*APPENDIX E*

# *GHG EMISSIONS CALCULATIONS*

***The Point at Northshore***
**SEPA GHG Emissions Worksheet**
**Amended by the City of Tacoma July 16, 2009**

Introduction

The Washington State Environmental Policy Act (SEPA) requires environmental review of development proposals that may have a significant adverse impact on the environment. If a proposed development is subject to SEPA, the project proponent is required to complete the SEPA Checklist, which includes questions relating to the development's air emissions. The emissions that have traditionally been considered cover smoke, dust, and industrial and automobile emissions. The City of Tacoma also recognizes the climate change impacts of Greenhouse Gas (GHG) emissions; however the City does not currently have any adopted method for measuring or regulating GHG emissions. In the absence of an adopted City of Tacoma methodology, this FSEIS uses the following worksheet created by King County to estimate GHG emissions.

Emissions created by Development

GHG emissions associated with development come from multiple sources:

- The extraction, processing, transportation, construction and disposal of materials and landscape disturbance (Embodied Emissions)
- Energy demands created by the development after it is completed (Energy Emissions)
- Transportation demands created by the development after it is completed (Transportation Emissions)

GHG Emissions Worksheet

King County has developed a GHG Emissions Worksheet that can assist applicants in answering the SEPA Checklist question relating to GHG emissions.

The SEPA GHG Emissions worksheet estimates all GHG emissions that will be created over the life span of a project. This includes emissions associated with obtaining construction materials, fuel used during construction, energy consumed during a buildings operation, and transportation by building occupants.

Using the Worksheet

1. Descriptions of the different residential and commercial building types can be found on the second tabbed worksheet ("Definition of Building Types"). If a development proposal consists of multiple projects, e.g. both single family and multi-family residential structures or a commercial development that consists of more than on type of commercial activity, the appropriate information should be estimated for each type of building or activity.

2. For paving, estimate the total amount of paving (in thousands of square feet) of the project.

3. The Worksheet will calculate the amount of GHG emissions associated with the project and display the amount in the "Total Emissions" column on the worksheet. The applicant should use this information when completing the SEPA checklist.

4. The last three worksheets in the Excel file provide the background information that is used to calculate the total GHG emissions.

5. The methodology of creating the estimates is transparent; if there is reason to believe that a better estimate can be obtained by changing specific values, this can and should be done. Changes to the values should be documented with an explanation of why and the sources relied upon.

6. Print out the “Total Emissions” worksheet and attach it to the SEPA checklist. If the applicant has made changes to the calculations or the values, the documentation supporting those changes should also be attached to the SEPA checklist.

**Emissions Worksheet**
**The Point at Northshore No Action Alternative**

| Type (Residential) or Principal Activity (Commercial) | # Units | Square Feet (in thousands of square feet) | Emissions Per Unit or Per Thousand Square Feet (MTCO2e) Embodied | Energy | Transportation | Lifespan Emissions (MTCO2e) | Annual Emmissions (MTCO2e)* |
|---|---|---|---|---|---|---|---|
| Single-Family Home..... | 0 | | 98 | 672 | 792 | **0** | **0** |
| Multi-Family Unit in Large Building .... | 0 | | 33 | 357 | 766 | **0** | **0** |
| Multi-Family Unit in Small Building .... | 0 | | 54 | 681 | 766 | **0** | **0** |
| Mobile Home..... | 0 | | 41 | 475 | 709 | **0** | **0** |
| Education ..... | | 0.0 | 39 | 646 | 361 | **0** | **0** |
| Food Sales ..... | | 0.0 | 39 | 1,541 | 282 | **0** | **0** |
| Food Service ..... | | **11.6** | 39 | 1,994 | 561 | **30088** | **481** |
| Health Care Inpatient ..... | | 0.0 | 39 | 1,938 | 582 | **0** | **0** |
| Health Care Outpatient ..... | | 0.0 | 39 | 737 | 571 | **0** | **0** |
| Lodging ..... | | 0.0 | 39 | 777 | 117 | **0** | **0** |
| Retail (Other Than Mall)..... | | 0.0 | 39 | 577 | 247 | **0** | **0** |
| Office ..... | | 0.0 | 39 | 723 | 588 | **0** | **0** |
| Public Assembly ..... | | 0.0 | 39 | 733 | 150 | **0** | **0** |
| Public Order and Safety ..... | | 0.0 | 39 | 899 | 374 | **0** | **0** |
| Religious Worship ..... | | 0.0 | 39 | 339 | 129 | **0** | **0** |
| Service ..... | | **18.5** | 39 | 599 | 266 | **16725** | **268** |
| Warehouse and Storage ..... | | 0.0 | 39 | 352 | 181 | **0** | **0** |
| Other ..... | | 0.0 | 39 | 1,278 | 257 | **0** | **0** |
| Vacant ..... | | 0.0 | 39 | 162 | 47 | **0** | **0** |

**Section II: Pavement.....**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pavement..... | | **183.30** | | | | **9165** | **147** |

**Total Project Emissions:** **55,978** **896**

**Column calculating total annual emissions has been added, and is based on King County's estimated lifespan of various construction types. See "The Point at Northshore Raw Data and Assumptions" worksheet for details*

**Emissions Worksheet**
**The Point at Northshore Proposed Action**

| Type (Residential) or Principal Activity (Commercial) | # Units | Square Feet (in thousands of square feet) | Emissions Per Unit or Per Thousand Square Feet (MTCO2e) Embodied | Energy | Transportation | Lifespan Emissions (MTCO2e) | Annual Emmissions (MTCO2e)* |
|---|---|---|---|---|---|---|---|
| Single-Family Home..... | **860** | | 98 | 672 | 792 | **1343182** | **23198** |
| Multi-Family Unit in Large Building ..... | 0 | | 33 | 357 | 766 | **0** | **0** |
| Multi-Family Unit in Small Building ..... | 0 | | 54 | 681 | 766 | **0** | **0** |
| Mobile Home..... | 0 | | 41 | 475 | 709 | **0** | **0** |
| Education ..... | | 0.0 | 39 | 646 | 361 | **0** | **0** |
| Food Sales ..... | | 0.0 | 39 | 1,541 | 282 | **0** | **0** |
| Food Service ..... | | 0.0 | 39 | 1,994 | 561 | **0** | **0** |
| Health Care Inpatient ..... | | 0.0 | 39 | 1,938 | 582 | **0** | **0** |
| Health Care Outpatient ..... | | 0.0 | 39 | 737 | 571 | **0** | **0** |
| Lodging ..... | | 0.0 | 39 | 777 | 117 | **0** | **0** |
| Retail (Other Than Mall)..... | | 0.0 | 39 | 577 | 247 | **0** | **0** |
| Office ..... | | 0.0 | 39 | 723 | 588 | **0** | **0** |
| Public Assembly ..... | | 0.0 | 39 | 733 | 150 | **0** | **0** |
| Public Order and Safety ..... | | 0.0 | 39 | 899 | 374 | **0** | **0** |
| Religious Worship ..... | | 0.0 | 39 | 339 | 129 | **0** | **0** |
| Service ..... | | 0.0 | 39 | 599 | 266 | **0** | **0** |
| Warehouse and Storage ..... | | 0.0 | 39 | 352 | 181 | **0** | **0** |
| Other ..... | | 0.0 | 39 | 1,278 | 257 | **0** | **0** |
| Vacant ..... | | 0.0 | 39 | 162 | 47 | **0** | **0** |

**Section II: Pavement.....**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pavement..... | | **729.00** | | | | **36450** | **630** |
| Annual Emissions | | | | | | | |
| | **Total Project Emissions:** | | | | | **1,379,632** | **23,828** |

**Column calculating total annual emissions has been added, and is based on King County's estimated lifespan of various construction types. See "The Point at Northshore Raw Data and Assumptions" worksheet for details*

**Emissions Worksheet**
**The Point at Northshore Proposed Action Alternative**

| Type (Residential) or Principal Activity (Commercial) | # Units | Square Feet (in thousands of square feet) | Emissions Per Unit or Per Thousand Square Feet (MTCO2e) Embodied | Energy | Transportation | Lifespan Emissions (MTCO2e) | Annual Emmissions (MTCO2e)* |
|---|---|---|---|---|---|---|---|
| Single-Family Home..... | **670** | | 98 | 672 | 792 | **1046432** | **18073** |
| Multi-Family Unit in Large Building ..... | 0 | | 33 | 357 | 766 | **0** | **0** |
| Multi-Family Unit in Small Building ..... | 0 | | 54 | 681 | 766 | **0** | **0** |
| Mobile Home..... | 0 | | 41 | 475 | 709 | **0** | **0** |
| Education ..... | | 0.0 | 39 | 646 | 361 | **0** | **0** |
| Food Sales ..... | | 0.0 | 39 | 1,541 | 282 | **0** | **0** |
| Food Service ..... | | 0.0 | 39 | 1,994 | 561 | **0** | **0** |
| Health Care Inpatient ..... | | 0.0 | 39 | 1,938 | 582 | **0** | **0** |
| Health Care Outpatient ..... | | 0.0 | 39 | 737 | 571 | **0** | **0** |
| Lodging ..... | | 0.0 | 39 | 777 | 117 | **0** | **0** |
| Retail (Other Than Mall)..... | | 0.0 | 39 | 577 | 247 | **0** | **0** |
| Office ..... | | 0.0 | 39 | 723 | 588 | **0** | **0** |
| Public Assembly ..... | | 0.0 | 39 | 733 | 150 | **0** | **0** |
| Public Order and Safety ..... | | 0.0 | 39 | 899 | 374 | **0** | **0** |
| Religious Worship ..... | | 0.0 | 39 | 339 | 129 | **0** | **0** |
| Service ..... | | 0.0 | 39 | 599 | 266 | **0** | **0** |
| Warehouse and Storage ..... | | 0.0 | 39 | 352 | 181 | **0** | **0** |
| Other ..... | | 0.0 | 39 | 1,278 | 257 | **0** | **0** |
| Vacant ..... | | 0.0 | 39 | 162 | 47 | **0** | **0** |

**Section II: Pavement.....**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pavement..... | | **729.00** | | | | **36450** | **630** |

**Total Project Emissions:** **1,082,882** **18,703**

**Column calculating total annual emissions has been added, and is based on King County's estimated lifespan of various construction types. See "The Point at Northshore Raw Data and Assumptions" worksheet for details*

Definition of Building Types

| Type (Residential) or Principal Activity (Commercial) | Description |
|---|---|
| Single-Family Home | Unless otherwise specified, this includes both attached and detached buildings |
| Multi-Family Unit in Large Building | Apartments in buildings with more than 5 units |
| Multi-Family Unit in Small Building | Apartments in building with 2-4 units |
| Mobile Home | |
| Education | Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office," dormitories are "Lodging," and libraries are "Public Assembly." |
| Food Sales | Buildings used for retail or wholesale of food. |
| Food Service | Buildings used for preparation and sale of food and beverages for consumption. |
| Health Care Inpatient | Buildings used as diagnostic and treatment facilities for inpatient care. |
| Health Care Outpatient | Buildings used as diagnostic and treatment facilities for outpatient care. Doctor's or dentist's office are included here if they use any type of diagnostic medical equipment (if they do not, they are categorized as an office building). |
| Lodging | Buildings used to offer multiple accommodations for short-term or long-term residents, including skilled nursing and other residential care buildings. |
| Retail (Other Than Mall) | Buildings used for the sale and display of goods other than food. |
| Office | Buildings used for general office space, professional office, or administrative offices. Doctor's or dentist's office are included here if they do not use any type of diagnostic medical equipment (if they do, they are categorized as an outpatient health care building). |
| Public Assembly | Buildings in which people gather for social or recreational activities, whether in private or non-private meeting halls. |
| Public Order and Safety | Buildings used for the preservation of law and order or public safety. |
| Religious Worship | Buildings in which people gather for religious activities, (such as chapels, churches, mosques, synagogues, and temples). |
| Service | Buildings in which some type of service is provided, other than food service or retail sales of goods |
| Warehouse and Storage | Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage). |
| Other | Buildings that are industrial or agricultural with some retail space; buildings having several different commercial activities that, together, comprise 50 percent or more of the floorspace, but whose largest single activity is agricultural, industrial/ manufacturing, or residential; and all other miscellaneous buildings that do not fit into any other category. |
| Vacant | Buildings in which more floorspace was vacant than was used for any single commercial activity at the time of interview. Therefore, a vacant building may have some occupied floorspace. |

Sources: .....

Residential 2001 Residential Energy Consumption Survey
Square footage measurements and comparisons
http://www.eia.doe.gov/emeu/recs/sqft-measure.html

Commercial Commercial Buildings Energy Consumption Survey (CBECS),
Description of CBECS Building Types
http://www.eia.doe.gov/emeu/cbecs/pba99/bldgtypes.html

Embodied Emissions Worksheet

**Section I: Buildings**

| Type (Residential) or Principal Activity (Commercial) | # thousand sq feet/ unit or building | Life span related embodied GHG missions (MTCO2e/ unit) | Life span related embodied GHG missions (MTCO2e/ thousand square feet) - See calculations in table below |
|---|---|---|---|
| Single-Family Home | 2.53 | 98 | 39 |
| Multi-Family Unit in Large Building | 0.85 | 33 | 39 |
| Multi-Family Unit in Small Building | 1.39 | 54 | 39 |
| Mobile Home | 1.06 | 41 | 39 |
| Education | 25.6 | 991 | 39 |
| Food Sales | 5.6 | 217 | 39 |
| Food Service | 5.6 | 217 | 39 |
| Health Care Inpatient | 241.4 | 9,346 | 39 |
| Health Care Outpatient | 10.4 | 403 | 39 |
| Lodging | 35.8 | 1,386 | 39 |
| Retail (Other Than Mall) | 9.7 | 376 | 39 |
| Office | 14.8 | 573 | 39 |
| Public Assembly | 14.2 | 550 | 39 |
| Public Order and Safety | 15.5 | 600 | 39 |
| Religious Worship | 10.1 | 391 | 39 |
| Service | 6.5 | 252 | 39 |
| Warehouse and Storage | 16.9 | 654 | 39 |
| Other | 21.9 | 848 | 39 |
| Vacant | 14.1 | 546 | 39 |

**Section II: Pavement**

| | | | |
|---|---|---|---|
| All Types of Pavement | | | 50 |

| | Columns and Beams | Intermediate Floors | Exterior Walls | Windows | Interior Walls | Roofs | | |
|---|---|---|---|---|---|---|---|---|
| Average GWP (lbs CO2e/sq ft): Vancouver, Low Rise Building | 5.3 | 7.8 | 19.1 | 51.2 | 5.7 | 21.3 | | |
| Average Materials in a 2,272-square foot single family home | 0.0 | 2269.0 | 3206.0 | 285.0 | 6050.0 | 3103.0 | Total Embodied Emissions (MTCO2e) | Total Embodied Emissions (MTCO2e/ thousand sq feet) |
| MTCO2e | 0.0 | 8.0 | 27.8 | 6.6 | 15.6 | 30.0 | 88.0 | 38.7 |

**Sources**

All data in black text — King County, DNRP. Contact: Matt Kuharic, matt.kuharic@kingcounty.gov

Residential floorspace per unit
2001 Residential Energy Consumption Survey (National Average, 2001)
Square footage measurements and comparisons
http://www.eia.doe.gov/emeu/recs/sqft-measure.html

Floorspace per building
EIA, 2003 Commercial Buildings Energy Consumption Survey (National Average, 2003)
Table C3. Consumption and Gross Energy Intensity for Sum of Major Fuels for Non-Mall Buildings, 2003
http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003excel/c3.xls

Average GWP (lbs CO2e/sq ft): Vancouver, Low Rise Building
Athena EcoCalculator
Athena Assembly Evaluation Tool v2.3- Vancouver Low Rise Building
Assembly Average GWP (kg) per square meter
http://www.athenasmi.ca/tools/ecoCalculator/index.html
Lbs per kg 2.20
Square feet per square meter 10.76

Average Materials in a 2,272-square foot single family home
Buildings Energy Data Book: 7.3 Typical/Average Household
Materials Used in the Construction of a 2,272-Square-Foot Single-Family Home, 2000
http://buildingsdatabook.eren.doe.gov/?id=view_book_table&TableID=2036&t=xls
See also: NAHB, 2004 Housing Facts, Figures and Trends, Feb. 2004, p. 7.

Average window size
Energy Information Administration/Housing Characteristics 1993
Appendix B, Quality of the Data. Pg. 5.
ftp://ftp.eia.doe.gov/pub/consumption/residential/rx93hcf.pdf

Pavement Emissions Factors
MTCO2e/thousand square feet of
asphalt or concrete pavement 50 (see below)

**Embodied GHG Emissions……..Worksheet Background Information**

*Buildings*
Embodied GHG emissions are emissions that are created through the extraction, processing, transportation, construction and disposal of building materials as well as emissions created through landscape disturbance (by both soil disturbance and changes in above ground biomass).

Estimating embodied GHG emissions is new field of analysis; the estimates are rapidly improving and becoming more inclusive of all elements of construction and development.

The estimate included in this worksheet is calculated using average values for the main construction materials that are used to create a typical family home. In 2004, the National Association of Home Builders calculated the average materials that are used in a typical 2,272 square foot single-family household. The quantity of materials used is then multiplied by the average GHG emissions associated with the life-cycle GHG emissions for each material.

This estimate is a rough and conservative estimate; the actual embodied emissions for a project are likely to be higher. For example, at this stage, due to a lack of comprehensive data, the estimate does not include important factors such as landscape disturbance or the emissions associated with the interior components of a building (such as furniture).

King County realizes that the calculations for embodied emissions in this worksheet are rough. For example, the emissions associated with building 1,000 square feet of a residential building will not be the same as 1,000 square feet of a commercial building. However, discussions with the construction community indicate that while there are significant differences between the different types of structures, this method of estimation is reasonable; it will be improved as more data become available.

Additionally, if more specific information about the project is known, King County recommends two online embodied emissions calculators that can be used to obtain a more tailored estimate for embodied emissions: www.buildcarbonneutral.org and www.athenasmi.ca/tools/ecoCalculator/.

*Pavement*
Four recent life cycle assessments of the environmental impacts of roads form the basis for the per unit embodied emissions of pavement. Each study is constructed in slightly different ways; however, the aggregate results of the reports represent a reasonable estimate of the GHG emissions that are created from the manufacture of paving materials, construction related emissions, and maintenance of the pavement over its expected life cycle. For specifics, see the worksheet.

**Special Section: Estimating the Embodied Emissions for Pavement**

Four recent life cycle assessments of the environmental impacts of roads form the basis for the per unit embodied emissions of pavement. Each study is constructed in slightly different ways; however, the aggregate results of the reports represent a reasonable estimate of the GHG emissions that are created from the manufacture of paving materials, construction related emissions, and maintenance of the pavement over its expected life cycle.

The results of the studies are presented in different units and measures; considerable effort was undertaken to be able to compare the results of the studies in a reasonable way. For more details about the below methodology, contact matt.kuharic@kingcounty.gov.

The four studies, Meil (2001), Park (2003), Stripple (2001) and Treolar (2001) produced total GHG emissions of 4-34 MTCO2e per thousand square feet of finished paving (for similar asphalt and concrete based pavements). This estimate does not including downstream maintenance and repair of the highway. The average (for all concrete and asphalt pavements in the studies, assuming each study gets one data point) is ~17 MTCO2e/thousand square feet.

Three of the studies attempted to thoroughly account for the emissions associated with long term maintenance (40 years) of the roads. Stripple (2001), Park et al. (2003) and Treolar (2001) report 17, 81, and 68 MTCO2e/thousand square feet, respectively, after accounting for maintenance of the roads.

Based on the above discussion, King County makes the conservative estimate that 50 MTCO2e/thousand square feet of pavement (over the development's life cycle) will be used as the embodied emission factor for pavement until better estimates can be obtained. This is roughly equivalent to 3,500 MTCO2e per lane mile of road (assuming the lane is 13 feet wide).

It is important to note that these studies estimate the embodied emissions for roads. Paving that does not need to stand up to the rigors of heavy use (such as parking lots or driveways) would likely use less materials and hence have lower embodied emissions.

Sources:

Meil, J. A Life Cycle Perspective on Concrete and Asphalt Roadways: Embodied Primary Energy and Global Warming Potential. 2006. Available: http://www.cement.ca/cement.nsf/eee9ec7bbd630126852566c40052107b/6ec79dc8ae03a782852572b90061b914/$FILE/ATTK0WE3/athena%20report%20Feb.%202%202007.pdf

Park, K, Hwang, Y., Seo, S., M.ASCE, and Seo, H. , "Quantitative Assessment of Environmental Impacts on Life Cycle of Highways," Journal of Construction Engineering and Management , Vol 129, January/February 2003, pp 25-31, (DOI: 10.1061/(ASCE)0733-9364(2003)129:1(25)).

Stripple, H. Life Cycle Assessment of Road. A Pilot Study for Inventory Analysis. Second Revised Edition. IVL Swedish Environmental Research Institute Ltd. 2001. Available: http://www.ivl.se/rapporter/pdf/B1210E.pdf

Treloar, G., Love, P.E.D., and Crawford, R.H. Hybrid Life-Cycle Inventory for Road Construction and Use. Journal of Construction Engineering and Management. P. 43-49. January/February 2004.

Energy Emissions Worksheet

| Type (Residential) or Principal Activity (Commercial) | Energy consumption per building per year (million Btu) | Carbon Coefficient for Buildings | MTCO2e per building per year | Floorspace per Building (thousand square feet) | MTCE per thousand square feet per year | MTCO2e per thousand square feet per year | Average Building Life Span | Lifespan Energy Related MTCO2e emissions per unit | Lifespan Energy Related MTCO2e emissions per thousand square feet |
|---|---|---|---|---|---|---|---|---|---|
| Single-Family Home | 107.3 | 0.108 | 11.61 | 2.53 | 4.6 | 16.8 | 57.9 | 672 | 266 |
| Multi-Family Unit in Large Building | 41.0 | 0.108 | 4.44 | 0.85 | 5.2 | 19.2 | 80.5 | 357 | 422 |
| Multi-Family Unit in Small Building | 78.1 | 0.108 | 8.45 | 1.39 | 6.1 | 22.2 | 80.5 | 681 | 489 |
| Mobile Home | 75.9 | 0.108 | 8.21 | 1.06 | 7.7 | 28.4 | 57.9 | 475 | 448 |
| Education | 2,125.0 | 0.124 | 264.2 | 25.6 | 10.3 | 37.8 | 62.5 | 16,526 | 646 |
| Food Sales | 1,110.0 | 0.124 | 138.0 | 5.6 | 24.6 | 90.4 | 62.5 | 8,632 | 1,541 |
| Food Service | 1,436.0 | 0.124 | 178.5 | 5.6 | 31.9 | 116.9 | 62.5 | 11,168 | 1,994 |
| Health Care Inpatient | 60,152.0 | 0.124 | 7,479.1 | 241.4 | 31.0 | 113.6 | 62.5 | 467,794 | 1,938 |
| Health Care Outpatient | 985.0 | 0.124 | 122.5 | 10.4 | 11.8 | 43.2 | 62.5 | 7,660 | 737 |
| Lodging | 3,578.0 | 0.124 | 444.9 | 35.8 | 12.4 | 45.6 | 62.5 | 27,826 | 777 |
| Retail (Other Than Mall) | 720.0 | 0.124 | 89.5 | 9.7 | 9.2 | 33.8 | 62.5 | 5,599 | 577 |
| Office | 1,376.0 | 0.124 | 171.1 | 14.8 | 11.6 | 42.4 | 62.5 | 10,701 | 723 |
| Public Assembly | 1,338.0 | 0.124 | 166.4 | 14.2 | 11.7 | 43.0 | 62.5 | 10,405 | 733 |
| Public Order and Safety | 1,791.0 | 0.124 | 222.7 | 15.5 | 14.4 | 52.7 | 62.5 | 13,928 | 899 |
| Religious Worship | 440.0 | 0.124 | 54.7 | 10.1 | 5.4 | 19.9 | 62.5 | 3,422 | 339 |
| Service | 501.0 | 0.124 | 62.3 | 6.5 | 9.6 | 35.1 | 62.5 | 3,896 | 599 |
| Warehouse and Storage | 764.0 | 0.124 | 95.0 | 16.9 | 5.6 | 20.6 | 62.5 | 5,942 | 352 |
| Other | 3,600.0 | 0.124 | 447.6 | 21.9 | 20.4 | 74.9 | 62.5 | 27,997 | 1,278 |
| Vacant | 294.0 | 0.124 | 36.6 | 14.1 | 2.6 | 9.5 | 62.5 | 2,286 | 162 |

**Sources**

All data in black text — King County, DNRP. Contact: Matt Kuharic, matt.kuharic@kingcounty.gov

Energy consumption for residential buildings

2007 Buildings Energy Data Book: 6.1 Quad Definitions and Comparisons (National Average, 2001)
Table 6.1.4: Average Annual Carbon Dioxide Emissions for Various Functions
http://buildingsdatabook.eren.doe.gov/
Data also at: http://www.eia.doe.gov/emeu/recs/recs2001_ce/ce1-4c_housingunits2001.html

Energy consumption for commercial buildings and Floorspace per building

EIA, 2003 Commercial Buildings Energy Consumption Survey (National Average, 2003)
Table C3. Consumption and Gross Energy Intensity for Sum of Major Fuels for Non-Mall Buildings, 2003
http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003excel/c3.xls

Note: Data in plum color is found in both of the above sources (buildings energy data book and commercial buildings energy consumption survey).

Carbon Coefficient for Buildings

Buildings Energy Data Book (National average, 2005)
Table 3.1.7. 2005 Carbon Dioxide Emission Coefficients for Buildings (MMTCE per Quadrillion Btu)
http://buildingsdatabook.eere.energy.gov/?id=view_book_table&TableID=2057
Note: Carbon coefficient in the Energy Data book is in MTCE per Quadrillion Btu.
To convert to MTCO2e per million Btu, this factor was divided by 1000 and multiplied by 44/12.

Residential floorspace per unit

2001 Residential Energy Consumption Survey (National Average, 2001)
Square footage measurements and comparisons
http://www.eia.doe.gov/emeu/recs/sqft-measure.html

average lief span of buildings, estimated by replacement time method

| | Single Family Homes | Multi-Family Units in Large and Small Buildings | All Residential Buildings | |
|---|---|---|---|---|
| New Housing Construction, 2001 | 1,273,000 | 329,000 | 1,602,000 | |
| Existing Housing Stock, 2001 | 73,700,000 | 26,500,000 | 100,200,000 | |
| Replacement time: | 57.9 | 80.5 | 62.5 | (national average, 2001) |

Note: Single family homes calculation is used for mobile homes as a best estimate life span.
Note: At this time, KC staff could find no reliable data for the average life span of commercial buildings.
Therefore, the average life span of residential buildings is being used until a better approximation can be ascertained.

Sources:

**New Housing Construction, 2001** **Quarterly Starts and Completions by Purpose and Design - US and Regions (Excel)**
**http://www.census.gov/const/quarterly_starts_completions_cust.xls**
**See also: http://www.census.gov/const/www/newresconstindex.html**

**Existing Housing Stock, 2001** **Residential Energy Consumption Survey (RECS) 2001**
**Tables HC1:Housing Unit Characteristics, Million U.S. Households 2001**
**Table HC1-4a. Housing Unit Characteristics by Type of Housing Unit, Million U.S. Households, 2001**
**Million U.S. Households, 2001**
**http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-4a_housingunits2001.pdf**

**Energy Consumption……Worksheet Background Information**

This section helps estimate the GHG emissions associated with energy used after the building has been constructed. It includes energy used by an average building. All estimates in this section are based on national average building energy usage from the Energy Information Administration and from the Department of Energy's Buildings Energy Data Book.

An important part of this estimate, as well as the transportation related estimate described in the next section, is to determine the average life span of buildings. This is not an easy task and no uniform estimates have been documented. However, one way to estimate building life spans is to estimate the ratio of the number of existing building units to that of annually constructed new units. This is the method employed in this worksheet. This method is most likely an underestimate of average building life spans as it does not account for growth in the total overall number of buildings. When compared with a literature review, the average life span of 62.5 years per building used in this worksheet is conservative but reasonable (e.g., 80-100 year average U.S. building service life reported by the Environment Policy Committee).

Environment Policy Committee. Design of Sustainable Building Policies: Scope for Improvement and Barriers. Organisation for Economic Co-operation and Development. Available: http://www.olis.oecd.org/olis/2001doc.nsf/43bb6130e5e86e5fc12569fa005d004c/203e895174de4e56c1256bd7003be835/$FILE/JT00128164.PDF

Transportation Emissions Worksheet

| Type (Residential) or Principal Activity (Commercial) | # people/ unit or building | # thousand sq feet/ unit or building | # people or employees/ thousand square feet | vehicle related GHG emissions (metric tonnes CO2e per person per year) | MTCO2e/ year/ unit | MTCO2e/ year/ thousand square feet | Average Building Life Span | Life span transportation related GHG emissions (MTCO2e/ per unit) | Life span transportation related GHG emissions (MTCO2e/ thousand sq feet) |
|---|---|---|---|---|---|---|---|---|---|
| Single-Family Home | 2.8 | 2.53 | 1.1 | 4.9 | 13.7 | 5.4 | 57.9 | 792 | 313 |
| Multi-Family Unit in Large Building | 1.9 | 0.85 | 2.3 | 4.9 | 9.5 | 11.2 | 80.5 | 766 | 904 |
| Multi-Family Unit in Small Building | 1.9 | 1.39 | 1.4 | 4.9 | 9.5 | 6.8 | 80.5 | 766 | 550 |
| Mobile Home | 2.5 | 1.06 | 2.3 | 4.9 | 12.2 | 11.5 | 57.9 | 709 | 668 |
| Education | 30.0 | 25.6 | 1.2 | 4.9 | 147.8 | 5.8 | 62.5 | 9247 | 361 |
| Food Sales | 5.1 | 5.6 | 0.9 | 4.9 | 25.2 | 4.5 | 62.5 | 1579 | 282 |
| Food Service | 10.2 | 5.6 | 1.8 | 4.9 | 50.2 | 9.0 | 62.5 | 3141 | 561 |
| Health Care Inpatient | 455.5 | 241.4 | 1.9 | 4.9 | 2246.4 | 9.3 | 62.5 | 140506 | 582 |
| Health Care Outpatient | 19.3 | 10.4 | 1.9 | 4.9 | 95.0 | 9.1 | 62.5 | 5941 | 571 |
| Lodging | 13.6 | 35.8 | 0.4 | 4.9 | 67.1 | 1.9 | 62.5 | 4194 | 117 |
| Retail (Other Than Mall) | 7.8 | 9.7 | 0.8 | 4.9 | 38.3 | 3.9 | 62.5 | 2394 | 247 |
| Office | 28.2 | 14.8 | 1.9 | 4.9 | 139.0 | 9.4 | 62.5 | 8696 | 588 |
| Public Assembly | 6.9 | 14.2 | 0.5 | 4.9 | 34.2 | 2.4 | 62.5 | 2137 | 150 |
| Public Order and Safety | 18.8 | 15.5 | 1.2 | 4.9 | 92.7 | 6.0 | 62.5 | 5796 | 374 |
| Religious Worship | 4.2 | 10.1 | 0.4 | 4.9 | 20.8 | 2.1 | 62.5 | 1298 | 129 |
| Service | 5.6 | 6.5 | 0.9 | 4.9 | 27.6 | 4.3 | 62.5 | 1729 | 266 |
| Warehouse and Storage | 9.9 | 16.9 | 0.6 | 4.9 | 49.0 | 2.9 | 62.5 | 3067 | 181 |
| Other | 18.3 | 21.9 | 0.8 | 4.9 | 90.0 | 4.1 | 62.5 | 5630 | 257 |
| Vacant | 2.1 | 14.1 | 0.2 | 4.9 | 10.5 | 0.7 | 62.5 | 657 | 47 |

**Sources**

All data in black text — King County, DNRP. Contact: Matt Kuharic, matt.kuharic@kingcounty.gov

# people/ unit — Estimating Household Size for Use in Population Estimates (WA state, 2000 average)
Washington State Office of Financial Management
Kimpel, T. and Lowe, T. Research Brief No. 47. August 2007
http://www.ofm.wa.gov/researchbriefs/brief047.pdf
Note: This analysis combines Multi Unit Structures in both large and small units into one category;
the average is used in this case although there is likely a difference

Residential floorspace per unit — 2001 Residential Energy Consumption Survey (National Average, 2001)
Square footage measurements and comparisons
http://www.eia.doe.gov/emeu/recs/sqft-measure.html

# employees/thousand square feet — Commercial Buildings Energy Consumption Survey commercial energy uses and costs (National Median, 2003)
Table B2 Totals and Medians of Floorspace, Number of Workers, and Hours of Operation for Non-Mall Buildings, 2003
http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set1/2003excel/b2.xls

Note: Data for # employees/thousand square feet is presented by CBECS as square feet/employee.
In this analysis employees/thousand square feet is calculated by taking the inverse of the CBECS number and multiplying by 1000.

vehicle related GHG emissions

Estimate calculated as follows (Washington state, 2006)_

| | |
|---|---|
| 56,531,930,000 | 2006 Annual WA State Vehicle Miles Traveled |
| | Data was daily VMT. Annual VMT was 365*daily VMT. |
| | http://www.wsdot.wa.gov/mapsdata/tdo/annualmileage.htm |
| 6,395,798 | 2006 WA state population |
| | http://quickfacts.census.gov/qfd/states/53000.html |
| 8839 | vehicle miles per person per year |
| 0.0506 | gallon gasoline/mile |
| | This is the weighted national average fuel efficiency for all cars and 2 axle, 4 wheel light trucks in 2005. This includes pickup trucks, vans and SUVs. The 0.051 gallons/mile used here is the inverse of the more commonly known term “miles/per gallon” (which is 19.75 for these cars and light trucks). |
| | Transportation Energy Data Book. 26th Edition. 2006. Chapter 4: Light Vehicles and Characteristics. Calculations based on weighted average MPG efficiency of cars and light trucks. |
| | http://cta.ornl.gov/data/tedb26/Edition26_Chapter04.pdf |
| | Note: This report states that in 2005, 92.3% of all highway VMT were driven by the above described vehicles. |
| | http://cta.ornl.gov/data/tedb26/Spreadsheets/Table3_04.xls |
| 24.3 | lbs CO2e/gallon gasoline |
| | The CO2 emissions estimates for gasoline and diesel include the extraction, transport, and refinement of petroleum as well as their combustion. |
| | Life-Cycle CO2 Emissions for Various New Vehicles. RENew Northfield. |
| | Available: http://renewnorthfield.org/wpcontent/uploads/2006/04/CO2%20emissions.pdf |
| | Note: This is a conservative estimate of emissions by fuel consumption because diesel fuel, |
| 2205 | with a emissions factor of 26.55 lbs CO2e/gallon was not estimated. |
| 4.93 | lbs/metric tonne |
| | vehicle related GHG emissions (metric tonnes CO2e per person per year) |

average lief span of buildings, estimated by replacement time method — See Energy Emissions Worksheet for Calculations

Commercial floorspace per unit — EIA, 2003 Commercial Buildings Energy Consumption Survey (National Average, 2003)
Table C3. Consumption and Gross Energy Intensity for Sum of Major Fuels for Non-Mall Buildings, 2003
http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003excel/c3.xls

**The Point at Northshore Raw Data and Assumptions**

| No Action Alternative | | | | |
|---|---|---|---|---|
| Pavement | | | Buildings | |
| Est. lineal feet of paved cart path | Pavement width | Est. square footage of pavement | Est. square footage of Service buildings | Est. square footage of Food Service buildings |
| 22918 | 8 | **183,344** | 529 | 11550 |
| | | | 1584 | |
| | | | 3136 | |
| | | | 6864 | |
| | | | 200 | |
| | | | 1220 | |
| | | | 1360 | |
| | | | 1840 | |
| | | | 1404 | |
| | | | 360 | |
| | | | **18,497** | **11,550** |

| Lifespan of Construction Type | |
|---|---|
| Type | Lifespan (Years) |
| Food Service | 62.5 |
| Service | 62.5 |
| Single family residence | 57.9 |
| Pavement -- associated with service or food service building* | 62.5 |
| Pavement -- associated with single family residence* | 57.9 |

*Due to the challenges of estimating pavement lifespan, for this analysis the City assumes the pavement to have the same lifespan as the buildings associated with its development.

| Proposed Action and Proposed Action Alternative | | | | | |
|---|---|---|---|---|---|
| Pavement | | | | Buildings | |
| Construction Phase | Proposed lineal square feet of pavement | Pavement width | Total square footage of pavement | Housing Units (Proposed Action) | Housing Units (Proposed Action Alternative) |
| 52' ROW: Phase III | 4110 | 28 | 115080 | **860** | **670** |
| 52' ROW: Phase III | 4336 | 28 | 121408 | | |
| 24' Private Drive: Phase II | 5567 | 20 | 111340 | | |
| 24' Private Drive: Phase IV | 5657 | 20 | 113140 | | |
| 60' ROW: Phase I | 904 | 46 | 41584 | | |
| 60' ROW: Phase II | 2395 | 46 | 110170 | | |
| 70; ROW: Phase I | 2520 | 46 | 115920 | | |
| | **25,489** | | **728,642** | | |

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# Construction Carbon Calculator Results

## Approximate net embodied CO2 for this project is

# 1,744 metric tons.

### Your Entries

| | |
|---|---|
| Total Square Feet | **0** |
| Stories Above Grade | **NA** |
| Stories Below Grade | **NA** |
| System Type | **mixed** |
| Ecoregion | **Marine West Coastal Forest** |
| Existing Vegetation Type | **Short Grass or Lawn** |
| Installed Vegetation Type | **Short Grass or Lawn** |
| Landscape Disturbed (SF) | **4,839,960** |
| Landscape Installed (SF) | **2,946,592** |

No building was detected so the calculation is only for the site - landscape disturbance and installation. If you meant to include a building please try again and make sure to enter a valid number for total square feet.

Construction Carbon Calculator formula version 0.03.5, last updated 2007.10.11. These results are an approximation. Your actual carbon footprint may vary. See assumptions for more information.

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# Construction Carbon Calculator Results

## Approximate net embodied CO2 for this project is

# 9,660 metric tons.

### Your Entries

| | |
|---|---|
| Total Square Feet | **0** |
| Stories Above Grade | **NA** |
| Stories Below Grade | **NA** |
| System Type | **mixed** |
| Ecoregion | **Marine West Coastal Forest** |
| Existing Vegetation Type | **Forest** |
| Installed Vegetation Type | **Short Grass or Lawn** |
| Landscape Disturbed (SF) | **5,052,960** |
| Landscape Installed (SF) | **4,839,960** |

No building was detected so the calculation is only for the site - landscape disturbance and installation. If you meant to include a building please try again and make sure to enter a valid number for total square feet.

Construction Carbon Calculator formula version 0.03.5, last updated 2007.10.11. These results are an approximation. Your actual carbon footprint may vary. See assumptions for more information.

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# Assumptions

Buildings, sites and construction processes vary widely — we've done our best to create an easy to use calculator for generating an estimate from averaged data. This will provide a rough approximation of the carbon load - not an exact one. Here are the assumptions made for the current iteration of the Construction Carbon Calculator. We welcome your feedback!

1. The calculator is accurate to about 25%, plus or minus. (This is similar to most operational carbon calculators.)
2. Landscape data are for soil organic carbon (SOC) only and do not include above ground biomass (trees, shrubs and grasses).
3. Disturbed soil retains an amount of residual carbon. This carbon factor has been accounted for in both the disturbed soil and the installed landscape accounting.
4. The land use categories are very broad and refer largely to mature natural landscapes - 5 years for grasslands, 10 years for shrublands and 30 years for forests.
5. The data are taken from a number of published references. Where there is a range for any vegetation type/ecoregion cell, the mid point is taken.
6. This takes no account of the variation of soil characteristics within each ecoregion.
7. This does not include data for conventional landscaped systems, which can vary considerably depending on inputs - the nearest vegetation type should be used (e.g. for a urban park use savanna/parkland; lawns use shortgrass/lawn).
8. Numbers have been built from a combination of project cost estimates including quantities and available web-based resources of

embodied carbon intensity ratios of different building materials.

9. The building data takes into account site excavation, shell and core (structural systems, building envelope and building systems). Tenant improvements, interiors or furniture, fixtures or equipment have not been included in version 0.01.

10. These carbon cost estimates are based primarily on commercial or multi-family projects. Residential projects may vary from these results.

11. The building data is based on Life Cycle Balancing: Building Shell, Interiors, & Furnishings Sub-Systems: Nursing and Biomedical Sciences Building, the University of Texas at Houston Health Sciences Center from the Center for Maximum Potential Building Systems. They had the following factors for different building elements: Shell - 24%, Service Systems - 22%, Service Sector - 14%, Substructure - 5%, Other/ Miscellaneous - 17%. This is 70% of the total for a complete building including interiors, but covers the materials being quantified in our analysis. Our breakdown was slightly different, taking into account the specific building elements for which we were able to accumulate data, and extrapolating the unknown factors. Our factors were as follows: Shell Known - 12%, Shell Unknown - 12%, Service Systems - 22%, Service Sector - 14%, Substructure Known - 2%, Substructure Unknown - 3%, Other/ Miscellaneous - 5%.

12. Building square footage intensity values have been generated from cost estimate data for excavation, steel, concrete and wood and material carbon intensity ratios.

13. Wood values assume non-certified wood sources. The values for the wood represent the carbon released converting the wood from a natural forested state to an installed condition. Certified wood will compensate for the carbon released and allow the wood in a building to count as a carbon sink.

14. Some data sets used in developing version 0.01 were smaller than others. Averaged values were available for certain building structural types, but for others it was based on one or two actual buildings.

If you have some good ideas for improvements, we'd like to hear about it!

See also:

- References - sources used in development of the Construction Carbon Calculator formula.
- Next Steps - what we're planning for the future of this site, including

expanded datasets and more detailed input options for the next version of the calculator.

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