance (return)	1	pkm	modal split of 5% and average return distance of 5 km	Estimate based on staff travel	ecoinvent 2.2 - transport, bicycle, CH (11342)	2 - Acc
Car distance (return)	2	pkm	modal split of 25% and average return distance of 26 km / vehicle occupancy rate of 3.1	Estimate based on staff travel	Custom ecoinvent EF - transport, passenger car, petrol, fleet average, 2010, RER - single passenger	2 - Acc
Bus-city distance (return)	18	pkm	modal split of 50% and average return distance of 36 km	Estimate based on staff travel	ecoinvent 2.2 - transport, regular bus, CH (6057)	2 - Acc
Bus- coach distance (return)	0	pkm	modal split of 0% and average return distance of 0 km	Estimate based on staff travel	ecoinvent 2.2 - transport, coach, CH (6058)	2 - Acc

OPPONENT TEAM TRAVEL AT UBC HOME GAMES

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Bus- coach distance (return)	273	pkm	modal split of 100% and average return distance of 450 km	UBC A&R	ecoinvent 2.2 - transport, coach - CH (6058)	2 - Acc
Plane (economy) distance (return)	2,800	pkm	modal split of 100% and average return distance of 3322 km	UBC A&R	ecoinvent 2.2 - transport, aircraft, passenger - RER (1895)	2 - Acc

Waste

Currently, UBC A&R does not track either the amount of waste generated at their games, or the % recycled and composted. Since the amount of waste generated by UBC A&R events and associated activities is relatively small in terms of the overall impact, it was deemed not to be feasible to carry out a detailed waste audit at each of the 14 game venues. The waste generated per person is therefore based on an audit carried out in a pilot study by Dolf et al. on an individual UBC A&R Basketball Game [5].

On-site observation at a number of events highlighted that there were few bins for recycling and none for composting. It is recommended that an audit be carried out in future and be included as part of regular reporting.

Waste includes all on–site garbage at the events. Off–site waste (i.e. for hotels and offices) are included separately in those sections. Impacts include transport to end-of-life as well as end-of-life treatment. For recycling, a cut-off, no benefits approach is applied to avoid giving credits to both the organization recycling the waste and the organization using the recycled material. This helps avoid the issue of whether 100% of waste sent to recycling actually gets recycled.

KEY FIGURES

Total waste generated by event participants: 2,400 kg

UBC recycling rate: 35%

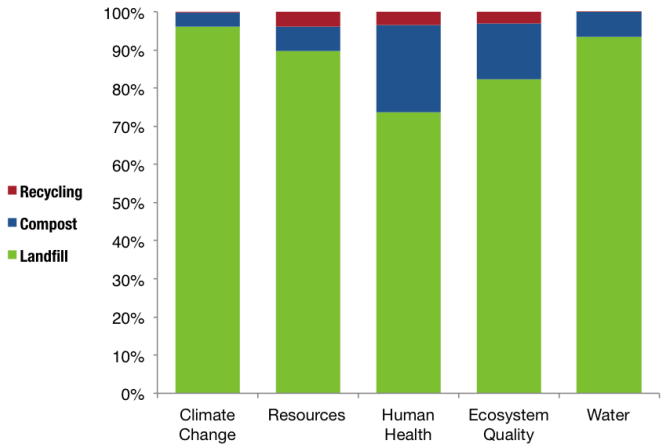
UBC composting rate: 8%

FUNCTIONAL UNIT

Waste generated per participant attending an average UBC Thunderbirds event.

IMPACTS PER FUNCTIONAL UNIT

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water (L)
0.017	0.014	1.10E-09	3.50E-04	0.014



Data Assumptions and Sources

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCES	ENVIRONMENTAL FACTOR	QUALITY
Municipal waste	0.029	kg	0.05 kg of waste per person per event * 57% of waste to landfill	Basketball pilot study (Dolf et al. 2011) & UBC Sustainability Office for recycling %	ecoinvent 2.2 - disposal, municipal solid waste, 22.9% water, to landfill [kg] - CH (2223)	2 - Acc
Waste to recycling	0.018	kg	No recycling credits	UBC Sustainability Office	n/a	2 - Acc
Waste to compost	0.002	kg	.08 kg / 2.33 mass conversion. 2.33 kg fresh organics to produce 1 kg compost	Amount: UBC Sustainability Office. Compost conversion: Boldrin et al., 2010	ecoinvent 2.2 - compost, at plant [kg] - CH (58)	2 - Acc
Transport to landfill	0.860	kgkm	Delta landfill is 30 km (one way) from UBC	Google Maps	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	2 - Acc
Transport to recycling	0.350	kgkm	Assume 20 km trip (one way) to recycling plant	Estimate	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	1 - High
Transport to compost	0.004	kgkm	Assume 1 km trip (one-way) to compost plant (at UBC)	UBC Sustainability Office	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	1 - High

Venues

UBC Thunderbirds compete in 14 different venues at UBC that are wholly owned and operated by UBC A&R. While the venues were designed primarily for varsity team competitions, a significant portion of the use is actually for other purposes including community programs, recreational events, and office lease space.

The annual impacts of each venue are calculated based on the period of September 1, 2010 - September 1, 2011. To determine impacts for a specific use or time period, an hourly or daily use can then be applied accordingly.

A detailed list of specific data and sources are listed in this section for each venue. The following indicators describe how the venue data are translated into environmental impacts.

FUNCTIONAL UNIT
Operation of each UBC venue for 1 year.

IMPACTS PER FUNCTIONAL UNIT
Please refer to '3.2 Thunderbirds Venues' on page 29 for a break-down for each venue.

Data Assumptions and Sources

The following tables outline the common flows applied for UBC A&R buildings, fields, and chemical use. Specific data, sources, and impacts for each venue are itemized in Chapter '3.2 Thunderbirds Venues' on page 29.

BUILDINGS –FOR ONE YEAR OF OPERATION

FLOW	DATA	UNIT	ASSUMPTIONS	ENVIRONMENTAL FACTOR	QUALITY
*Building construction materials - hall	see sect. 3.2	m2	Applied to buildings with primarily large open spaces, i.e. gym, pool, arena	ecoinvent 2.2 - building, hall, steel construction - CH (547)	3 - Low
*Building construction materials - multi-storey	see sect. 3.2	m3	Applied to buildings similar to a typical concrete multi-story office building	ecoinvent 2.2 - building, multi-storey RER (549)	3 - Low
Electricity	see sect. 3.2	kWh	For lighting, plug loads, heating	Quantis EF - Electricity, medium voltage, at grid/ BC [kWh] - BC (N-A Background)	1 - High
Fuels (natural gas)	see sect. 3.2	MJ	For heating and hot water. UBC buildings primarily use natural gas	ecoinvent 2.2 - natural gas, burned in boiler modulating >100kW [MJ] - RER (1362)	1 - High
Steam	see sect. 3.2	MJ	Natural gas Conversion: 1 lb steam = 1.055 MJ energy. Steam conversion efficiency 78% and transport loss to building 25%	ecoinvent 2.2 - natural gas, burned in boiler modulating >100kW [MJ] - RER (1362)	1 - High
Water	see sect. 3.2	L	Water from Metro Vancouver	ecoinvent 2.2 - tap water, at user [kg] - RER (2288)	1 - High
Wastewater	see sect. 3.2	m3	Assume all water goes to wastewater	ecoinvent 2.2 - treatment, sewage, to wastewater treatment, class 2 [m3] - CH (2276)	3 - Low
Waste	see sect. 3.2	kg	4 kg waste per m2 per year of building area. 57% to landfill, 35% to recycling, 8% to compost, includes transport	ecoinvent 2.2 - Custom EF - 1 kg average waste [kg] - UBC (custom)	3 - Low

*Note that depending on the building type, either the "hall" or "multi-storey" flow is applied.

GRASS FIELDS – ANNUAL OPERATION FOR 1 FIELD

FLOW	DATA	UNIT	ASSUMPTIONS	ENVIRONMENTAL FACTOR	QUALITY
Fuel (tractors)	see 3.2	MJ	L fuel x 37.2 energy value into MJ	ecoinvent 2.2 - diesel, burned in diesel-electric generating set [MJ] - GLO (1544)	1 - High
Water (irrigation)	see 3.2	L	All water from Metro Vancouver tap water	ecoinvent 2.2 - tap water, at user [kg] - RER (2288)	1 - High
Fertilizers	see 3.2	kg	Fertilizer 18-18-18 & Fertilizer 23-3-23	ecoinvent 2.2 - fertilizer [kg] - GLO (custom)	2 - Acc

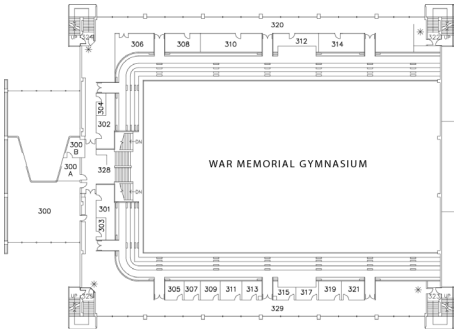
SYNTHETIC FIELDS – FOR 1 SQUARE METER OF SYNTHETIC FIELD

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCE	ENVIRONMENTAL FACTOR	QUALITY
Sand for base	22.00	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - silica sand, at plant [kg] - DE (479)	2 - Acc
Synthetic grass	1.29	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - Steel at plant + sheet rolling + cold impact extrusion + manufacturing	2 - Acc
Primary backing	0.27	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - packaging glass, green, at regional storage, CH (825)	2 - Acc
Rubber pellets	16.65	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - polyethylene, HDPE at plant + injection moulding	2 - Acc
Secondary coating	0.61	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - textiles, woven cotton, at plant, GLO (10177)	2 - Acc
Waste	18.82	kg	Impact allocated over 10 years	Turf manufacturer	ecoinvent 2.2 - disposal, plastics, mixture, 15.3% water, to sanitary landfill [kg] - CH (2230)	2 - Acc
Transport from distribution centre to venue	10,205	kgkm	Impact allocated over 10 years	Turf manufacturer	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	2 - Acc
Transport to landfill	565	kgkm	Impact allocated over 10 years	Quantis guidelines for average transport in NA market	Quantis EF - transport, 53' dry van (Class 8) [tkm] - NA	2 - Acc

POOL CHEMICALS – ANNUAL OPERATION FOR THE AQUATIC CENTRE (INDOOR & OUTDOOR POOL)

FLOW	DATA	UNIT	ASSUMPTIONS	DATA SOURCE	ENVIRONMENTAL FACTOR	QUALITY
Sodium Hypochlorite	105,000	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - sodium hypochlorite, 15% in H2O, at plant [kg] - RER (337)	1 - High
Calcium chloride	14,000	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - calcium chloride, CaCl2, at regional storage [kg] - CH (260)	1 - High
Sodium Bicarbonate	28,000	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - sodium carbonate from ammonium chloride production, at plant [kg] - GLO (7246)	1 - High
Sodium thio sulfate	100	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - sodium sulphate, powder, production mix, at plant [kg] - RER (343)	1 - High
Calcium Hypochlorite	300	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - calcium chloride, from hypochlorination of allyl chloride, at plant [kg] - RER (6255)	1 - High
Soda ash	50	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - soda, powder, at plant [kg] - RER (325)	1 - High
Cyanuric Acid	100	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - acetic acid from butane, at plant [kg] - RER (6607)	1 - High
Muriatic acid	37,440	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - hydrochloric acid, 30% in H2O, at plant [kg] - RER (282)	1 - High
Diatomaceous earth	35,000	kg	Annual use	UBC Pool Manager	ecoinvent 2.2 - silica sand, at plant [kg] - DE (479)	1 - High
Chemical transport	158,392,800	kgkm	Assume 720 km travel from regional storage	Quantis guidelines for NA market	ecoinvent 2.2 - transport, 53' dry van (Class 8) [tkm] - NA (Quantis EF)	1 - High

3.2 Thunderbirds Venues



UBC A&R manages seven buildings and approximately 14 athletic fields, of which 4 are synthetic. They are grouped in two clusters on the UBC campus (see map Figure 15). The John M.S. Lecky Boathouse for rowing is located off-campus approximately 15 kilometers to the southeast.

This section provides an overview of annual impacts for each UBC venue used by the Varsity teams. The purpose is to both provide the key parameters used to measure impacts and at the same time to provide a baseline for the 2011/12 season.

When examining the environmental impacts of an individual event or team, Quantis SUITE 2.0 can apply daily or hourly impacts derived from annual facility impacts. Refer to 'Venues' on page 27 for an overview of how impacts were derived. The sports teams of Cross Country running, Skiing, Golf, and Softball do not have any events hosted at UBC and make use of external venues. Impacts of these venues are considered out of scope both because they are not owned and managed by UBC A&R and because the few hours of use are negligible compared to other impacts.

The annual impacts for the following 14 UBC A&R event venues are modelled in Quantis SUITE 2.0 for the 2011/12 season:

- Aquatics Centre & Empire Pool [swimming]
- Baseball diamond [Baseball]
- Doug Mitchell Thunderbird Arena [Ice Hockey]
- John M.S. Lecky Boathouse [Rowing]
- Rashpal Dhillon Oval [Track & Field]
- Wolfson Fields and Rugby Pavilion [Rugby]
- Student Recreation Centre [Multi-use]
- Thunderbird Stadium [American football]
- UBC Tennis Centre [Tennis]
- Varsity Soccer Field [Soccer]
- War Memorial Gym [Basketball & Volleyball]
- Warren Soccer Field [Soccer]
- Wolfson Fields and Pavilion [Rugby]
- Wright Field [Field Hockey]

Figure 15: Location of Athletics Facilities on the UBC Campus

Continuous tracking of key venue numbers such as energy, waste, chemical, and water usage will allow both for further refinement of the accuracy of these impacts as well as future benchmarking. A comparison of venue impacts follows.

Figure 16: Direct water (L) use by UBC A&R Venues from September, 2010 to September, 2011

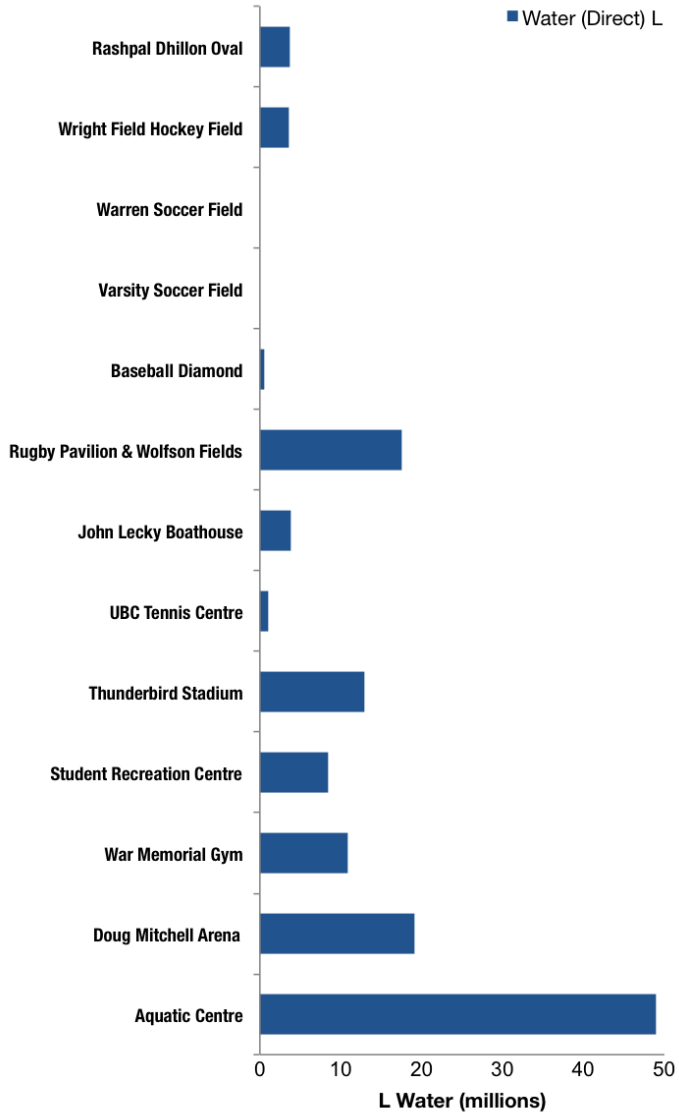
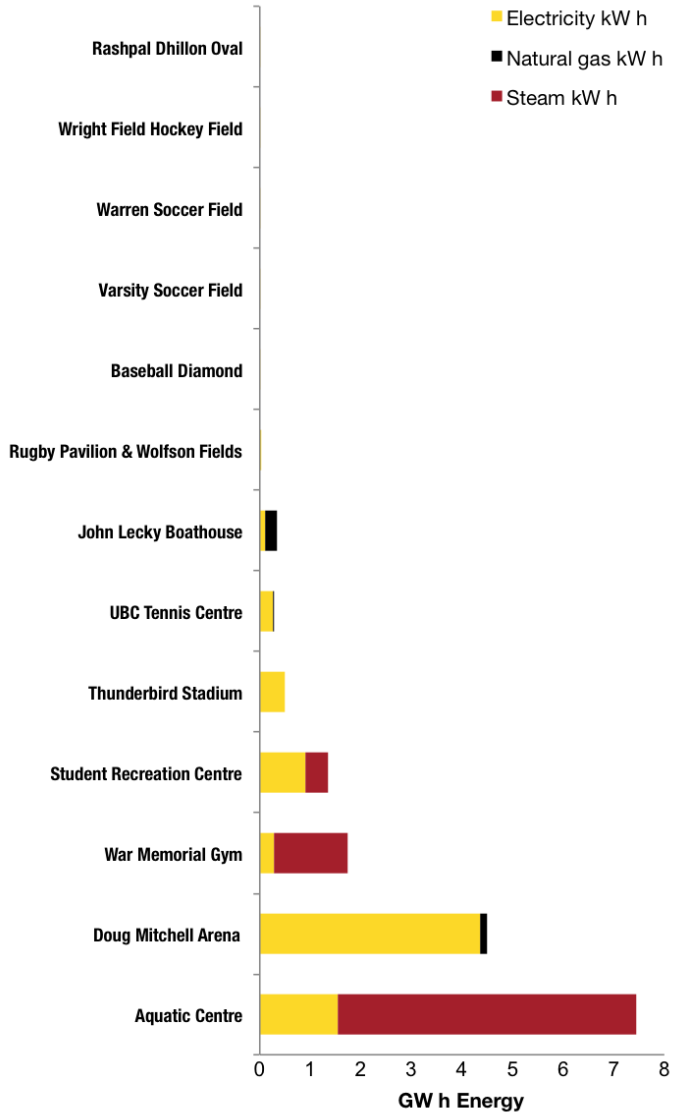


Figure 17: Energy (kWh) use in UBC A&R Venues from September, 2010 to September, 2011



Water

Total direct water use by venues for the baseline year September 1, 2010 to September 1, 2011 was 190M Liters. As a comparison, in 2009 UBC purchased 4.3B liters of water [27]. Figure 16 shows the annual water use break-down by venue. The synthetic fields (Warren, Varsity, and the Baseball Diamond use significantly less water than grass fields. The rugby pavilion has a proportionally very large water use compared to the other facilities. It is not clear why this is and this should be investigated further. It is important to stress that this figure shows 'direct' water use, as opposed to 'indirect' use, which includes *water withdrawal* associated with the full supply chain including venue construction, energy use, etc. The venue impacts in this section include both 'direct' and 'indirect' *water withdrawal*.

Energy

Total energy use by venues for predominantly heating, lighting, and plug loads for the baseline year was approximately 16 GWh, of which 8 GWh was electricity, 7.8 GWh steam, and 365 MWh natural gas (note that natural gas is also used to generate the steam and was factored in the impact assessment). Figure 17 shows the energy use break-down by venue. It should be noted that the fields with lights use approximately 1 MWh each of electricity, however this amount is too small to show up on the chart.

Figure 18: GHG Emissions of UBC A&R Venues from September, 2010 to September, 2011

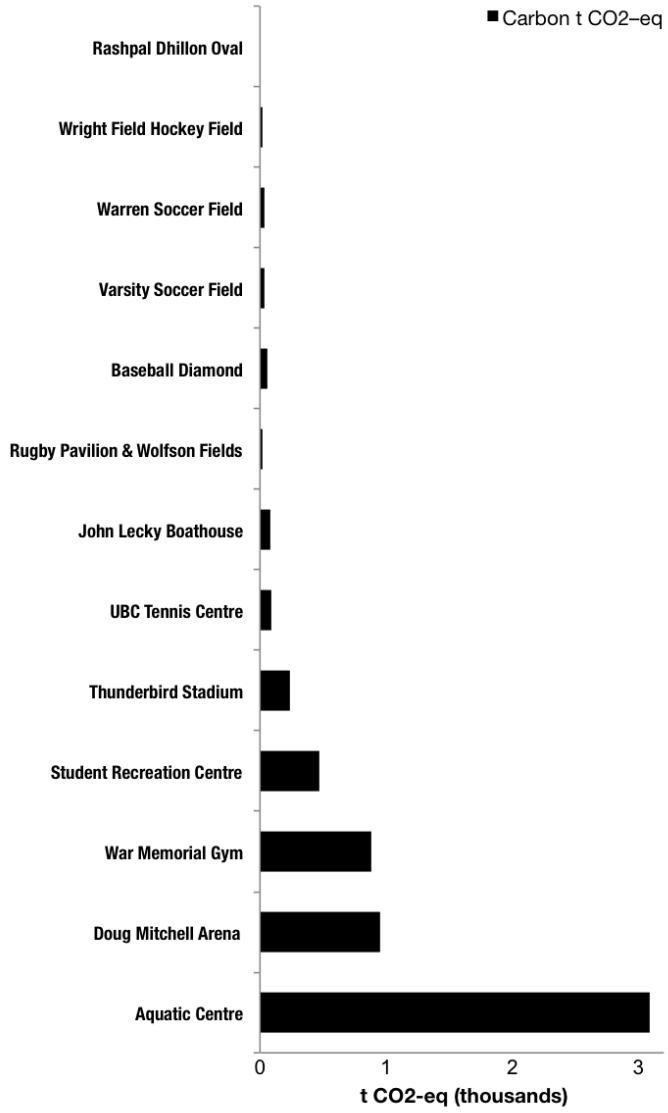
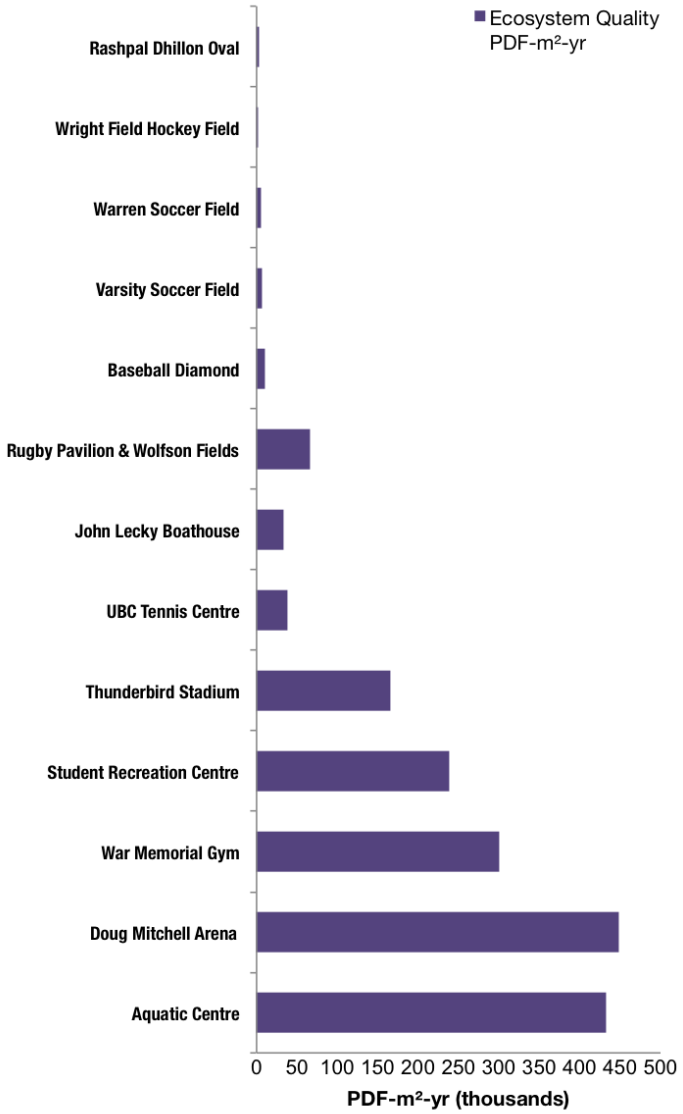


Figure 19: Ecosystem Quality impacts of UBC A&R Venues from September, 2010 to September, 2011



Carbon

The total *carbon footprint* for venues is approximately 6,000 tonnes of CO_2–eq. The results are fairly proportional to energy use by the venues. A notable exception is the relatively lower impact of the Doug Mitchell Arena, largely because a larger percentage of its energy use is hydro electricity. The Aquatic Centre, due to its higher energy use for pool heating, is the largest carbon emitter, more than 3 times that of any other venue.

Ecosystem Quality

The total *ecosystem quality* impact for venues is 1,800,00 PDF•m²•yr. There is a significant change in relative impacts for this category compared with energy, water, and energy use. In most cases, this appears to be due to the relatively higher ecosystems impacts related to venue construction and materials. Contributions from wastewater to this damage category are also significant in a number of venues.

Figure 21: GHG Emissions of UBC A&R Venues from September, 2010 to September, 2011

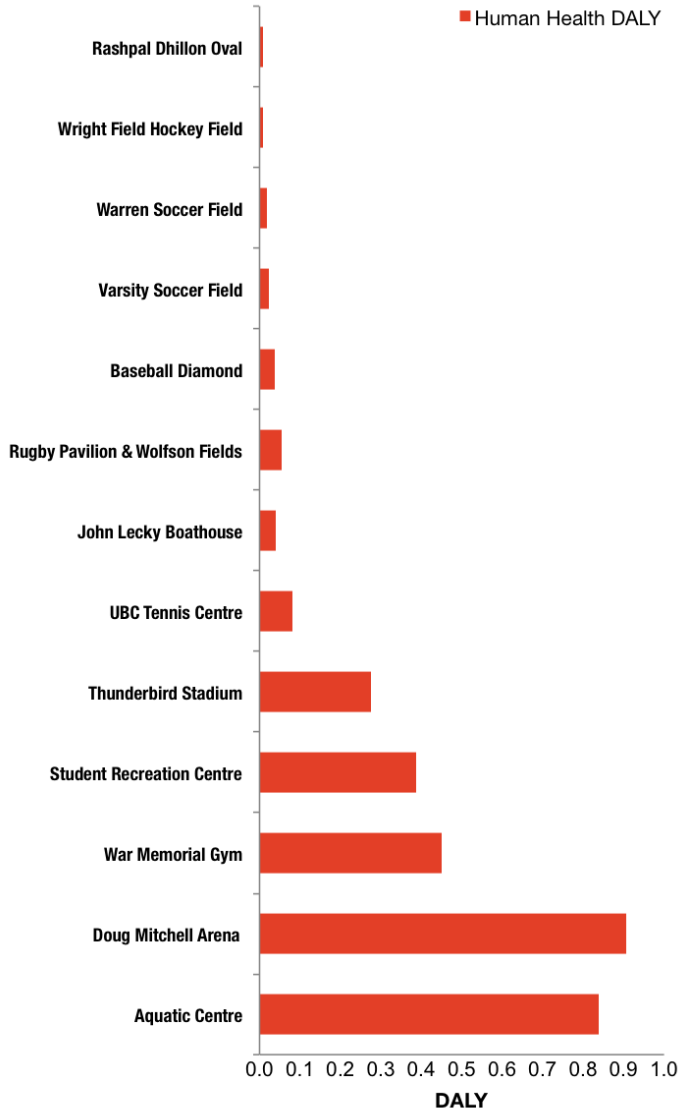
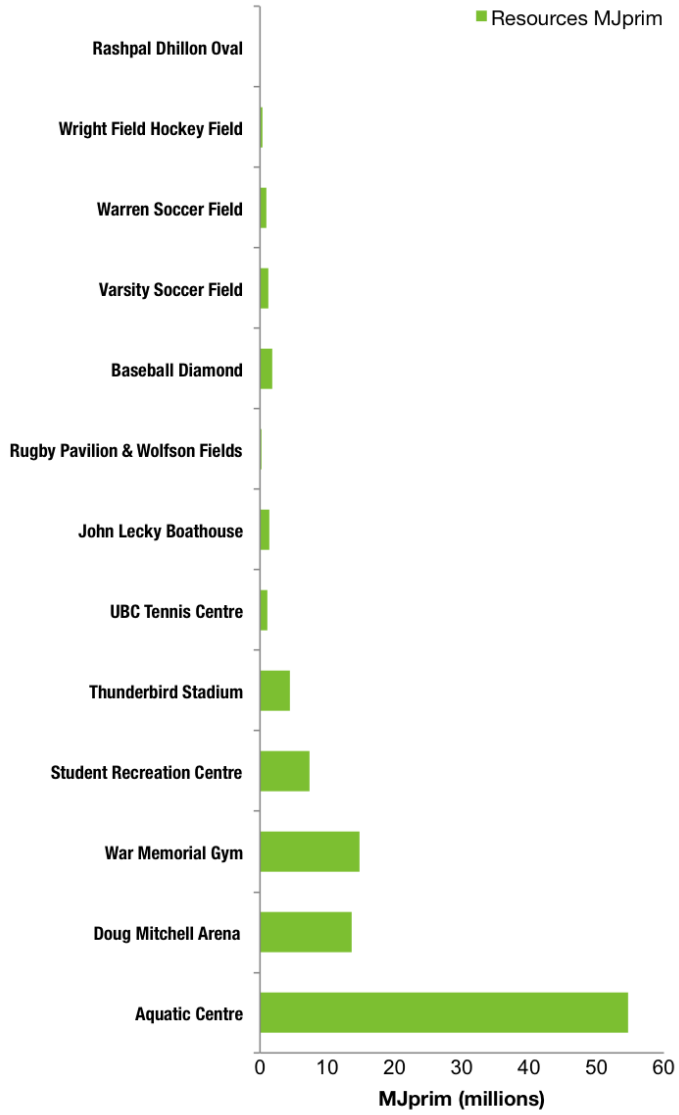


Figure 20: Resource Impacts of UBC A&R Venues from September, 2010 to September, 2011



Human Health

The total *human health* impact is approximately 3.2 disability adjusted life years (DALY's). As in the *ecosystem quality* category, the Doug Mitchell Arena, the War Memorial Gym, the Student Recreation Centre, and the Thunderbird Stadium figure most prominently. For the synthetic fields, the construction materials are the largest contributor to this category. For the grass fields, the fuel use for field maintenance is also quite significant.

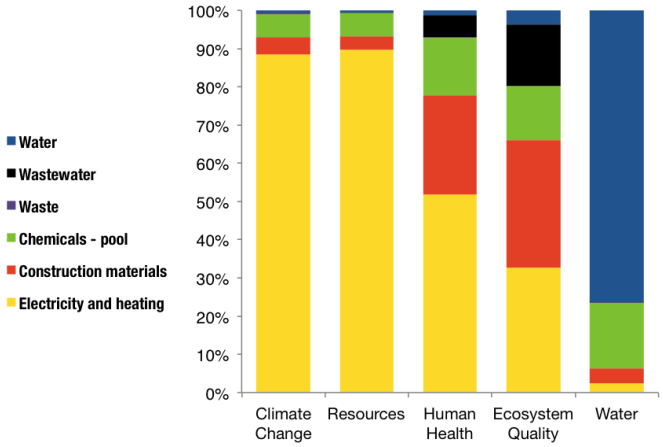
Resources

The total *resources* impact by venues is 100,000,000 MJ of primary (non-renewable) energy. The Aquatic Centre is the major contributor to this category, followed by the remaining buildings. The fields contribute a relatively small impact in comparison to the buildings. The *resources* category is typically very closely tied to the *climate change* category.

Aquatic Centre + Empire Pool [Swimming]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
3,100,000	55,000,000	0.840	430,000	73,000,000



INTERPRETATION

The results represent combined impacts from the Aquatic Centre, consisting of an indoor facility housing a 50 meter pool, and the 50 meter outdoor Empire Pool. The total impact for this venue is quite significant; in the *climate change* and *water withdrawal* damage categories the Aquatic Centre impact is roughly equivalent to all the other facilities combined.

Hydro electricity and steam for heating are major contributors in the categories of *climate change*, *resources*, *human health*, and *ecosystem quality* (88%, 90%, 52% and 33% respectively). Much of the steam use goes to pool heating, particularly for the year-round heating of the uncovered outdoor pool. UBCs planned conversion of steam to a hot water heating system should lead to a reduction in overall energy use.

Construction materials contribute less than 5% each for *climate change*, *resources,* and *water withdrawal*; but more significantly to *human health* and *ecosystem quality* at 26% and 33% respectively. The assumptions are based on average construction materials per m^2 of a typical building, which is not necessarily representative of a swimming pool.

A relatively large amount of pool chemicals are used per year; this translates into contributions of 15% for *human health*, 14% for *ecosystem quality* and 17% for *water withdrawal*.

Waste impacts are negligible at under 1% for all categories.

Wastewater impacts in the *human health* (6%) and *ecosystem quality* (16%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 75% of water becomes wastewater, with 25% lost to evaporation and leakage.

The pool uses approximately 48 million liters of municipal tap water. Including indirect *water withdrawal* from other areas, the total impact is 73 million liters.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Swimming
- Year built: 1978 [1]
- Anticipated life span: 40 years [2]
- Spectator seating capacity: 2,500 [1]
- Venue area: 7,688 m2 (AC) & 1,314 m2 (Empire) [3]
- Venue volume: 26,429 m3 (AC) [3]
- Floors: 3 [3]
- Primary construction materials: Concrete [3]
- Grid electricity: 1,546,800 kWh (AC) [4]
- Steam: 3,361,318 kWh (AC) & 2,546,594 kWh (Empire) [4]
- Water: 48,903,000 L [4]
- Overlay materials: negligible
- Waste: 105,716 kg [5]
- Maintenance (pool chemicals):
  - Sodium hypochlorite: 105,000 kg [6]
  - Calcium chloride: 14,000 kg [6]
  - Diatomaceous earth: 35,000 kg [6]
  - Sodium bicarbonate: 28,000 kg [6]
  - Sodium thio sulfate: 100 kg [6]
  - Calcium hypochlorite: 300 kg [6]
  - Soda ash: 50 kg [6]
  - Muriatic acid: 37,440 kg [6]
  - Cyanuric acid: 100 kg [6]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R Facilities Manager

[3] Source: UBC Campus & Community Planning & UBC LiDar

[4] Source: UBC Utilities

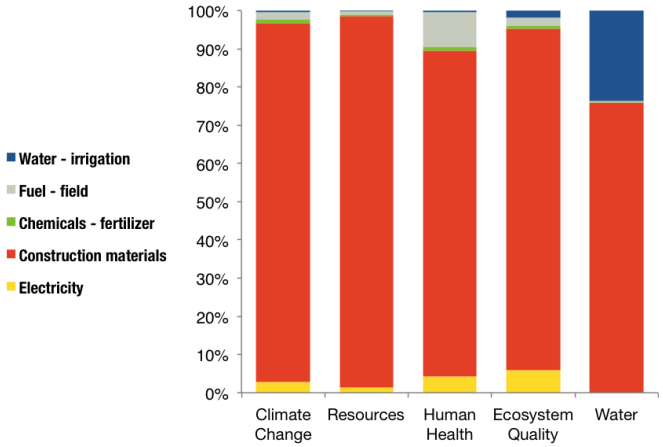
[5] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

[6] Source: UBC Aquatics facilities manager

Baseball Diamond [Baseball]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change ($kg CO_2$–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality ($PDF \cdot m^2 \cdot yr$)	Water Withdrawal (L)
60,000	1,900,000	3.70E-02	10,100	2,880,000



INTERPRETATION

The Baseball Diamond consists of a synthetic grass field and has no permanent facilities attached.

Electricity contributes 6% or less of the impact to all damage categories. These impacts come mainly from the use of hydro electricity for field lighting.

Construction materials are the primary impact across all categories at 94%, 97%, 85%, 89%, and 76% for *climate change*, *resources*, *human health*, *ecosystem quality*, and *water withdrawal* respectively. Within the materials used to construct the synthetic field, rubber contributes over 80% of the impact in all categories. Although the turf manufacturer reported using recycled rubber, the LCA process used is based on virgin rubber and therefore these results likely represent a higher impact. Also, information from the turf manufacturer was only provided for one average field type; the material composition of individual fields may vary.

The impacts from water irrigation and chemical fertilizer use are minor as they are only applied to the real grass on the field periphery.

Waste impacts are negligible.

Fuel use by tractors for field maintenance contribute 9% to *human health* and 1-2% to the remaining categories.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's Baseball
- Year built: 2008
- Anticipated life span: 10 years [1]
- Spectator seating capacity: None
- Venue area: 10,426 m2 [1]
- Field type: Synthetic grass
- Grid electricity (field lighting): 11,400 kWh [2]
- Water (for irrigation): 600,000 L [2]
- Overlay materials: Negligible
- Waste: Negligible
- Construction materials:
  - Grass (polyethylene): 1.288 kg per m2 [3]
  - Primary backing (polypropylene): 0.271 kg per m2 [3]
  - Secondary coating .61 kg per m2 [3]
  - Sand 22 kg per m2 [3]
  - Rubber 16.65 kg per m2 [3]
- Field maintenance:
  - Diesel: 1,800 L [4]
  - Fertilizer 23-3-23: 400 kg [4]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Utilities

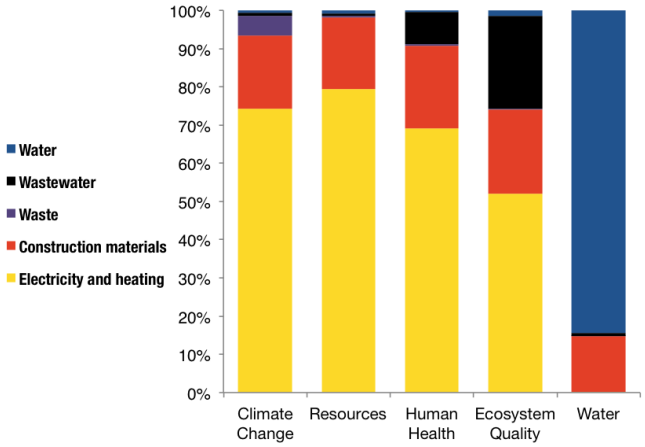
[3] Estimate based on information from turf manufacturer

[4] Source: UBC A&R maintenance

Doug Mitchell Arena [Ice Hockey]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
950,000	14,000,000	9.10E-01	450,000	26,000,000



INTERPRETATION

The Doug Mitchell Arena houses three ice hockey rinks, office space, a fitness area, and multi-purpose rooms. The new addition of a 6,000 seat arena built to LEED (Leadership in Energy and Design) Silver specifications was added in 2008 to the two existing ice hockey arenas.

Electricity and heating are the largest contributors to the impact categories of *climate change*, *resources*, *human health*, and *ecosystem quality* was energy use for electricity and heating (74%, 77%, 69% and 52% respectively). This is primarily due to hydro electricity for lighting and plug loads as well as some natural gas use for heating.

Construction materials contribute approximately 19% to *climate change*. The assumptions are based on average construction materials per square meter of a typical building, which is not necessarily representative of an ice hockey arena. The LEED Silver design specifications suggest that it likely has a lower construction–related impact than typical ice hockey arenas.

Wastewater impacts in the *human health* (8%) and *ecosystem quality* (24%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 100% of water becomes wastewater.

Waste impacts, although likely overestimated, contribute less than 5% of the impacts in all categories.

Tap water makes up the largest portion of the *water withdrawal* impacts at 84%, with the remainder associated with water requirements of the other areas.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Ice Hockey
- Year built: 2008 [1]
- Anticipated life span: 60 years [2]
- Spectator capacity: 5,000 [1]
- Venue area: 36,410 m2 [3]
- Venue volume: not available
- Floors: 3 [3]
- Primary construction materials: Concrete [3]
- Grid electricity: 4,361,241 kWh [4]
- Natural gas: 133,042 kWh [4]
- Water: 19,070,000 L [4]
- Overlay materials: negligible
- Waste: 145,640 kg [5]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R facilities manager

[3] Source: UBC Campus & Community Planning

[4] Source: UBC Utilities

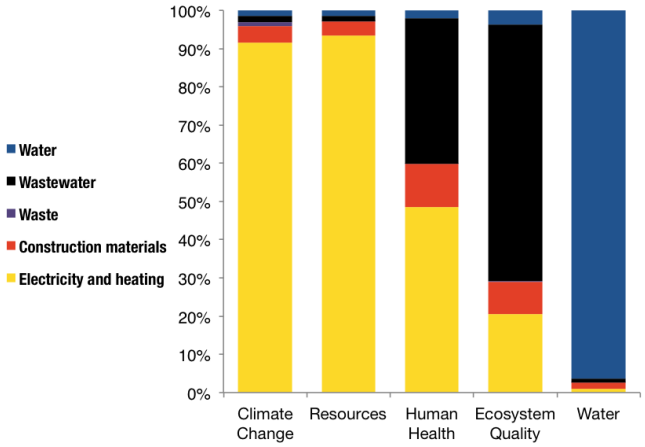
[5] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

*Note: Cooling systems is ammonia based

John M. S. Lecky Boathouse [Rowing]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
82,000	1,400,000	4.10E-02	33,000	4,600,000



INTERPRETATION

The John M. S. Lecky Boathouse is located outside of the UBC Campus, approximately 15 km to the Southeast.

Electricity and heating are the largest contributors for the impact potential categories of *climate change* at 91% and *resources* at 93%. This is largely due to grid electricity for lighting and plug loads, and natural gas for heating.

Construction materials contribute approximately 4% to *climate change*, 4% to *resources*, 11% to *human health*, 8% to *ecosystem quality*, and 2% to *water withdrawal* respectively. The assumptions are based on average construction materials per square meter of a typical building, which is not necessarily representative of this boathouse. Due to the use of primarily wood materials and the relatively low amount of materials per m^2, the construction impacts are likely overestimated.

Waste contributes a negligible impact.

Wastewater impacts in the *human health* (38%) and *ecosystem quality* (67%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 100% of water becomes wastewater.

Direct water use from tap water makes up the largest portion of the *water withdrawal* impacts of the supply chain. Wastewater impacts in the *human health* and *ecosystem quality* categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Rowing
- Year built: 2006 [1]
- Anticipated life span: 40 years [2]
- Spectator capacity: 192 [1]
- Venue area: 540 m2 [3]
- Venue volume: not available
- Floors: 2 [3]
- Primary construction materials: Wood [3]
- Grid electricity: 100,010 kWh [3]
- Natural gas: 231,056 kWh [3]
- Water: 3,855,000 L [4]
- Overlay materials: negligible
- Waste: 2,160 kg [5]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R facilities manager

[3] Source: Boathouse facilities manager

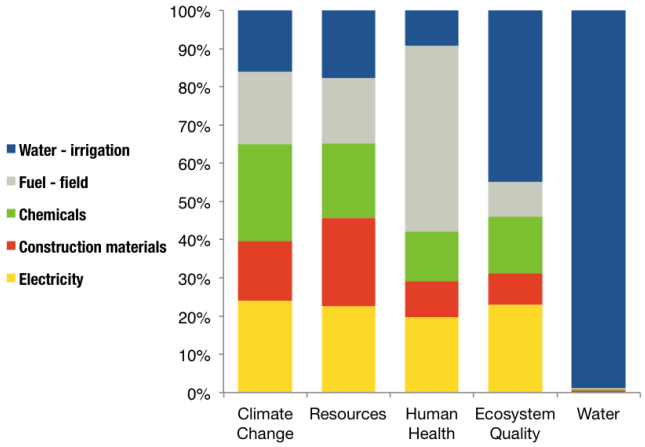
[4] Source: UBC Utilities

[5] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

Rashpal Dhillon Oval [Track & Field]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water Withdrawal (L)
7,300	120,000	1.20E+05	2,600	4,200,000



INTERPRETATION

The Rashpal Dhillon Oval consists of a synthetic track surrounding a grass field in the centre. No permanent buildings are attached.

Electricity contributes 24% for *climate change*, 23% for *resources*, 20% for *human health*, 23% for *ecosystem quality*, and <1% for *water withdrawal*. These impacts can be attributed to the use of hydro electricity for field lighting.

Construction materials are the primary impact for all categories at 16%, 23%, 9%, 8%, and <1% for *climate change*, *resources*, *human health*, *ecosystem quality*, and *water withdrawal* respectively. The material break-down of the track was not available and therefore an estimate is made for sand and rubber based on the composition of the other synthetic field types. It is recommended that further investigation be undertaken to determine the construction materials present in this venue. No construction materials are attributed to the natural grass field portion of this venue.

The impacts from chemical – fertilizer use for the grass field are 25% for *climate change*, 20% for *resources*, 13% for *human health*, 15% for *ecosystem quality*, and 1% for *water withdrawal*.

Waste impacts are negligible.

Fuel use by tractors for field maintenance contribute 19% for *climate change*, 17% for *resources*, 49% for *human health*, 9% for *ecosystem quality*, and <1% for *water withdrawal*.

Tap water makes up the largest portion of the *water withdrawal* impacts at 99%, with the remainder associated with water requirements of the other areas.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Track
- Year built: 2009
- Anticipated life span: 10 years [1]
- Spectator capacity: None
- Venue area: 10,426 m2 [1]
- Field type: Rubber track & grass field
- Grid electricity (field lighting): 11,400 kWh [2]
- Water (for irrigation): 3,681,000 L [2]
- Overlay materials: Negligible
- Waste: Negligible
- Construction materials (for track)
  - Sand: 22 kg per m2 [3]
  - Rubber: 16.65 kg per m2 [3]
- Field maintenance:
  - Diesel: 400 L [4]
  - Fertilizer 23-3-23: 1,000 kg [4]
  - Fertilizer 18-18-18: 250 kg [4]
  - Lime: 1,680 kg [4]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Utilities

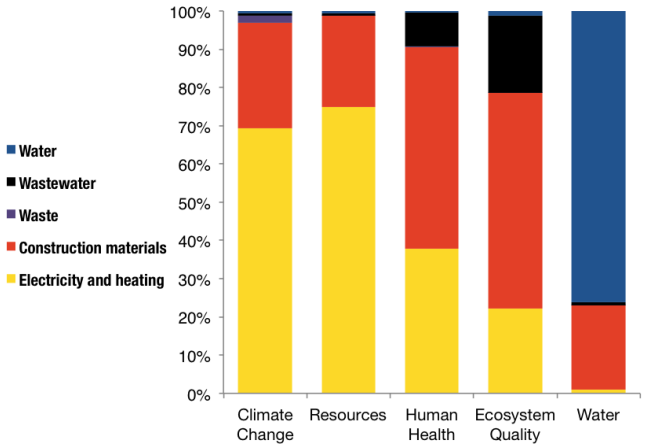
[3] Estimate based on information from turf manufacturer

[4] Source: UBC A&R maintenance

Student Recreation Centre [Fitness, Multi-use]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water Withdrawal (L)
470,000	7,400,000	3.90E-01	240,000	13,000,000



INTERPRETATION

The Student Recreation Centre is a multi-purpose building, housing fitness gyms, basketball courts, martial arts studies, office space, and fitness rooms. It does not host a specific Thunderbirds team but it is used by them for training and fitness purposes.

Electricity and heating contribute 69% for *climate change*, 75% for *resources*, 38% for *human health*, 22% for *ecosystem quality*, and 1% for *water withdrawal*. This is primarily due to hydro electricity for lighting and plug loads as well as steam for heating.

Construction materials contribute approximately 28% to *climate change*, 24% to *resources*, 53% to *human health*, 56% to *ecosystem quality*, and 22% to *water withdrawal* respectively. The assumptions are based on average construction materials per square meter of a typical building, which is not necessarily representative of this building. It is recommended that a future investigation be carried out to improve the accuracy of these estimations.

Wastewater impacts in the *human health* (9%) and *ecosystem quality* (20%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 100% of water becomes wastewater.

Waste impacts, although likely overestimated, contribute less than 2% of the impacts in all categories.

Tap water makes up the largest portion of the *water withdrawal* impacts at 76%, with the remainder associated with water requirements of the other areas.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: None
- Year built: 1995 [1]
- Anticipated life span: 60 years [2]
- Spectator capacity: none
- Venue area: 6,790 m2 [3]
- Venue volume: 37,040 m3 [4]
- Floors: 3 [3]
- Primary construction materials: Concrete [3]
- Grid electricity: 907,200 kWh [5]
- Heating from steam: 444,770 kWh [5]
- Water: 8,431,000 L [5]
- Overlay materials: negligible
- Waste: 27,160 kg [6]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R facilities manager

[3] Source: UBC Campus & Community Planning

[4] Source: UBC LiDar

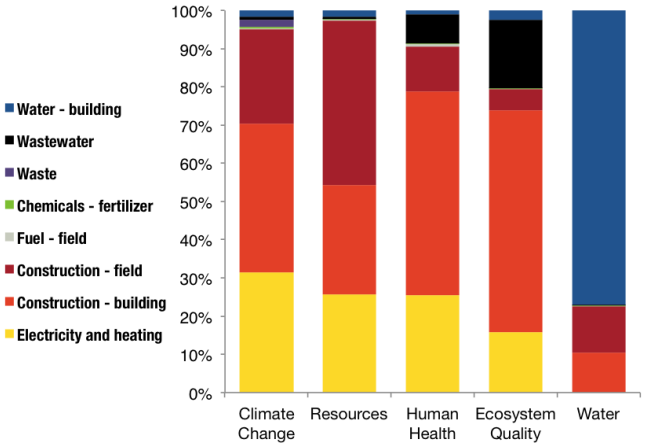
[5] Source: UBC Utilities

[6] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

Thunderbird Stadium [Football]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
240,000	4,400,000	2.70E-01	170,000	19,000,000



INTERPRETATION

The Thunderbird Stadium venue comprises cement stands with integrated office spaces and a synthetic football field.

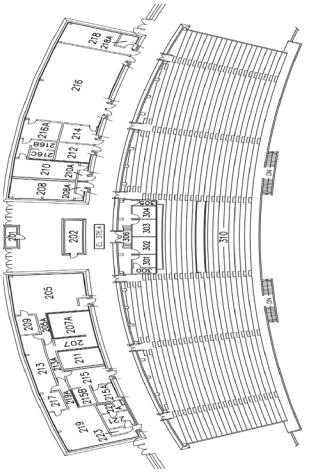
Electricity and heating contributed 31% for *climate change*, 26% for *resources*, 25% for *human health*, 16% for *ecosystem quality*, and <1% for *water withdrawal*. These impacts can be attributed to the use of hydro electricity for lights, plug loads, and heating.

Construction materials for the field contribute 25% for *climate change*, 43% for *resources*, 12% for *human health*, 5% for *ecosystem quality*, and 12% for *water withdrawal*. Construction materials for the building contribute 39%, 29%, 53%, 58%, and 10% respectively. The main impact for the synthetic is due to rubber. Although the turf manufacturer reported using recycled rubber, the LCA process used is based on virgin rubber and therefore these results likely represent a higher impact. Also, information from the turf manufacturer was only provided for one average field type; the material composition of individual fields may vary.

The impacts from chemical–fertilizers are minor contributors as they are primarily used for the real grass on the field periphery.

Waste impacts, although likely overestimated, contribute less than 2% of the impacts in all categories. Wastewater impacts in the *human health* (8%) and *ecosystem quality* (18%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 40% of water is used by the stadium and becomes wastewater, whereas the 60% used for the field does not become wastewater.

Tap water makes up the largest portion of the *water withdrawal* impacts at 77%, with the remainder associated with water requirements of the other areas.



FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's Football
- Year built: 1967
- Anticipated life span: 60 years [1]
- Spectator capacity: 3,500 [1]
- Venue area: 3,156 m2 (building) & 11,250 m2 (field) [1]
- Venue volume: 26,608 m3 [2]
- Primary construction materials: Concrete
- Field type: Synthetic grass
- Grid electricity: 490,000 kWh [3]
- Water: 12,969,000 L [3]
- Overlay materials: Negligible
- Waste: 12,600 kg
- Construction materials (for field)
  - Grass (polyethylene): 1.288 kg per m2 [4]
  - Primary backing (polypropylene): 0.271 kg per m2 [4]
  - Secondary coating .61 kg per m2 [4]
  - Sand 22 kg per m2 [4]
  - Rubber 16.65 kg per m2 [4]
- Field maintenance:
  - Diesel: 200 L [5]
  - Fertilizer 23-3-23: 475 kg [5]
  - Fertilizer 18-18-18: 125 kg [5]

[1] Source: UBC A&R facilities manager

[2] Source: UBC LiDar

[3] Source: UBC Utilities

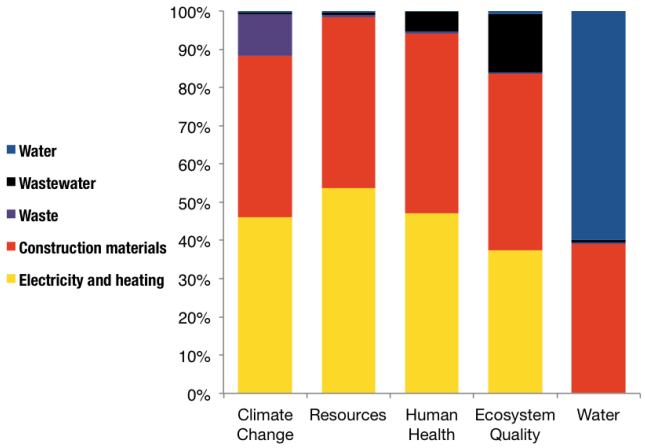
[4] Source: UBC A&R

[5] Source: UBC A&R maintenance

UBC Tennis Centre [Tennis]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
89,000	1,200,000	8.00E-02	38,000	1,900,000



INTERPRETATION

The UBC Tennis Centre was built in September, 2011 and consists of six indoor tennis courts, offices, and a viewing area.

Electricity and heating contribute 46% for *climate change*, 54% for *resources*, 47% for *human health*, 37% for *ecosystem quality*, and <1% for *water withdrawal*. This is primarily due to hydro electricity for lighting and plug loads as well as natural gas for heating.

Construction materials contribute approximately 42% to *climate change*, 45% to *resources*, 47% to *human health*, 46% to *ecosystem quality*, and 39% to *water withdrawal* respectively. The assumptions are based on average construction materials per square meter of a typical building, which is not necessarily representative of this building since it is an open structure with few walls. It is recommended that a future investigation be carried out to improve the accuracy of these estimations.

Wastewater impacts in the *human health* (5%) and *ecosystem quality* (15%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 100% of water becomes wastewater.

Waste impacts, although likely overestimated, contribute 11% to *climate change* and less than 1% of the impacts in the other categories.

Tap water makes up the largest portion of the *water withdrawal* impacts at 60%, with the remainder associated with water requirements of the other areas. A full year's worth of water metering is not yet available and therefore an estimate is made based on the first four months of usage.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Tennis
- Year built: 2011 [1]
- Anticipated life span: 60 years [2]
- Spectator capacity: none [1]
- Venue area: 7,178 m2 [3]
- Venue volume: not available
- Floors: 1 [3]
- Primary construction materials: Steel [3]
- Grid electricity: 264,600 kWh [4]
- Heating from natural gas: 540 kWh [4]
- Water: 1,000,000 L [5]
- Overlay materials: Negligible
- Waste: 29,000 kg [6]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R facilities manager

[3] Source: UBC Campus & Community Planning

[4] Source: UBC Utilities

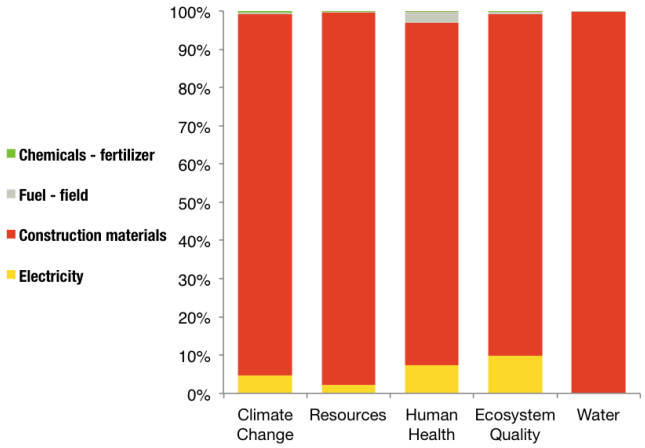
[5] Estimate based on average use of other UBC A&R buildings (water meter information not yet available)

[6] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

Varsity Field [Soccer]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
38,000	1,200,000	2.20E-02	6,200	1,400,000



INTERPRETATION

The Varsity Soccer Field consists of a synthetic grass field and has no permanent facilities attached.

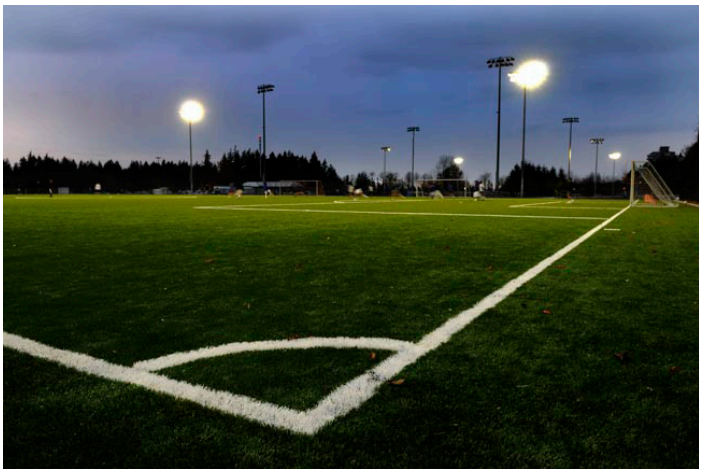
Electricity and heating contribute 10% or less of impacts to all damage categories. These impacts can be attributed to the use of hydro electricity for field lighting.

Construction materials are the primary impact for all categories at 95%, 97%, 90%, 89%, and 100% for *climate change*, *resources*, *human health*, *ecosystem quality*, and *water withdrawal* respectively. Within the materials used to construct the synthetic field, rubber contributes over 80% of the impact in all categories. Although the turf manufacturer reported using recycled rubber, the LCA process used is based on virgin rubber and therefore these results likely represent a higher impact. Also, information from the turf manufacturer was only provided for one average field type; the material composition of individual fields may vary.

The impacts from water irrigation and chemical fertilizer use are minor as they are only applied to the real grass on the field periphery.

Waste impacts are negligible at under 0.1% for all categories.

Fuel use by tractors for field maintenance contribute 3% to the *human health* impact and less than 1% to the remaining categories.



FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's Soccer
- Year built: 2008
- Anticipated life span: 10 years [1]
- Spectator capacity: 300 [1]
- Venue area: 6,898 m2 [1]
- Field type: Synthetic grass
- Grid electricity (field lighting): 11,400 kWh [2]
- Water (for irrigation): 0 L [2]
- Overlay materials: Negligible
- Waste: Negligible
- Construction materials (for field)
  - Grass (polyethylene): 1.288 kg per m2 [3]
  - Primary backing (polypropylene): 0.271 kg per m2 [3]
  - Secondary coating .61 kg per m2 [3]
  - Sand 22 kg per m2 [3]
  - Rubber 16.65 kg per m2 [3]
- Field maintenance:
  - Diesel: 30 L [4]
  - Fertilizer 23-3-23: 75 kg [4]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Utilities

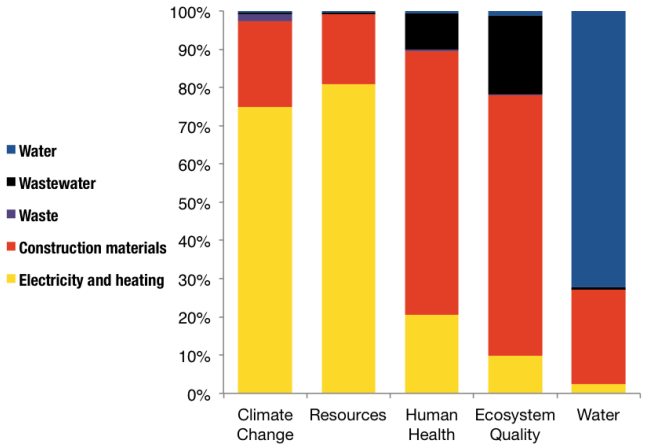
[3] Source: UBC A&R

[4] Source: UBC A&R maintenance

War Memorial Gym [Basketball, Volleyball]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
880,000	15,000,000	4.50E-01	300,000	17,000,000



INTERPRETATION

The War Memorial Gymnasium consists of an indoor basketball/volleyball gymnasium with spectator seats, offices, classrooms, and research laboratories.

Electricity and heating contribute 75% for *climate change*, 81% for *resources*, 21% for *human health*, 10% for *ecosystem quality*, and 2% for *water withdrawal*. This is primarily due to hydro electricity for lighting and plug loads as well as steam for heating.

Construction materials contribute approximately 22% to *climate change*, 18% to *resources*, 69% to *human health*, 68% to *ecosystem quality*, and 25% to *water withdrawal* respectively. The assumptions are based on average construction materials per m^2 of a typical building, which is not necessarily representative of this building since it has a number of open spaces with few walls. It is recommended that a future investigation be carried out to improve the accuracy of these estimations.

Wastewater impacts in the *human health* (10%) and *ecosystem quality* (21%) categories are a result of treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that 100% of water becomes wastewater.

Waste impacts, although likely overestimated, contribute less than 2% of the impacts in all categories.

Tap water makes up the largest portion of the *water withdrawal* impacts at 72%, with the remainder associated with water requirements of the other areas.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Basketball, Men's & Women's Volleyball
- Year built: 1950 [1]
- Anticipated life span: 65 years [2]
- Spectator capacity: 2,800 [1]
- Venue area: 12, 674 m2 [3]
- Venue volume: 61,082 m3 [3]
- Floors: 5 [3]
- Primary construction materials: Concrete [3]
- Grid electricity: 275,000 kWh [4]
- Heating from steam: 1,469,000 kWh [4]
- Water: 10,840,000 L [4]
- Overlay materials: Negligible
- Waste: 51,000 kg [5]

[1] Source: www.athletics.ubc.ca

[2] Source: UBC A&R facilities manager

[3] Source: UBC Campus & Community Planning

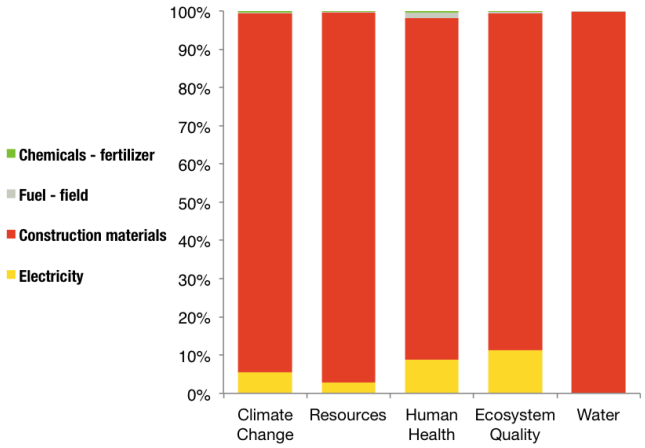
[4] Source: UBC Utilities

[5] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

Warren Field [Soccer]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m^2•yr)	Water Withdrawal (L)
31,000	970,000	1.80E-02	5,400	1,200,000



INTERPRETATION

The Warren Soccer Field consists of a synthetic grass field and has no permanent facilities attached

Electricity and heating contribute 11% or less of impacts to all damage categories. These impacts can be attributed to the use of hydro electricity for field lighting.

Construction materials were the primary impact for all categories at 93%, 97%, 88%, 88%, and 100% for *climate change*, *resources*, *human health*, *ecosystem quality*, and *water withdrawal* respectively. Within the materials used to construct the synthetic field, rubber contributes over 80% of the impact in all categories. Although the turf manufacturer reported using recycled rubber, the LCA process used is based on virgin rubber and therefore these results likely represent a higher impact. Also, information from the turf manufacturer was only provided for one average field type; the material composition of individual fields may vary.

The impacts from water irrigation and chemical fertilizer use are minor as they are only applied to the real grass on the field periphery.

Waste impacts are negligible at under 0.1% for all categories.

Fuel use by tractors for field maintenance contribute 3% to the *human health* impact and less than 1% to the remaining categories.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Women's Soccer
- Year built: 2008
- Anticipated life span: 10 years [1]
- Spectator capacity: 300 [1]
- Venue area: 5,434 m2 [1]
- Field type: Synthetic grass
- Grid electricity (field lighting): 11,400 kWh [2]
- Water (for irrigation): 0 L [2]
- Overlay materials: Negligible
- Waste: Negligible
- Construction materials (for track)
  - Grass (polyethylene): 1.288 kg per m2 [3]
  - Primary backing (polypropylene): 0.271 kg per m2 [3]
  - Secondary coating .61 kg per m2 [3]
  - Sand 22 kg per m2 [3]
  - Rubber 16.65 kg per m2 [3]
- Field maintenance:
  - Diesel: 31 L [4]
  - Fertilizer 23-3-23: 75 kg [4]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Utilities

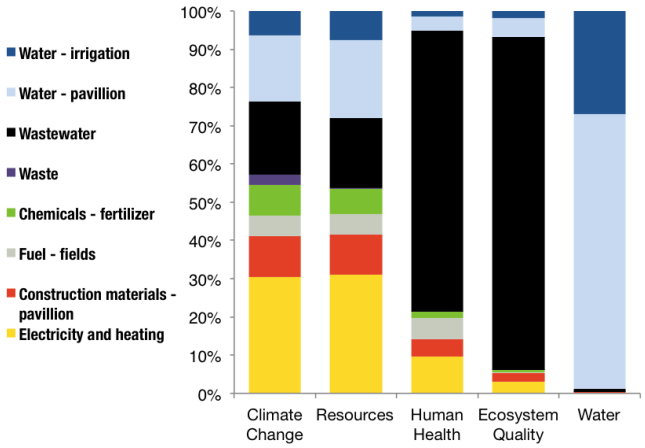
[3] Estimate based on information from turf manufacturer

[4] Source: UBC A&R maintenance

Wolfson Fields & Pavilion [Rugby]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
19,000	275,000	5.50E-02	66,000	16,000,000



INTERPRETATION

The Rugby venue comprises two grass fields and a small wood frame pavilion with locker rooms and office space.

Electricity and heating contribute 30% for *climate change*, 31% for *resources* and less than 10% in the other categories. This is primarily due to hydro electricity for lighting, plug loads, and heating.

Construction materials contribute 11% to *climate change*, 10% to *resources*, 5% to *human health*, 2% to *ecosystem quality*, and <1% to *water withdrawal* respectively. The assumptions are based on average construction materials per square meter of a typical building, which is not necessarily representative of this venue. It is recommended that a future investigation be carried out to improve the accuracy of these estimations.

The impacts from chemical fertilizer use for the grass field are 8% for *climate change*, 7% for *resources*, 2% for *human health*, 1% for *ecosystem quality*, and <1% for *water withdrawal*.

Waste impacts, although likely overestimated, contribute less than 3% of the impacts in all categories

Wastewater impacts contribute 19% for *climate change*, 18% for *resources*, 73% for *human health* and 87% for *ecosystem quality*. Wastewater impacts are large compared to other venues due to the high water consumption for the relatively small pavilion. Impacts include treatment of wastewater contents and the associated infrastructure materials, transports, and land use burdens. This scenario assumes that only the water used by the pavilion becomes wastewater; the water for irrigation is evaporated of drains naturally.

Tap water used by the pavilion makes up the largest portion of the *water withdrawal* impacts at 72%, followed by 27% from water for irrigation. The remainder is associated with water requirements of the other areas.

Photo by Komail Naqvi

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's & Women's Rugby
- Year built: 1963
- Anticipated life span: 50 years [1]
- Spectator capacity: 3,500 [1]
- Venue area: 376 m2 [2] (pavilion) & 13,796 m2 (fields) [1]
- Venue volume (pavilion): 1,309 m3 [2]
- Floors: 1 [2]
- Primary construction materials: Wood [2]
- Field type: Grass
- Grid electricity (pavilion): 36,700 kWh [3]
- Water: 10,017,000 L (pavilion) & 7,525,000 L (fields) [3]
- Overlay materials: Negligible
- Waste: 1,500 kg [5]
- Field maintenance:
  - Diesel: 600 L [6]
  - Fertilizer 23-3-23: 1,500 kg [6]
  - Fertilizer 18-18-18: 500 kg [6]
  - Lime: 3,600 kg [6]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Campus and Community Planing & UBC LiDar

[3] Source: UBC Utilities (electricity figure missing, estimate for pavilion based on 100 kWh per m2 based on usage of other Athletics buildings)

[4] Source: UBC A&R

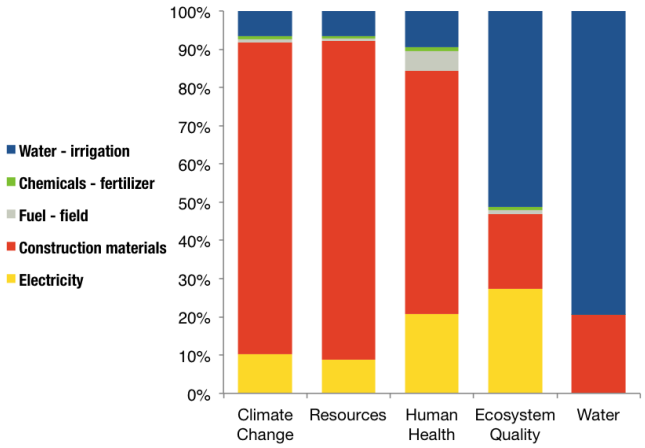
[5] Estimate based on UBC average of 4 kg waste per m2 per year (source: UBC Sustainability Office)

[5] Source: UBC A&R maintenance

Wright Fields [Field Hockey]

IMPACTS FOR ONE YEAR – SEPT 2011/12

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
17,000	300,000	7.80E-03	2,200	5,100,000



INTERPRETATION

The Wright Field Hockey Field consists of a synthetic turf field and has no permanent facilities attached.

Electricity and heating contribute 11% to *climate change*, 9% to *resources*, 22% to *human health*, and 55% to *ecosystem quality*. These impacts can be attributed to the use of hydro electricity for field lighting.

Construction materials are the primary impact for most categories at 78%, 89%, 66%, 39%, and 99% for *climate change*, *resources*, *human health*, *ecosystem quality*, and *water withdrawal* respectively. Within the materials used to construct the synthetic field, nylon for the synthetic grass contribute the majority of impacts in all categories. Information from the turf manufacturer was only provided for one average field type; the material composition of individual fields may vary.

The impacts from water irrigation and chemical fertilizer use are minor as they are only applied to the real grass on the field periphery.

Waste impacts are negligible at under 0.1% for all categories.

Fuel use by tractors for field maintenance contribute 11% to the *human health* impact and less than 5% to the remaining categories.

FACTS & FIGURES

(Based on annual consumption Sept. 2010 - Sept. 2011)

- Varsity sports teams: Men's Baseball
- Year built: 2003
- Anticipated life span: 8 years [1]
- Spectator capacity: none
- Venue area: 5,973 m2 [1]
- Field type: Synthetic turf
- Grid electricity (field lighting): 11,400 kWh [2]
- Water (for irrigation): 3,500,000 L [2]
- Overlay materials: Negligible
- Waste: Negligible
- Construction materials (for track)
  - Grass (nylon): 2.046 kg per m2 [3]
  - Primary backing (polypropylene): 0.26 kg per m2 [3]
  - Secondary coating 0.186 kg per m2 [3]
  - Sand 22 kg per m2 [3]
- Field maintenance:
  - Diesel: 40 L [4]
  - Fertilizer 23-3-23: 100 kg [4]

[1] Source: UBC A&R facilities manager

[2] Source: UBC Utilities

[3] Estimate based on information from turf manufacturer

[4] Source: UBC A&R maintenance

3.3 Thunderbird Teams

This section provides an overview of the environmental impacts attributed to each UBC Thunderbirds team for the 2011/12 season. Associated activity data is also included for:

- average number of team members (if they vary significantly between home and away games this is noted)
- number of events (home, regular, playoff)
- % games played at home versus away
- allocation of associated venue to the team (estimated on an annual % basis to cover unused time, practice times, rentals to other users, office use, etc.)
- number of annual spectators in attendance
- total km travelled by the UBC team
- total number of UBC hotel nights (per person)
- total paper and waste generated

CARBON FOOTPRINT PER TEAM

The *carbon footprint* per team is shown in Figure 24 (next page). Travel dominates *climate change* impacts — and indeed all damage categories except water (see following pages for detailed impacts per team for all damage categories). Travel impacts are mostly due to long distance travel by the teams and spectators. Importantly, on a per team or per event basis, travel has a larger impact than venues because only a portion of the venue is allocated (see "Sensitivity Analysis" on page 60). Also, certain teams such as Baseball, Skiing, and Golf, don't host any events at UBC and therefore have their venue impacts displaced to the host Universities.

CARBON FOOTPRINT INTENSITY PER TEAM

Figure 25 (next page) shows the *carbon footprint* intensity per participant for each team. Intensity is arrived at by dividing the total impact by the number of participants attending each team's events over a season. UBC A&R has a mandate to increase the total number of spectators at events and therefore a key aim should be to reduce the intensity per person along with the total impact.

The impact intensity per team varies significantly and is affected by a number of factors including the number of games requiring long distance travel; the number of spectators and staff; the number of team members; the impact and use of the associated venue; and the number of home and away games.

CARBON FOOTPRINT OF PARTICIPANT TRAVEL

Participant travel is dominant for teams, however significant variation exists between participant types.

The total *carbon footprint* is dominated by spectators and teams, largely from air travel (Figure 22). On a per person basis (intensity), spectators and staff contribute less (Figure 23). This is due to the large amount of long-distance travel by teams. The discrepancy between UBC and opponent teams is explained by the fact that both home and away games are counted for UBC whereas only away games are counted for the visiting team (as defined by the system boundary).

Figure 22: Carbon Footprint for total participants travelling to Thunderbird events in the 2011/12 season

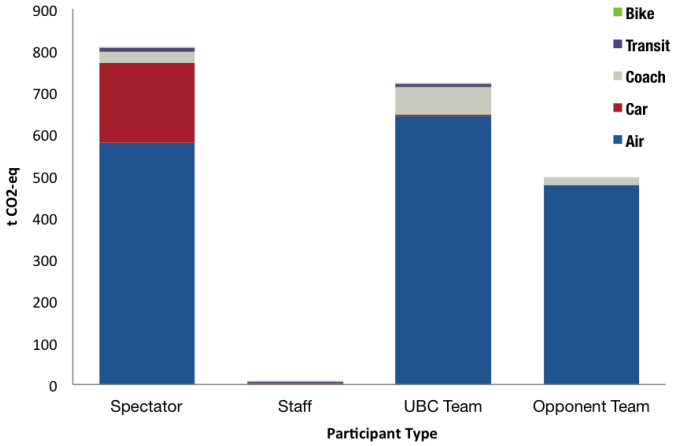


Figure 23: Carbon Footprint per typical participant travelling Thunderbird events in the 2011/12 season

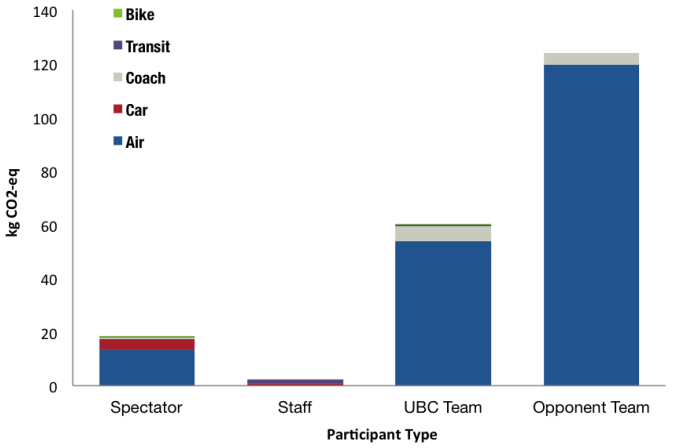


Figure 24: Total Carbon Footprint for each Thunderbird team in the 2011/12 season.

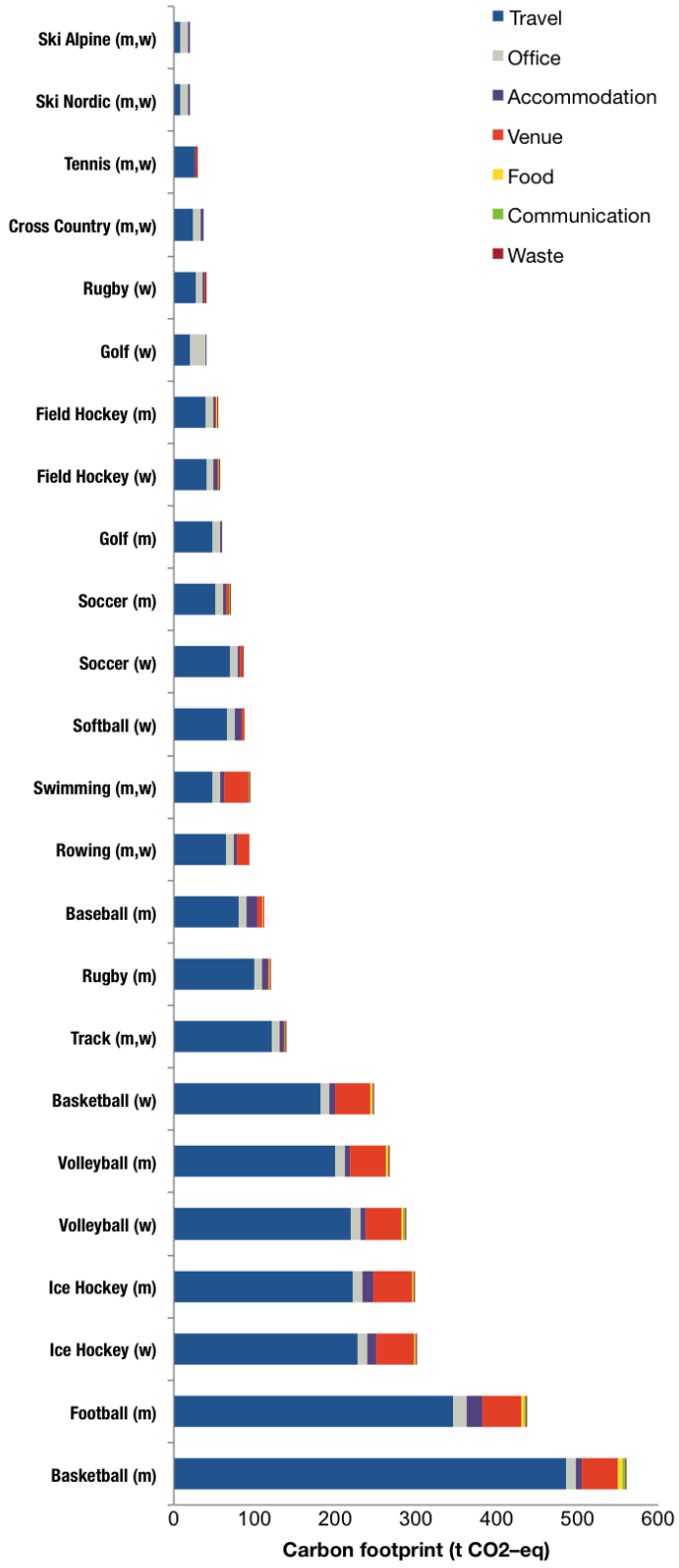
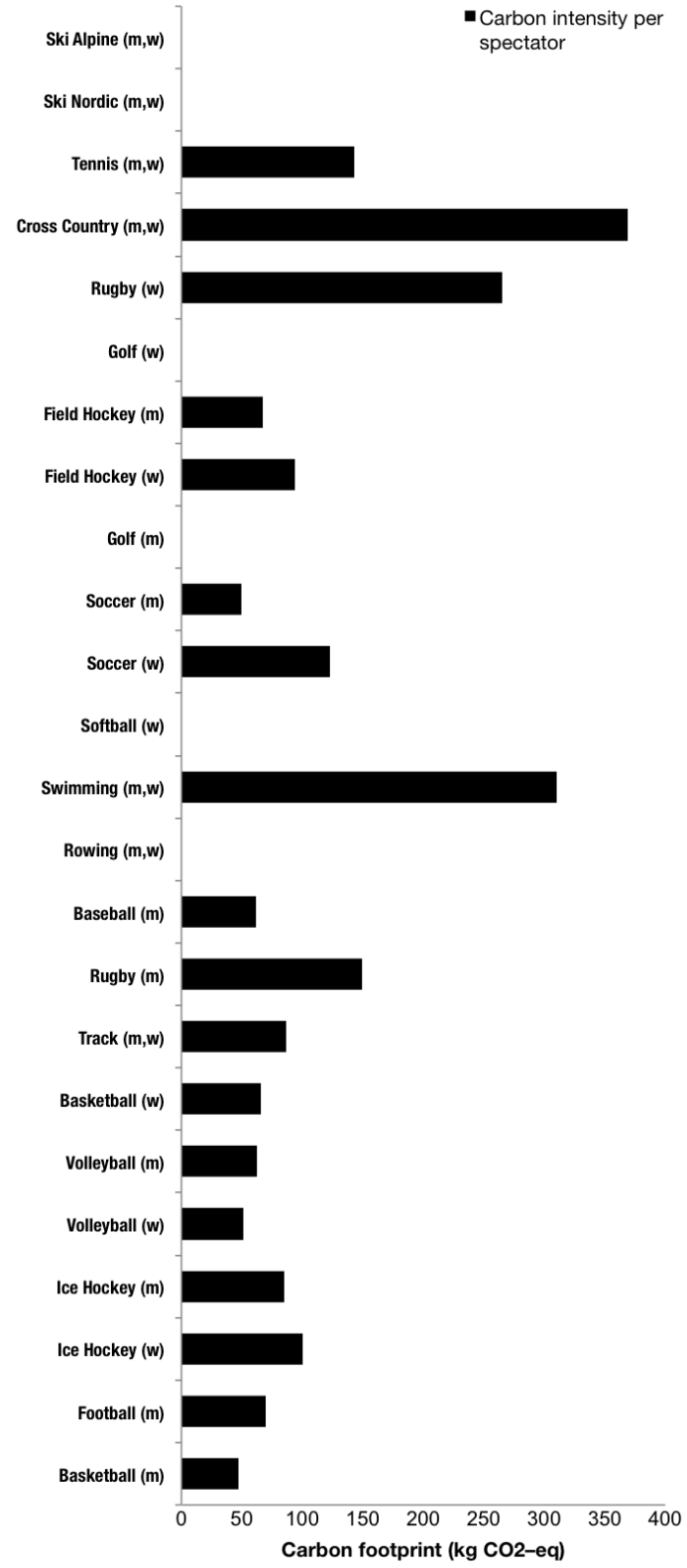


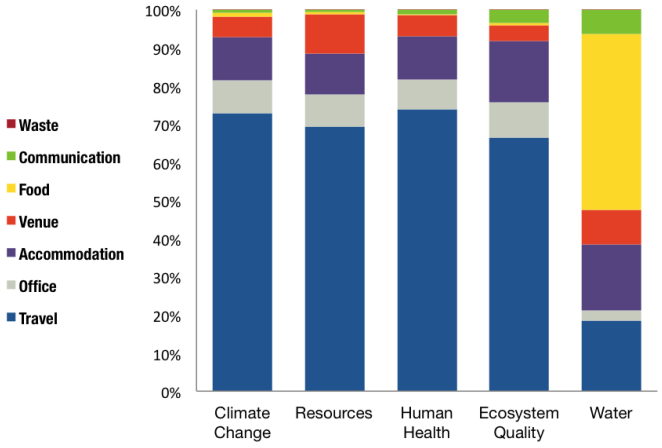
Figure 25: Carbon Footprint per typical participant (includes staff/spectator/team) of each Thunderbird team in the 2011/12 season.



Baseball (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
110,000	1,800,000	6.70E-02	24,000	2,400,000



FACTS & FIGURES

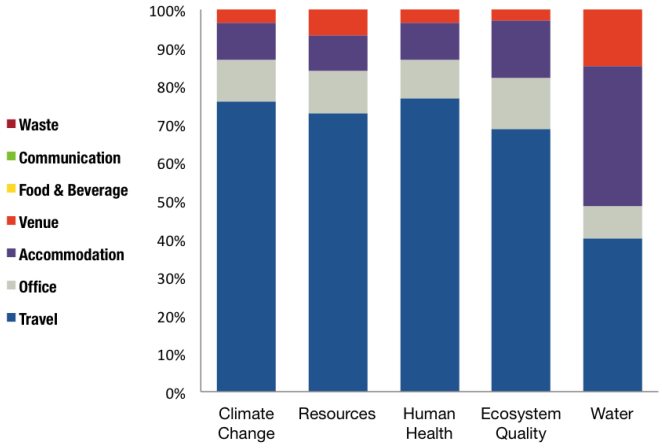
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 29
- Events: 0 Exhibition / 25 Regular / 11 Playoff
- Games played at home: None
- Venue: Baseball Diamond (10% annual allocation)
- Spectators: 1,800
- UBC team travel: 11,000 km
- UBC team hotel nights: 22
- Paper: 50 kg
- Waste generated: 120 kg

Softball (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
110,000	1,800,000	6.70E-02	24,000	2,400,000



FACTS & FIGURES

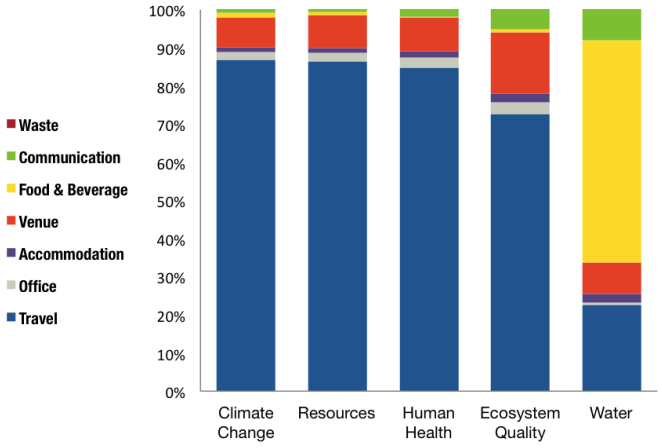
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 0 Exhibition / 33 Regular / 4 Playoff
- Games played at home: None
- Venue: Baseball Diamond (5% annual allocation)
- Spectators: Not applicable
- Total UBC team travel: 19,000 km
- UBC team hotel nights: 23
- Paper: 0 kg
- Waste generated: 0 kg

Basketball (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
560,000	8,600,000	2.50E-01	93,000	10,000,000



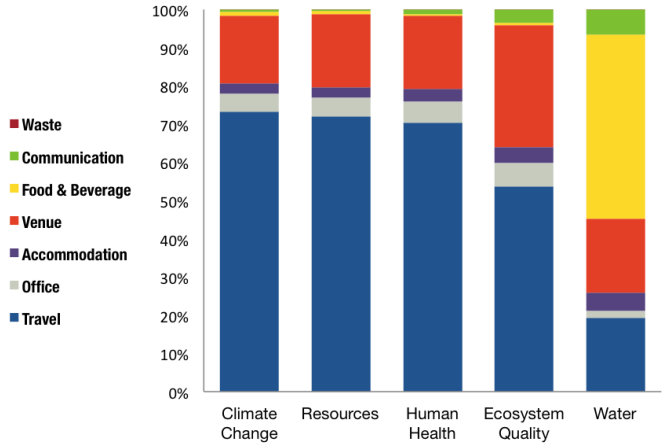
FACTS & FIGURES -
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 11 Exhibition / 19 Regular / 7 Playoff
- Games played at home: 52%
- Venue: War Memorial Arena (5% annual allocation)
- Spectators: 12,000
- UBC team travel: 16,000 km
- UBC team hotel nights: 18
- Paper: 270 kg
- Waste generated at events: 670 kg

Basketball (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
250,000	3,800,000	1.20E-01	47,000	4,400,000



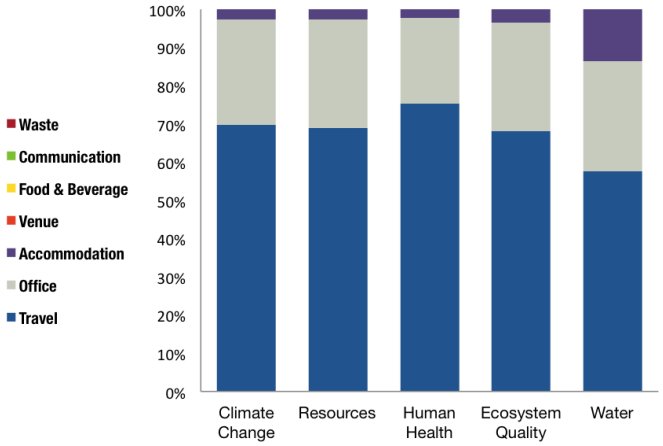
FACTS & FIGURES
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 8 Exhibition / 17 Regular / 7 Playoff
- Games played at home: 44 %
- Venue: War Memorial Arena (5% annual allocation)
- Spectators: 3,800
- UBC team travel: 13,000 km
- UBC hotel nights: 19
- Paper: 90 kg
- Waste generated at events: 230 kg

Cross Country (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
34,000	540,000	2.40E-02	8,000	220,000



FACTS & FIGURES

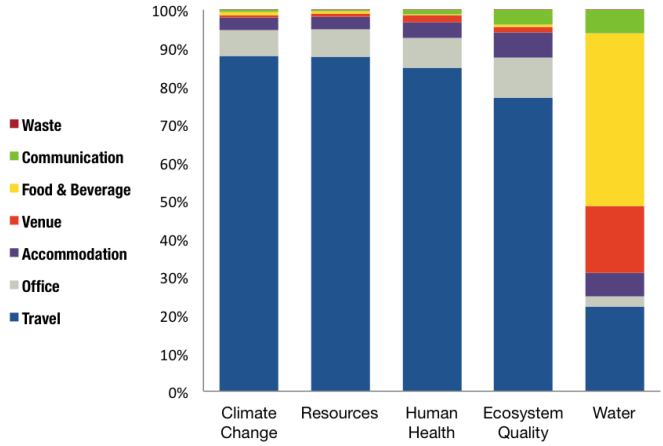
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 0 Exhibition / 4 Regular / 4 Playoff
- Games played at home: 13 %
- Venue: Off-site (no venue allocation)
- Spectators: 100
- UBC team travel: 6,400 km
- UBC team hotel nights: 4
- Paper: 0 kg
- Waste generated: 0 kg

Track and Field (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
140,000	2,100,000	6.70E-02	21,000	2,400,000



FACTS & FIGURES

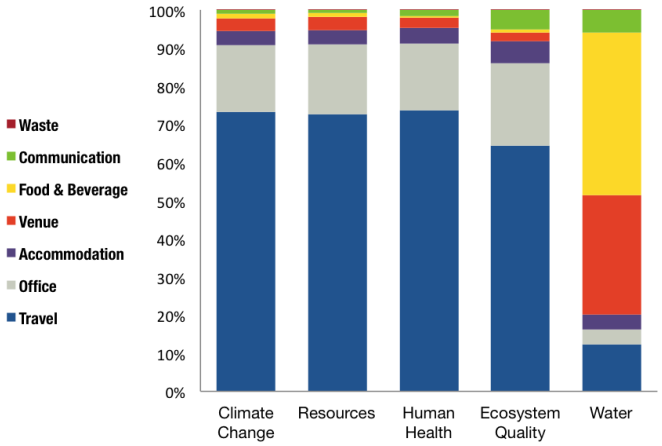
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 45
- Events: 0 Exhibition / 19 Regular / 3 Playoff
- Games played at home: 32 %
- Venue: Rashpal Dhillon Oval (10% annual allocation)
- Spectators: 1,600
- UBC team travel: 13,000 km
- UBC team hotel nights: 9
- Paper: 50 kg
- Waste generated: 120 kg

Field hockey (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
54,000	840,000	3.00E-02	11,000	1,600,000



FACTS & FIGURES

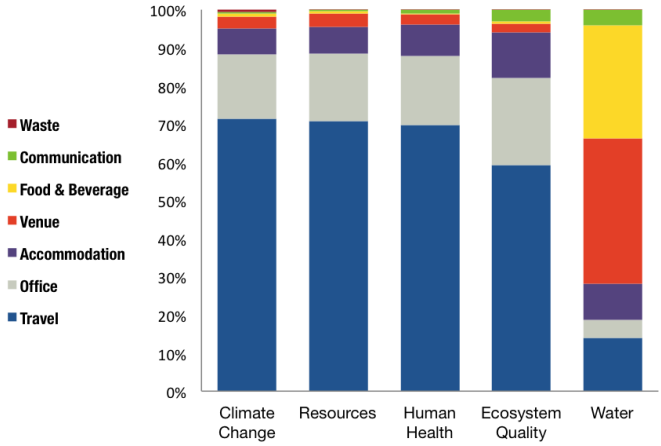
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 22
- Events: 4 Exhibition / 32 Regular / 0 Playoff
- Games played at home: 44 %
- Venue: Wright Field (10% annual allocation)
- Spectators: 800
- UBC team travel: 4,400 km
- UBC team hotel nights: 6
- Paper: 30 kg
- Waste generated: 80 kg

Field Hockey (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
56,000	870,000	2.90E-02	10,000	1,300,000



FACTS & FIGURES

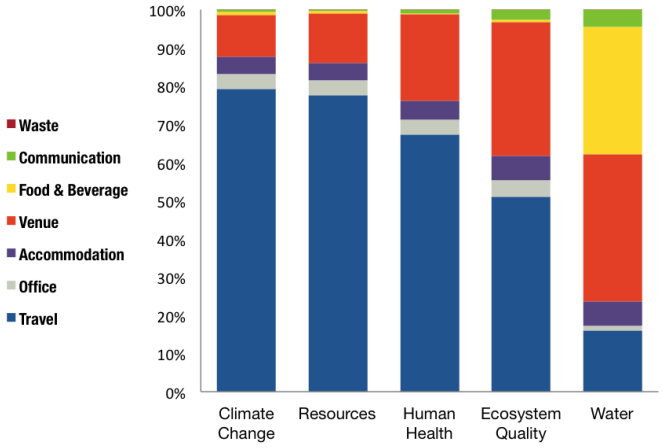
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 22
- Events: 0 Exhibition / 12 Regular / 5 Playoff
- Games played at home: 55 %
- Venue: Wright Field (10 % annual allocation)
- Spectators: 600
- Travel UBC team travel: 4,500 km
- UBC team hotel nights: 11
- Paper: 20 kg
- Waste generated: 40 kg

Football (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
440,000	6,800,000	2.40E-01	95,000	10,000,000



FACTS & FIGURES

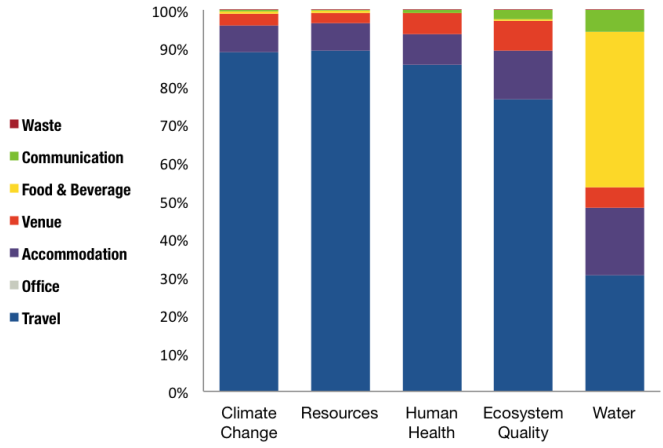
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 100 (50 on the road)
- Events: 1 Exhibition / 8 Regular / 2 Playoff
- Games played at home: 45 %
- Venue: Thunderbird Stadium (20% annual allocation)
- Spectators: 6,200
- UBC team travel: 12,000 km
- UBC team hotel nights: 10
- Paper: 150 kg
- Waste generated: 370 kg

Tennis (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
29,000	430,000	1.50E-02	4,800	360,000



FACTS & FIGURES

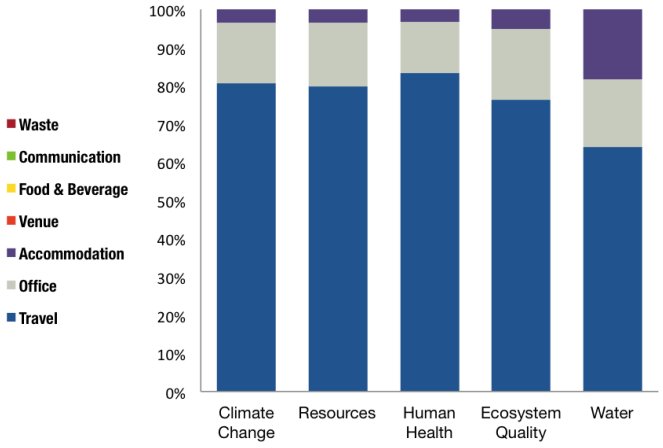
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 16
- Events: 4 Exhibition / 6 Regular / 3 Playoff
- Games played at home: 25 %
- Venue: UBC Tennis Centre (1% annual allocation)
- Spectators: 200
- UBC team travel: 8,600 km
- UBC team hotel nights: 8
- Paper: 10 kg
- Waste generated: 20 kg

Golf (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
59,000	920,000	3.90E-02	12,000	360,000



FACTS & FIGURES

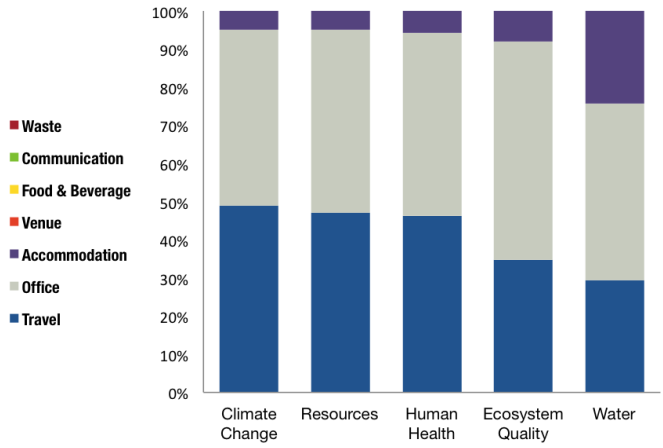
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 6
- Events: 0 Exhibition / 16 Regular / 4 Playoff
- Games played at home: None
- Venue: Off-site (no venue allocation)
- Spectators: Not applicable
- UBC team travel: 17,000 km
- UBC team hotel nights: 30
- Paper: 0 kg
- Waste generated: 0 kg

Golf (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
41,000	640,000	2.20E-02	7,900	270,000



FACTS & FIGURES

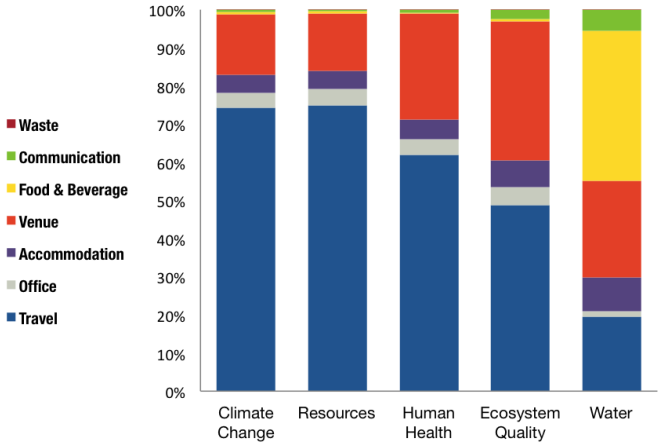
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 6
- Events: 0 Exhibition / 16 Regular / 4 Playoff
- Games played at home: None
- Venue: Off-site (no venue allocation)
- Spectators: Not applicable
- UBC team travel: 27,000 km
- Total UBC team hotel nights: 30
- Paper: 0 kg
- Waste generated: 0 kg

Ice Hockey (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
300,000	4,500,000	1.60E-01	61,000	5,100,000



FACTS & FIGURES

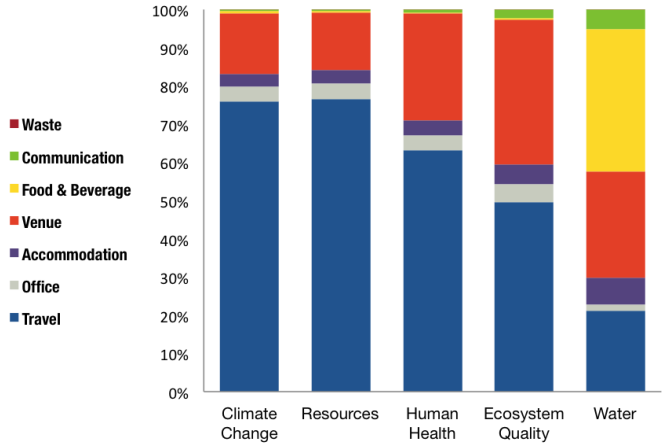
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 27
- Events: 6 Exhibition / 29 Regular / 3 Playoff
- Games played at home: 37 %
- Venue: Doug Mitchell Thunderbird Arena (5% annual allocation)
- Spectators: 3,500
- UBC team travel: 27,000 km
- UBC team hotel nights: 38
- Paper: 90 kg
- Waste generated: 220 kg

Ice Hockey (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
300,000	4,500,000	1.60E-01	59,000	4,700,000



FACTS & FIGURES

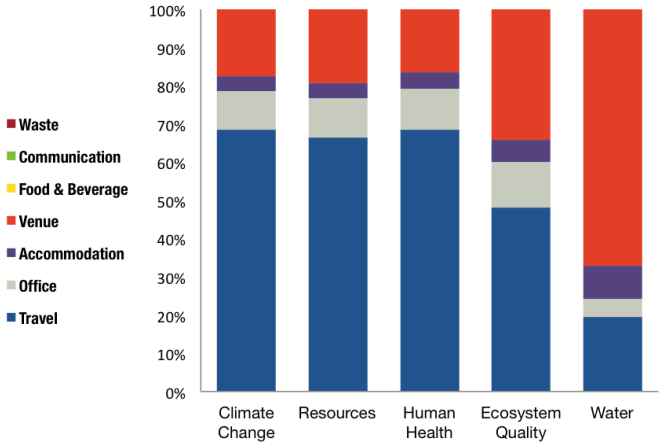
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 6 Exhibition / 23 Regular / 0 Playoff
- Games played at home: 38 %
- Venue: Doug Mitchell Thunderbird Arena (5% annual allocation)
- Spectators: 3,000
- UBC team travel: 27,000 km
- UBC team hotel nights: 24
- Paper: 80 kg
- Waste generated: 190 kg

Rowing (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
94,000	1,500,000	4.90E-02	19,000	1,400,000

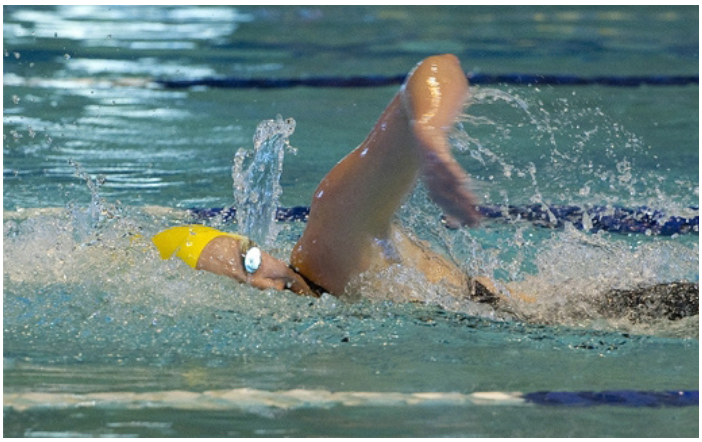


FACTS & FIGURES

(For the Season Sept. 2011 - Sept. 2012)

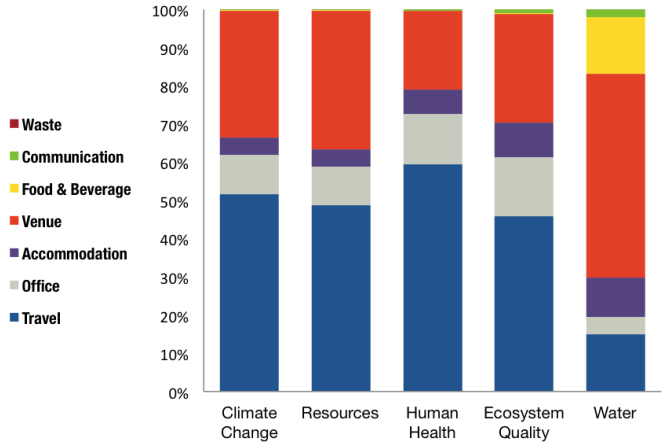
- Team members: 40
- Events: 2 Exhibition / 6 Regular / 0 Playoff
- Games played at home: None
- Venue: John M. S. Lecky Boathouse (20% annual allocation)
- Spectators: Not applicable
- UBC team travel: 12,000 km
- UBC team hotel nights: 16
- Paper: 0 kg
- Waste generated: 0 kg

Swimming (Men, Women)



IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
93,000	1,500,000	4.00E-02	15,000	1,400,000



FACTS & FIGURES

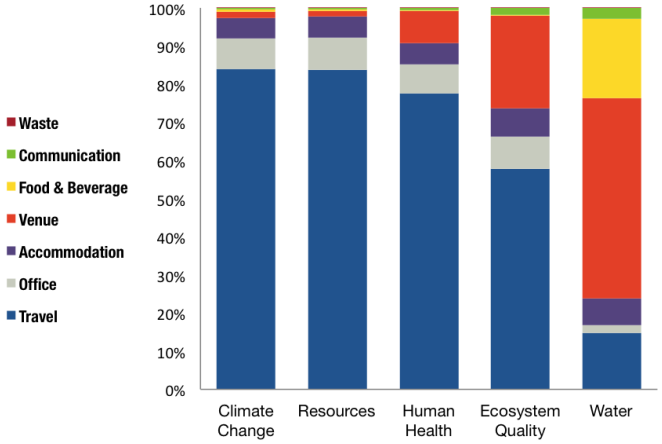
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 0 Exhibition / 13 Regular / 6 Playoff
- Games played at home: 16 %
- Venue: Aquatic Centre (1% annual allocation)
- Spectators: 300
- UBC team travel: 11,000 km
- UBC team hotel nights: 16
- Paper: 10 kg
- Waste generated: 20 kg

Rugby (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
120,000	1,800,000	6.90E-02	27,000	3,000,000



FACTS & FIGURES

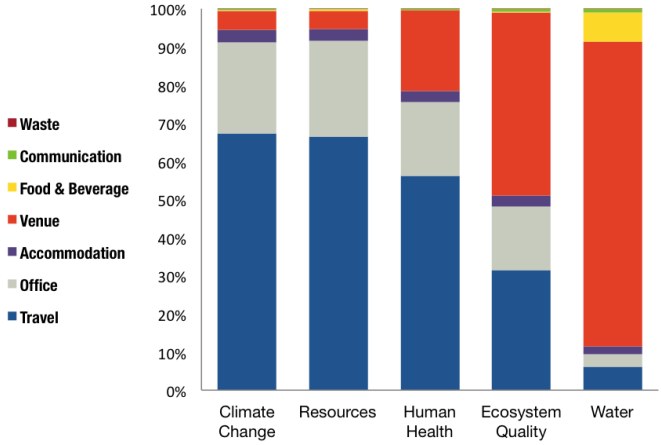
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 31
- Events: 2 Exhibition / 9 Regular / 11 Playoff
- Games played at home: 36 %
- Venue: Wolfson Fields & Rugby Pavilion (10% annual allocation)
- Spectators: 800
- UBC team travel: 9,000 km
- UBC team hotel nights: 13
- Paper: 30 kg
- Waste generated: 70 kg

Rugby (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
40,000	620,000	2.70E-02	14,000	2,000,000



FACTS & FIGURES

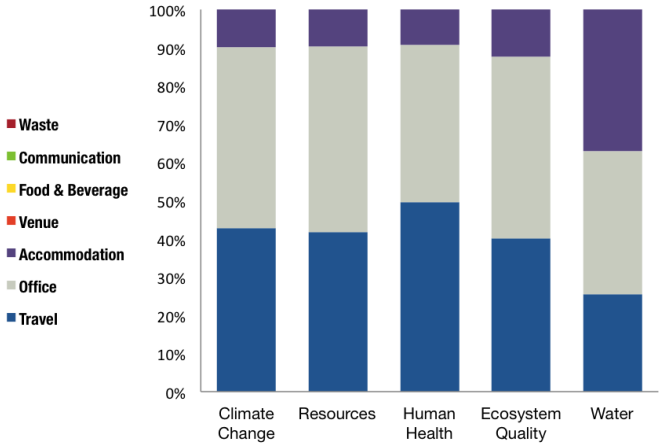
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 22
- Events: 0 Exhibition / 4 Regular / 0 Playoff
- Games played at home: 75 %
- Venue: Wolfson Fields & Rugby Pavilion (10% annual allocation)
- Spectators: 150
- UBC team travel: 100 km
- UBC team hotel nights: 3
- Paper: 10 kg
- Waste generated: 20 kg

Ski Alpine (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
20,000	320,000	1.30E-02	4,800	170,000



FACTS & FIGURES

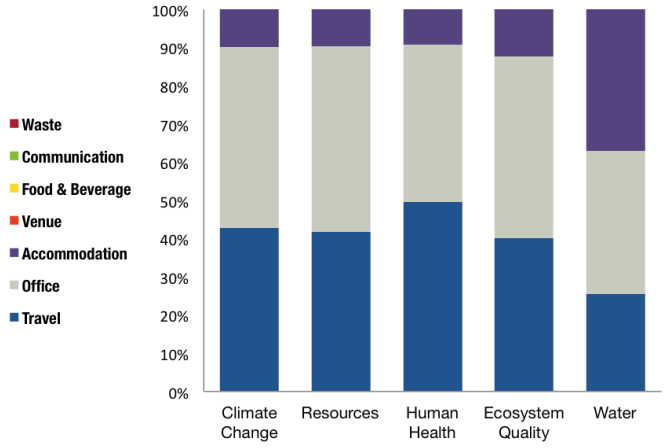
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 10
- Events: 0 Exhibition / 6 Regular / 7 Playoff
- Games played at home: None
- Venue: Off-site (no venue allocation)
- Spectators: Not applicable
- UBC team travel: 9,000 km
- UBC team hotel nights: 17
- Paper: 0 kg
- Waste generated: 0 kg

Ski Nordic (Men, Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
20,000	320,000	1.30E-02	4,800	170,000



FACTS & FIGURES

(For the Season Sept. 2011 - Sept. 2012)

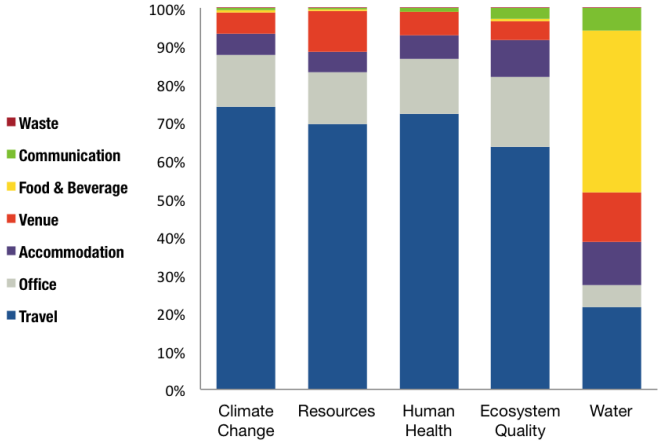
- Team members: 10*
- Events: 0* Exhibition / 6* Regular / 7* Playoff
- Games played at home: None
- Venue: Off-site (no venue allocation)
- Spectators: Not applicable
- UBC team travel: 9,000 km
- UBC team hotel nights: 17
- Paper: 0 kg
- Waste generated: 0 kg

*Note: Figures for Nordic Skiing team not available and therefore the same figures as the Alpine Skiing team are applied.

Soccer (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
69,000	1,100,000	3.70E-02	12,000	1,100,000



FACTS & FIGURES

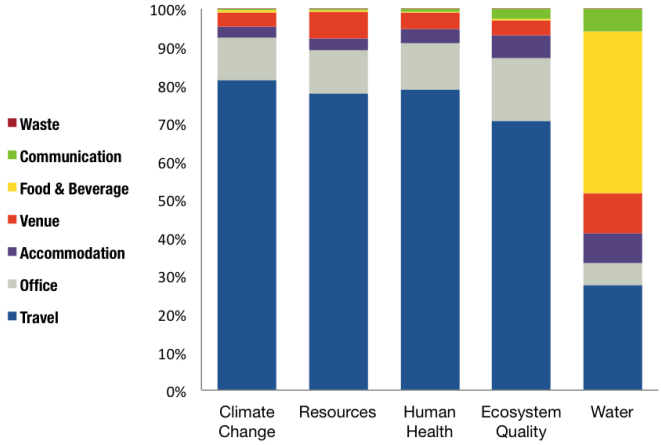
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 21
- Events: 0 Exhibition / 14 Regular / 6 Playoff
- Games played at home: 35 %
- Venue: Varsity Field (10% annual allocation)
- Spectators: 1,400
- UBC team travel: 5,000 km
- UBC team hotel nights: 11
- Paper: 20 kg
- Waste generated: 50 kg

Soccer (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
86,000	1,400,000	4.30E-02	14,000	1,100,000



FACTS & FIGURES

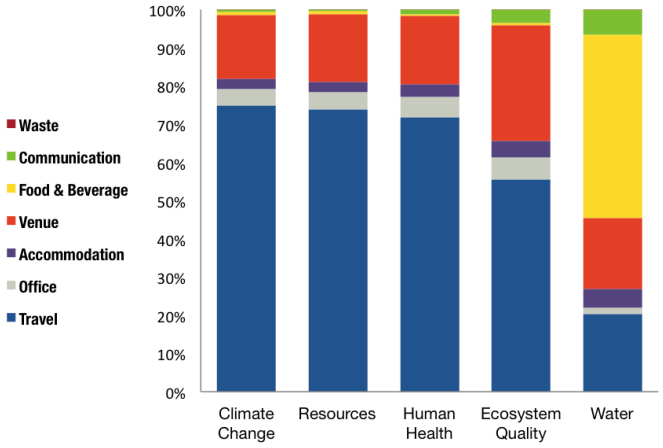
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 22
- Events: 0 Exhibition / 12 Regular / 4 Playoff
- Games played at home: 44 %
- Venue: Warren Field (10% annual allocation)
- Spectators: 700
- UBC team travel: 9,000 km
- UBC team hotel nights: 7
- Paper: 20 kg
- Waste generated: 50 kg

Volleyball (Men)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
270,000	4,100,000	1.30E-01	50,000	4,600,000



FACTS & FIGURES

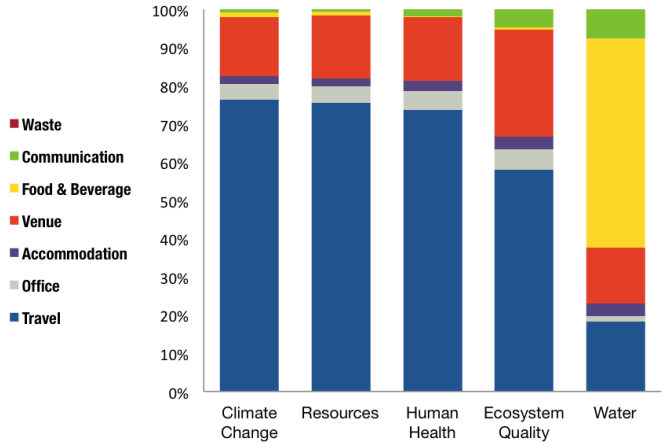
(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 15 Exhibition / 20 Regular / 2 Playoff
- Games played at home: 29 %
- Venue: War Memorial Gym (5% annual allocation)
- Spectators: 4,200
- UBC team travel: 31,000 km
- UBC team hotel nights: 28
- Paper: 100 kg
- Waste generated: 250 kg

Volleyball (Women)

IMPACTS FOR 2011/12 SEASON

Climate Change (kg CO_2–eq)	Resources (MJ Prim)	Human Health (DALY)	Ecosystem Quality (PDF•m²•yr)	Water Withdrawal (L)
290,000	4,500,000	1.30E-01	54,000	5,900,000



FACTS & FIGURES

(For the Season Sept. 2011 - Sept. 2012)

- Team members: 20
- Events: 6 Exhibition / 20 Regular / 7 Playoff
- Games played at home: 43 %
- Venue: War Memorial Gym (5% annual allocation)
- Spectators: 5,600
- UBC team travel: 17,000 km
- UBC team hotel nights: 17
- Paper: 140 kg
- Waste generated: 360 kg

4. Sensitivity Analysis

LCA studies are required to perform a sensitivity analysis to test critical assumptions and parameters [16]. Since it is not feasible to carry out statistical uncertainty analysis on all parameters, the following are selected based on data uncertainty and potential to significantly change results. *Climate change* is used since it contains the lowest uncertainty of the damage categories.

VARYING THE ELECTRICITY GRID

The UBC A&R venues reported using approximately 8,000 MWh of electricity in their venues. Figure 26 provides a comparison of different environmental factors across three different energy grids. This study applies an environmental factors for the BC Grid supplied by Quantis Intl (based on the Canadian LCI database under development). BC energy has a very low *carbon footprint* as it generates primarily hydro electricity. Applying the Canadian or North American grid averages would lead to substantially higher carbon emissions since they derive a higher percent of energy from coal, oil, gas, and nuclear sources. On the other hand, applying the environmental factor supplied by the BC Ministry of Environment guidelines for reporting on Public Sector Greenhouse Gas Emissions (taken from BC Hydro) [2], leads to a much lower estimate of emissions for the BC Grid: a six fold difference. Further investigation into these differences is needed, however they are mostly attributable to the fact that imports and exports of energy are not included in the BC Ministry environmental factor.

Figure 26: Carbon Footprint comparison of environmental factors for energy grids in BC, Canada, and North America

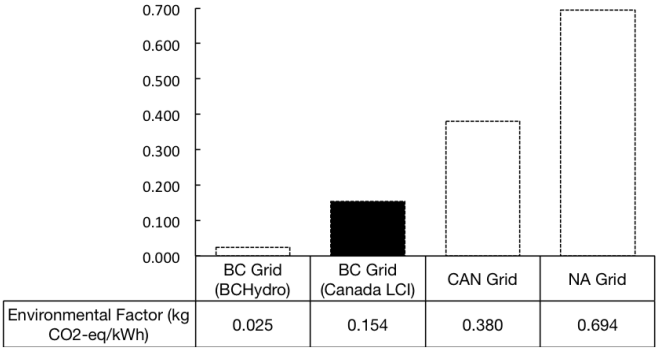


Figure 27: Carbon Footprint of various energy grid assumptions as a percent of the total venue impact

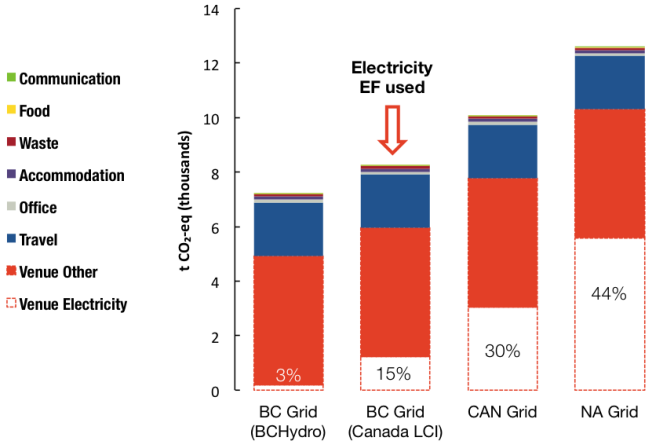


Figure 27 shows the *carbon footprint* proportion of the venues due to energy use. The current assumptions show that energy makes up approximately 15% of the total impact. Applying the Canadian Grid would increase this to 30% of the total and applying the NA Grid to 44%, holding all other assumptions constant.

This sensitivity test shows that if other energy grid numbers are applied, the results would either decrease only slightly or increase quite significantly. In all scenarios the total venues have the largest impact among organizational areas and should be a key area for impact reduction initiatives.

TRAVEL OCCUPANCY RATE ESTIMATES

The *carbon footprint* environmental factors (EF) for passenger travel use a per person km unit:

*GHG emissions = people (p) * distance (km) * EF (kg CO_2-eq / pkm)*

For example, in the case of 100 spectators travelling by city bus to a UBC event, the equation would be:

*100 p * 50 km (ave) * 0.104 kg CO_2-eq = 520 kg CO_2-eq*

A number of underlying assumptions affect how the vehicle EF is derived including occupancy rate, fuel type and efficiency, and vehicle life. Vehicle occupancy in particular can affect results significantly. Using background information supplied by the ecoinvent LCA database [7] and by Tuchschmid & Halder [21], we factor in the vehicle occupancy rate as follows:

*GHG emissions = people (p) * distance/person (km) * EF (kg CO_2-eq/ vkm) / occupancy (p/v)*

For this study we gathered the vehicle occupancy rates for spectator and staff car travel and therefore modified the population average of 1.6 persons per vehicle to 2.7.

Figure 28 shows sensitivity of each mode of travel to changes in occupancy. The red marker shows the average rate, the upper bound shows the maximum occupancy rate possible (optimistic) and the lower bound shows a minimal (pessimistic rate). The considerable overlap of the ranges demonstrates the importance of obtaining accurate occupancy rates.

As can be seen in Figure 29, when applying the three scenarios (pessimistic, average, and optimistic) to the total impact, the results range from an increase of 20% to a decrease of 6%.

Sport events often have unique patterns due to the high volume of participants travelling over a short period of time. More research is needed to capture this both at UBC and at other events.

Figure 28: Carbon Footprints based on pessimistic, average and optimistic vehicle occupancy rates by mode

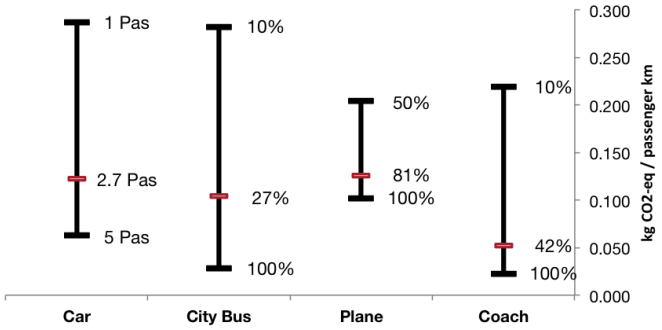
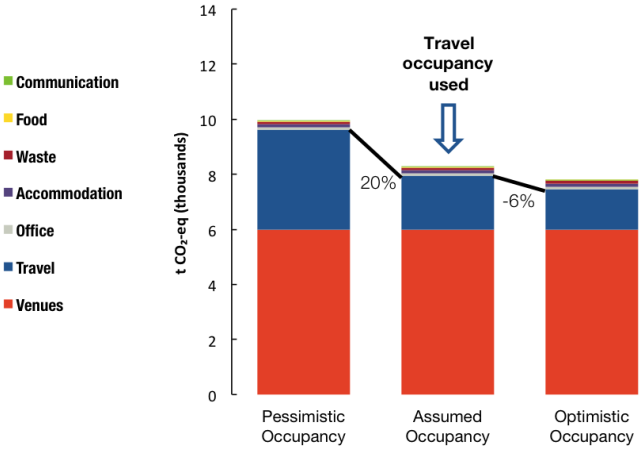


Figure 29: Total Carbon Footprint using different occupancy scenarios for travel



VENUE ALLOCATION FOR TEAMS

While we allocate 100% of venue use to UBC A&R overall impacts, results per team are based on assigning only a portion of venue use. This is because (a) venues are used by multiple teams, (b) venues are made available to other users, and (c) some of the venue space is allocated to other uses such as offices or classrooms.

The Men's Ice Hockey and Women's Soccer teams are shown below with venue allocation scenarios varying between <1% and 100% compared to the allocations assumed for this study (5% and 10% respectively). The Ice Hockey Team is assigned a maximum of 50% of the venue because it shares the arena with the Women's team.

The sensitivity analysis shows that venue allocation changes results quite significantly, increasing the overall team impact by up to 134% in the case of the Men's Ice Hockey team and by 33% for the Women's Soccer team.

Figure 30: Contribution of Doug Mitchell Arena to Mens Ice Hockey Carbon Footprint based on allocation assumptions

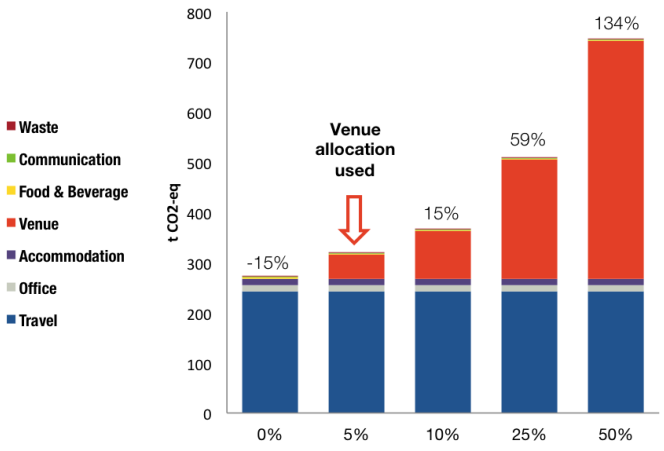
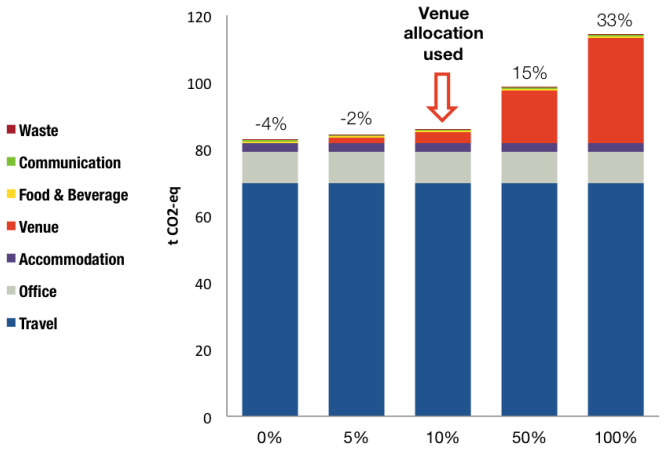


Figure 31: Contribution of Wright Field to Womens Soccer Carbon Footprint based on allocation assumptions



5. Recommendations & Conclusions

This study demonstrates that of all UBC A&R Thunderbirds activities over the 2011/2012 season examined here, the two organizational areas with the biggest *climate change* impacts are venues at 72% and travel at 24%. However, from the perspective of a single team or event, travel is the most significant contributor.

Future initiatives should therefore focus on mitigating the environmental impact of buildings — throughout their construction, operation, and end-of-life phases — and on travel distance and mode prioritization. On the other hand, other interventions still have symbolic value and could be considered as a means of gathering support for a comprehensive strategy.

Such a comprehensive strategy would address all organizational areas. The following recommendations could form the basis of a detailed investigation and feasibility plan for sustainability initiatives. Recommendations are tied primarily to *climate change* results because this damage category is the most robust and because it has been identified as a priority area by UBC. It is recommended however, that any sustainability action plan include considerations for potential impacts across multiple damage categories.

Recommendations by Organizational Area

ACCOMMODATION

Accommodation accounts for approximately 1.4% of the total *carbon footprint*. This is primarily due to energy use and construction materials of the hotels but includes travel impacts to and from the venues. To reduce impacts in this area, UBC A&R could designate hotels that are energy efficient and located close to the venue. UBC A&R could also set up agreements with their primary hotel to partner on impact reduction initiatives and to record data in order to profile their specific impacts.

COMMUNICATION

Although the *carbon footprint* of communication is relatively small at 0.2%, strategies to reduce the paper and non-recyclable/non-compostable products nevertheless carry symbolic value. Possible strategies include: provide web-based tickets, event program and results; webcast games; target local spectators (of the events surveyed, only 14% came from campus); and use recycled / FSC certified / and chlorine free paper. One potential paper supplier of interest may be the new Canadian company Prairie Pulp & Paper. They are launching an 80% tree-free paper that is made from wheat straw waste, bleached with a chlorine-free process, and is certified by FSC and the Rainforest Alliance (www.prairie-paper.com).

It may even make sense to increase the level of communication in order to encourage behaviour change and raise awareness of UBC A&Rs sustainability initiatives. Using athletes as a communication platform is often an effective way of raising visibility and engaging fans.

FOOD

Food is a small contributor in all categories at <1%, except in terms of *water withdrawal,* where it contributed 9% of the total. Environmental impacts of food are highly variable depending on the ingredients, farming method, climate, distance, etc. This study used a generic meal to represent food impacts, however UBC A&R would benefit from working with their food suppliers to track specific up-stream food sourcing information.

Food at the events consists primarily of pre–packaged snacks such as chips, chocolate bars, and popcorn. Some venues also sell hot food, which consists primarily of high-fat and processed foods such as hot dogs, burgers, chicken fingers and french fries. Beverages sold on-site are primarily bottled soft-drinks, juices, beer, and wine.

The environmental and health impacts of the food and beverages could be improved by promoting fresh, unpackaged, local, seasonal, organic foods, and low-meat options [10]. The UBC farm represents a unique opportunity to promote local ingredients produced on-site. The UBC CIRS building (Centre for Interactive Research on Sustainability) has, for example, adopted a tiered strategy prioritizing local/organic/fresh food when available and feasible. Such an approach allows for flexibility and improvements over time as suppliers adapt. Providing tap-water and reusable food and beverage containers could also reduce the impact. UBC A&R could tie into the UBC Food Services program that offers a 15 cent discount for using personal mugs or dishes [25].

Because A&R provides food sales through contractors and sponsors, we suggest that initiatives be developed in partnership with all key stakeholders.

OFFICE

This organizational area contributes 1.1% to the total *carbon footprint*, all of it due to employee commuting. All

other office impacts were included within existing Athletics venues. In general we recommend that UBC A&R develop a staff sustainability program and nominate sustainability coordinators to put in place office and transportation initiatives. The UBC Sustainability Office offers a comprehensive programs and resources such as the "New Employee Sustainability Guide" [26].

TRAVEL

Travel contributes 24% of the overall *carbon footprint*. The environmental performance can generally be improved in two ways, decrease carbon intensity (impacts per person) and decrease the absolute total impact.

General travel recommendations:

- Encourage low/no impact travel such as walking, cycling, public transit, and trains.
- Promote the use of vehicles with high fuel efficiency, low weight, and using eco-friendly fuels [21].
- Increase vehicle occupancy rates. The higher the occupancy rate, the lower the travel impact per person.
- Reduce long distance travel.

UBC A&R specific recommendations:

- Teams could prioritize low-impact transportation, reduce the number of people travelling, and regionalize leagues where possible. Schedules could be adapted to cluster events and play more games close to UBC.
- Spectator travel impact intensity could be reduced by encouraging people to attend who live close to UBC. Long distance travel of spectators (primarily visiting team fans) could potentially be reduced by televising or webcasting games.
- Put in place programs that encourage low impact travel such as "walk/bike to the game" incentives, "car-share" and "bus-game ticket combos".
- Clearly communicate transportation options, maps and schedules on all relevant UBC A&R channels.

VENUE

Venues are the largest overall contributor for all damage categories. Within each venue however, there is significant variation depending on venue type, size, use, etc. The following recommendations are generally applicable and should form the basis of a more thorough venue review in future:

- Install smart meters to track real-time energy use and identify reduction opportunities. Some venues such as the Doug Mitchell Arena already have this in place.
- Monitor water use and implement water reduction strategies such as low-flow taps, showers, and toilets.
- Investigate how much wastewater is generated by each venue. In particular, the *ecosystem quality* and *human health* impacts associated with wastewater were significant for buildings with high water use.
- Look for opportunities to reduce the amount of water for irrigation. UBC is currently investigating stormwater capture solutions; it may be possible to use this water for field irrigation instead of tap water.
- Reduce fertilizer and fuel use on the grass fields and select suitable grass varieties [6].
- The impact of plastic materials dominate for synthetic fields. Prolonging the life of these fields and prioritizing eco-friendly materials with end-of-life reuse potential would reduce their impact [6].
- The pool facilities contribute significant impacts. UBC is currently deliberating the construction of a new facility. This represents a strong opportunity for UBC A&R to support a state-of-the-art facility that would prioritize long-term energy, water, and pool chemical use reductions.

It is strongly recommended that UBC A&R carry out individual LCAs of their venues to improve the level of detail and accuracy for this area. For buildings in particular, the UBC Sustainability Initiative strongly encourages the use of LCA and in fact UBC has North America's largest LCA database for building stocks. UBC A&R has an opportunity to contribute to this.

WASTE

Although waste represents only 1.1% of the total *carbon footprint*, it has important visual and symbolic importance that affect the credibility of environmental programs. Within the waste impacts, the vast majority were attributed to landfill treatment.

According to the UBC Waste Action Plan, in 2009-2010 UBC had a waste diversion rate of 44% and it aspires to reach 55% in the short term [24]. As a point of comparison, the City of Vancouver has a waste diversion rate of 52%. UBC is also prioritizing composting; currently approximately 25% of the 350 tonnes of organic waste UBC produces are being treated by their award winning large-scale composting system.

UBC A&R could design its waste strategies to tie in with the UBC Waste Action Plan objectives. In general, impact reduction initiatives should prioritize a reduction of the total amount of materials disposed of and increasing the percentage of materials reused, recycled, and composted. More specifically, we recommend that:

- All UBC venues should have clearly marked recycling and composting bins to aid in effective waste sorting.
- Awareness and communication campaigns be put in place to highlight these efforts.
- Food sales — which produce the largest proportion of waste

— should minimize packaging, prioritize reusable serving-ware, and compost food waste.

Strategic Plan & Performance Monitoring

This study provides a tool and a baseline of environmental impacts related to UBC A&R Thunderbirds activities for the 2010/2011 season. A comprehensive sustainability strategy is important to continually monitor performance and to address other UBC A&R environmental, social and economic considerations such as health, accessibility, equity, and ethical practices.

MEASUREMENT AND MONITORING

To assess ongoing performance, it is recommended that a monitoring and tracking system be put in place. The framework of this LCA is designed to simplify data inputting as much as possible by providing aggregated indicators for each of the seven organizational areas, e.g. one hotel night per person.

UBC A&R should collect data at least once a year for:

- Event participants
- Venue energy and water use
- Waste amounts and % recycled/composted
- Team, spectator and staff travel distances and modes
- Food and beverage sales and types of food sold
- Fertilizer and other chemical use
- Fuel use for field maintenance

In order to do this effectively, data collection could be made part of the job description for the relevant staff members. In addition one member would ideally be responsible for centralizing this information and updating the result in Quantis SUITE 2.0. UBC A&R could also provide internships to UBC students to collect data, implement strategies, and generate learning opportunities.

This report also highlighted data quality in terms of reliability and representativeness for each organizational area. Some areas, such as travel, were based on primary data collection and were of high quality. Other areas, such as food and waste, were based on estimations as little data was available. Aspects with a low data quality rating and a high overall impact should be prioritized. In particular, assumptions for venue construction and operation could be investigated further.

STRATEGIC PLAN

A sustainability strategy and management plan would allow UBC A&R to concentrate resources, prioritize actions and communicate effectively. This is also a core requirement of the Canadian Standards Association (CSA) Z2010 Sustainable Management of Events standard. Such a document should include:

- Public vision and commitment statement
- Scope definition of commitment and responsibilities
- Roles and responsibilities of stakeholders
- Assignment of leadership and resources
- Identification of major sustainability issues
- Demonstration of compliance with applicable legal requirements
- Objectives and key performance indicators
- Reporting and communication procedure

Sign-off from UBC A&R leadership and key stakeholders will help ensure that it will be fully implemented and supported.

This LCA study and tool is a first among University Athletic departments in North America (if not internationally). UBC A&R has a unique opportunity to contribute not only to UBCs sustainability vision but also to show leadership among other event organizers.

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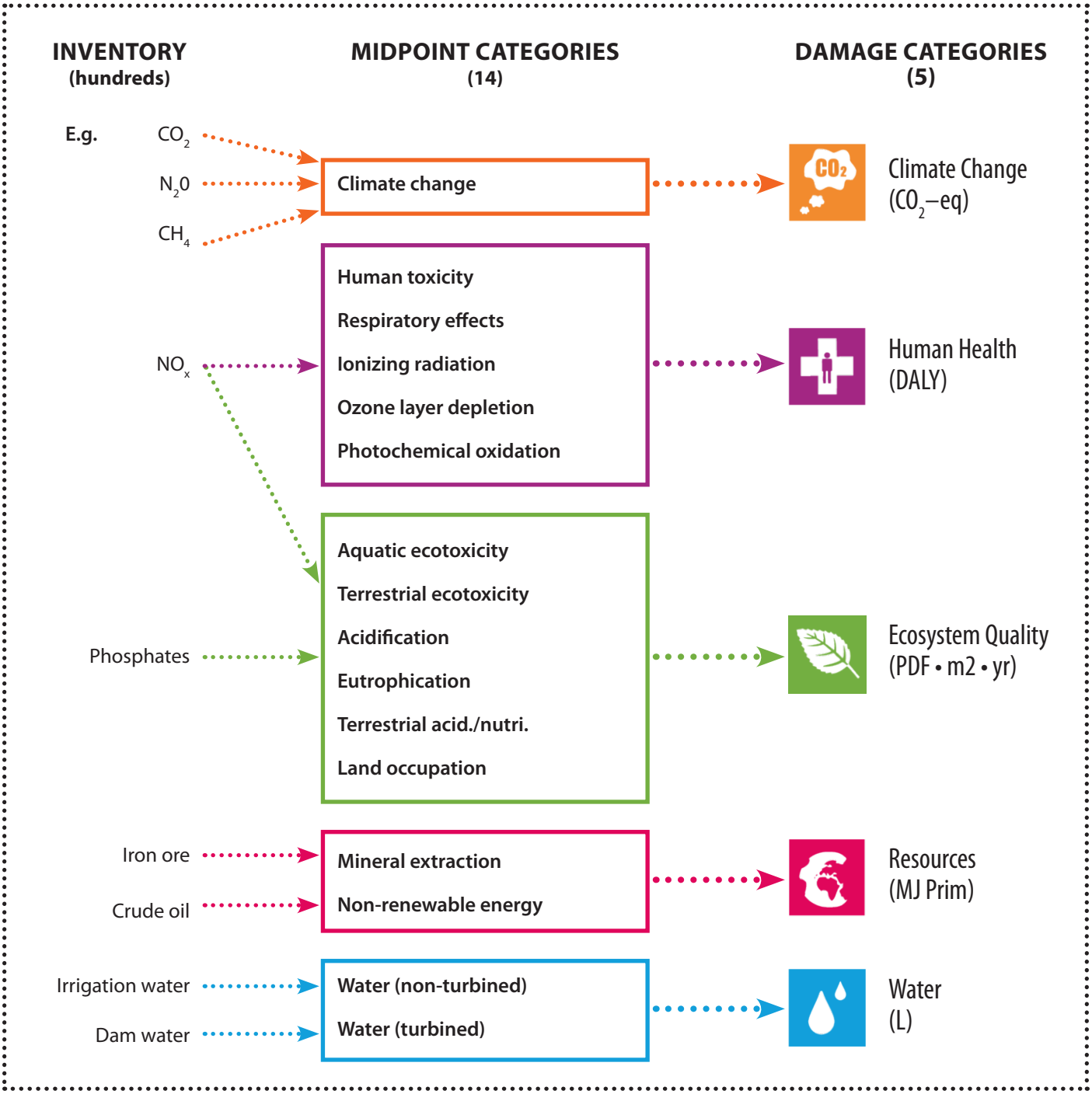
APPENDIX I - IMPACT 2002+ LCA METHOD

An overview of the IMPACT 2002+ LCA Method with the addition of water withdrawal. Adapted from Joliet et al. (2003), as updated by Humbert et al. (2011) [14, 15].



Legend - Damage Categories

CO_2–eq: Carbon dioxide equivalents

DALY: Disability adjusted life years

PDF•m^2•yr: Potential disappeared fraction of species per square meter per year

MJ Prim: Megajoules of primary energy

L: Liters of water

Midpoint and Damage Categories

The term 'midpoint' refers to an intermediate point of impact that occurs somewhere between the measured activities and the resulting potential damage or 'endpoint', an example of a midpoint would be land use change. An 'endpoint' or 'damage' category refers to the step of representing these midpoint categories to one or more groupings representing potential quality changes to the environment. The damage category therefore is a quantified representation of this quality change. According to the ecoinvent report *Implementation of Life Cycle Impact Assessment Methods* (2009), "... a damage indicator result is always a simplified model of a very complex reality, giving only a coarse approximation of the result."

IMPACT 2002+ Damage Categories

CLIMATE CHANGE

The climate change category uses the IPCCs (International Panel on climate change) 100-year ratings of the Global Warming Potential (GWP) of various substances (IPCC, 2007). Substances known to contribute to climate change are adjusted based on an identified Global Warming Potential, expressed in kilograms of carbon dioxide (CO_2) equivalents. Because the uptake and emission of CO_2 from biological sources can often lead to misinterpretations of results, this biogenic CO_2 is usually omitted from consideration when evaluating Global Warming Potentials. This follows the recommendation of the Publicly Available Standard (PAS) 2050 product carbon footprinting guidance in not considering either the uptake or emission of CO_2 from biological systems. In order to account for the effect from its degradation to CO_2, the GWP from methane of fossil origin is adjusted to 27.75 kg CO_2–eq/kg CH_4, and the one of methane from biogenic and unspecified origin to 25 kg CO_{2-eq}/kg CH_4.

HUMAN HEALTH

Human Health impact can be caused by the release of substances that effect humans through acute toxicity, cancer-based toxicity, respiratory effects, and increases in UV radiation among others. An evaluation of the overall impact of a system on human health has been made following the human health endpoint in the IMPACT 2002+ method (Jolliet et al., 2003), in which substances are evaluated based on their ability to cause each of a variety of damages to human health.

ECOSYSTEM QUALITY

Ecosystem Quality can be impaired by the release of substances that cause acidification, eutrophication, toxicity to wildlife, land occupation, and a variety of other types of impact. An evaluation of the overall impact of a system on ecosystem quality has been made following the ecosystem quality endpoint IMPACT 2002+ method (Jolliet et al., 2003), in which substances are evaluated based on their ability to cause each of a variety of damages to wildlife species.

RESOURCES

Resource depletion is caused when non-renewable resources are used, or when renewable resources are used at a rate greater than they can be renewed. Individual materials can be assigned a level of importance based on their abundance and difficulty to obtain. An evaluation of the overall impact of a system on resource depletion has been performed following the resources endpoint in the IMPACT 2002+ method (Jolliet et al., 2003), which combines non-renewable primary energy use and mineral extraction. Non-renewable primary energy use accounts for the consumption of fossil and nuclear resources and excludes sources of renewable energy at all stages of the life cycle and in all upstream processes. Mineral extraction is an estimate of the increased amount of energy that will be required to obtain additional incremental amounts of substances from the earth due to removal of resources inventoried for each system (based on the Eco-indicator 99 LCA method). Non-renewable primary energy use accounts for the consumption of fossil and nuclear resources but excludes sources of renewable energy at all stages of the life cycle and in all upstream processes (however, non-renewable energy needed to produce renewable energy is considered). This metric is expressed in megajoules (MJ) of primary energy.

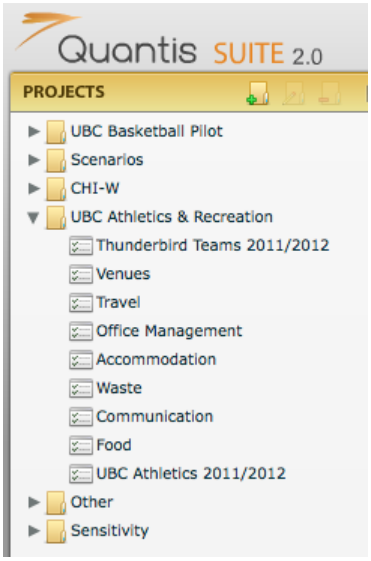
WATER WITHDRAWAL

The water footprint is the total volume of freshwater that is used directly and indirectly by a product, service, community, or organization. The Water Footprint consists of three components: Blue water (surface water), Green water (evaporated water), and Grey water (polluted water). Both 'direct' and 'indirect' water withdrawal are included. Direct withdrawal refers to the operational water use, e.g. tap water for field irrigation. Indirect withdrawal refers to the water used by the supply chain to produce the product or service, e.g. water required to produce the food purchased.

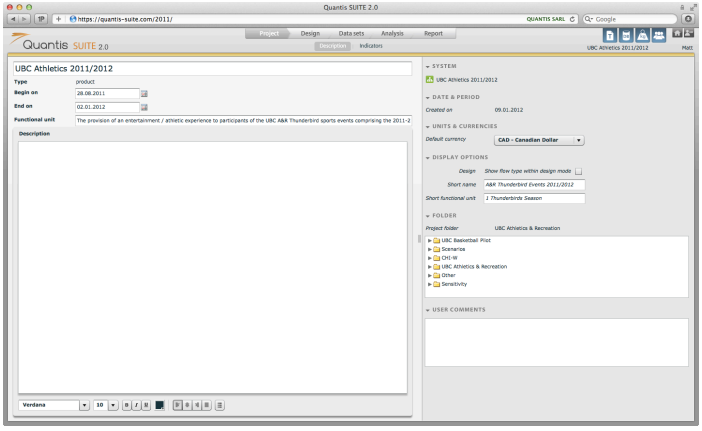
APPENDIX II - QUANTIS SUITE 2.0

QUANTIS SUITE 2.0 OVERVIEW

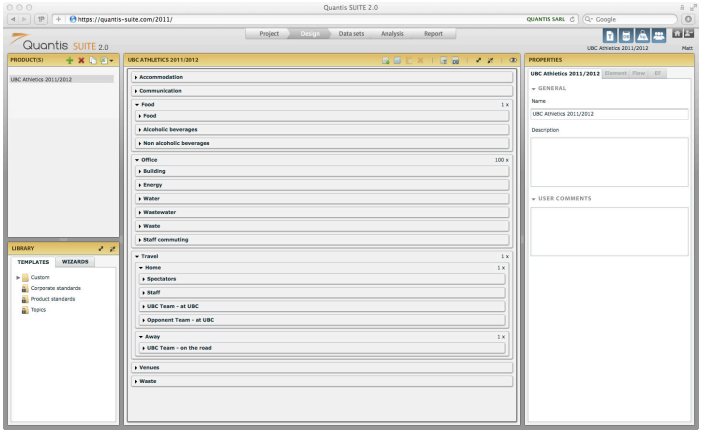
1. Create/select a project



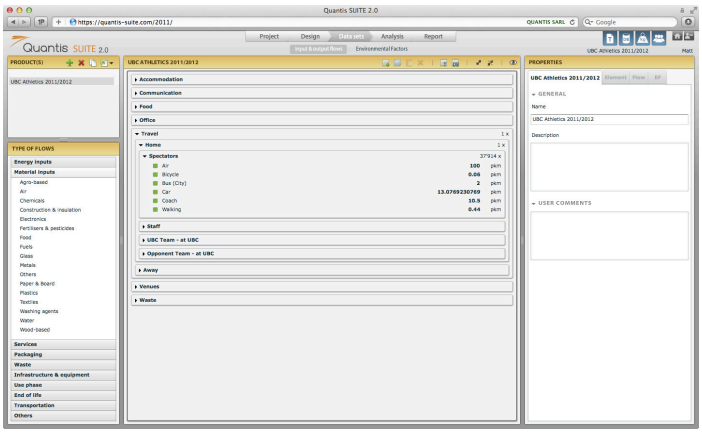
2. Add the details of the project



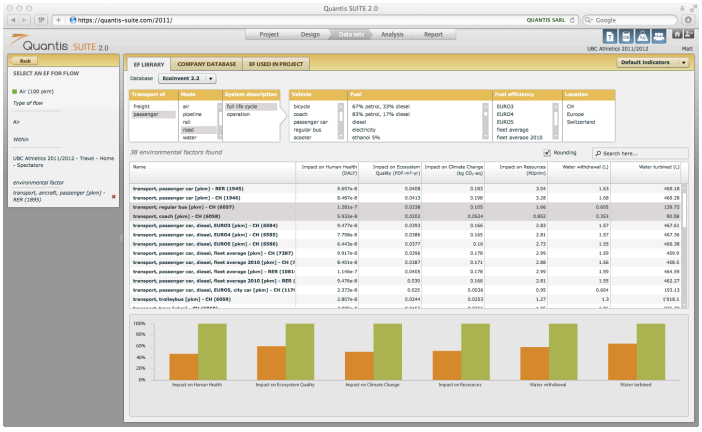
3. Set up the product system by creating and embedding "elements" (as seen in the main section below). These elements will contain all flows, activity data and EFs.

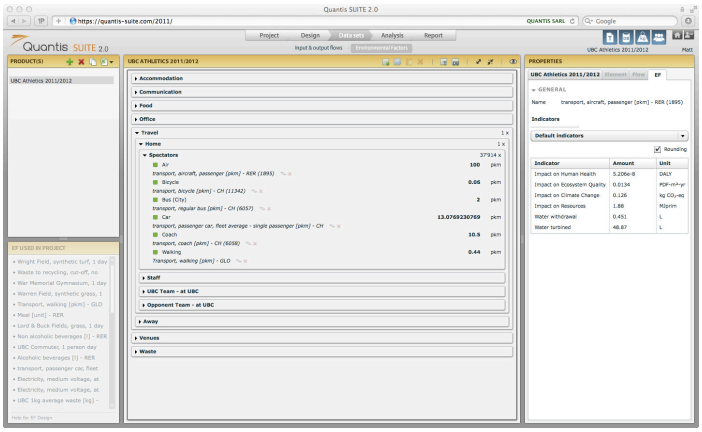


4. Add input-output "flows" (e.g. materials) to the elements by dragging them from the pre-defined menu items on the bottom left of the screen.



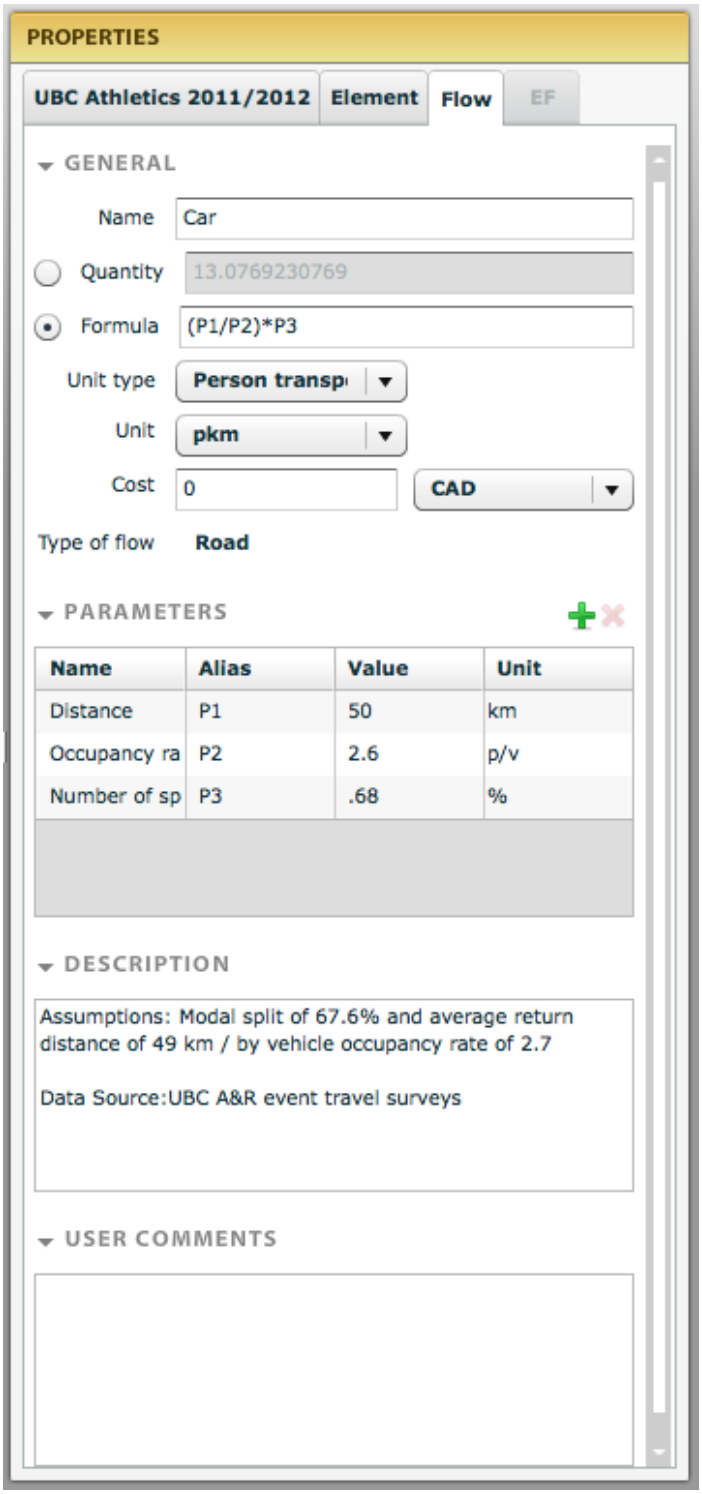
5. Assign environmental factors (EF's) to your flows. Clicking on the grey 'EF' button takes you to the ecoinvent database (first pic). Here you can filter through the 4,000 EFs and also compare impacts by selecting two or more at the same time. Double clicking assigns the EF and it will then appear on under the flow (second pic).



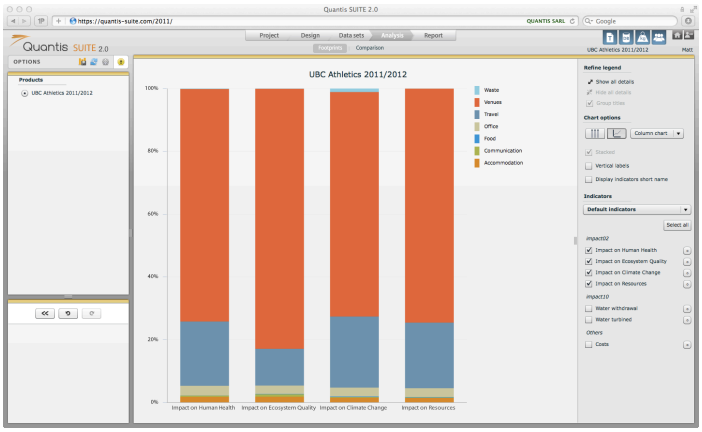


Appendix IV - QUANTIS SUITE 2.0 (continued)

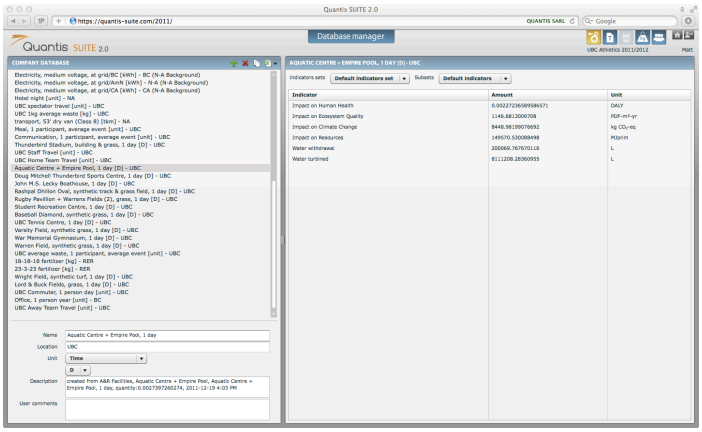
6. Enter the activity data. The example below shows spectator car travel. Data can be entered directly into the "Quantity" field or, as is the case here, parameters can be used to set up a "Formula". In all cases the "Units" must match up with that required by the EF (e.g. passenger kilometers - pkm). Note that data can be added at either the element or flow level.



7. The "Analysis" tab shows the impacts through an interactive graphical interface.



8. A custom database of environmental factors can also be created.



9. The "Report" section can export results to excel