CORRIM Report:
Life Cycle Assessment for the Production of SE Engineered I-Joist

Richard D. Bergman
USDA Forest Service
Forest Products Laboratory
Madison, WI
rbergman@fs.fed.us

Sevda Alanya-Rosenbaum
USDA Forest Service
Forest Products Laboratory
Madison, WI
salanyarosenbaum@fs.fed.us

Report version
April 2017

Revised for 2019 PCR
August 2019
March 2020

Revisions by
Maureen Puettmann, PhD.
WoodLife Environmental Consultants
Corvallis, OR
Maureen.puettmann@woodlifeconsulting.com

CORRIM
maureen@corrim.org

CORRIM
Consortium for Research on Renewable Industrial Materials

Table of Contents

Table of Contents **2**

List of Figures **4**

List of Tables **4**

Addendum **5**

Abbreviations **7**

Glossary of Terms **8**

1 Background **9**

2 Goal and Scope **9**

2.1 Goal and Objectives *9*
2.1.1 Goals 9
2.1.2 Intended Audience 9
2.1.3 Comparative Assertions 9

2.2 Scope of Considered System *10*
2.2.1 Functional and declared unit 10
2.2.2 System boundary 10
2.2.3 Allocation rules 12
2.2.4 Cut off rules 12
2.2.5 Data collection 12
2.2.6 Calculation rules 12

3 Description of Industry **13**

3.1 Categories of products and co-products *13*

3.2 Annual operating and production statistics of the industry (us total, regional) *13*

3.3 Typical emission control measures by plant type *13*

4 Description of Product **14**

4.1 Wood species *16*

4.2 Moisture content *16*

5 Life cycle inventory analysis **16**

5.1 A1- Resource extraction *16*
5.1.1 Harvesting Operations 16
5.1.2 LVL production 17
5.1.3 Oriented strandboard production 17
5.1.4 Finger-jointed lumber production 17
5.1.5 Resin production 17

5.2 A2 – Transport *17*

5.3 A3 – Product Manufacturing *18*

5.3.1 Material Flows 18
5.3.2 I-joists Manufacturing 19
5.3.3 Equipment: Type and fuel consumption 21
5.3.4 Energy use and generation 21
5.3.5 Wood-base fuels 21
5.3.6 Packaging 21
5.4 Secondary Data Sources 21
6 Life cycle impact assessment 24
7 Interpretation 28
7.1 Identification of the Significant Issues 28
7.2 Life cycle phase contribution analysis 28
7.3 Uncertainty Analysis 30
7.4 Completeness, consistency and sensitivity 31
7.5 Limitations 32
8 Treatment of Biogenic Carbon 32
9 Discussion 34
10 Conclusions 35
11 Critical review 36
11.1 Internal Review 36
11.2 External Review 36
12 Acknowledgements 36
13 Units and Conversions 37
14 References 38
15 Appendix 1 Conformance to North American Structural and Architectural Wood Product Category Rules .. 40
16 Appendix 2 Original LCA Report 43

List of Figures

Figure 1 Cradle-to-gate system boundary for composite I-joist production in the SE region 11
Figure 2 A Composite I-joist made from LVL and OSB 15
Figure 3 Typical composite I-joist made with laminated veneer lumber (LVL) flanges and an oriented strandboard (OSB) web. 15

List of Tables

Table A1 Original and updated reporting requirements 5
Table 1 System boundary inclusions and exclusions for the cradle-to-gate of SE I-joists production 10
Table 2 Common dimensions for composite I-joists. 13
Table 3 Fuel consumption for SE region forest resource management processes (regeneration, thinning, and harvest) (Puettmann, et al. 2013) 16
Table 4 Weighted-average delivery distance (one way) by mode for materials to SE I-joists plant. 18
Table 5 Mass balance of SE I-joists manufacturing per linear meter. 18
Table 6 Unit process inputs–outputs to produce one linear meter of SE I-joists. 20
Table 7 Weighted-average on-site energy inputs for SE I-joists manufacturing 21
Table 8 Materials used in packaging and shipping per meter of SE I-joists 21
Table 9 Secondary Data Sources and Data Quality Assessment 22
Table 10 Selected impact indicators, characterization models, and impact categories 24
Table 11 Environmental performance of 1 linear meter of I-joist, SE 27
Table 12 Distribution of waste generation by life cycle stage; A1-Resource extraction, A2-Transportation, and A3 Product manufacturing. 28
Table 13 Distribution of waste generation in the A1-Resource extraction life cycle stage. 28
Table 14 Cradle-to-gate SE I-joists LCIA contribution analysis LCIA results for A1-Resource extraction, A2-Transportation, and A3-Product production 29
Table 15 Cradle-to-gate SE I-joists LCIA energy use contribution analysis results by fuel type for A1-Resource extraction, A2-Transportation, and A3-Laminated veneer production 30
Table 16 Cradle-to-gate SE I-joists LCIA energy use contribution analysis results by A1-Resource extraction, A2-Transportation, and A3- Laminated veneer production 30
Table 17 Survey data statistics for selected parameters, mass balance 30
Table 18 Survey data statistics for Selected Parameters, on-site energy use 31
Table 19 Key parameters on changing natural gas consumption during I-joists production. 31
Table 20 Key parameters on changing electricity consumption during I-joists production. 32
Table 21 Biogenic carbon inventory parameters 34
Table 22 LCIA comparison between updated 2013 data (based on 2007 industry surveys) and current study data (based on 2012 industry surveys) on I-joists production in the SE 35
Table 23 Wood conversion in developing the laminated veneer lumber 37

Addendum

The original report "CORRIM Report – Module F2 Cradle-To-Gate Life-Cycle Assessment of Composite I-Joists Produced in the Southeast Region of The United States was revised to meet the Product Category Rule (PCR) Guidance for Building-Related Products and Services Part B: Structural and Architectural Wood Products EPD Requirements. This revision was performed by WoodLife Environmental Consultants under contract with the Consortium for Research on Renewable Industrial Materials as part of the American Wood Council (AWC) EPD development of North American Wood Products.

The report might be reduced in content from the original to include only those reporting requirements for the PCR. Reference to the LCA on southeast (SE) I-joists should be made to the original as well as this revised report. Changes and additions from the original report may include additional required reporting impact factors and impact methods (Table A1) per the PCR and ISO (ISO 2006a-b) requirements on sensitivity analysis and interpretation of results.

Table A1 Original and updated reporting requirements

Revised Report					Original Report
Reporting Category Per Tables E1-E5 in ISO 21930:2017	**Indicator Name**	**Abbreviation**	**Units**	**Calculation Method**	**In report**
Core Mandatory Impact Indicators	Global warming potential, biogenic[1]	GWP	kg CO2e	TRACI + Manual	No
Core Mandatory Impact Indicators	Global warming potential, fossil	GWP	kg CO2e	TRACI	Yes
Core Mandatory Impact Indicators	Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	TRACI	Yes
Core Mandatory Impact Indicators	Acidification potential of soil and water sources	AP	kg SO2e	TRACI	Yes
Core Mandatory Impact Indicators	Eutrophication potential	EP	kg PO4e	TRACI	Yes
Core Mandatory Impact Indicators	Formation potential of tropospheric ozone	SFP	kg O3e	TRACI	Yes
Core Mandatory Impact Indicators	Abiotic depletion potential (ADPfossil) for fossil resources;	ADPf	MJ, NCV	CML-IA Baseline V3.05	No
Core Mandatory Impact Indicators	Fossil fuel depletion	FFD	MJ Surplus	TRACI	Yes
Use of Primary Resources	Renewable primary energy carrier used as energy	RPRE	MJ, NCV	CED, NCV	Yes
Use of Primary Resources	Renewable primary energy carrier used as material	RPRM	MJ, NCV	Manual	No
Use of Primary Resources	Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	CED, NCV	Yes
Use of Primary Resources	Renewable primary energy carrier used as material	NRPRM	MJ, NCV	Manual	No
Secondary material, secondary fuel and recovered energy	Secondary material	SM	kg	N/A	No
Secondary material, secondary fuel and recovered energy	Renewable secondary fuel	RSF	MJ, NCV	Manual	No
Secondary material, secondary fuel and recovered energy	Non-renewable secondary fuel	NRSF	MJ, NCV	N/A	No
Secondary material, secondary fuel and recovered energy	Recovered energy	RE	MJ, NCV	N/A	No

[1] This indicator includes both biogenic and fossil-based carbon released. The TRACI method was modified to included CO2, biogenic removals and emissions.

Revised Report					Original Report
Mandatory Inventory Parameters	Consumption of freshwater resources;	FW	m3	Manual	Yes
Indicators Describing Waste	Hazardous waste disposed	HWD	kg	SP: Process Contribution	Yes
Indicators Describing Waste	Non-hazardous waste disposed	NHWD	kg	SP: Process Contribution	
Indicators Describing Waste	High-level radioactive waste, conditioned, to final repository	HLRW	kg or m3	SP: Process Contribution	
Indicators Describing Waste	Intermediate- and low-level radioactive waste, conditioned, to final repository	ILLRW	kg or m3	SP: Process Contribution	
Indicators Describing Waste	Components for re-use	CRU	kg	Manual	No
Indicators Describing Waste	Materials for recycling	MR	kg	Manual	No
Indicators Describing Waste	Materials for energy recovery	MER	kg	Manual	No
Indicators Describing Waste	Recovered energy exported from the product system	EE	MJ, NCV	Manual	No
Must include following if part of GWP					
Additional Inventory Parameters for Transparency	Biogenic Carbon Removal from Product	BCRP	kg CO2e	Manual	Yes
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Product	BCEP	kg CO2e	Manual	Yes
Additional Inventory Parameters for Transparency	Biogenic Carbon Removal from Packaging	BCRK	kg CO2e	Manual	No
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Packaging	BCEK	kg CO2e	Manual	No
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	BCEW	kg CO2e	Manual	Yes
Additional Inventory Parameters for Transparency	Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	CWNR	kg CO2e	Manual	No

Abbreviations

Cunit	100 cubic feet
EPDs	Environmental Product Declarations
GWP	Global Warming Potential
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
m^3	Cubic meter
MSF	1000 square feet
odkg	Oven Dry Weight Wood in Kilograms
PCR	Product Category Rules
tkm	Metric Tonne – Kilometers

Glossary of Terms

Allocation - A way of dividing emissions and resource use among the different products of a process. The partitioning can be made on weight basis, energy content, or economic value.

Cradle-to-gate - LCA model which includes upstream part of the product life cycle, i.e. all steps from raw material extraction to product at factory gate.

Declared Unit - Quantity of a wood building product for use as a reference unit, e.g. mass, volume, for the expression of environmental information needed in information modules.

Functional Unit - expresses the function of studied product in quantitative terms and serves as basis for calculations. It is the reference flow to which other flows in the LCA are related. It also serves as a unit of comparison in comparative studies.

Life cycle assessment (LCA) - Method for the environmental assessment of products covering their lifecycle from raw material extraction to waste treatment

Life cycle inventory (LCI) - LCA study that goes as far as an inventory analysis but does not include impact assessment.

Life cycle impact assessment (LCIA) - Phase of an LCA study during which the environmental impacts of the product are assessed and evaluated.

Product Category Rules (PCR) - Set of specific rules, requirements and guidelines for the development of type III environmental declarations for one or more product categories (ISO 14025, ISO 21930)

System boundary - A set of criteria that specifies which unit processes are part of a product system (adapted from ISO 14044)

1 Background

The environmental consequences of producing a material such as laminated veneer lumber (I-joists) are carried forward into the life cycle of products such as wooden structures. CORRIM, the Consortium for Research on Renewable Industrial Materials, has derived life cycle inventory (LCI) data for major wood products manufactured in several regions of the United States. The life cycle inventory data cover from forest regeneration through to final product at the mill gate. Research has covered nine major forest products, both structural and nonstructural, and four major regions: in this report we focus on I-joists produced in the US southeast (SE) region.

This report describes the energy and materials for producing I-joists in the SE region of the US through a cradle-to-gate life cycle inventory on the manufacturing process. The environmental impacts, global warming, ozone depletion, acidification, smog, and eutrophication are discussed.

The focus of this report is an industry average I-joists production in the SE region of the United States. LCI data are then used to estimate life-cycle impact assessments (LCIA). This study updates the cradle-to-gate manufacturing for I-joists in the SE (Wilson and Dancer 2004).

The data collection was performed under "CORRIM Guidelines for Performing Life Cycle Inventories on Wood Products", undated, but current in the fall of 2012, a scientifically sound and consistent process established by CORRIM. It follows ISO 14040 standards (ISO 2006), ISO 21930 (ISO 2017), the Product Category Rules (PCR) for North American Structural and Architectural Wood Products (UL 2019) that will provide the guidance for preparation of North American wood product Environmental Product Declaration (EPD) and Part A: Life Cycle Assessment Calculations Rules and Report Requirements (UL 2018).

2 Goal and Scope

It is the goal and scope that provide the plan for conducting the LCI including data collection, compilation, and interpretation.

2.1 Goal and Objectives

2.1.1 Goals

The primary goal is to generate a gate-to-gate LCA of SE USI-joists manufacturing and use this data to develop a cradle-to-gate profile of SE US I-joists. The cradle-to-gate LCA will follow data and reporting requirements as outlined in the PCR (UL 2019) will provide the guidance for preparation of a business-to-business EPD.

2.1.2 Intended Audience

The primary audience for the results of this LCA report is I-joists producers in the US and CORRIM LCA practitioners.

2.1.3 Comparative Assertions

The report does not include product use and end of life phases which are required for comparative assertions relative to substitute products. If future comparative studies are intended and disclosed to the public, the LCA boundary would need to be expanded to include the use and end of life phases consistent with the ISO 14044:2006 guidelines and principles and ISO 21930 core rules for EPDs (ISO 2006, ISO 2017), and compliance with the Wood Products PCR, Part A and B (UL 2018, 2019).

2.2 Scope of Considered System

2.2.1 Functional and declared unit

In accordance with the PCR the declared unit for I-joists was one linear meter, with an oven-dried moisture content of 6 percent, dry basis. A declared unit is used in instances where the function and the reference scenario for the whole life cycle of a wood building cannot be stated (UL 2019). The inventory input data is presented as unallocated flows, all input and output flows allocated to the main product. This analysis does not take the declared unit to the use stage no service life is assigned.

The cradle-to-gate LCI was generated by combing the SE I-joists manufacturing data collected by survey with previously published datasets for upstream manufacturing of forestry and harvesting operations, fuels, electricity, and ancillary material use.

2.2.2 System boundary

The cradle-to-gate system boundary is shown in Figure 1. The system boundary begins with regeneration in the forest and ends with I-joists at the mill gate. The system boundary included forest resource management activities such as site preparation and planting seedlings; fertilization and thinning on a subset of hectares; final harvest through transportation of roundwood to the primary breakdown facility; oriented strandboard (OSB), laminated veneer lumber (LVL), and finger joint lumber (FJL) production; transportation to the I-joist facility if needed; and I-joist production. The I-joist production complex was modeled as a single unit approach representing all the steps necessary to make I-joists. Three main unit processes exist in manufacturing I-joists: (1) routing and shaping of web and flanges, (2) assembly of I-joists, and (3) sawing and curing with energy generation as an auxiliary process. A single unit (i.e. black box) approach was used to model the I-joist process because little wood left the system except as the final product and because of the relative simplicity of the I-joist manufacturing processes. This simply means all process inputs and outputs are grouped into one I-joist process.

Fuel resources used for the cradle-to-gate production of energy and electricity were included within the cumulative system boundary. Off-site emissions include those from grid electricity production; transportation of feedstock; OSB, LVL, and FJL production; transportation to the I-joist facility; and production of fuels off site and consumed both on and off site. Ancillary material consumption data such as motor oil, waxes, paint, and hydraulic fluid were included in the analysis. Excluded from the system boundaries are fixed capital equipment and facilities, transportation of employees, land use, delivery of I-joists to construction site, construction, maintenance, use, and final disposal. Disposal of on-site waste from production manufacturing is included in the system boundary. Table 1 lists the inclusion and exclusion within the system boundaries of this study.

Table 2 System boundary inclusions and exclusions for the cradle-to-gate of SE I-joists production

Included	Excluded
• Production of upstream processes for all resources, raw materials, fuels, and energy for I-joists production used in forestry operations, harvesting, and softwood I-joists manufacturing	• Fixed capital equipment and facilities
• Transportation of materials throughout the cradle-to-gate manufacturing life stages.	• Transportation of employees
• Packaging	• Construction, maintenance, use, and end of life treatment

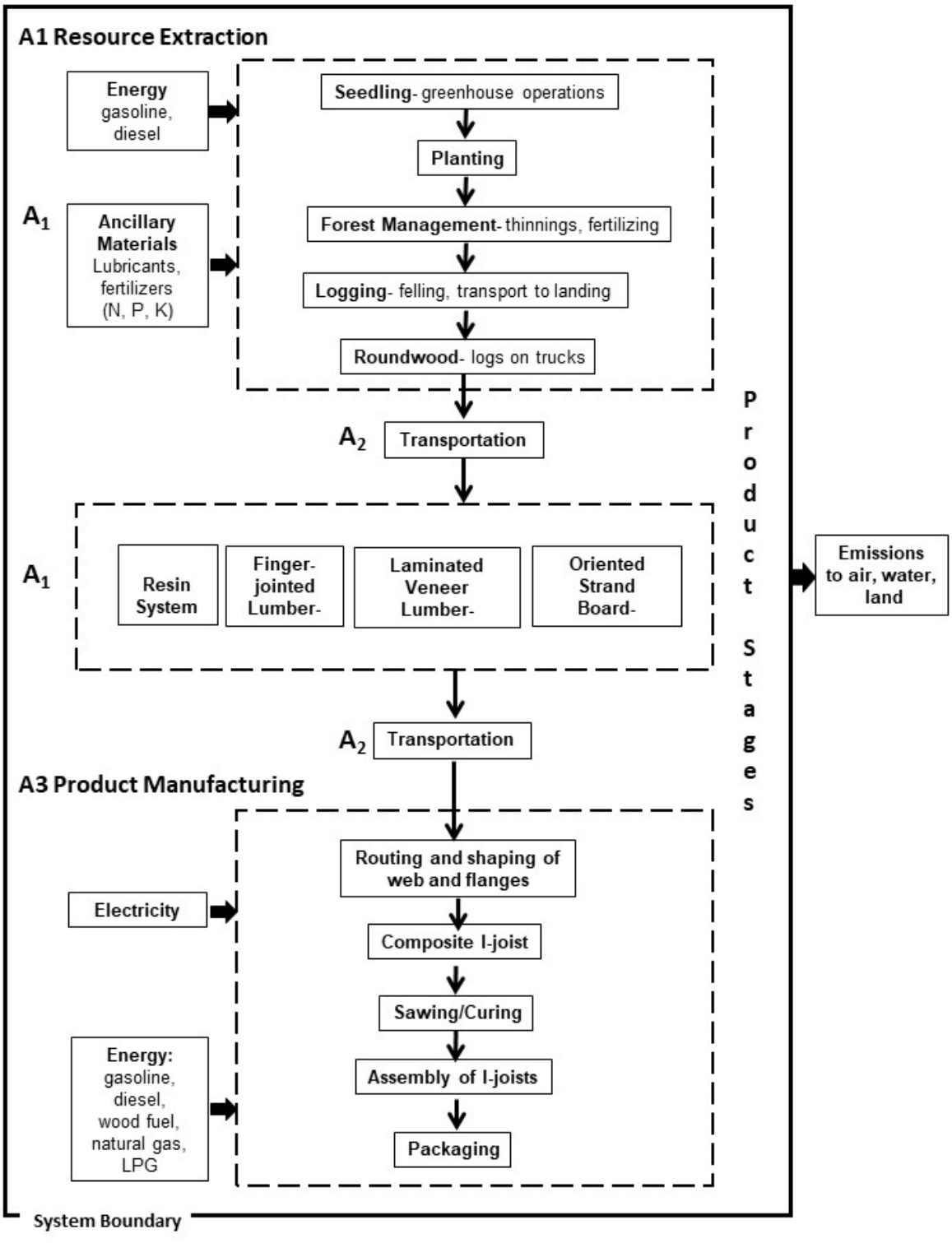


Figure 1 Cradle-to-gate system boundary for composite I-joist production in the SE region

2.2.3 Allocation rules

Allocation is the method used to partition the environmental load of a process when several products or functions share the same process. The input material is finished oriented OSB, LVL, and FJL. A mass allocation for coproduct outputs was conservatively chosen.

2.2.4 Cut off rules

According to the PCR, if the mass/energy of a flow is less 1 percent of the cumulative mass/energy of the model flow it may be excluded, provided its environmental relevance is minor. This analysis for SE I-joists included all energy and mass flows for primary data. No cut-offs were used in the impact assessment.

2.2.5 Data collection

Surveys were used to collect the LCI data in accordance with CORRIM guidelines and ISO standards. This study relied almost exclusively on production and emissions data provided by I-joists producers in the SE, with some secondary data on fuels and electrical grid inputs from the US LCI database and European datasets (Datasmart2018 and Ecoinvent 3.4). Three mills provided data for 2012 I-joists and co-product production, raw material and fuel use, electricity consumption, and on-site emissions.

2.2.6 Calculation rules

For U.S. production, I-joists is commonly reported in linear feet. The survey results were converted to a unit production basis, of one linear meter (m), and a weighted average of input data was calculated based on production.

This approach resulted in an I-joists complex that represents a composite of the North American mills surveyed but may not represent any mill in particular. The U.S. LCI database was used to assess off-site impacts associated with the materials and energy used. SimaPro, version 8+ (Pré Consultants 2016) was used as the accounting program to track all of the materials. The primary data obtained from the surveys were weight-averaged using the formula shown below (Milota 2015):

$$w_1 = \frac{y_1}{(y_1 + y_2 + y_3)} = \frac{y_1}{Y_{total}} \qquad eq.1$$

w_1 = weighing factor for mill 1
Y_{total} = total annual production of "y" mills
y_1 = annual production of Mill 1

Missing data were defined as data not reported in surveys by the I-joists facilities. When missing data occurred for survey items, they were checked with plant personnel to determine if it was an unknown value or zero. Missing data were carefully noted to make sure they were not averaged as zeros. Any outliers were resolved by contacting mill personnel.

3 Description of Industry

This study focused on large-scale production facilities that are representative of the industry. Production values and study results were reported per linear meter with an assumed average depth of 30 cm as shown in Figure 2 (depth goes from the top to the bottom of the 'I'). I-joist depth varies notably, but large quantities of I-joists made in the United States have a depth of 30 cm. These engineered structural wood products are designed to be used in the same manner as solid wood products such as sawn lumber but with different properties.

Production of I-joists is measured on a linear basis (feet, meters) with no measurement for the dimensions of height and width, which is the practice for the I-joist data given in this study. The most common dimensions of I-joists for the SE can be found in Table 2. This LCA uses a weighted average for producing a generic I-joist (Table 2). This I-joist is slightly larger than you would expect to find in that region because of the small amount of waste and inefficiencies of producing the I-joists included in the product.

Table 3 Common dimensions for composite I-joists.

Common I–joist dimensions					
Depth	**Flange thickness**	**Width**	**Height**	**Flange thickness**	**Width**
millimeters		**inches**			
241.30	33.34	44.45	9.50	1.31	1.75
301.75	38.10	44.45	11.88	1.50	1.75
301.75	38.10	38.10	11.88	1.50	1.50
301.63	79.38	38.10	11.88	3.13	1.50
Generic I-joists dimension					
298.45	33.34	47.75	11.75	1.31	1.88

3.1 Categories of products and co-products

The main product from SE I-joists mills is I-joists. Other products (co-products) are also produced from trimming, sawing, finishing of I-joists. These co-products could include trim, and sawdust.

3.2 Annual operating and production statistics of the industry (us total, regional)

Total U.S. I-joist production for 2012 was 109 million meters (358.900 million ft) (APA 2014). Two U.S. I-joist plants representing 27.1 percent of 2012 U.S. production, 29.5 million meters (96.8 million ft) participated in the study by providing primary data for the SE. The surveyed plants provided detailed annual production data on their facilities, including on-site energy consumption; electrical usage; LVL, OSB, and FJL volumes; and I-joist production for 2012. Wilson and Dancer (2004) performed a 2000 U.S. I-joist LCI study that covered 33 percent (21.3 million m) of production in the SE. Production from surveyed facilities for 2012 was an increase of 58 percent compared with 2000. In addition, unlike the earlier 2000 study, 2012 I-joist production data were not available by region. Therefore, production data by region could not be quantified for 2012.

3.3 Typical emission control measures by plant type

Common emission control devices are regenerative thermal oxidizers (RTOs) for the reduction of volatile organic compounds (VOC's) and electrostatic precipitators (ESPs) for the removal of particulate matter or particle pollution (PM). Regenerative catalytic oxidizers (RCOs) can remove more than 99.9 percent of

VOCs, but release nitrogen oxides by burning natural gas or liquefied petroleum gas. RCOs are designed to destroy VOCs and other emissions including PM and soot (USEPA 2003a). Electrostatic precipitators are used to collect particulate matter (PM) pollution but are not effective in reducing volatile organic compounds (VOC's) or hazardous air (HAP) emissions. The surveyed mills reported the installation and use of RCOs.

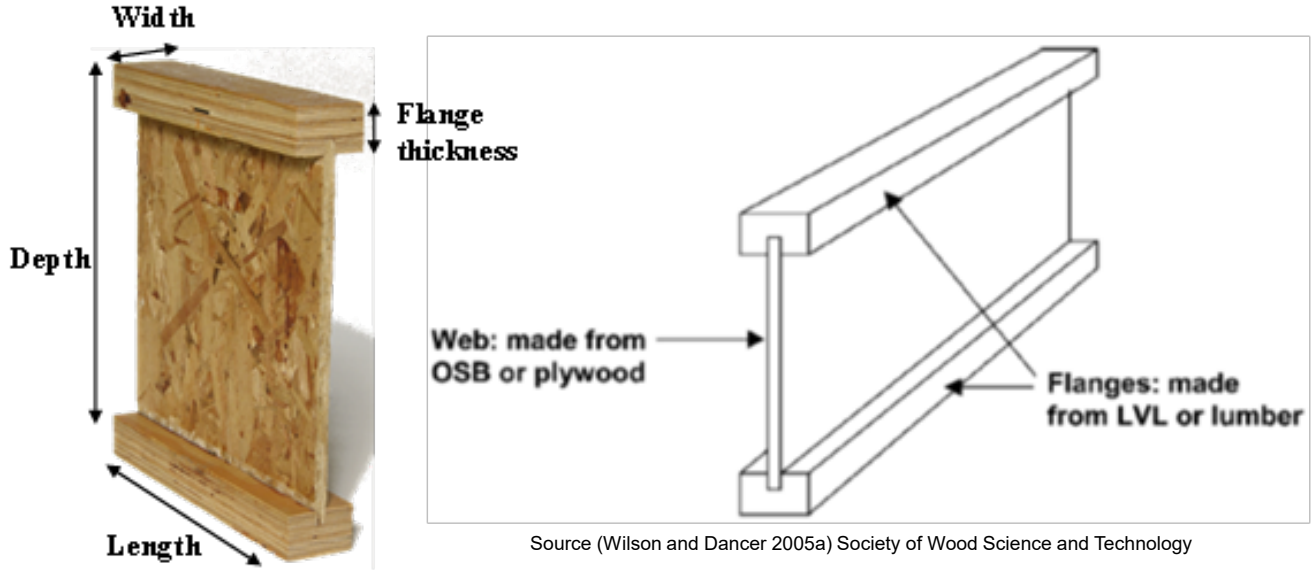
Air emission data were collected from surveyed mills. The air emission data were augmented by a secondary resource for acetone emissions from I-joist plants (USEPA 2002). Baghouses are the primary collectors of particulate matter with all three surveyed plants using this ECD. I-joist manufacturers reported on-site air emissions of acetone, carbon monoxide, formaldehyde, methanol, nitrous oxides, particulate matter, phenol, sulfur dioxide, and VOCs. All waterborne emissions occurred off site for gate-to-gate I-joist production. I-joist plants are zero- discharge facilities. Solid emissions were dominated by LVL and I-joist production stages. A total of 0.423 kg/m solid waste was generated. No dangerous substances were reported by industry that fall under ISO 21930 (ISO 2017).

4 Description of Product

I-joists fall into the North American Industry Classification System (NAICS) Code 321213—engineered wood member (except truss) manufacturing, which includes other structural wood engineered products such as FJL, parallel strand lumber, and glued–laminated timbers (USCB 2012; ASTM 2014). Additional classification codes for I-joists are the United Nations Standard Products and Services Code (UNSPSC) for wood joists 301036 07 and Construction Specifications Institute (CSI) code for engineer wood products 06 11 13 and wood I-joists 06 17 33.

I-joists have an "I" shape and are measured in linear feet in the United States (Figure 2). A composite I-joist is comprised of a web made from a structural wood panel, usually OSB but sometimes plywood (Figure 3). The web is glued between two flanges that are sometimes made from solid-sawn lumber or FJL but more commonly from LVL (USEPA 2002; Wilson and Dancer 2004; Stark et al. 2010; ASTM 2014). Typical flange size depends on the material. For LVL, the common size is 1.75 by 1.5 in. (44.5 by 38.1 mm), and for lumber flanges, the size is nominal 2 by 3 –in. (50.8 by 76.2 mm). There are many different dimensions of composite I-joists, but the most common are dimensions that directly replace 2 by 10 in. (50.8 by 254 mm) and 2 by 12 in. (50.8 by 304.8 mm) structural lumber (Table 2). I-joists are usually made in continuous lengths and then cut to 60-ft (18.29-m) lengths for shipping.

Figure 2 A Composite I-joist made from LVL and OSB



Source (Wilson and Dancer 2005a) Society of Wood Science and Technology

Figure 3 Typical composite I-joist made with laminated veneer lumber (LVL) flanges and an oriented strandboard (OSB) web.

This study focused on large-scale production facilities that are representative of the industry. Production values and study results were reported per linear meter with an assumed average depth of 30 cm as shown in Figure 3 (depth goes from the top to the bottom of the 'I'). I-joist depth varies notably, but large quantities of I-joists made in the United States have a depth of 30 cm. These engineered structural wood products are designed to be used in the same manner as solid wood products such as sawn lumber but with different properties.

4.1 Wood species

I-joists in the SE region are primarily made with southern pine species including a mix of longleaf pine (*P. palustris*), shortleaf pine (*P. echina*ta), slash pine (*P. elliotti*), and loblolly pine (*P. taeda* L.) along with some hardwood mostly from yellow poplar (*Liriodendron tulipfera*) and a little from red maple (*Acer rubrum*) used to make the LVL flanges.

4.2 Moisture content

For products and coproducts produced during I-joist production a 6 percent MC on a dry basis was assumed.

5 Life cycle inventory analysis

The LCI was calculated based on 2012 production and the corresponding flows of materials during that period. No data gaps were recorded. As shown in Figure 1, the cradle-to-gate process for I-joists production is considered to comprise wood material production inputs and their transport to I-joists production and ion-site I-joists production.

5.1 A1- Resource extraction

5.1.1 Harvesting Operations

Consideration of the logs used in the production of softwood plywood in the SE region includes the establishment, growth, and harvest of trees. This group of activities is collectively referred to as forest resource management. Data for the forest resources management component of this analysis (Table 3) come from the research of Johnson et al. (2005), as updated in Puettmann, et al. (2013).

Table 4 Fuel consumption for SE region forest resource management processes (regeneration, thinning, and harvest) (Puettmann, et al. 2013)

Forest Resource Management	Unit	Fuel Consumption per m^3
Seedling, Site Prep, Plant, Pre-commercial Thinning		
Diesel and gasoline	L	0.515
Lubricants	L	0.009
Electricity	kWh	0.455
Commercial Thinning and Final Harvest		
Diesel	L	2.930
Lubricants	L	0.050
Total Forest Extraction Process		
Gasoline and Diesel	L	3.440
Lubricants	L	0.054
Electricity	kWh	0.455

5.1.2 LVL production

Inputs into composite I-joist manufacturing include LVL. In the SE, for every linear meter of I-joist produced, 2.367 kg (0.0042 m^3) of LVL was incorporated into the final product. Dry veneers and resins are the primary raw materials consumed for the production of SE LVL. For this study, LVL production included veneer production and transportation but not the forest resource life-cycle stage. This was consistent with OSB and FJL as well. For detailed information on the production of LVL see Bergman and Alanya-Rosenbaum (2016a).

5.1.3 Oriented strandboard production

Inputs into composite I-joist manufacturing include OSB. For every linear meter of I-joist produced, 1.943 kg of OSB (0.0032 m^3) was incorporated into the final product. Chips and resins are the primary raw materials consumed for the production of SE OSB (Puettmann et al. 2016)

5.1.4 Finger-jointed lumber production

Inputs into composite I-joist manufacturing include FJL. For every linear meter of I-joist produced, 0.0258 kg (0.0001 m^3) of FJL was incorporated into the final product. Finger joints are machined on both ends of softwood lumber with special cutter heads. A structural resin such as MUF is applied, and the joints in successive boards are coupled. The resin is cured with the joint end under pressure and heat. Most manufacturers use a continuous radio-frequency curing system for this step. The surveyed mills provided primary data on FJL production and MUF resin consumption, whereas electrical consumption data for cutting or forming joints for FJL was embedded in the electricity consumed for I-joist production and therefore not noted separately. For this study, FJL production included the impacts of softwood lumber production as well as resin production.

5.1.5 Resin production

Phenol-resorcinol-formaldehyde resin is the primary resin used for both web-to-web and web-to-flange joints. PRF resins differ somewhat from other resins in that hardeners are required to help in curing glue-laminated timbers and I-joists.

5.2 A2 – Transport

Wood raw materials were delivered to the I-joist plants by truck and rail; the wood material consists primarily of OSB and FJL purchased from off site.

Based on mill surveys, the weighted-average one-way haul distance for feedstock along with the components of the resin system are shown in Table 4. All upstream transportation of inputs to LVL, FJL, and OSB production were included in the respective LCI input values. For example, LVL production incorporated not only dry veneer production but transportation as well. The average haul distance for feedstock along with the components of the resin system are shown in Table 4.

Table 5 Weighted-average delivery distance (one way) by mode for materials to SE I-joists plant.

Material delivered to mill	Delivery distance
	km
OSB to I-joist plant, by truck	175
LVL to I-joist plant	112
FJL to I-joist plant	230
Resin to I-joist plant	89

5.3 A3 – Product Manufacturing

This study collected primary data from representative I-joist manufacturers in the SE that use average technology for their regions. The raw wood material to produce I-joists comes produced in manufacturing facilities in the SE in the form LVL and FJL. For OSB, U.S. manufacturing of this material is in the southeast. In the SE, most I-joist production occurs in conjunction with production of LVL and FJL in the same engineered wood facility or nearby. For the surveyed mills in this study, all LVL and most FJL production occurred at the same site as I-joist production.

5.3.1 Material Flows

To evaluate data quality, a mass balance was performed (Table 5). Unallocated input feedstocks of LVL, OSB, and FJL per 1 m of I-joist were 2.212, 2.597 and 0.0283 kg (oven-dry), respectively. The major coproduct produced was sawdust (0.411 OD kg), whereas I-joist produced constituted about 91 percent by mass of the total output. Phenol-resorcinol-formaldehyde resin made up most of the additives, which were overall about 0.7 percent by mass of the total input.

Table 6 Mass balance of SE I-joists manufacturing per linear meter.

	(OD kg)	Mass (%)	CoVw [a] (%)
	Inputs		
Feedstocks			
LVL	2.5970	53.7	2.4
OSB	2.2120	45.7	7.0
FJL	0.0283	0.6	
Total	4.8090	99.4	2.2
Resin system			
PRF resin	0.0335	0.7	141
Aqueous emulsion polymer	0.0015	0.0	141
Total	0.0360	0.7	46.2
Total inputs	2.5970	100	
Products	Outputs		
I-joist	4.4150	91.2	4.6
Coproducts			
Sawdust, sold	0.4110	8.5	4.6
Sawdust, wood fuel	0.0010	0.0	141
Panel trim, sold	0.0170	0.4	141
Total	0.4280	8.8	39
Total outputs	4.8440	100.0	

[a] Production weight-averaged coefficient of variation.

5.3.2 I-joists Manufacturing

Routing and shaping of web and flanges are the first steps in producing composite I-joists. This process requires machining of the OSB web pieces so they fit together at the ends as well as tapering them on the top and bottom edges so that they can be fitted into the flanges. Flanges are made primarily from LVL along with some FJL. The flanges are routed their entire length to accept the inserted tapered OSB web material. The coproduct created during this process is dry sawdust.

Resin application and pressing of the I-joist web and flanges members is the next step. Resin is applied in web-to-web and web-to-flange joints. Resins can include MDI and PRF. Assembly is done mechanically, pressing web sections end-to-end and into the top and bottom flange, which are also pressed end-to-end; the result is a continuous ribbon of I-beam that can be of infinite length. No coproducts are created during this process. The final step before packaging is sawing the I-joists to length and allowing the joints to cure. In some cases, the I-joist may be heated in a radio-frequency oven to accelerate resin cure time. For more information about composite I-joist manufacturing, see Wilson and Dancer (2004).

Table 6 gives a detailed description of the material and energy inputs and outputs crossing the system boundary of I-joist production, gate-to-gate. Under materials, wood feedstocks include OSB, LVL, and FJL. Electricity consumed on site for the SE was calculated to be 0.258 kWh/m (unallocated). Natural gas was the primary fossil fuel used on site (0.041 m^3/m). Air emissions were derived from the surveyed mills along with pertinent emissions data categorized by the EPA (USEPA 2002, 2003a, 2003b, 2003c, 2015). When available, surveyed air emission data as primary data were selected rather than secondary data.

Table 7 Unit process inputs–outputs to produce one linear meter of SE I-joists.

	Unit/m	Value	Allocation[a] (%)
Products			
I-joist	m	1.00E+00	91.15%
Sawdust, sold	kg	4.11E-01	8.48%
Panel trim, sold	kg	6.86E-04	0.01%
Sawdust	kg	1.71E-02	0.30%
Resources			
Water, well, in ground	L	4.63E-03	
Materials/fuels			
Wood feedstock, LVL, oven-dried	kg	2.60E+00	
Wood feedstock, OSB, oven-dried	kg	2.21E+00	
Wood feedstock, FJL, oven-dried	kg	2.83E-02	
PRF resin	kg	3.35E-02	
Polymer emulsion	kg	1.47E-03	
Polyurethane polymer		3.12E-04	
PRF Hardner	kg	5.50E-04	
Electricity, at grid	kWh	2.58E-01	
Diesel, combusted in industrial equipment	L	4.77E-03	
Gasoline, combusted in equipment	L	2.17E-04	
Propane, combusted in industrial equipment	L	4.74E-03	
Natural gas, combusted in industrial boiler	m^3	4.10E-02	
Transport, combination truck, diesel power, LVL	tkm	3.08E-01	
Transport, combination truck, diesel power, OSB	tkm	4.11E-01	
Transport, combination truck, diesel power, FJL	tkm	7.15E-03	
Transport, combination truck, diesel powered, PRF resin	kg	4.76E-03	
Hydraulic fluid	kg	2.55E-05	
Greases	kg	6.38E-06	
Motor oil	kg	2.55E-05	
Plastic wrapping	kg	2.11E-03	
Steel strapping	kg	1.87E-04	
Potable water	kg	3.15E-04	
Plastic strapping	kg	6.38E-05	
Wrapping material - packaging	kg	4.75E-02	
Emissions to air			
Acetone[b]	kg	2.08E-07	
Carbon monoxide	kg	5.52E-05	
Formaldehyde	kg	4.59E-06	
Methanol	kg	3.98E-05	
Nitrous oxide	kg	6.71E-05	
PM10	kg	1.03E-04	
Phenol	kg	1.03E-04	
VOCs	kg	7.11E-07	
Waste to treatment			
Waste to landfill	kg	5.18E-01	
Waste to recycling	kg	6.38E-03	

[a] Mass allocation approach.
[b] Secondary data (EPA 2002).

5.3.3 Equipment: Type and fuel consumption

Electrically driven motors in the mill are used for material conveying and trims saws. The emissions controls equipment is powered by electricity or natural gas. Lifts for transporting products and materials in the mill are powered by liquefied propane gas.

5.3.4 Energy use and generation

Weighted-average energy inputs consumed at the I-joist manufacturing site were developed from survey data (Table 7). Electricity and natural gas were the primary energy inputs at 0.258 kWh and 0.041 m^3 for the SE per linear meter of I-joist.

Table 8 Weighted-average on-site energy inputs for SE I-joists manufacturing

	Quantity	Unit	CoVw [a] (%)
Energy inputs			
Electricity	0.2580	kWh	33
Natural gas	0.0410	m^3	49
Diesel	0.0048	L	16
Propane	0.0047	L	5.3
Gasoline	0.0002	L	141

[a] Production-weighted coefficient of variation.

5.3.5 Wood-base fuels

Wood-based by-products are commonly used in the wood product industry to produce heat for the thermal energy intense processes drying and hot pressing. All wood fuel was burned in the production of upstream feedstocks (LVL, lumber, and OSB) (Bergman and Alanya-Rosenbaum 2016a, Milota 2015, Puettmann et al. 2016)

5.3.6 Packaging

Finished I-joists are packaged for transport. Inputs include final product (I-joist), and outputs include packaged I-joist. For this study, it was assumed that only wrapping material was used for each I-joist. Packing materials represent 1.08 percent of the cumulative mass of the model flow (Table 8).

Table 9 Materials used in packaging and shipping per meter of SE I-joists

Material	Value	Unit	Percentage
Wrapping material	0.0475	kg	99.87%
Plastic strapping	0.0001	kg	0.13%
Total	0.0475	kg	100

5.4 Secondary Data Sources

Table 9 list the secondary LCI data sources used in this LCA study for raw material inputs, ancillary materials and packaging, transportation of materials and resources, fuels and energy for manufacturing, water sources, and waste streams.

Table 10 Secondary Data Sources and Data Quality Assessment

A1: Raw Material Inputs				
Inputs	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Wood resource	Database: CORRIM dataset Process: Roundwood, softwood, average, at forest road, SE Laminated veneer lumber, at LVL plant, SE Oriented Strand Board, OSB mill, US Finger-jointed lumber, at I-joist plant, US SE	North America – Region Specific	2005 - 2019	Technology: good; Process models region-specific technology. Time: good; Some data is less than 10 years old Geography: very good; Data is representative of regional production.
Resin	Database: US EI 2.2 (Datasmart2018) Process: Phenol-resorcinol-formaldehyde resin, at plant NREL/US U	North America	2018	Technology: very good; Process models average North American technology Time: good; Data is less than 10 years old Geography: very good; Data is representative of North American
Polymer emulsion	Database: US EI 2.2 (Datasmart2018) Process: Methylene diphenyl diisocyanate resin, at plant, NREL/US U	North America	2018	Technology: very good; Process models average North American technology Time: good; Data is less than 10 years old Geography: very good; Data is representative of North American
Polyurethane polymer	Database: US EI 2.2 (Datasmart2018) Process: Polyurethane, flexible foam, at plant/RER with US electricity U	North America	2018	Technology: very good; Process models average North American technology Time: good; Data is less than 10 years old Geography: very good; Data is representative of North American
A2: Raw Material Transportation				
Inputs	LCI Data Source	Geography	Year	Data Quality Assessment
Trucking	Database: US EI 2.2 (Datasmart2018) Process: Transport, combination truck, Diesel powered NREL/US U	North America	2018	Technology: very good; Process models average North American technology Time: good; Data is less than 10 years old Geography: very good; Data is representative of North American trucking.
A3: Manufacturing				
Energy Inputs	LCI Data Source	Geography	Year	Data Quality Assessment
Electricity	Database: Ecoinvent 3.4 Process: Electricity, low voltage {SERC}| market for | Cut-off, U	North America – Region Specific egrid	2018	Technology: very good; Process models average electricity technology specific to regional grids Time: very good; Data is less than 5 years old Geography: very good; Data is representative of regional electricity generation.
Gasoline	Database: US EI 2.2 (Datasmart2018)	North America	2018	Technology: very good; Process models average North American technology Time: very good; Data is less than 5 years old

	Process: Gasoline, combusted in equipment NREL/US U			Geography: very good; Data is representative of North American propane production and combustion.
Diesel	Database: US EI 2.2 (Datasmart2018) Process: Diesel, combusted in industrial equipment NREL/US U	North America	2018	Technology: very good; Process models average North American technology Time: very good; Data is less than 5 years old Geography: very good; Data is representative of North American diesel production and combustion.
Ancillary Materials and Packaging	LCI Data Source	Geography	Year	Data Quality Assessment
Hydraulic Fluid and Lubricants	Database: US EI 2.2 (Datasmart2018) Process: Lubricating oil, at plant/US- US-EI U	North America	2018	Technology: very good; Process models average North American technology Time: very good; Data is less than 5 years old Geography: very good; Data is representative of North American processes.
Plastic Strap	Database: US EI 2.2 (Datasmart2018) Process: Polyethylene, HDPE, granulate, at plant/US- US-EI U	North America	2018	Technology: very good; Process models average North American technology Time: very good; Data is less than 5 years old Geography: very good, Data is representative of North American processes.
Greases and oils	Database: US EI 2.2 (Datasmart2018) Process: Proxy Oil and grease, at plant NREL/US U	North America	2018	Technology: very good; Process models average North American technology Time: very good; Data is less than 5 years old Geography: very good Data is representative of North American processes.

6 Life cycle impact assessment

The life cycle impact assessment (LCIA) phase establishes links between the life cycle inventory results and potential environmental impacts. The LCIA calculates impact indicators, such as global warming potential and smog. These impact indicators provide general, but quantifiable, indications of potential environmental impacts. The target impact indicator, the impact category, and means of characterizing the impacts are summarized below. Environmental impacts are determined using the TRACI method (Bare 2011, 2012). Each impact indicator is a measure of an aspect of a potential impact. This LCIA does not make value judgments about the impact indicators, meaning comparison indicator values are not valid. Additionally, each impact indicator value is stated in units that are not comparable to others. For the same reasons, indicators should not be combined or added. Additionally, the LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. The primary fuels categorized into non-renewable (fossil and nuclear) and renewable (biomass, geothermal, solar, wind, hydro). Table 10 summarizes the source and scope of each impact category reported in this report as required to be in conformance with the PCR.

Table 11 Selected impact indicators, characterization models, and impact categories

Reporting Category Per Tables E1-E5 in ISO 21930:2017	Indicator Name	Abbreviation	Units
Core Mandatory Impact Indicators	Global warming potential, with biogenic[2]	GWP	kg CO2e
Core Mandatory Impact Indicators	Global warming potential, fossil	GWP	kg CO2e
Core Mandatory Impact Indicators	Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e
Core Mandatory Impact Indicators	Acidification potential of soil and water sources	AP	kg SO2e
Core Mandatory Impact Indicators	Eutrophication potential	EP	kg PO4e
Core Mandatory Impact Indicators	Formation potential of tropospheric ozone	SFP	kg O3e
Core Mandatory Impact Indicators	Abiotic depletion potential (ADP fossil) for fossil resources;	ADPf	MJ, NCV
Core Mandatory Impact Indicators	Fossil fuel depletion	FFD	MJ Surplus
Use of Primary Resources	Renewable primary energy carrier used as energy	RPRE	MJ, NCV
Use of Primary Resources	Renewable primary energy carrier used as material	RPRM	MJ, NCV
Use of Primary Resources	Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV
Use of Primary Resources	Renewable primary energy carrier used as material	NRPRM	MJ, NCV
Secondary material, secondary fuel and recovered energy	Secondary material	SM	kg
Secondary material, secondary fuel and recovered energy	Renewable secondary fuel	RSF	MJ, NCV
Secondary material, secondary fuel and recovered energy	Non-renewable secondary fuel	NRSF	MJ, NCV

[2] This indicator includes both biogenic and fossil-based carbon released. The TRACI method was modified to included CO2, biogenic removals and emissions

Reporting Category Per Tables E1-E5 in ISO 21930:2017	Indicator Name	Abbreviation	Units
Secondary material, secondary fuel and recovered energy	Recovered energy	RE	MJ, NCV
Mandatory Inventory Parameters	Consumption of freshwater resources;	FW	m3
Indicators Describing Waste	Hazardous waste disposed	HWD	kg
Indicators Describing Waste	Non-hazardous waste disposed	NHWD	kg
Indicators Describing Waste	High-level radioactive waste, conditioned, to final repository	HLRW	kg or m3
Indicators Describing Waste	Intermediate- and low-level radioactive waste, conditioned, to final repository	ILLRW	kg or m3
Indicators Describing Waste	Components for re-use	CRU	kg
Indicators Describing Waste	Materials for recycling	MR	kg
Indicators Describing Waste	Materials for energy recovery	MER	kg
Indicators Describing Waste	Recovered energy exported from the product system	EE	MJ, NCV
Additional Inventory Parameters for Transparency	Biogenic Carbon Removal from Product	BCRP	kg CO2e
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Product	BCEP	kg CO2e
Additional Inventory Parameters for Transparency	Biogenic Carbon Removal from Packaging	BCRK	kg CO2e
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Packaging	BCEK	kg CO2e
Additional Inventory Parameters for Transparency	Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	BCEW	kg CO2e
Additional Inventory Parameters for Transparency	Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	CWNR	kg CO2e

Cradle-to-gate environmental performance results for all reporting indicators listed in Table 11 for SE I-joists. The LCIA results in these tables show the absolute values for A1-Resource Extraction, A2-Transportation, and A3-I-joists Production. For GWP, 14 percent of the CO_2 equivalent emissions come from producing I-joists (0.431 kg CO_2 eq), with 83 percent assigned to resource extraction (forestry operations, LVL, OSB, FJL, and resin) (2,536 kg CO_2 eq). Transportation was 100 kg CO_2 eq or 3 percent of the cradle-to-gate GWP impact.

Table 11 also provides indicators related to energy use, material resource consumption, and the waste generated. The total cradle to gate energy use was 86.92 MJ/m. Fossil energy, 68.70 MJ/m, is used for machinery, transportation, electricity, pressing, and drying and represents 79 percent of the total energy cradle to gate. Energy from renewable sources represented 21 percent or 18.21 MJ/m. Biomass energy

consumed during LVL, OSB, and FJL production and pressing of I-joists was 17.70 MJ of the total energy, or 20 percent of the total cradle-to-gate energy.

Most of the freshwater use is in the A1 life cycle stage (86%). In the resource extraction stage, I-joist feedstock production (LVL, OSB, FJL) consumed 97 percent (14.78 L) of the total freshwater use (15.30 L) in A1. Total cradle-to-gate freshwater use was 17.70 L.

Most of the waste, 0.398 kg/m, is generated in the A1 life cycle stage (86%) (Table 12). Composite I-joist (A3) generated a total of 0.562 kg/m or 12, 15, and 12 percent for total waste, hazardous, and non-hazardous waste, respectively (Table 12). The A1 phase generated 85 percent of the total cradle to gate hazardous waste and 86 percent of the non-hazardous (Table 12). Within the A1 phase, feedstock production generated 95 percent of the hazardous, with OSB and LVL represented 34 and 61 percent of the total waste (Table 13). Forestry operations and resins represented 2.4 and 2.3 percent, of the total waste, respectively.

Table 12 Environmental performance of 1 linear meter of I-joist, SE

		Units	A1	A2	A3	Total
Core Mandatory Impact Indicator						
Global warming potential, w/biogenic	GWP	kg CO2e	(6.723)	0.100	9.690	3.068
Global warming potential, fossil	GWP	kg CO2e	2.536	0.100	0.431	3.068
Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	9.61E-08	1.67E-10	1.90E-08	1.15E-07
Acidification potential of soil and water sources	AP	kg SO2e	0.057	0.001	0.001	0.059
Eutrophication potential	EP	kg Ne	0.012	0.000	0.002	0.014
Formation potential of tropospheric ozone	SFP	kg O3e	1.886	0.016	0.016	1.918
Abiotic depletion potential (ADPfossil) for fossil resources;	ADPf	MJ, NCV	41.427	1.255	7.300	49.982
Fossil fuel depletion	FFD	MJ Surplus	4.874	0.177	0.856	5.908
Use of Primary Resources						
Renewable primary energy carrier used as energy	RPRE	MJ, NCV	16.359	0.003	1.850	18.212
Renewable primary energy carrier used as material	RPRM	MJ, NCV	112.857	-	-	112.857
Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	58.764	1.273	8.667	68.705
Non-renewable primary energy carrier used as material	NRPRM	MJ, NCV	1.166			1.166
Secondary Material, Secondary Fuel and Recovered Energy						
Secondary material	SM	kg	-	-	-	-
Renewable secondary fuel	RSF	MJ, NCV	2.599		-	2.599
Non-renewable secondary fuel	NRSF	MJ, NCV	-	-	-	-
Recovered energy	RE	MJ, NCV	-	-	-	-
Mandatory Inventory Parameters						
Consumption of freshwater resources	FW	m^3	0.015	0.0000	0.002	0.018
Indicators Describing Waste						
Hazardous waste disposed	HWD	kg	0.002	-	0.000	0.002
Non-hazardous waste disposed	NHWD	kg	0.397	0.009	0.056	0.461
High-level radioactive waste, conditioned, to final repository	HLRW	kg or m3	-	-	-	-
Intermediate- and low-level radioactive waste, conditioned, to final repository	ILLRW	kg or m3	-	-	-	-
Components for re-use	CRU	kg	-	-	-	-
Materials for recycling	MR	kg	-	-	-	-
Materials for energy recovery	MER	kg	-	-	-	-
Recovered energy exported from the product system	EE	MJ, NCV	-	-	-	-

Table 13 Distribution of waste generation by life cycle stage; A1-Resource extraction, A2-Transportation, and A3 Product manufacturing.

	A1	A2	A3	TOTAL cradle-to-gate
Total Waste	0.3981	0.0085	0.0562	0.4628
Hazardous waste	0.0016	-	0.0003	0.0018
Non-hazardous waste	0.3966	0.0085	0.0559	0.4610
% Hazardous waste	85%	0%	15%	100%
% Non-hazardous waste	86%	2%	12%	100%
% Total	86%	2%	12%	100%

Table 14 Distribution of waste generation in the A1-Resource extraction life cycle stage.

	A1-Resource extraction		
	Forestry operations	Resin Production	Feedstock Production
% Total waste	2.35%	2.26%	95.39%
% Hazardous waste	0.81%	7.75%	91.43%
% Non-hazardous waste	2.36%	2.24%	95.40%

7 Interpretation

As defined by ISO (2006a-b), the term life cycle interpretation is the phase of the LCA that the findings of either the LCI or the LCIA, or both, are combined consistent with the defined goal and scope in order to reach conclusions and recommendations. This phase in the LCA reports the significant issues based on the results of the presented in LCI and the LCIA of this report. Additional components report an evaluation that considers completeness, sensitivity and consistency checks of the LCI and LCIA results, and conclusions, limitations, and recommendations.

7.1 Identification of the Significant Issues

The objective of this element is to structure the results from the LCI or the LCIA phases to help determine the significant issues found in the results and presented in previous sections of this report. A contribution analysis was applied for the interpretation phase of this LCA study. Contribution analysis examines the contribution of life cycles stages (A1 and A3), unit process contributions in a multi-unit manufacturing process, or specific substances which contribute an impact.

7.2 Life cycle phase contribution analysis

For global warming impact, 14 percent of the CO_2 equivalent emissions come from producing I-joists (A3), with 83 and 3 percent assigned to extraction (A1) and transportation (A2), respectively (Table 14). Resource extraction (A1) represented the highest impacts in all environmental impact categories (GWP, eutrophication, acidification, smog, and ozone depletion). Cradle-to-gate, freshwater use was also almost exclusively consumed during the A1 life cycle stages (86%) with 14 percent in A3 (Table 14).

Most of the renewable fuels were used in the A1 life-cycle stage (Table 14. Biomass energy is used in the feedstock materials production. Ninety percent of the biomass fuel cradle-to-gate (A1-A3) is consumed in the A1 life cycle stage. I-Joist production made up the other 10 percent, mainly from the production of FJL onsite at some mills (Table 15). Non-renewable fuel consumption cradle-to-gate was 79 percent. In summary, cradle to gate total energy for producing SE I-joists, which includes fuel for process heat and equipment and electricity, comes from 58 percent fossil fuels, 22 percent nuclear, 20 percent renewable biomass fuel, and <1 other renewable (Table 16).

Table 15 Cradle-to-gate SE I-joists LCIA contribution analysis LCIA results for A1-Resource extraction, A2-Transportation, and A3-Product production

Indicator Name	Abbreviation	Units	A1	A2	A3	Total
Global warming potential, fossil	GWP	kg CO2e	74%	8%	18%	100%
Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	79%	0%	20%	100%
Acidification potential of soil and water sources	AP	kg SO2e	94%	3%	3%	100%
Eutrophication potential	EP	kg Ne	82%	1%	17%	100%
Formation potential of tropospheric ozone	SFP	kg O3e	95%	3%	2%	100%
Abiotic depletion potential (ADPfossil) for fossil resources;	ADPf	MJ, NCV	75%	6%	19%	100%
Fossil fuel depletion	FFD	MJ Surplus	74%	7%	19%	100%
Renewable primary energy carrier used as energy	RPRE	MJ, NCV	91%	0%	9%	100%
Renewable primary energy carrier used as material	RPRM	MJ, NCV	100%	0%	0%	100%
Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	79%	5%	16%	100%
Non-renewable primary energy carrier used as material	NRPRM	MJ, NCV				
Secondary material	SM	kg				
Renewable secondary fuel	RSF	MJ, NCV				
Non-renewable secondary fuel	NRSF	MJ, NCV				
Recovered energy	RE	MJ, NCV				
Consumption of freshwater resources;	FW	m3	83.93%	0.12%	15.94%	100.00%
Hazardous waste disposed	HWD	kg	78.18%	0.01%	21.80%	100%
Non-hazardous waste disposed	NHWD	kg	80.15%	3.91%	15.94%	100%
High-level radioactive waste, conditioned, to final repository	HLRW	kg or m3				
Intermediate- and low-level radioactive waste, conditioned, to final repository	ILLRW	kg or m3				
Components for re-use	CRU	kg				
Materials for recycling	MR	kg				
Materials for energy recovery	MER	kg				
Recovered energy exported from the product system	EE	MJ, NCV				

Table 16 Cradle-to-gate SE I-joists LCIA energy use contribution analysis results by fuel type for A1-Resource extraction, A2-Transportation, and A3-Laminated veneer production

	Unit per m	Total	A1	A2	A3
Non-renewable, fossil	MJ	82.88%	2.51%	14.61%	100%
Non-renewable, nuclear	MJ	92.61%	0.10%	7.30%	100%
Non-renewable, biomass	MJ	3.90%	0.00%	96.10%	100%
Renewable, biomass	MJ	90.08%	0.00%	9.92%	100%
Renewable, wind, solar, geothermal	MJ	84.02%	0.81%	15.17%	100%
Renewable, water	MJ	80.77%	0.37%	18.87%	100%

Table 17 Cradle-to-gate SE I-joists LCIA energy use contribution analysis results by A1-Resource extraction, A2-Transportation, and A3- Laminated veneer production

	Unit per m	Total	A1	A2	A3
Non-renewable, fossil	MJ	57.50%	55.14%	98.36%	69.42%
Non-renewable, nuclear	MJ	21.54%	23.08%	1.43%	12.99%
Non-renewable, biomass	MJ	0.00%	0.00%	0.00%	0.00%
Renewable, biomass	MJ	20.36%	21.22%	0.04%	16.69%
Renewable, wind, solar, geothermal	MJ	0.09%	0.09%	0.05%	0.11%
Renewable, water	MJ	0.50%	0.47%	0.13%	0.79%
		100.00%	100%	100%	100%

7.3 Uncertainty Analysis

Some degree of uncertainty is present in the results due to the variation amongst different data providers. Tables 17-20 provides statistics for some of the key modeling parameters found to be most significant in I-joists production.

Table 18 Survey data statistics for selected parameters, mass balance

	Weighted average (OD kg)	Mean	Min.	Max.	Mass (%)	CoVw[a](%)
Feedstocks			**Inputs**			
LVL	2.5970	2.5460	2.4790	2.6130	53.7	2.4
OSB	2.2120	2.0850	1.9170	2.2530	45.7	7.0
FJL	0.0280	0.1170	-	0.2340	0.6	2.2
Total feedstock	4.8090	4.7480	4.6310	4.8660	99.4	
Resin system						
PRF resin	0.0335	0.0191	-	0.0381	0.7	141
Aqueous emulsion polymer	0.0015	0.0061	-	0.0122	0.0	141
Total resin	0.0360	0.0290	0.0190	0.0380	0.7	46.2
Total inputs	4.8400	4.7770	4.6500	4.9040	100	
Products			**Outputs**			
I-joist	4.4150	4.3080	4.1670	4.4490	91.2	4.6
Coproducts						
Sawdust, sold	0.4110	0.3750	0.3280	0.4220	8.5	18
Sawdust, wood fuel	0.0010	0.0030	-	0.0060	0.0	141
Panel trim, sold	0.0170	0.0710	-	0.1420	0.4	141
Total coproducts	0.4280	0.4490	0.4220	0.4760	8.8	39
Total outputs	4.8440	4.7570	4.6430	4.8710	100	

[a] Production weight-averaged coefficient of variation.

Table 19 Survey data statistics for Selected Parameters, on-site energy use

Energy inputs	Weighted average	Unit	Mean	Min.	Max.	CoVw [a] (%)
Electricity	2.5800	kWh	3.1300	2.4000	3.8500	33
Natural gas	0.4100	m^3	0.3200	0.2100	0.4400	49
Diesel	0.0477	L	0.0521	0.0463	0.0578	16
Propane	0.0474	L	0.0460	0.0443	0.0478	5.3
Gasoline	0.0022	L	0.0090	-	0.0180	141

[a] Production-weighted coefficient of variation.

7.4 Completeness, consistency and sensitivity

Evaluating the LCAs completeness, sensitivity, and consistency offers confidence in and reliability of the LCA results. The completeness check process verifies whether information from the life-cycle phases of an LCA are sufficient for reaching the goals and scope and conclusions of the study and making sound interpretations of the results. Three life-cycle stages (forestry operations, wood material production, and I-joists production) were checked for data completeness including all input elements such as raw and ancillary materials input, energy input, transportation scenarios, water consumption, and outputs such as products and coproducts, emissions to air, water, and land, and final waste disposals. All input and output data were found to be complete, and no data gaps were identified.

The consistency check process verifies that the assumptions, methods, and data are consistently applied throughout the study and are in accordance with the goal and scope of the LCA. A comprehensive review process was completed for this LCA to make certain consistency was applied to the assumptions made, methods used, models, data quality including data sources, data accuracy, age, time-related coverage, technology, and geographical coverage.

Sensitivity analysis can be applied to the LCA to determine changes in results caused by variations in assumptions, methods, and data. Sensitivity analysis is a systematic approach for estimating the effects of the choices made concerning methods and data on the outcome of a study. Sensitivity analysis is a key component of data quality analysis and can be applied to quantify the impact of changes in assumptions or input data on study results. A sensitivity analysis was completed per ISO standards (ISO 2006a, 2006b) to model the effects of natural consumption and electricity consumption for I-joists production. Sensitivity analysis can be useful to understand how various process parameters contribute to environmental output factors.

During I-joists manufacturing, natural gas is used for curing resin. Changing the consumption of natural gas may have a significant effect on CPEC and GHG emissions. Lower (-20%) and higher (+20%) natural gas consumptions were selected to compare with the baseline fuel mix developed from the mill survey data. Although the usage changed by 20 percent, the outcomes changed less than 1 percent for both GHG emissions and CPEC (Table 19).

Table 20 Key parameters on changing natural gas consumption during I-joists production.

Parameter	Unit	Low (-20%)	Surveyed (0%)	High (+20%)
		Values		
GHG emissions	kg CO_2e	2.6980	2.7160	2.7340
CPEC	GJ	0.0725	0.0728	0.0731

However, changing electricity consumption by 20 percent affects the outcomes less than 1.2 percent for both GHG emissions and CPEC(Table 20).

Table 21 Key parameters on changing electricity consumption during I-joists production.

Parameter	Unit per m	Low (-20%)	Surveyed	High (+20%)
		Values		
GHG emissions	kg CO_2e	2.6830	2.7160	2.7500
CPEC	GJ	0.0722	0.0728	0.0734

Neither natural gas nor electrical consumption on-site had a substantial impact on the overall process because on-site I-joist production CPEC contributed roughly 13% of the energy impacts of cradle-to-gate I-joist production.

7.5 Limitations

This LCA was created using industry average data for upstream materials. Variation can result from differences in supplier locations, manufacturing processes, manufacturing efficiency and fuel type used. This LCA does not report all of the environmental impacts due to manufacturing of the product, but rather reports the environmental impacts for those categories with established LCA-based methods to track and report. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change, and habitat destruction. In order to assess the local impacts of product manufacturing, additional analysis is required.

This LCA report documents the results of a 'cradle-to-gate' analysis and is not a comparative assertion, defined as an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. This LCA does not make any statements that the product covered by the LCA is better or worse than any other product.

8 Treatment of Biogenic Carbon

The treatment of biogenic carbon in this LCA follows the requirements set out in the reference PCR. Reporting of biogenic carbon removals and emissions is reported in as per ISO 21930 standard (ISO 2017). When biogenic carbon enters the product system it is characterized in the impact assessment with a factor of -1 kg CO_2 eq. During production, biogenic carbon emissions (CO_2) are released through the combustion of biomass fuels in boilers. As per ISO 21930, when biogenic carbon leaves the product system as CO_2 emission it has a factor of +1 kg CO_2 eq. When any wood material (product and coproducts) that contain biogenic carbon leaves the system boundary, it must be expressed with a factor of +1 kg CO_2 eq.

Forests are understood as a natural system with multiple functions, the production function of timber being one of them. Therefore, natural growth and decay processes including natural disturbances, etc., are not attributable to the production function of forests and are therefore not considered in LCA. Harvesting operations lead to temporal decreases in forest carbon pools in the respective stand. Impacts on forest carbon pools resulting from the sustainable or unsustainable management of forests, however, cannot be defined or assessed on stand level but requires the consideration of carbon pool changes on landscape level, i.e., the level based on which management decisions are made. Resulting from the fundamental principle of sustainable forest management to preserve the production function of forest, total forest carbon pools can be considered stable (or increasing) under sustainable forest management. This is due to the fact that temporal decreases of forest carbon pools resulting from harvesting on one site are compensated by increases of carbon pools on the other sites, forming together the forest area under sustainable forest management.

It is acknowledged that excessive extraction of slash, litter or roots for the purpose of bioenergy generation can lead to decreases in forest carbon pools. These activities, however, are not causally linked to the extraction of timber for the material use of wood. Effects on forest carbon pools related to the extraction of slash, litter or roots are not attributable to the material use of wood and are therefore not considered in this document.

In order to reflect the biogenic nature of wood, its renewability and its potential carbon neutrality, the system boundary between nature and the product system under study is defined as follows:

- Wood entering the product system from nature accounts for the energy content and the biogenic carbon content as material inherent properties.
- All technical processes related to forestry operations intended to produce timber, (e.g. stand establishment, tending, thinning(s), harvesting, establishment and maintenance of forest roads) are considered within the system boundary and are subject to co-product allocations as outlined in the reference PCR.
- Potential implications due to the unknown origin of wood or unsustainably produced timber are considered.
- Human induced impacts on forest carbon pools resulting in deforestation are included.

As the degradation of forest carbon pools resulting from unsustainable management of forests cannot be attributed to a specific log but is a process on landscape level, the effect of forest degradation is considered by not assuming carbon neutrality. In the case of land-use changes from forests to other land uses (e.g., deforestation), the loss of carbon in the forest carbon pools are to be considered.

Consideration of the biogenic carbon neutrality of wood is valid for North American wood products as national level inventory reporting shows overall increasing and/or neutral forest carbon stocks in recent years[3].

Using the method described above, -9.23 kg CO_2e (A1) were removed in the production of 1 meter of SE I-joists (Table 21). One meter of SE I-joists stores 2.21 kg of carbon or +8.09 kg CO_2e (C3/C4). The coproducts produced during I-joists production account for an additional +0.33 kg CO_2e (A3) for a total "emission" in wood product leaving the system boundary of +8.42 kg CO_2e. The combustion of wood fuel emitted 0.83 kg CO_2e (mostly in A1). Packaging resulting in removal of -0.038 kg CO_2e) and an emission of +0.043 kg CO_2e (A5). In summary, total removals was -9.23 kg CO_2e and total "emissions" was +9.23 kg CO_2e from cradle-to-gate (A1-A3) (Table 21). In Table 21, CO_2 flows are presented unallocated to consider co-products leaving the product system (A3). In accordance with ISO 21930, emission from packaging (BCEK) is reported in A5 and emission from main product is reported in C3/C4. The system boundary for this LCA only includes module A1-A3.

[3] National forest carbon stocks are reported under the United Nations Framework Convention on Climate Change. See Table 7.1 for United States forest carbon stocks and Table 7.1 for Canadian forest carbon stocks. Canadian forest carbon stocks have fluctuated near net neutrality in recent years (ranging from -98 Tg to +69 Tg since 1990) while United States forest carbon stocks have shown annual stock increases of 600-900 Tg annually since 1990.

Table 22 Biogenic carbon inventory parameters

Additional Inventory Parameters		A1	A2	A3	A5	C3/C4	Total
	kg CO2e/m						
Biogenic Carbon Removal from Product	BCRP	(9.2592)	-	-			(9.2592)
Biogenic Carbon Emission from Product	BCEP			0.3255	-	8.0942	8.4197
Biogenic Carbon Removal from Packaging	BCRK	-	-	(0.0383)		-	(0.0383)
Biogenic Carbon Emission from Packaging	BCEK	-	-		0.0429		0.0429
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production	BCEW	0.7940	-	0.0409			0.8349

9 Discussion

In 2013 CORRIM updated Wilson and Dancer (2004) to reflect updates in electricity grids and wood boilers (Puettmann et al. 2013). At that time, an LCIA was also conducted using the LCI data developed by Wilson and Dancer (2004). The updates were necessary to comply with the 2015 PCR for North American Structural Wood Products so an EPD on North American I-joists could be produced (https://awc.org/pdf/greenbuilding/epd/AWC-EPD-IJoists-190328.pdf). This current study conducted new mill surveys and reported results based on the 2019 PCR (UL 2019) (Bergman and Alanya-Rosenbaum, 2016b).

As noted earlier, total energy for producing 1 meter of I-joists from the SE region was 86.92 MJ, 49 percent higher than (58.25) MJ/m from Puettmann et al. (2013) (Table 22). The 2013 report that only updated to include an LCIA and updates electricity grid mix and wood boiler data. This current study updated the full gate-to-gate LCI data for I-joists production based on new surveys to industry. Other changes between the two LCA's is the use of lower and higher heating values. The current study uses LHV. The 2013 study determined total energy use by calculating from the fuel raw material extraction. The current study uses a more complete capture of fuel resource use by using the Cumulative Energy Demand Method (CED).

Table 22 shows the changes between the 2013 updated LCA and the current LCA. Global warming impacts increased by 66 percent, while eutrophication increased by over 1,700 percent and water use by 281 percent (Table 22). Use of biomass energy decreased by 23 percent. These differences can be attributed to differences in reporting requirements, LCIA methodologies, and LCI accounting methods, as well as better reporting by industry and better representation of the regional industry as a whole. Other measurements in material use also changed primarily because of requirement changes in reporting details between the previous PCR (FPInnovations 2015) and the current PCR (UL 2019) under which this report conforms too.

Table 23 LCIA comparison between updated 2013 data (based on 2007 industry surveys) and current study data (based on 2012 industry surveys) on I-joists production in the SE

Impact category	Unit	Current Study	Past Study 2013
Global warming potential	kg CO_2 eq	3.0676	1.8438
Eutrophication Potential	kg N eq	0.0137	0.0007
Smog Potential	kg O_3 eq	1.9180	0.2273
Non-renewable fossil	MJ	49.9788	30.8340
Non-renewable nuclear	MJ	18.7259	4.3130
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	0.5159	0.0460
Renewable, biomass	MJ	17.6956	23.0560
Fresh water	L	17.6992	4.6397
Solid waste (hazardous and non-hazardous)	kg	0.4628	0.2918

10 Conclusions

The cradle to gate LCA for SE I-joists includes the LCI of forest resources and veneer production and the LCI of I-joists manufacturing that relies on primary survey data. The survey results were representative operations in the SE region that would produce structural I-joists panels. The survey data are representative of the I-joists types and production volumes consistent with trade association production data.

Emissions from the forest resources LCI are small relative to manufacturing emissions. While other processes such as resin and veneer production that are listed in the A1 life cycle stage contribute significantly to the cradle-to-gate impacts. At the I-joists production facilities emissions to land and water are very small. Mill site airborne emissions originate mainly at presses and particulates from sawing and trimming operations.

Composite I-joist production (A3) consumed only 12 percent of the total energy with 86 percent from resin, feedstock materials, and forest operations, and 1.5 percent to transport. Energy generated by renewable fuels, such as woody biomass, represents about 20 percent of the total energy from cradle to gate. Biomass energy only represented 17 percent onsite at I-joist facilities. This good be a source of environmental improvement by I-joist producers.

11 Critical review

11.1 Internal Review

The purpose of the LCA Report internal review is to check for errors and conformance with the PCR prior to submittal to for external review. The technical and editorial comments of the reviewers were carefully considered and, in most instances, incorporated into the final document. CORRIM addressed the internal review comments, as appropriate, and maintains a record of all comments and responses for future reference.

11.2 External Review

The external review process is intended to ensure consistency between the completed LCA and the principals and requirements of the International Standards on LCA (ISO 2006) and ISO 21930 - Sustainability in Buildings and Civil Engineering Works - Core Rules for Environmental Product Declarations of Construction Products and Services (ISO 2017), the Product Category Rules for North American Structural and Architectural Wood Products Part B (UL 2019) and Part A: Life Cycle Assessment Calculations Rules and Report Requirements (UL 2018).

Following CORRIM's internal review evaluation, documents were submitted to UL Environment (UL) for independent external review. The independent external review was conducted by Thomas Gloria, Ph.D., Industrial Ecology Consultants, LCACP ID: 2008-03.

12 Acknowledgements

Primary funding for this project was through a cooperative agreement between the USDA Forest Service Forest Products Laboratory and the Consortium for Research on Renewable Industrial Materials (13-CO-11111137-014). We especially thank those companies and their employees that participated in the surveys to obtain production data. In addition, this research was supported in part by an appointment to the US Forest Service Research Participation Program administered by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the US Department of Energy and the US Department of Agriculture Forest Service. ORISE is managed by Oak Ridge Associated Universities (ORAU) under DOE contract number DE-AC05-06OR23100. All opinions expressed in this report are the authors' and do not necessarily reflect the policies and views of USDA, DOE, or ORAU–ORISE.

LCIA work for this updated report to conform with the new PCR (UL 2019) was funded by the American Wood Council and the Canadian Wood Council through CORRIM.

13 Units and Conversions

Table 24 Wood conversion in developing the laminated veneer lumber

To convert from	to	multiply by
Cubic feet (ft^3)	Cubic meters (m^3)	0.02831685
Pounds (avdp) (lb)	Kilograms (kg)	0.4535924
Cubic inches (in^3)	Cubic centimeters (cm^3)	16.393
Btu's	Joules (J)	1054
Cubic yards (yd^3)	Cubic meters (m^3)	0.7645549
Feet (ft)	Meters (m)	0.305
Kilometers	Meters (m)	0.001
Gallons (US) (gal)	Liters (L)	3.785
Kilowatt-hours (kWh)	Megajoules (MJ)	3.6
Miles (mi)	Kilometers (km)	1.609
Ounces (avdp) (oz)	Kilograms (kg)	0.028
Square feet (ft^2)	Square meters (m^2)	0.093
Tons (short)	Kilograms (kg)	907.185
Tons (short)	Metric tons (t)	0.9071847
Pounds (lb)	Metric tons (t)	0.0004
Watts (W)	Joules/second (J/s)	1
Yards (yd)	Meters (m)	0.914
Acres (a)	Hectares (ha)	0.405

14 References

APA. 2014. Engineered wood statistics: Third quarter 2014. APA—The Engineered Wood Association. Tacoma, WA. 9 pp.

ASTM International. 2014. ASTM D 5456-14b. Standard specification for evaluation of structural composite lumber products. American Society for Testing and Materials, West Conshohocken, PA. 33 pp.

Bare, J. 2012. Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - Software Name and Version Number: TRACI version 2.1 - User's Manual. Washington, D.C.: U.S. EPA.

Bare, J. 2011. TRACI 2.0: the tool for the reduction and assessment of chemical and other environmental impacts 2.0. Clean Technologies and Environmental Policy Vol.13(5), pp.687-696.

Bergman R.D., S. Alanya-Rosenbaum. 2016b. Cradle-to-gate life-cycle assessment of laminated veneer lumber (LVL) produced in the southeast region of the United States. Module H1 CORRIM Final Report. pp 92.

Bergman R.D. and S. Alanya-Rosenbaum. 2016b. Cradle-to-gate life-cycle assessment of composite I-joists produced in the southeast region of the United States. Module F1 CORRIM Final Report. pp 100.

CORRIM. 2019. Research guidelines for life-cycle inventories (working document). Consortium for Research on Renewable Industrial Materials (CORRIM)

FPInnovations. 2015. Product category rule (PCR): For preparing an environmental product declaration (EPD) for North American structural and architectural wood products. UN CPC 31. NAICS 321.

ISO. 2006a. Environmental management—Life-cycle assessment—Requirements and guidelines. ISO 14044. International Organization for Standardization, Geneva, Switzerland. 46 pp.

ISO. 2006b. Environmental management—Life-cycle assessment—Principles and framework. ISO 14040. International Organization for Standardization, Geneva, Switzerland. 20 pp.

ISO. 2006c. Environmental labels and declarations—Type III environmental declarations—Principles and procedures. ISO 14025. International Organization for Standardization, Geneva, Switzerland. 25 pp.

ISO. 2017. Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services. International Organization for Standardization. Second edition (ISO 21930:2017-07) 80pp.

Johnson L.R., B.R. Lippke, J.D. Marshall, and J. Comnick. 2005. Life-cycle impacts of forest resource activities in the Pacific Northwest and Southeast United States. Wood Fiber Sci 37(CORRIM Special Issue):30- 46.

Milota M.R. 2015. Life cycle assessment for the production of southeastern softwood lumber. Module C-CORRIM Final Report. https://corrim.org/wp-content/uploads/Module-C-SE-Lumber.pdf. Accessed September 2019 72 pp.

Pré Consultants, B.V. 2019. Simapro8.5.2 Life-Cycle Assessment Software Package, Version 36. Plotter 12, 3821 BB Amersfoort, The Netherlands. Http://www.pre.nl/.

Puettmann, M., D. Kaestner, and A. Taylor. 2016. Module E Life cycle assessment of softwood oriented strandboard (OSB) production. CORRIM Report. 71pp. https://corrim.org/wp-content/uploads/Module-E-OSB-Final-w-survey.pdf As accessed September 2019

Puettmann M.E., E.E. Oneil, J. Wilson, and L. Johnson. 2013. Cradle to gate life cycle assessment of engineered I-joists production from the southeast. Consortium for Research on Renewable Industrial Materials (CORRIM). https://corrim.org/wp-content/uploads/2018/06/SE-I-Joists-July-2013.pdf. As accessed September 2019. 48 pp.

Stark N.M., Z. Cai, and C. Carll. 2010. Wood-based composite materials: Panel products, glued-laminated timber, structural composite lumber, and wood–nonwood composite materials. In: Wood handbook— Wood as an engineering material. Gen Tech Rep FPL-GTR-113. USDA For Serv Forest Products Laboratory, Madison, WI. pp. 11-1–11-28.

USCB. 2012. 2012 North American industry classification system definitions. 321215 Structural wood product manufacturing. United States Census Bureau. www.census.gov/eos/www/naics/ (16 March 2016).

USEPA. 2002. AP 42 Section 10.9 Engineered wood products manufacturing. United States Environmental Protection Agency, Washington, DC. pp. 10.9-1–24. http://www.epa.gov/ttnchie1/ap42/ch10/final/c10s09.pdf. (16 March 2016).

USEPA. 2003a. Air pollution control technology fact sheet. EPA-452/F-03-021. Regenerative incinerator. United States Environmental Protection Agency, Washington, DC. 5 pp. http://www.epa.gov/ttn/catc/dir1/fregen.pdf. (16 March 2016).

USEPA. 2003b. Air pollution control technology fact sheet. EPA-452/F-03-025. Fabric filter (baghouse).

USEPA. 2003c Air pollution control technology fact sheet. EPA-452/F-03-015. Packed-bed/packed-tower wet scrubber. United States Environmental Protection Agency, Washington, DC. 6 pp. http://www.epa.gov/ttn/catc/dir1/fpack.pdf. As accessed September 2019

United States Environmental Protection Agency, Washington, DC. 6 pp. http://www.epa.gov/ttn/catc/dir1/ff-pulse.pdf. As accessed September 2019.

USEPA. 2015. Industrial commercial institutional boilers and process heaters. United States Environmental Protection Agency, Washington, DC.Wilson JB, Dancer ER (2004) Composite I-joists–Pacific Northwest and Southeast. In CORRIM Phase I Final Report Module F. https://corrim.org/wp-content/uploads/2018/03/composite-i-joists-pnw-and-se.pdf. As accessed September 2019. 122 pp.

UL. 2018. Product Category Rules for Building-Related Products and Services - Part A: Life Cycle Assessment Calculation Rules and Report Requirements, v3.2.

UL. 2019. Product Category Rule Guidance for Building-Related Products and Services, Part B: Structural and Architectural Wood Products, EPD Requirements UL 10010-9 v.1.0.

Wilson J.B. and E.R. Dancer. 2004. Composite I-joists–Pacific Northwest and Southeast. In CORRIM Phase I Final Report Module F. https://corrim.org/wp-content/uploads/2018/03/composite-i-joists-pnw-and-se.pdf. As accessed September 2019. 122 pp.

15 Appendix 1 Conformance to North American Structural and Architectural Wood Product Category Rules

Industrial Ecology Consultants
35 Bracebridge Road
Newton, Massachusetts 02459

Review of LCA Studies of Conformance to North American Structural and Architectural Wood Product Category Rules

March 27, 2020

Introduction

Underwriters Laboratory Environment (ULE) commissioned a life cycle assessment (LCA) expert to perform a verification of supporting LCAs to be used as the basis for Environmental Product Declarations (EPDs) for North American Structural and Architectural Wood products (UN CPC 31 and NAICS 321).

The review was conducted by:

Thomas P. Gloria, Ph.D., LCACP
Managing Director, Industrial Ecology Consultants
Director, Sustainability Programs, Harvard University Division of Continuing Education

This document identifies the LCA studies under review and summarizes the review objectives and the results of revisions made based on a first pass of the review.

LCA Studies Reviewed

The LCA studies reviewed include the following:

LCA Study Title	Practitioner	Date
LCA for the Production of Inland Northwest Softwood Lumber	CORRIM	March 2020
LCA for the Production of Northeast – Northcentral Softwood Lumber	CORRIM	March 2020
LCA for the Production of Oriented Strandboard Production	CORRIM	March 2020
LCA for the Production of Pacific Northwest Glued Laminated Timbers	CORRIM	March 2020
LCA for the Production of Pacific Northwest Engineered I-Joist,	CORRIM	March 2020
LCA for the Production of Pacific Northwest Softwood Lumber	CORRIM	March 2020
LCA for the Production of Pacific Northwest Laminated Veneer Lumber	CORRIM	March 2020
LCA for the Production of Pacific Northwest Softwood Plywood	CORRIM	March 2020
LCA for the Production of Southeast Glued Laminated Timbers	CORRIM	March 2020
LCA for the Production of Southeastern Engineered I-Joist	CORRIM	March 2020
LCA for the Production of Southeastern Softwood Lumber	CORRIM	March 2020
LCA for the Production of Southeast Laminated Veneer Lumber	CORRIM	March 2020
LCA for the Production of Southeast Softwood Plywood	CORRIM	March 2020
A C-to-G LCA of Canadian Glulam	Athena	March 2020
A C-to-G LCA of Canadian Wood I-Joists	Athena	March 2020
A C-to-G LCA of Canadian Surfaced Dry Softwood Lumber	Athena	March 2020
A C-to-G LCA of Canadian Laminated Veneer Lumber (LVL)	Athena	March 2020
A C-to-G LCA of Canadian Oriented Strandboard (OSB)	Athena	March 2020
A C-to-G LCA of Canadian Plywood	Athena	March 2020

Critical Review Objectives

The reviewer reviewed the LCA studies for conformance to the following applicable documents regarding the ability to support Business to Business (BtB) EPDs:

- ISO 14044:2006, Environmental management - Life cycle assessment - Requirements and guidelines;
- ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework;
- ISO 14025:2006, Environmental labeling and declarations - Type III environmental declarations - Principles and procedures;
- ISO 21930:2017, Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.

- UL Environment: PCR for Building-Related Products and Services - Part A: Calculation Rules for the LCA and Requirements, v.3.2, December 2018.
- UL Environment: Part B: Structural and Architectural Wood Products EPD Requirements UL 10010-9 v.1.0. September 2018.

Review Results
A first pass review was performed, revisions were made by the LCA practitioners, Athena Sustainable Materials Institute (Athena) and the Consortium for Research on Renewable Industrial Materials (CORRIM). The documents listed above were reviewed against the general requirements for conformance:

- Are methods used to carry out the LCA were consistent with ISO 14040/14044 standards?
- Are methods used to carry out the LCA were scientifically and technically valid?
- Are data used were appropriate and reasonable in relation to the goal of the study?
- Do interpretations reflected the limitations identified and the goal of the study?
- Was the study report transparent and consistent?

Summary
On the basis of the objectives set forth to review the aforementioned LCA studies, **the reviewer concludes that all studies conform to the applicable standards.** The reviewer greatly appreciates the responsiveness and cooperation of all parties involved in the review process.

Respectfully,

Thomas P. Gloria, Ph.D., Newton, Massachusetts

16 Appendix 2 Original LCA Report

CRADLE-TO-GATE LIFE-CYCLE ASSESSMENT OF COMPOSITE I-JOISTS PRODUCED IN THE SOUTHEAST REGION OF THE UNITED STATES

CORRIM FINAL REPORT

Module F2

By:

Richard D. Bergman
Research Forest Products Technologist
Economics, Statistics, and Life-Cycle Analysis Unit
USDA Forest Service
Forest Products Laboratory
One Gifford Pinchot Drive

Madison, WI 53726
Email: rbergman@fs.fed.us

Sevda Alanya-Rosenbaum
Postdoctoral Fellow
USDA Forest Service
Forest Products Laboratory
salanyarosenbaum@fs.fed.us

Bergman R, Alanya-Rosenbaum S. 2017c. Cradle-to-gate life-cycle assessment of composite I-joists produced in the southeast region of the United States. CORRIM Final Report. Module F2. University of Washington. Seattle, WA. Revised April 2017. 115 p.

April 2017

Information contained in this report is based on new survey data (2012) and supersedes information in the original Phase I report (Wilson and Dancer 2004). This report is a cradle to gate LCA and includes all forestry related upstream processes and packaging of final product. CORRIM REPORT - Life Cycle Assessment of I-joist Production has not been certified but is written in compliance to the Product Category Rules North American Structural and Architectural Wood Products (June 2015) and can serve as a LCA for an Environmental Product Declaration.

1 EXECUTIVE SUMMARY

1.1 Study Goals

The goal of this study was to update life-cycle assessment (LCA) data on I-joist production in the southeast (SE) region of the United States. The authors collected primary mill data from I-joist production facilities per Consortium on Research for Renewable Industrial Materials (CORRIM) research guidelines. Comparative assertions were not a goal of this study.

1.2 Method

The authors collected mill data through a survey mailed to I-joist manufacturing plants. This survey tracked raw material inputs (including energy), product and coproduct outputs, and pertinent emissions to water and air as well as solid waste generation. The study used an industry-standard production unit to a metric production unit, one thousand linear meters (km) (i.e. declared unit). At I-joist production facilities, finger-jointed lumber (FJL) and laminated veneer lumber (LVL) production may occur on site; in those cases, data were collected for those processes too. Secondary data, such as pre-I-joist production gate processes (e.g. forestry operations, oriented strandboard (OSB) production, and electricity production), were taken from peer-reviewed literature, public databases, or other life-cycle inventory (LCI) studies completed concurrently. Using primary and secondary data, material and energy balances were calculated. With these material and energy data, the LCA was constructed to conform with internationally accepted standards. The study based all allocations on the mass of products and coproducts. The life-cycle impact assessment (LCIA) was performed using the Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) 2 method. The following five TRACI impact categories were examined: global warming potential (GWP (kg CO_2-eq)), acidification (kg SO_2-eq), eutrophication (kg N-eq), ozone depletion (kg chlorofluorocarbons-11-eq), and photochemical smog (kg NOx-eq). Primary energy consumption, material resources consumption, and waste generation were also examined.

1.3 Life-Cycle Inventory

Composite I-joist manufacturing comprises five steps: (1) forestry operations, (2) OSB production, (3) FJL production, (4) LVL production, and (5) I-joist production. The most energy-consumptive step was LVL production, followed by OSB, I-joist, and FJL production stages. Emission data produced through modeling found that the total estimated fossil and biomass carbon dioxide (CO_2) emissions were 2,482 and 1,442 kg/km.

The amount and type of energy used during production of building materials such as I-joists are important to the holistic environmental impact of the product. Total cumulative primary energy consumption (CPEC) for the cradle-to-gate production of SE I-joists was 72.8 GJ/km. Use of renewable energy in manufacturing I-joists was substantial. Renewable biomass, by far the largest renewable energy source, represented about 27% of the total CPEC for all stages of production. Energy consumed during phenol-resorcinol formaldehyde (PRF) resin production along with the additives of the resin system were included in the fossil fuel use for I-joists as an upstream process.

1.4 Life-Cycle Impact Assessment

Environmental performance results were provided for the five impact categories (global warming (GW), acidification, eutrophication, ozone depletion and smog), energy consumption from nonrenewables, renewables, and wind, hydro, solar, geothermal, and nuclear fuels, renewable and nonrenewable resources, and solid waste. The five environmental impacts associated with I-joist production were small compared with the impacts associated with LVL production. This included its upstream production impacts.

1.5 Interpretation

Emissions from the forest resources LCI are small relative to manufacturing emissions (OSB, LVL, FJL, and I-joists). At the I-joist production facility, emissions mainly originate from heat production for resin curing. Boiler emissions released were a function of the fuel burned, whereas other emissions were a function of the unit process and associated emission control devices (ECD).

Composite I-joists are primarily made of wood and thus store carbon. Carbon content for wood products is assumed to be 50% percent by mass of oven-dried (OD) wood. Excluding the resin system, the carbon stored in the wood portion of 1.0 km of I-joist on a production-weighted average is equivalent to 7,285 kg CO_2 emissions if left to decay.

For the surveyed mills, a mass balance was performed to verify data quality. Data quality was high. Inputs and outputs were consistent for the two surveyed mills on a cubic meter basis. In addition, total wood mass in and total wood mass out were calculated. Difference for overall wood mass was less than 2% for the region.

The authors compared the energy inputs from the current 2012 study to the earlier CORRIM Phase I study on gate-to-gate I-joist production to show how the cumulative primary energy consumption (CPEC) was affected. About a 22% increase in CPEC is observed compared with the Phase I study for the SE region. For both studies, the energy generated by woody biomass and fossil fuels constituted the majority of the total energy consumed. However, with that being said, no statistical analysis was conducted on the earlier data and different companies provided the primary data for 2000. Therefore, only speculation can made on the apparent differences. In this study, the weighted coefficient of variation representing the variability in the collected process data was calculated and presented.

1.6 Sensitivity Analysis

A sensitivity analysis was completed per the International Organization for Standardization (ISO) 14040 standards to model the effects of natural gas consumption and electricity consumption for I-joist production. The analysis showed that the five environmental impacts associated with producing I-joists were small compared with the environmental impacts associated with LVL production. Therefore, for the I-joist production life-cycle stage, neither natural gas nor electrical consumption on site had a substantial impact on the cradle-to-gate process.

1.7 Key Findings

The results of this study were compared with the earlier CORRIM study on life-cycle evaluation of I-joist manufacturing in the United States. The current study found the CPEC to be higher (about 25%) for the SE compared with the earlier CORRIM study. This may have resulted from increased use of ECD because of increased regulatory controls in the United States since the 2000s, particularly at LVL production facilities. Adoption of ECD other than baghouses results in higher energy consumption, and this may explain the lower energy use in Phase I survey data. Besides, although forest operations contribute only 2.8% of the CPEC in this study, the previous CORRIM study did not include energy use resulting from forest operations.

2 ACKNOWLEDGMENT

Primary funding for this project was through a cooperative agreement between the USDA Forest Service Forest Products Laboratory and the Consortium for Research on Renewable Industrial Materials (13-CO-11111137-014). We especially thank those companies and their employees that participated in the surveys to obtain production data. In addition, this research was supported in part by an appointment to the USDA Forest Service Research Participation Program administered by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the U.S. Department of Energy and the USDA Forest Service. ORISE is managed by Oak Ridge Associated Universities (ORAU) under DOE contract number DE-AC05-06OR23100. All opinions expressed in this paper are those of the authors and do not necessarily reflect the policies and views of USDA, DOE, or ORAU/ORISE.

TABLE OF CONTENTS

1 Executive Summary ii
1.1 Study Goals ii
1.2 Method ii
1.3 Life-Cycle Inventory ii
1.4 Life-Cycle Impact Assessment ii
1.5 Interpretation iii
1.6 Sensitivity Analysis iii
1.7 Key Findings iii
2 Acknowledgment iv
3 Background 1
4 Introduction 1
4.1 Life-Cycle Assessment 1
4.2 Description of the Product 2
5 Method 4
5.1 Goal 4
5.2 Scope 4
5.2.1 Intended audience 4
5.2.2 Comparative assertions 4
5.2.3 Allocation procedure 4
5.2.4 Functional and declared unit 5
5.2.5 System boundaries 5
5.2.6 Cut-off rules 6
5.2.7 Data quality requirements 7
5.2.8 Assumptions and limitations 7
5.2.9 Data collection 7
5.2.10 Calculation rules 8
5.2.11 Life-cycle impact assessment method 9
6 Detailed Description of Data and Processes 10
6.1 Forestry Operations 10
6.2 Product Manufacturing 11
6.2.1 Resource transport 11
6.2.2 Laminated veneer lumber process 11
6.2.3 Oriented strandboard process 11
6.2.4 Finger-jointed lumber production 11

6.2.5 Methylene diphenyl di-isocyanate resin 11
6.2.6 Phenol resorcinol formaldehyde resin 12
6.2.7 Melamine urea formaldehyde resin 12
6.2.8 Energy generation 12
6.2.9 I-joist manufacturing 12
6.2.10 Packaging 13
6.3 Air Emissions 13
7 Inputs and Outputs 13
7.1 Material Transportation 13
7.2 Energy Sources 14
7.3 Gate-to-Gate I-Joist Production 14
7.4 Material Flows 16
7.5 On-Site Energy Inputs 16
8 Life-Cycle Inventory Data 17
9 Life-Cycle Impact Assessment 19
10 Comparison of Updated Life-Cycle Inventory with a Previous Study 19
11 Treatment of Biogenic Carbon 20
12 Life-Cycle Interpretation 21
12.1 Identification of Significant Issues 21
12.2 Life-Cycle Phase Contribution Analysis 21
12.3 Substance Contribution Analysis 23
12.4 Completeness, Sensitivity, and Consistency Checks 23
12.5 Cumulative Primary Energy Consumption 24
12.6 Electricity Consumption 24
13 Conclusion, limitations, and recommendations 24
14 Critical Review 25
14.1 Internal Review 25
14.2 External Review 25
15 References 26
16 Appendix A: Conversion factors 29
17 Appendix B: SouthEast I- joist life-cycle inventory flows, mass allocation 30
18 Appendix C: SouthEast I- joist life-cycle impact assessment, economic allocation 52
19 Appendix D: Substance Contribution Analysis 55
20 Appendix E: SouthEast I- joist Life-cycle inventory flows, economic allocation 57
21 Appendix F: Production facility survey questionnaires 78

FIGURES

Figure 1. Steps involved in a life-cycle assessment (ISO 2006a) 2
Figure 2. Typical composite I-joists shown here made with laminated veneer lumber (LVL) flanges and an oriented strandboard (OSB) web. 3
Figure 3. Cradle-to-gate system boundary and process flow for production of I-joists. 6

TABLE OF TABLES

Table 1. Common dimensions for composite I-joists. 4
Table 2. Secondary LCI data sources used. 8
Table 3. Selected impact indicators, characterization models, and impact categories. 9
Table 4. Inputs to the regeneration phase and midrotation fertilization per hectare (ha) of SE forest (Puettmann et al. 2013) 10
Table 5. Materials used in packaging and shipping per kilometer I-joist. 13
Table 6. Weighted-average delivery distance (one way) by mode for materials to I-joist plants. 13
Table 7. Percentage of each energy source for electricity for producing I-joists in the SE[a] (NREL 2012). 14
Table 8. Unit process inputs and outputs to produce 1 km of composite I-joists, SE, gate-to-gate. 15
Table 9. Mass balance of I-joist manufacturing per kilometer I-joist, SE, gate-to-gate. 16
Table 10. On-site energy inputs for I-joist manufacturing, SE, gate-to-gate. 16
Table 11. Raw material energy consumption per kilometer I-joist produced, cradle-to-gate, mass allocation. 17
Table 12. Cumulative primary energy consumption per kilometer I-joist produced, cradle-to-gate, mass allocation. 18
Table 13. Waste to treatment (kg) per kilometer I-joist, cradle-to-gate, mass allocation. 18
Table 14. Environmental performance of 1 km of I-joist, cradle-to-gate, mass allocation. 19
Table 15. Production weighted-average SE on-site energy inputs for manufacturing 1 km of I-joist 20
Table 16. Carbon balance per kilometer I-joist 21
Table 17. Life-cycle stages contribution analysis of 1 km of I-joist, cradle-to-gate, mass allocation. 22
Table 18. Life-cycle stages contribution analysis of 1 km of I-joist, cradle-to-gate, economic allocation. 22
Table 19. Substance contribution analysis to GWP (kg CO_2 eq) by life-cycle stage (total percentage basis and values are displayed per kilometer I-joist, cradle-to-gate)[a] 23
Table 20. Key parameters for changing on-site natural gas consumption during 1 km of I-joist production, cradle-to-gate, mass allocation. 24
Table 21. Key parameters on changing electricity consumption during 1 km of I-joist production, cradle-to-gate, mass allocation. 24
Table 22. Common conversions from English to SI units.[a] 29
Table 23. Electricity grids and dataset name by source. 29
Table 24. Energy contents and densities of various fuels. 29
Table 25. Mass allocation inventory 30
Table 26. Raw material energy consumption per kilometer I-joist produced, cradle-to-gate, economic allocation. 52
Table 27. Cumulative primary energy consumption per kilometer I-joist produced, cradle-to-gate, economic allocation. 53
Table 28. Waste to treatment (kg) per kilometer I-joist, cradle-to-gate, economic allocation. 53
Table 29. Environmental performance of 1 km of I-joist, cradle-to-gate, economic allocation. 54
Table 32. Substance contribution analysis to acidification (kg SO_2 eq.) by life-cycle stage (total percentage basis and values are displayed) 55

Table 33. Substance contribution analysis to eutrophication (kg N eq.) by life-cycle stage (total percentage basis and values are displayed) 56
Table 34. Economic allocation inventory 57

3 BACKGROUND

The Consortium for Research on Renewable Industrial Materials has derived LCI data for major wood products and wood production regions in the United States. The LCI data covers forest regeneration through to the final product at the mill output gate. Research has covered nine major forest products including both structural and nonstructural uses and four major regions. This report focuses on industry-average composite I-joist production in the SE region of the United States (Wilson and Dancer 2004a). Life-cycle inventory data are then used to quantify LCIA. This study updates the cradle-to-gate manufacturing LCIA data for I-joists for the SE. To ensure comparability and consistency, treatment of biogenic carbon was taken from the Norwegian Solid Wood Product Product Category Rules (PCR) (Aasestad 2008) and the PCR for North American structural and architectural wood products (FPInnovations 2015). This report does not include any comparative assertions. Using the LCIA outcomes, the APA – The Engineered Wood Association and its members can explore potential process and parameter improvements internally and new conversion technologies along with the identification of environmental hotspots. LCA practitioners can use the data for their studies, product customers can use the data (perhaps in the eventual form of an environmental product declaration (EPD)) to assist in product selection, and building specifiers can find green building products with documentation. This LCA is in conformance with the PCR for North American structural and architectural wood products (FPInnovations 2015) and ISO 14040/14044 standards (ISO 2006a, 2006b). This report follows data and reporting requirements as outlined in the PCR and contains the LCA components for producing a North American EPD including economic allocation for producing 1 km of composite I-joist in the SE (ISO 2006c; FPInnovations 2015).

4 INTRODUCTION

Documenting the environmental performance of building products is becoming widespread because of many green marketing claims made without scientific merit (i.e. green washing). Developing EPDs for building products is one way to accomplish this objective for scientific documentation and to counter green washing (ISO 2006c; Bergman and Taylor 2011). In addition, developing wood product LCI data helps construct product LCAs that are then used to develop whole-building LCAs for environmental footprint software such as the Athena Impact Estimator for Building (ASMI, 2016). Conducting whole-building LCAs provides for points that go toward green building certification in rating systems such as LEED v4, Green Globes, and the ICC-700 National Green Building Standard (Ritter et al. 2011). This study can be categorized as a cradle-to-gate LCA and includes forestry operations to the manufacturing of OSB, LVL, FJL, and finally composite I-joists ready to be shipped out from the mill gate.

4.1 Life-Cycle Assessment

Life-cycle assessment is an internationally accepted method to analyze complex environmental impacts of a product or process. It is intended to be an objective and holistic examination of a product that identifies and quantifies energy and materials used and emissions and wastes released to the environment and assesses the impact of those energy and material uses and releases on the environment. Life-cycle assessment studies can evaluate full product life cycles, often referred to as cradle-to-grave, or incorporate only a portion of the products life cycle, referred to as cradle-to-gate or gate-to-gate.

As defined by the ISO (ISO 2006a), LCA is a multiphase process consisting of a (1) goal and scope definition, (2) LCI, (3) LCIA, and (4) interpretation (Figure 1). These steps are interconnected, and their outcomes are based on goals of the study.

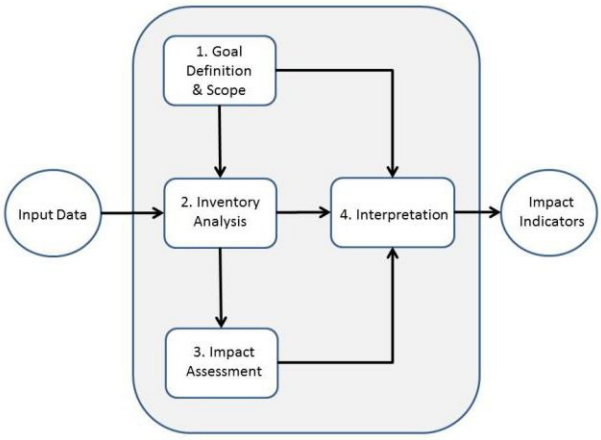


Figure 1. Steps involved in a life-cycle assessment (ISO 2006a).

The key component for conducting an LCA is the LCI step, which is the process of quantifying energy and raw material requirements, air emissions, waterborne effluents, solid waste, and other environmental releases occurring within the system boundaries.

The LCIA process characterizes and assesses the effects of environmental releases identified in the LCI into impact categories such as global warming, acidification, carcinogenics, respiratory effects, eutrophication, ozone depletion, ecotoxicity, and smog. For assessing the environmental impacts of I-joist production, the TRACI 2.0 impact method was used. TRACI is a midpoint-oriented LCIA method developed by the US Environmental Protection Agency specifically for North America using input parameters consistent with U.S. locations (Bare 2011). TRACI is available through the LCA software used for modeling the I-joist process (PRé Consultants 2016).

The life-cycle interpretation is the phase in which the findings of the LCI and/or the LCIA are evaluated in relation to the goal of the study to reach conclusions and recommendations. This final step in an LCA involves an investigation of significant environmental aspects (e.g. energy use and greenhouse gases), their contributions to the indicators under consideration, and determination of which unit processes in the system they come from. For example, if the outcome of an LCIA indicates a particularly high value for GWP, the analyst could refer to the inventory to determine which environmental flows are contributing to the high value and from which unit processes those outputs are coming.

4.2 Description of the Product

Many engineered structural wood products have been developed in the last several decades, e.g., I-joists, OSB, LVL, etc. (Figure 2). I-joists fall into the North American Industry Classification System (NAICS) Code 321213—engineered wood member (except truss) manufacturing, which includes other structural wood-engineered products such as FJL, parallel strand lumber, and glue-laminated timbers (USCB 2012; ASTM 2014). A composite I-joist contains a web made from a structural wood panel, usually OSB but sometimes plywood. The web is glued between two flanges that are sometimes made from solid-sawn lumber or FJL but more commonly from LVL (USEPA 2002; Wilson and Dancer 2004a, 2005a; Stark et al. 2010; ASTM 2014). The typical flange size depends on material. For LVL, the common size is 1.75 by 1.5 in. (44.5 by 38.1 mm), and lumber flanges are usually nominal 2 by 3 in. (50.8 by 76.2 mm). I-joists have an “I” shape form and are measured in linear feet in the United States (Figure 2). There are many different dimensions of composite I-joists, but the most common are dimensions that directly replace 2-

by 10-in. (50.8- by 254-mm) and 2- by 12-in. (50.8- by 304.8-mm) structural lumber (Table 1). I-joists are usually made in continuous lengths and are then cut to 60-ft (18.29-m) lengths for shipping.

This study focused on large-scale production facilities that are representative of the industry. Production values and study results were reported per linear kilometer with an assumed average depth of 30 cm. As shown in Figure 2, depth goes from the top to the bottom of the 'I'. I-joist depth varies notably, but large quantities of I-joists made in the United States have a depth of 30 cm. These engineered structural wood products are designed to be used in the same manner as solid wood products such as sawn lumber but with different properties. In the SE region, I-joists are primarily made with southern pine species including a mix of longleaf pine (*P. palustris*), shortleaf pine (*P. echina*ta), slash pine (*P. elliotti*), and loblolly pine (*P. taeda* L.) along with some hardwood mostly from yellow poplar (*Liriodendron tulipfera*) and a little from red maple (*Acer rubrum*) used to make the LVL flanges.

Production of I-joists is measured on a linear basis (feet, meters) with no measurement for the dimensions of height and width, which is the practice for the I-joist data given in this study. The most common dimensions of I-joists for the SE can be found in Table 1. This LCA uses a weighted average for producing a generic I-joist (Table 1). This I-joist is slightly larger than you would expect to find in that region because of the small amount of waste and inefficiencies of producing the I-joists included in the product.

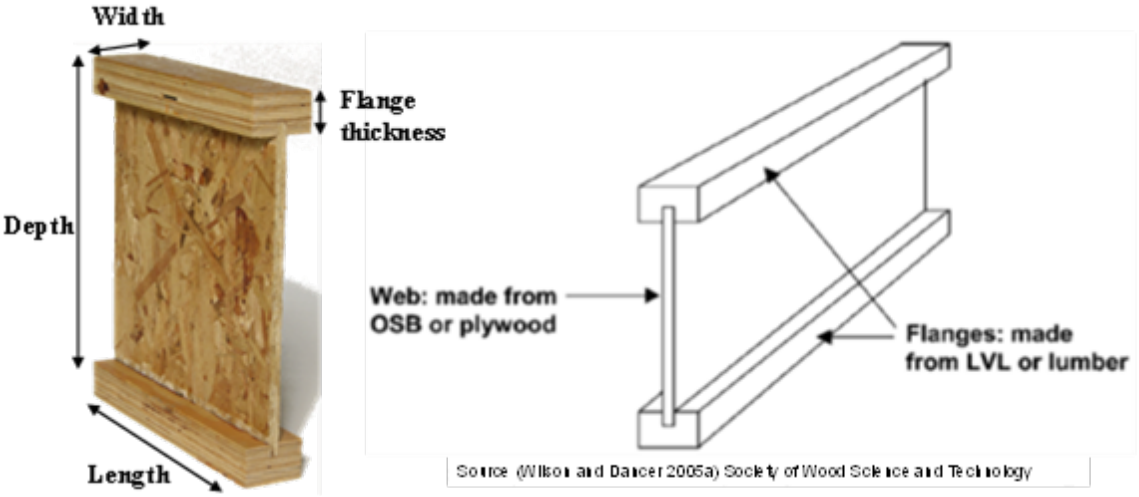


Figure 2. Typical composite I-joists shown here made with laminated veneer lumber (LVL) flanges and an oriented strandboard (OSB) web.

Table 1. Common dimensions for composite I-joists.

Common I-Joist Dimensions					
Depth	**Flange thickness**	**Width**	**Height**	**Flange thickness**	**Width**
millimeters			**inches**		
241.30	33.34	44.45	9.50	1.31	1.75
301.75	38.10	44.45	11.88	1.50	1.75
301.75	38.10	38.10	11.88	1.50	1.50
301.63	79.38	38.10	11.88	3.13	1.50
Generic I-Joist Dimensions					
298.45	33.34	47.75	11.75	1.31	1.88

5 METHOD

5.1 Goal

The goal of the study was to update the cradle-to-gate LCA of I-joist manufacturing for the SE. The authors updated the gate-to-gate I-joist manufacturing LCI data developed by Wilson and Dancer (2005a) and developed FJL manufacturing LCI data from collected primary data and secondary data (Milota 2015; Puettmann and Wilson 2005). The authors then linked the data to available forest resource LCI data (Johnson et al. 2005; Puettmann et al. 2013), OSB production LCI data (Kaestner 2015; Puettmann et al. 2015), and LVL production LCI data (Bergman and Alanya-Rosenbaum 2016).

5.2 Scope

In accordance with ISO 14040 and 14044 standards (ISO 2006a, 2006b; ILCD 2010), the scope of this LCA study was to cover the life-cycle stages of I-joists from forest resource activities through OSB, LVL, and FJL production to the final product — I-joists ready for shipping from the plant. Impacts from OSB and LVL production were included in the analysis using LCI data developed from updating LVL for the SE and OSB (Bergman and Alanya-Rosenbaum 2016; Kaestner 2015; Puettmann et al. 2015). Analyses included CPEC of I-joist production and environmental impacts in several impact categories including GW.

5.2.1 Intended audience

The primary audience for the LCA report includes the American Wood Council, Canadian Wood Council, APA – The Engineered Wood Association, North American wood I-joist manufacturers, and other LCA practitioners.

5.2.2 Comparative assertions

The report does not include product use and end of life phases which are required for comparative assertions relative to substitute products. If future comparative studies are intended and disclosed to the public, the LCA boundary would need to be expanded to include the use and end of life phases consistent with the ISO 14040/44:2006 (ISO 2006a) guidelines and principles and compliance with the wood products PCR (FPInnovations 2015). (If the LCA is used to develop an EPD, internal and/or external critical review would be required).

5.2.3 Allocation procedure

Selecting an allocation approach is an important part of an LCA study. In this study, all primary energy and environmental outputs were assigned to various coproducts by mass allocation. The decision was

based on the understanding that the wood residues were coproducts with a value rather than a waste material. Economic allocation was performed in addition to mass allocation, because product category rules suggest using economic allocation for a multioutput process when the difference in revenues is more than 10% (FPInnovations 2015) as it was for this study. The results of analysis using economic allocation are provided in Appendix C (Tables 26-31).

5.2.4 Functional and declared unit

In accordance with the PCR developed (FPInnovations 2015), the declared unit for I-joists was one kilometer (1.0 km). A declared unit is used in instances in which the function and the reference scenario for the whole life cycle of a wood building product cannot be stated (FPInnovations 2015). For conversion of units from the U.S. I-joist industry measure, 1 km equals 3.281 thousand feet with an oven-dried moisture content of 6%. All input and output data were allocated to the declared unit of product based on the mass and economics of products and coproducts in accordance with ISO 14044 (ISO 2006b) and the North American structural and architectural wood products PCR (FPInnovations 2015). Because the analysis did not take the declared unit to the stage of being an installed building product, no service life was assigned.

5.2.5 System boundaries

The system boundary began with regeneration in the forest and ended with the final I-joist product. The system boundary included forest resource management activities such as site preparation and planting seedlings, fertilization and thinning on a subset of hectares, and final harvest; transportation of roundwood to the primary breakdown facility; OSB, LVL, and FJL production; transportation to the I-joist facility if needed; and I-joist production (Figure 3). The I-joist production complex was modeled as a single unit approach representing all the steps necessary to make I-joists. Three main unit processes exist in manufacturing I-joists: (1) routing and shaping of web and flanges, (2) assembly of I-joists, and (3) sawing and curing with energy generation as an auxiliary process (USEPA 2002; Wilson and Dancer 2005a; Puettmann et al. 2013). A single unit (i.e. black box) approach was used to model the I-joist process because little wood left the system except as the final product and because of the relative simplicity of the I-joist manufacturing processes. This simply means all process inputs and outputs are grouped into one I-joist process.

Fuel resources used for the cradle-to-gate production of energy and electricity were included within the cumulative system boundary. Off-site emissions included those from grid electricity production; transportation of feedstock; OSB, LVL, and FJL production; transportation to the I-joist facility; and production of fuels off site and consumed both on and off site. Ancillary material consumption data such as motor oil, waxes, paint, and hydraulic fluid were included in the analysis.

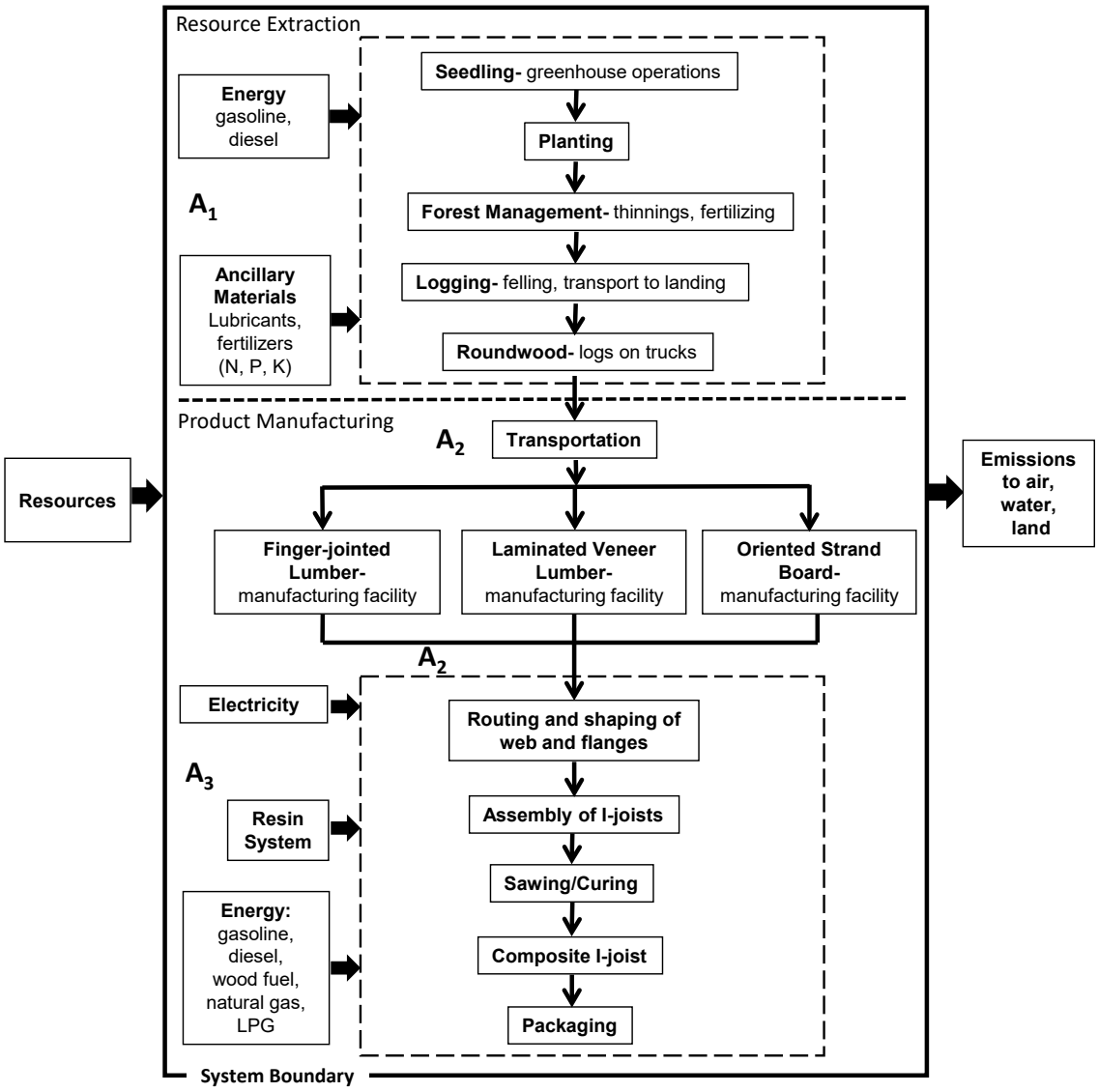


Figure 3. Cradle-to-gate system boundary and process flow for production of I-joists.

5.2.6 Cut-off rules

According to the PCR, if the mass/energy of a flow is less than 1% of the cumulative mass/energy of the model flow, it may be excluded, provided its environmental relevance is minor. This analysis included all energy and mass flows for the primary data collected.

In the primary surveys, manufacturers were asked to report total hazardous air pollutants (HAPs) specific to their wood products manufacturing process, regardless of whether or not they were less than the 1% cutoff. If applicable to the wood product, HAPs are reported later in the LCI data section and thus are not excluded from this LCI. Under Title III of the Clean Air Act Amendments of 1990, the EPA has designated HAPs that wood products facilities are required to report as surrogates for all HAPs. These are methanol, acetaldehyde, formaldehyde, propionaldehyde (propanal), acrolein, and phenol. All HAPS are included in the LCI; no cut-off rules apply. HAPS are reported in Appendix B and were included in the

impact assessment. There were no cut-offs used in the impact assessment. Therefore, a complete list of all air emissions is located in Appendix B of thisreport.

5.2.7 Data quality requirements

This study collected primary data from representative I-joist manufacturers in the SE that use average technology for their regions. The raw wood material to produce I-joists comes from manufacturing facilities in the SE region in the form of OSB, LVL, and FJL. In the SE, most I-joist production occurs in conjunction with production of LVL and FJL in the same engineered wood facility or nearby. For one of the two surveyed mills, LVL production occurred at the same site as I-joist production, and most FJL production occurred at the same site as well. This study used OSB manufacturing LCI data for the SE developed by Puettmann et al. (2015) but with the OSB transported from Canada.

Total U.S. I-joist production for 2012 was 109 thousand km (358,900 thousand ft) (APA 2014). Two U.S. I-joist plants representing 27% of 2012 U.S. production, 29.5 thousand km (96,799.180 thousand ft) participated in the study by providing primary data for the SE regions. The surveyed plants provided detailed annual production data on their facilities, including on-site energy consumption; electrical usage; LVL, OSB, and FJL volumes; and I-joist production for 2012. Wilson and Dancer (2005a) performed a 2000 U.S. I-joist LCI study that covered 33% (21.3 thousand km) of production in the SE. The production of surveyed facilities for 2012 was an increase of 26% from 2000. In addition, unlike the earlier 2000 study, 2012 I-joist production data were not available by region. Therefore, production data by region could not be quantified for 2012.

5.2.8 Assumptions and limitations

All flow analyses of wood and bark in the process were determined on an OD weight basis with a weighted-average green specific gravity of 0.55.

Although small in quantity relative to the wood mass, impacts from production of the resin system were included in the analysis. Because of the small consumption values for sodium hydroxide, catalyst, and melamine components of the resin system, no transportation data were provided or incorporated into the analysis. However, impacts from cradle-to-gate production of the entire resin system were included in the analysis.

Melamine-urea-formaldehyde (MUF) resin was used as proxy for melamine-formaldehyde (MF) resin, which was used in the FJL production life-cycle stage.

5.2.9 Data collection

Primary data for the LCI were collected through surveys in accordance with CORRIM and ISO 14040 standards along with a site visit at a joint operating LVL/I-joist manufacturing facility. This study relied almost exclusively on production and emissions data provided by I-joist producers in the United States, with some secondary data on electrical grid inputs and resource forest activities from the U.S. LCI database (Goemans 2010; NREL 2012). The survey data represented I-joist production in terms of input materials, electricity, fuel use, and emissions for the 2012 production year. Two production facilities were surveyed and selected to be representative of SE region production practices. Questionnaires were used to survey the I-joist manufacturing processes to collect primary data (Appendix F). The primary data obtained from the surveys were weight-averaged using the formula shown in the next section, Calculation rules (Milota 2004).

Secondary data sources are shown in Table 2. All nonwood related LCI data came from the U.S. LCI Database (NREL 2012), whereas wood LCI data came from previous or concurrent CORRIM research.

Table 2. Secondary LCI data sources used.

Process	LCI data source	Publication date
Electricity	USLCI data for "Electricity, at Grid, SERC[a], 2008/RNA[b] U"	2008
Diesel truck	USLCI data for "Transport, combination truck, diesel powered/US"	2008
Forestry and harvesting	CORRIM data for PNW softwood forestry operation; CORRIM data for SE softwood forestry operations	2005, 2010, updated 2013
LVL	CORRIM data for LVL production	2005, updated 2016
OSB	CORRIM data for OSB production	2005, updated 2016
Natural gas	USLCI data for "Natural gas, combusted in industrial boiler/US, Athena"	2008
Resin	CORRIM data resin production obtained from the USLCI	2009
Slack wax	CORRIM data for Slack wax obtained from the USLCI	2004
Emulsion polymer	USLCI data for "Methylene diphenyl diisocyanate resin, at plant, US SE/US"	2008
Polyurethane polymer	US-EI data for "Polyurethane, flexible foam, at plant/RER with US electricity U"	2009
Hardener	USLCI data for "Phenol-resorcinol-formaldehyde hardener, at plant/US"	2008
Gasoline	USLCI data for "Gasoline, combusted in equipment/US"	2008
Hydraulic fluid, lubricants, oil, and grease	USLCI data for "Gasoline, at refinery/l/US" without combustion emissions	2008
Plastic strapping/wrapping material	USLCI data for "Low density polyethylene resin, at plant/RNA"	2008

[a]SERC stands for Southeastern Electric Reliability Council
[b]North America

5.2.10 Calculation rules

In the surveys, I-joist production was reported in linear feet. These data were converted to 1 km and a weighted average based on production (Eq. 1). This approach resulted in an I-joist complex that represents a composite of the mills surveyed in the SE region but does not represent any mill in particular. The U.S. LCI database was used to assess off-site impacts associated with the materials and energy used. SimaPro, version 8+ (Pré Consultants 2016) was used as the accounting program to track all of the materials.

$$\bar{P}_{weighted} = \frac{\sum_{i=1}^{n} P_i x_i}{\sum_{i=1}^{n} x_i} \quad (1)$$

Where $\bar{P}_{weighted}$ is the weighted average of the values and was reported by n mills, P_i is the reported mill value, and x_i is the fraction of the mill's value to total production of the surveyed mills for that specific value. Because the surveyed mill data varied between facilities, a statistical analysis was conducted. In

this study, the weighted coefficient of variation was calculated (NIST ITL 1996) (Eq. 3). The weighted coefficient of variation (CoV_w) is the weighted standard deviation (sd_w) (Eq. 2) divided by the weighted mean ($\bar{P}_{weighted}$) (Eq. 1):

$$CoV_W = \frac{sd_w}{\bar{P}_{weighted}} \quad (2)$$

$$sd_w = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x}_w)^2}{\frac{(N'-1)\sum_{i=1}^{N} w_i}{N'}}} \quad (3)$$

Where w_i is the weight of the i^{th} observation, N is the number of nonzero weights, and $\bar{x}_w$ is the weighted mean of the observations.

Missing data were defined as data not reported in surveys by the I-joist facilities. Whenever missing data occurred for survey items, they were checked with plant personnel to determine whether it was an unknown value or zero. Missing data were carefully noted to prevent them from being averaged as zeros. Any outliers were resolved by contacting mill personnel. A summary of conversion factors used in calculations can be found in Appendix A, Tables 22-24.

5.2.11 Life-cycle impact assessment method

The LCIA was performed using the TRACI 2 method (Bare 2011). The five impact categories examined were GW (kg CO_2-eq), acidification (kg SO_2-eq), eutrophication (kg N-eq), ozone depletion (kg chlorofluorocarbons-11-eq), and photochemical smog (kg NOx-eq).

The life cycle impact assessment (LCIA) phase establishes links between the life cycle inventory results and potential environmental impacts. The LCIA calculates impact indicators, such as global warming potential and smog. These impact indicators provide general, but quantifiable, indications of potential environmental impacts. The target impact indicator, the impact category, and means of characterizing the impacts are summarized in Table 3. These five impact categories reported were consistent with the requirement of the wood products PCR (FPInnovations 2015).

Table 3. Selected impact indicators, characterization models, and impact categories.

Impact Indicator	Characterization Model	Impact Category
Greenhouse gas (GHG) emissions	Calculate total emissions in the reference unit of CO_2 equivalents for CO_2, methane, and nitrous oxide.	Global warming
Releases to air decreasing or thinning of ozone layer	Calculate the total ozone forming chemicals in the stratosphere including CFCs HCFCs, chlorine, and bromine. Ozone depletion values are measured in the reference units of CFC equivalents.	Ozone depletion
Releases to air potentially resulting in acid rain (acidification)	Calculate total hydrogen ion (SO_2) equivalent for released sulfur oxides, nitrogen oxides, hydrochloric acid, and ammonia. Acidification value of SO_2 mole- eq. is used as a reference unit.	Acidification
Releases to air potentially resulting in smog	Calculate total substances that can be photo-chemically oxidized. Smog-forming potential of O_3 is used as a reference unit.	Photochemical smog
Releases to air potentially resulting in eutrophication of water bodies	Calculate total substances that contain available nitrogen or phosphorus. Eutrophication potential of N-eq. is used as a reference unit.	Eutrophication

Each impact indicator is a measure of an aspect of a potential impact. This LCIA does not make value judgments about the impact indicators, meaning that no single indicator is given more or less value than any of the others. Additionally, each impact indicator value is stated in units that are not comparable with others. For the same reasons, indicators should not be combined or added.

6 DETAILED DESCRIPTION OF DATA AND PROCESSES

6.1 Forestry Operations

Logs used in the production of I-joists include in their life cycle the upstream activities associated with establishment, growth, and harvest of trees. This group of activities is collectively referred to as forest resource management. Forest operations modeled as inputs to production processes were based on forest resource LCI data inputs from the SE softwood forests (Johnson et al. 2005; Puettmann et al. 2013). Forestry operations vary regionally (Johnson et al. 2005) but typically include some combination of growing seedlings, regeneration, site preparation, planting (where applicable), thinning, fertilization (where applicable), and final harvest. Harvesting includes felling, skidding, processing, and loading for both commercial thinning and final harvest operations.

For SE forests, reforestation occurs primarily by planting that requires inputs from human-related activities (i.e., the technosphere) for seedlings, site preparation, planting, and precommercial thinning (Table 4). Weighted-average allocation to different processes takes into account inherent differences in site productivity and energy usage by different kinds of logging equipment. Inputs to the forest resources management LCI include seed, electricity used during greenhouse operations, fertilizer used during seedling production and stand growth, and the fuel and lubricants needed to power and maintain equipment for thinning, and (final) harvest operations. The primary output product is a log destined for softwood veneer or plywood, OSB, or lumber. The coproduct, nonmerchantable (logging) slash, is generally left at a landing. Slash disposal was not modeled as it was assumed to decay in-situ.

Table 4. Inputs to the regeneration phase and midrotation fertilization per hectare (ha) of SE forest (Puettmann et al. 2013).

Inputs	Unit	Low intensity	Medium intensity	High intensity	Weighted average
		Reforesting 1 ha			
Diesel and gasoline	L	38.55	132.27	272.21	104.59
Seedlings, at greenhouse	p[a]	1,794	1,794	1,794	1,794
Nitrogen in fertilizer					
In seedlings	kg	0.14	0.14	0.14	0.14
On site	kg	-	264.52	712.86	189.06
Phosphorous in fertilizer					
In seedlings	kg	0.01	0.01	0.01	0.01
On site	kg	-	72.86	128.90	48.70
Potassium in fertilizer					
In seedlings	kg	0.08	0.08	0.08	0.08
On site	kg	-	-	-	-

[a] p = individual seedling.

In the SE region, most harvested lands are reforested for the next crop cycle with the sequence of treatments from planting to harvest averaging 27 years for the SE (Johnson et al. 2005; Puettmann et al. 2013). Forestry operations and their associated impacts are not stationary and will change based on both

past and prospective technologies, evolving forest management procedures, and market demands. Given that the nature of productivity gains is not confirmed or well developed, this assessment was based on data representing the current state of the art in forest operations. It does not discount future operations or estimate potential productivity gains from future technologies. Outputs representing quantities of product, measures of consumed resources, and the emissions associated with those consumed resources were developed as a weighted average across the hectares managed for timber production. These quantities of product are used as inputs to the LVL manufacturing LCI, and the consumed resources and emissions are tracked for inclusion in the cradle-to-gate LCI.

6.2 Product Manufacturing

6.2.1 Resource transport

Wood raw materials were delivered to the I-joist plants by truck and rail; the wood material consists primarily of OSB, FJL, and LVL purchased off site. For the surveyed mills, one mill produced LVL and the other one produced FJL on site.

6.2.2 Laminated veneer lumber process

Inputs into composite I-joist manufacturing include LVL. For every kilometer of I-joist produced, 2,597 kg (4.6 m^3) of LVL were incorporated into the final product for the SE. Dry veneers, parallel laminated lumber, and resins are the primary raw materials consumed for the production of SE LVL. Wilson and Dancer (2004b, 2005b) and Bergman and Alanya-Rosenbaum (2016) give detailed information on the production of LVL.

6.2.3 Oriented strandboard process

Inputs into composite I-joist manufacturing include OSB. For every kilometer of I-joist produced, 2,212 kg of OSB were incorporated into the final product. Chips and resins are the primary raw materials consumed for the production of SE OSB. Kline (2005) and Kaestner (2015) give detailed information about SE OSB manufacturing.

6.2.4 Finger-jointed lumber production

Inputs into composite I-joist manufacturing include FJL. For every kilometer of I-joist produced, 28.3 kg of FJL were incorporated into the final product. Finger joints are machined on both ends of softwood lumber with special cutter heads. A structural resin, such as MUF is applied, and the joints in successive boards are coupled. The resin is cured with the joint under end pressure and heat. Most manufacturers use a continuous radio-frequency curing system for this step. For this study, the surveyed mills provided primary data on FJL production and MUF resin consumption, whereas electrical consumption data for cutting or forming the joint for FJL was embedded in the electricity consumed for I-joist production and therefore not noted separately. Also, FJL production included the impacts of softwood lumber production as well as resin production.

6.2.5 Methylene diphenyl di-isocyanate resin

Methylene diphenyl diisocyanate (MDI) resin[1] is used in the production of I-joists. The LCI for production of MDI resin was based on a cradle-to-gate study of plastic resins and polyurethane precursors completed by Franklin Associates (2011). Franklin Associates collected primary data for MDI production including data on the following MDI precursors: olefins, benzene, chlorine–caustic soda, and nitric acid–

[1] MDI is listed under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) of US EPA and subject to reporting requirements according to EPCRA Section 313 Toxic Chemicals

nitrobenzene–aniline. For MDI production, data were gathered from four North American producers that represent approximately 95% of North American production capacity (Franklin Associates 2011).

6.2.6 Phenol resorcinol formaldehyde resin

Phenol-resorcinol-formaldehyde resin is the primary resin used for both web-to-web and web-to-flange joints. The PRF data were collected by survey from eight plants in the United States that represented 63% of total production for the year 2005 (Wilson 2009). Total annual production of PRF was 15,513,000 kg (34,166,667 lb) of neat[2] resin at 60% nonvolatile solids content. PRF resins differ somewhat from other resins in that hardeners are required to help in curing glue-laminated timbers and I-joists.

6.2.7 Melamine urea formaldehyde resin

Melamine-urea-formaldehyde resin is used for FJL. The MUF production data were collected by survey from six plants in the United States that represented 77% of total production for the year 2005 (Wilson 2009). Total annual production was 86,588,000 kg (190,893,000 lb) of neat resin at 60% nonvolatile solids content. Essentially, MUF production is identical to production of urea formaldehyde resin (these resins are used for particleboard and medium-density fiberboards) with the exception that melamine, about 8% by weight on a neat resin basis, is substituted for a portion of the urea input. The inputs to produce 1.0 kg of neat MUF resin at 60% nonvolatile solids content consist of three primary chemicals on a dry basis of melamine at 0.081 kg, urea at 0.397 kg, and methanol at 0.304 kg; much lesser amounts of formic acid, ammonium sulfate, and sodium hydroxide; and 0.791 kg of water. A significant portion of the processing water is recycled back into the resin. Based on CORRIM Phase I glulam surveys, 0.96 kg of MUF resin was used to produce 1.0 m^3 of FJL (Puettmann and Wilson 2005; Puettmann et al. 2013). In this study, the MUF consumption value in the FJL manufacturing process was quantified as 1.235 kg/m^3 based on primary mill data. The resin was assumed to have a solids content of 65% (Silva et al. 2015).

6.2.8 Energy generation

Energy production for manufacturing of I-joists comes from electricity, natural gas, diesel, and liquid petroleum gas (LPG). Electricity was used for mechanical pressing during resin application, for running the saws and assembly machinery as well as for pneumatic and mechanical conveying equipment, fans, and other equipment in the plant. Natural gas was used for the purpose of generating heat for resin curing. Diesel was used for rolling stock, which transported materials outside the plant, and LPG used in rolling stock including forklift trucks, which operated inside the plant. Kaestner (2015) provides information on energy consumption for producing OSB, and Bergman and Alanya-Rosenbaum (2016) provide information on energy consumption for producing LVL.

6.2.9 I-joist manufacturing

Routing and shaping of web and flanges is the first step in producing composite I-joists. This process requires machining of the OSB web pieces so they fit together at the ends as well as tapering them on the top and bottom edges so that they can be fitted into the flanges. Flanges are made primarily from LVL along with some FJL. The flanges are routed their entire length to accept the inserted tapered OSB web material. The coproduct created during this process is dry sawdust.

Resin application and pressing of the I-joist web and flange members is the next step. Resin is applied in web-to-web and web-to-flange joints. Resins may be MDI or PRF. Assembly is done mechanically, pressing web sections end-to-end and into the top and bottom flange, which are also pressed end-to-end. The result is a continuous ribbon of I-beam that can be of infinite length. No coproducts are created during this process. The final steps before packaging are sawing the I-joists to length and allowing the

[2] Neat resin means the resin as purchased from the supplier, does not include any inert fillers.

joints to cure. In some cases, the I-joist may be heated in a radio-frequency oven to accelerate resin cure time. Wilson and Dancer (2004a, 2005a) provide more information about composite I-joist manufacturing.

6.2.10 Packaging

Finished I-joists are packaged for transport. Inputs include final product (I-joist) and outputs include packaged I-joist. For this study, it was assumed that only wrapping material was used for each I-joist. Packing materials represent about 1% of the cumulative mass of the model flow. The material list was provided by Puettmann et al. (2013) (Table 5).

Table 5. Materials used in packaging and shipping per kilometer I-joist.

Material	Value	Unit
Wrapping material – HDPE[a] and LDPE[b] laminated paper	47.45	kg
PET[c] strapping	-	kg
Cardboard strap protectors	-	kg
Wooden spacers	-	kg
Total	-	kg

[a]High-density polyethylene (HDPE)
[b]Low-density polyethylene (LDPE)
[c]Polyethylene terephthalate (PET)

6.3 Air Emissions

The main emission sources were from hot presses. Baghouses were the primary collectors of particulate matter, and both surveyed plants used the ECD. To decrease volatile organic compound (VOC) emissions from dryers, plants reported the use of regenerative catalytic oxidizers (RCOs), which are sometimes referred to as regenerative thermal oxidizers (RTOs) and wet scrubbers. RCOs are designed to destroy VOCs and other emissions including particulate matter (PM) and soot (USEPA 2003a).

7 INPUTS AND OUTPUTS

7.1 Material Transportation

Based on mill surveys, the weighted-average one-way haul distance for feedstock along with the components of the resin system are shown in Table 6. All upstream transportation of inputs to LVL, FJL, and OSB production were included in the respective LCI input values.

Table 6. Weighted-average delivery distance (one way) by mode for materials to I-joist plants.

Material delivered to mill	Delivery distance
	km
OSB to I-joist plant, by truck	175
OSB to I-joist plant, by rail	0
LVL to I-joist plant	112
FJL to I-joist plant	230
MDI and PRF resin to I-joist plant	89

7.2 Energy Sources

For I-joist production, thermal energy generated from natural gas was commonly produced in the form of steam and then used in the hot-pressing unit process for resin curing. Electricity (grid) was the main energy source used on site, which was derived from off-site sources. Table 7 shows the electrical grid composition for I-joist production in the SE region of the United States. Nuclear (25.2%) and coal (56.4%) power comprises most of the SE grid (SERC). Outputs included electricity and emissions primarily of fossil CO_2.

Table 7. Percentage of each energy source for electricity for producing I-joists in the SE[a] (NREL 2012).

Energy source	Percentage of total grid electricity
Natural gas	13.4
Coal	56.4
Oil	0.7
Nuclear	25.2
Hydro	2.0
Wind	0.0
Biomass	1.5
Geothermal	0.0
Miscellaneous	0.8
Total	100.0

[a] SERC is the electric grid comprised of Alabama, Georgia, Mississippi, North Carolina, South Carolina, and parts of Arkansas, Florida, Illinois, Iowa, Kentucky, Louisiana, Missouri, Tennessee, Texas, and Virginia.

7.3 Gate-to-Gate I-Joist Production

Table 8 shows the detailed description of the material and energy inputs and outputs crossing the system boundary of I-joist production, gate-to-gate. Electricity consumed on site for the SE was calculated to be 257.8 kWh/km. Natural gas was the primary fossil fuel used on site. Air emissions were derived from the surveyed mills along with pertinent emissions data categorized by the U.S. Environmental Protection Agency (USEPA 2002, 2003a, 2003b, 2003c, 2015). When available, surveyed air emission data as primary data were selected rather than secondary data.

Table 8. Unit process inputs and outputs to produce 1 km of composite I-joists, SE, gate-to-gate.

Products	**Unit/km**	**Value**	**Allocation[a]**
I-joists	km	1.000E+00	91.15%
Sawdust, sold	kg	4.109E+02	8.48%
Panel trim, sold	kg	6.863E-01	0.01%
Rejects	kg	1.713E+01	0.30%
Resources	**Unit/km**	**Value**	
Water, well, in ground	L	3.189E-01	
Materials/fuels[b]	**Unit/km**	**Value**	
Wood feedstock, LVL, oven-dried	kg	2.597E+03	
Wood feedstock, OSB, oven-dried	kg	2.212E+03	
Wood feedstock, FJL, oven-dried	kg	2.826E+01	
Phenol-resorcinol-formaldehyde resin	kg	3.352E+01	
MDI (proxy for emulsion polymer isocyanate)	kg	1.469E+00	
Polyurethane polymer	kg	3.121E-01	
Hardener	kg	5.496E-01	
Electricity, at grid	kWh	2.578E+02	
Diesel, combusted in industrial equipment	L	4.772E+00	
Gasoline, combusted in equipment	L	2.173E-01	
Propane, combusted in industrial equipment	L	4.735E+00	
Natural gas, combusted in industrial boiler	m^3	4.096E+01	
Transport, combination truck, diesel power, LVL	tkm	3.082E+02	
Transport, combination truck, diesel power, OSB	tkm	4.108E+02	
Transport, combination truck, diesel power, FJL	tkm	7.148E+00	
Transport, combination truck, diesel powered, PRF resin	tkm	4.759E+00	
Hydraulic fluid	kg	2.551E-02	
Greases	kg	6.377E-03	
Motor oil	kg	2.551E-02	
Potable water	kg	3.153E-01	
Plastic strapping	kg	6.377E-02	
Wrapping material - packaging	kg	4.745E+01	
Emissions to air	**Unit/km**	**Value**	
Acetone[c]	kg	2.083E-04	
Acrolein	kg	not reported	
Carbon monoxide	kg	5.517E-02	
Formaldehyde	kg	4.593E-03	
Methanol	kg	3.982E-02	
Nitrous oxide	kg	6.705E-02	
PM_{10}	kg	1.027E-01	
Phenol	kg	1.027E-01	
Propionaldehyde	kg	9.428E-02	
Sulfur dioxide	kg	not reported	
VOC	kg	7.114E-04	
Waste to treatment	**Unit/km**	**Value**	
Waste to inert landfill	kg	0.000E+00	
Waste to recycling	kg	6.379E+00	

[a] Mass allocation approach.
[b] Wood feedstocks include OSB, LVL, and FJL.
[c] Secondary data (USEPA 2002).

7.4 Material Flows

To evaluate data quality, a mass balance was performed (Table 9). For the SE, LVL, OSB and FJL usage in OD kg basis was 2,597, 2,212, and 28 per 1 km of I-joist produced. The major coproduct produced was sawdust (412 OD kg on average), whereas I-joists produced constituted about 91% by mass of the total output. Purchased LVL made up the largest portion of feedstock consumed at the facility at 2,597 OD kg per km of SE I-joist. The second largest portion was OSB. Phenol-resorcinol-formaldehyde resin made up most of the additives, which were overall about 0.7% by mass of the total input.

Table 9. Mass balance of I-joist manufacturing per kilometer I-joist, SE, gate-to-gate.

	(OD kg)	Mass (%)	CoVw[a] (%)
Feedstocks	**Inputs**		
LVL	2,597	53.7	2.4
OSB	2,212	45.7	7.0
FJL	28	0.6	
Total, feedstock	**4,809**	**99.4**	**2.2**
Additives			
Phenol-resorcinol-formaldehyde resin	33.5	0.7	141
Aqueous emulsion polymer	1.5	0.0	141
Polyurethane polymer	0.3	0.0	141
Hardener	0.5	0.0	141
Total, additives	**36**	**0.7**	**46.2**
Total, in	**4,840**	**100**	
Products	**Outputs**		
I-joists	4,415	91.2	4.6
Coproducts			
Sawdust, sold	411	8.5	18
Sawdust, wood fuel	1	0.0	141
Panel trim, sold	17	0.4	141
Total, coproducts	**428**	**8.8**	**39**
Total, outputs	**4,844**	**100**	

[a] Coefficient of variation, production-weighted.

7.5 On-Site Energy Inputs

Weighted-average energy inputs consumed at the I-joist manufacturing site were developed from survey data (Table 10). Electricity and natural gas were the primary energy inputs at 258 kWh and 41 m^3 for the SE per linear km of I-joist.

Table 10. On-site energy inputs for I-joist manufacturing, SE, gate-to-gate.

	Quantity	Unit	CoVw[a] (%)
Energy inputs			
Electricity	258	kWh	33
Natural gas	41	m^3	49
Diesel	4.77	L	16
Propane	4.74	L	5.3
Gasoline	0.217	L	141

[a] Coefficient of variation.

8 LIFE-CYCLE INVENTORY DATA

Cradle-to-gate LCI flows for composite I-joist manufacturing was presented by five life stages: (1) forestry operations, (2) OSB production, (3) FJL production, (4) LVL production, and (5) I-joist production. As noted previously, LVL production included dry veneer production and veneer transportation to LVL plants. Thus, because dry veneer production was captured within LVL production and LVL was the heaviest component of an I-joist, most raw material energy consumption occurred during LVL production followed by OSB and I-joist stages with a small portion arising from FJL production and forestry operations (Table 11). In particular, wood fuel consumption was dominated by the LVL stage resulting from veneer input to LVL production. As with this study, wood is burned primarily at the veneer production facility to generate thermal energy for log conditioning and drying veneers (Wilson and Dancer 2005b; Bergman and Taylor 2011; Kaestner 2015).

Table 11. Raw material energy consumption per kilometer I-joist produced, cradle-to-gate, mass allocation.

Fuel	Unit	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Wood fuel	OD kg	0.00E+00	1.18E+02	9.94E+00	7.97E+02	9.18E+00
Gas, natural, in ground	m^3	1.04E+01	1.46E+02	2.87E-01	3.35E+02	1.01E+02
Coal, in ground	kg	2.20E+00	1.54E+02	1.15E+00	3.18E+02	9.22E+01
Uranium oxide, in ore	kg	5.08E-05	4.37E-03	3.22E-05	8.97E-03	2.22E-03
Oil, crude, in ground	kg	3.43E+01	4.39E+01	2.98E-01	8.19E+01	5.05E+01

Primary energy is energy embodied in the original resources such as crude oil and coal before conversion. Table 12 shows the CPEC for cradle-to-gate production of SE I-joist. The LVL stage consumed the most primary energy at 45.1 GJ/m^3 (61.9%). For LVL production, wood and natural gas were used to generate thermal energy for log conditioning and for drying and pressing veneers. At the I-joist life-cycle production stage, natural gas was used to generate thermal energy for resin curing, whereas electricity was consumed for sawing, trimming, and the radio-frequency ovens. Cradle-to-gate primary energy was derived from wood fuel at 19.5 GJ/m^3 and natural gas at 22.7 GJ/m^3 with CPEC for all five life-cycle stages at 72.8 GJ/m^3, representing more than 58% of the CPEC. Coal consumption was third with 20.4% contribution from generating electricity. Other renewable energy sources of hydro and wind along with wood fuel comprised 27% of CPEC. Total energy use at the I-joist production stage was dominated by fossil fuels of which the greatest contributor was natural gas (28.5%), unlike the upstream products for which biomass dominated. Other major primary energy sources were coal and crude oil.

Wood products typically consume more energy during the manufacturing stage than any other stage (Puettmann and Wilson 2005; Winistorfer et al. 2005; Puettmann et al. 2010). To compare with an earlier CORRIM study on making 1 km of I-joist in the SE, cumulative allocated energy consumptions is 58.2 GJ/m^3 with a biomass energy percentage of 45% (Wilson and Dancer 2005a, Puettmann et al 2013). Like the present study, mass allocation was used.

Table 12. Cumulative primary energy consumption per kilometer I-joist produced, cradle-to-gate, mass allocation.

Fuel	Percentage	Total	Forestry Operations	OSB Production	FJL Production	LVL Production	I-joist Production
		MJ/ km					
Wood fuel	26.9	1.95E+04	0.00E+00	2.47E+03	2.08E+02	1.67E+04	1.92E+02
Gas, natural, in ground	31.2	2.27E+04	3.97E+02	5.58E+03	1.10E+01	1.28E+04	3.88E+03
Coal, in ground	20.4	1.49E+04	5.77E+01	4.03E+03	3.01E+01	8.33E+03	2.41E+03
Oil, crude, in ground	13.2	9.60E+03	1.56E+03	2.00E+03	1.36E+01	3.73E+03	2.30E+03
Uranium oxide, in ore	8.2	5.96E+03	1.94E+01	1.66E+03	1.23E+01	3.42E+03	8.44E+02
Hydro	0.2	1.29E+02	2.35E-01	3.21E+01	2.31E-01	7.74E+01	1.92E+01
Wind	0.0	3.96E+00	0.00E+00	5.27E-01	3.38E-04	8.74E-01	2.56E+00
Solar	0.0	4.45E-02	0.00E+00	2.41E-03	3.13E-06	6.08E-03	3.60E-02
Geothermal	0.0	1.95E-01	0.00E+00	1.95E-01	2.71E-07	5.18E-06	0.00E+00
Total	100	7.28E+04	2.04E+03	1.58E+04	2.75E+02	4.51E+04	9.64E+03
Total, by percentage		100	2.8	21.7	0.4	61.9	13.2

Air emission data were collected from surveyed mill data that were augmented by a secondary resource for acetone emissions from I-joist plants (USEPA 2002). As mentioned previously, baghouses are the primary collectors of PM, and both surveyed plants used the ECD. I-joist manufacturers reported on-site air emissions (Table 8) of acetone, carbon monoxide, formaldehyde, methanol, nitrous oxides, PM, phenol, sulfur dioxide, and VOCs. The emissions greater than 10^{-4} and HAPs generated from I-joist production along with the ones reported by the mills themselves are reported in Appendix B. Fossil and biogenic CO_2 released in the production of 1 km of I-joist were 2,482 and 1,442 kg, respectively.

All waterborne emissions occurred off site for gate-to-gate I-joist production (Table 25). I-joist plants are zero-discharge facilities. For unspecified suspended solids, most of the emissions came from natural gas extraction, then crude oil production, followed by production of PRF resin. Most chloride emissions were from the same sources.

Solid emissions were dominated by LVL and I-joist production stages. Solid emissions include ash generated at the wood boiler during veneer production for LVL production and primarily fuels and resins used (Table 13). A total of 107 kg/km solid waste was generated (Table 16). Overall, 84% of the solid waste generated was landfilled.

Table 13. Waste to treatment (kg) per kilometer I-joist, cradle-to-gate, mass allocation.

Waste to treatment	Total	Forestry operations	OSB production	FJL production	LVL production	I-joist production
	kg/km					
Waste in inert landfill	9.05E+01	0.00E+00	1.17E+01	1.89E-04	7.77E+01	1.03E+00
Waste to recycling	1.70E+01	0.00E+00	0.00E+00	0.00E+00	1.12E+01	5.81E+00
Total waste	1.07E+02	0.00E+00	1.17E+01	1.89E-04	8.89E+01	6.85E+00

9 LIFE-CYCLE IMPACT ASSESSMENT

Table 14 shows environmental performance results for impact categories (GW, acidification, eutrophication, ozone depletion, and smog), primary energy consumption from nonrenewable and renewable sources (wind, hydro, solar, geothermal, and nuclear fuels), consumption of renewable and nonrenewable resources, and solid waste generated. Values in Table 14 are the cumulative impact of all upstream processes required for I-joist production including those from forestry; OSB, FJL, and LVL production; and I-joist production as well as the transportation energy required to move these materials to the I-joist facility. For example, differences between I-joist production data in Table 8 and those in Table 14 are a result of the resources and fuels used in the upstream processes, e.g. fresh water use. In addition, the contribution of major substances to the overall impact for eutrophication, acidification, smog, and GW impact categories are provided in Appendix D (Tables 30-31). The data on solid waste generated during OSB and LVL production were obtained from Kaestner (2015) and Bergman and Alanya-Rosenbaum (2016), respectively.

Table 14. Environmental performance of 1 km of I-joist, cradle-to-gate, mass allocation.

Impact category	Unit	Total	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Global warming	kg CO_2 eq	2.72E+03	1.29E+02	6.36E+02	3.82E+00	1.49E+03	4.57E+02
Acidification	kg SO_2 eq	2.66E+01	1.72E+00	6.26E+00	4.03E-02	1.40E+01	4.50E+00
Eutrophication	kg N eq	1.22E+00	3.14E-01	1.64E-01	1.20E-03	3.65E-01	3.78E-01
Ozone depletion	kg CFC-11 eq	1.78E-04	1.10E-08	2.21E-06	3.66E-09	7.71E-07	1.75E-04
Smog	kg O_3 eq	2.91E+02	4.87E+01	6.40E+01	8.00E-01	1.36E+02	4.14E+01
Total primary energy consumption	**Unit**	**Total**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total	MJ	7.28E+04	2.04E+03	1.58E+04	2.75E+02	4.51E+04	9.64E+03
Nonrenewable fossil	MJ	4.72E+04	2.02E+03	1.16E+04	5.46E+01	2.49E+04	8.58E+03
Nonrenewable nuclear	MJ	5.96E+03	1.94E+01	1.66E+03	1.23E+01	3.42E+03	8.44E+02
Renewable[a]	MJ	1.33E+02	2.35E-01	3.28E+01	2.31E-01	7.82E+01	2.18E+01
Renewable, biomass	MJ	1.95E+04	0.00E+00	2.47E+03	2.08E+02	1.67E+04	1.92E+02
Material resources consumption (nonfuel resources)	**Unit**	**Total**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Nonrenewable materials	kg	1.49E+01	0.00E+00	6.18E+00	1.06E-03	8.08E+00	6.16E-01
Renewable materials	kg	4.07E+03	7.17E+02	2.07E+01	3.62E+01	3.27E+03	1.99E+01
Fresh water	L	1.22E+04	4.22E-01	1.40E+03	3.23E+01	6.12E+03	4.61E+03
Waste generated	**Unit**	**Total**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Solid waste	kg	1.07E+02	0.00E+00	1.17E+01	1.89E-04	8.89E+01	6.85E+00

[a] solar, wind, hydroelectric, and geothermal.

10 COMPARISON OF UPDATED LIFE-CYCLE INVENTORY WITH A PREVIOUS STUDY

The on-site, industry-average energy inputs reported in 2012 were substantially higher than for Phase I except for the electricity and propane consumption (Wilson and Dancer 2005a; Puettmann et al. 2013). In particular, diesel and natural gas consumption is driving the total impact from energy with changes of 33% and 587%, respectively (Table 15). Therefore, a sensitivity analysis investigating the energy inputs into I-joist production was completed in Section 13 to see their overall impact. The CPEC of gate-to-gate

I-joist production was quantified as 58.2 GJ/km in the earlier CORRIM Phase I study (Wilson and Dancer 2005a), which is about 22% lower compared with the current study. Similarly, at the I-joist facilities in the earlier study, natural gas was used to generate heat for resin curing although at a much lower consumption. For both studies, the energy generated by woody biomass and fossil fuels constituted the majority of the total energy consumed. However, with that being said, no uncertainty estimate was provided with the earlier data and different companies provided the primary 2000. Therefore, only speculation can made on the apparent differences. In this study, the weighted coefficient of variation representing variability in the collected process data was calculated and presented in the report. In addition, in this study, a sensitivity analysis was performed investigating the impact of the variation of energy inputs into I-joist production to the overall output.

Table 15. Production weighted-average SE on-site energy inputs for manufacturing 1 km of I-joist.

	SE Phase I	SE 2012		
Energy inputs	**Quantity**	**Quantity**	**Unit**	**Change (%)**
Electricity	246	257.8	kWh	5
Natural gas	5.95	40.9	m^3	587
Diesel	3.6	4.77	L	33
Propane	4.72	4.74	L	0

11 TREATMENT OF BIOGENIC CARBON

Treatment of biogenic carbon is consistent with the Intergovernmental Panel for Climate Change (IPCC 2006) inventory reporting framework. There is no assumption that biomass combustion is carbon neutral, but net carbon emissions from biomass combustion are accounted for under the Land-Use Change and Forestry (LUCF) sector and are therefore ignored in energy emissions reporting for the product LCA. This prevents double counting. Standards such as ASTM D 7612 (2010), which are used in North America to define legal, responsible, and/or certified sources of wood materials, are in place to provide assurances regarding forest regeneration and sustainable harvest rates and serve as proxies to ensure stable carbon balances in the forest sector. They are outside the accounting framework for this LCA.

This approach to the treatment of biogenic carbon was taken from the Norwegian Solid Wood Product PCR (Aasestad 2008), and the North American PCR (FPInnovations 2015) adopted an identical approach to ensure comparability and consistency. The North American PCR approach is followed here for GW impact reporting. Therefore, the default TRACI impact assessment method was used. This default method does not count the CO_2 emissions released during the combustion of woody biomass during production. Other emissions associated from wood combustion, e.g. methane or nitrogen oxides, do contribute to and are included in the GW impact category. Bare (2011) provides a complete list of emissions factors for the GW impact method used. Using this method, 2,716 kg CO_2eq were released in the cradle-to-gate production of 1 km of I-joist for the SE (Table 14). That same 1 km of I-joist stores 7,285[3] kg CO_2eq (Table 16).

[3] 4,415 OD kg of wood in I-joist x 0.9 × (0.5 kg carbon/1.0 OD kg wood) × (44 kg CO_2/kmole/12 kg carbon/kmole) = 7,285 kg CO_2eq.

Table 16. Carbon balance per kilometer I-joist.

Source	kg CO_2 equivalent
Released forestry operations	129
Released manufacturing	2,588
CO_2eq. stored in product	7,285

12 LIFE-CYCLE INTERPRETATION

As defined by ISO (2006a, b), the term life-cycle interpretation is the phase of the LCA that the findings of either the LCI or the LCIA, or both, are combined consistent with the defined goal and scope to reach conclusions and recommendations. This phase in the LCA reports the significant issues based on the results presented in the LCI and LCIA of this report. Additional components report an evaluation that considers completeness, sensitivity, and consistency checks of the LCI and LCIA results and conclusions, limitations, and recommendations.

12.1 Identification of Significant Issues

The objective of this element is to structure the results from the LCI or the LCIA phases to help determine the significant issues found in the results and presented in previous sections of this report. A contribution analysis was applied for the interpretation phase of this LCA study. Contribution analysis examines the contribution of life-cycle stages, unit process contributions in a multi-unit manufacturing process, or specific substances that contribute to particular impact categories.

12.2 Life-Cycle Phase Contribution Analysis

Allocation was performed using both mass and economic methodologies to investigate the influence of the allocation method on the results. The contribution of five life-cycle stages to the LCA results for mass and economic allocation are provided in Table 17 and Table 18, respectively. Overall, the cradle-to-gate environmental impacts from I-joist production for the five impact categories resulted in less than a 10% difference between economic and mass allocation. Applying economic allocation resulted in a 10% increase in the impact resulting from the I-joist production stage in all impact categories, which was caused by the environmental burdens shifted toward the production of I-joists, whereas economic value of the coproducts was minor.

Table 17. Life-cycle stages contribution analysis of 1 km of I-joist, cradle-to-gate, mass allocation.

Impact category	Unit	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Global warming	kg CO_2 eq	4.7%	23.4%	0.1%	54.9%	16.8%
Acidification	kg SO_2 eq	6.5%	23.6%	0.2%	52.9%	17.0%
Eutrophication	kg N eq	25.7%	13.4%	0.1%	29.9%	31.0%
Ozone depletion	kg CFC-11 eq	0.0%	1.2%	0.0%	0.4%	98.3%
Smog	kg O_3 eq	16.8%	22.0%	0.3%	46.7%	14.3%
Total primary energy consumption	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total	MJ	2.8%	21.7%	0.4%	61.9%	13.2%
Nonrenewable fossil	MJ	4.3%	24.6%	0.1%	52.8%	18.2%
Nonrenewable nuclear	MJ	0.3%	27.9%	0.2%	57.4%	14.2%
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	0.2%	24.6%	0.2%	58.7%	16.3%
Renewable, biomass	MJ	0.0%	12.7%	1.1%	85.3%	1.0%
Material resources consumption (nonfuel resources)	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Nonrenewable materials	kg	0.0%	41.5%	0.0%	54.3%	4.1%
Renewable materials	kg	17.6%	0.5%	0.9%	80.5%	0.5%
Fresh water	L	0.0%	11.5%	0.3%	50.3%	37.9%
Waste generated	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Solid waste	kg	0.0%	10.9%	0.0%	82.7%	6.4%

Table 18. Life-cycle stages contribution analysis of 1 km of I-joist, cradle-to-gate, economic allocation.

Impact category	Unit	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Global warming	kg CO_2 eq	4.5%	24.2%	0.2%	53.5%	17.6%
Acidification	kg SO_2 eq	6.2%	24.4%	0.2%	51.5%	17.8%
Eutrophication	kg N eq	24.5%	13.8%	0.1%	29.1%	32.4%
Ozone depletion	kg CFC-11 eq	0.0%	1.2%	0.0%	0.4%	98.3%
Smog	kg O_3 eq	16.2%	23.0%	0.4%	45.3%	15.1%
Total primary energy consumption	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total	MJ	2.7%	22.8%	0.5%	59.8%	14.2%
Nonrenewable fossil	MJ	4.1%	25.3%	0.2%	51.5%	19.0%
Nonrenewable nuclear	MJ	0.3%	28.8%	0.3%	55.8%	14.8%
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	0.2%	25.1%	0.2%	57.6%	16.9%
Renewable, biomass	MJ	0.0%	14.2%	1.5%	83.2%	1.1%
Material resources consumption (nonfuel resources)	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Nonrenewable materials	kg	0.0%	44.7%	0.0%	50.7%	4.5%
Renewable materials	kg	18.0%	0.6%	1.5%	79.4%	0.5%
Fresh water	L	0.0%	12.2%	0.3%	46.8%	40.6%
Waste generated	**Unit**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Solid waste	kg	0.0%	10.9%	0.0%	82.2%	6.9%

12.3 Substance Contribution Analysis

The contribution of substances released to GWP is presented in Table 19. The major substances that contributed to GWP for the five life-cycle stages of I-joist manufacturing include fossil carbon dioxide (CO_2), methane (CH_3), and nitrous oxide (N_2O). The results are presented for both mass and economic allocation, for both of which CO_2 emissions had the highest contribution.

Table 19. Substance contribution analysis to GWP (kg CO_2 eq) by life-cycle stage (total percentage basis and values are displayed per kilometer I-joist, cradle-to-gate)[a]

		Mass allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartments		**100.00**	5%	23%	0.1%	55%	17%
Carbon dioxide	Air	91.4%	1.15E+02	5.84E+02	3.61E+00	1.37E+03	4.14E+02
Methane	Air	7.9%	6.15E+00	5.13E+01	1.99E-01	1.20E+02	3.82E+01
Nitrous oxide	Air	0.6%	7.57E+00	1.33E+00	1.30E-02	4.49E+00	4.08E+00
Other substances	Air	<1	5.19E-05	5.44E-02	3.10E-03	3.61E-01	5.36E-01
		Economic allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartments		**100.00**	5%	24%	0.2%	54%	18%
Carbon dioxide	Air	91.4%	1.15E+02	6.31E+02	5.17E+00	1.40E+03	4.54E+02
Methane	Air	8.0%	6.15E+00	5.55E+01	2.78E-01	1.23E+02	4.19E+01
Nitrous oxide	Air	0.6%	7.57E+00	1.39E+00	1.86E-02	4.77E+00	4.47E+00
Other substances	Air	<1	5.19E-05	5.86E-02	4.09E-03	3.38E-01	5.88E-01

[a] Additional substance contributions for other impact categories can be found in Appendix D of this report.

12.4 Completeness, Sensitivity, and Consistency Checks

Evaluating the completeness, sensitivity, and consistency of an LCA offers confidence in and the reliability of the LCA results. The ***completeness check*** process verifies whether information from the life-cycle phases of an LCA is sufficient for reaching the goals and scope and conclusions of the study and making sound interpretations of the results. Three life-cycle stages (forestry operations, wood material production, and I-joist production) were checked for data completeness including all input elements, such as raw and ancillary materials input, energy inputs, transportation scenarios, water consumption, and outputs such as products and coproducts, emissions to air, water, and land, and final waste disposals. All input and output data were found to be complete, and no data gaps were identified.

The consistency check process verifies that the assumptions, methods, and data are consistently applied throughout the study and are in accordance with the goal and scope of the LCA. A comprehensive review process was completed for this LCA to make certain consistency was applied to the assumptions made, methods used, models, data quality including data sources, data accuracy, age, time-related coverage, technology, and geographical coverage.

Sensitivity analysis can be applied to the LCA to determine changes in results caused by variations in assumptions, methods, and data. Sensitivity analysis is a systematic approach for estimating the effects of the choices made concerning methods and data on the outcome of a study. Sensitivity analysis is a key component of data quality analysis and can be applied to quantify the impact of changes in assumptions or input data on study results. A sensitivity analysis was completed per ISO 14040 standards (ISO 2006a, b) to model the effects of natural consumption and electricity consumption for I-joist production. Sensitivity analysis can be useful to understand how various process parameters contribute to environmental output factors.

12.5 Cumulative Primary Energy Consumption

During gate-to-gate I-joist manufacturing, natural gas is used for curing resin. Changing the on-site consumption of natural gas may have a significant effect on CPEC and GHG emissions for cradle-to-gate I-joist production. Lower (-20%) and higher (+20%) natural gas consumptions were selected to compare with the baseline fuel mix developed from the mill survey data (Table 20). Although natural gas usage changed by 20%, the outcomes changed less than 1% for both GHG emissions and CPEC.

Table 20. Key parameters for changing on-site natural gas consumption during 1 km of I-joist production, cradle-to-gate, mass allocation.

Parameter	Unit	Low (-20%)	Surveyed (0%)	High (+20%)
		Values		
GHG emissions	kg CO_2eq	2,698	2,716	2,734
CPEC	GJ	72.5	72.8	73.1

12.6 Electricity Consumption

During gate-to-gate I-joist manufacturing, electricity is used in the mechanical pressing during resin application, running the saws and assembly machinery as well as pneumatic and mechanical conveying equipment, fans, radio-frequency ovens, and other equipment in the plant. However, changing the electricity consumption by 20% changed the outcome by less than 1.2% for both GHG emissions and CPEC for cradle-to-gate I-joist production (Table 21).

Table 21. Key parameters on changing electricity consumption during 1 km of I-joist production, cradle-to-gate, mass allocation.

Parameter	Unit	Low (-20%)	Surveyed (0%)	High (+20%)
		Values		
GHG emissions	kg CO_2eq	2,683	2,716	2,750
CPEC	GJ	72.2	72.8	73.4

Neither natural gas nor electrical consumption on-site had a substantial impact on the overall process because on-site I-joist production CPEC contributed roughly 13% of the energy impacts of cradle-to-gate I-joist production.

13 CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

The cradle-to-gate LCA for I-joists includes the LCI of (1) forest resources, (2) OSB production, (3) FJL production, (4) LVL production, and (5) I-joist production. It relies on primary survey data and secondary data for process inputs such as natural gas, diesel, and electricity. The survey results for I-joists were representative of the SE region of the United States. The survey data were representative of the I-joist sizes and production volumes consistent with trade association production data.

The amount and type of energy used has a substantial impact on the holistic environmental impacts of the production of building materials. For I-joists from the SE region, from cradle-to-gate, 26.9% of the cumulative energy was from biomass (wood fuel) and 65% was from nonrenewable fossil fuels, leaving a small portion of energy needs coming from nuclear (8.2%) and the remaining (0.2%) from hydro, wind,

solar, and geothermal. Emissions from the forest resources LCI was small relative to other manufacturing emissions (LVL, OSB, FJL, and I-joists).

Cradle-to-gate LCI results showed 2,482 kg fossil CO_2 were released in the production of 1 km of I-joist. Carbon content for wood products is assumed to be 50% by mass of OD wood. Excluding the resin system (about 10% by mass), the carbon stored in the wood portion of 1 km of I-joist on a production-weighted average is equivalent to 7,285 kg CO_2 emissions if left to decay.

Data quality was high. A wood mass balance was performed to verify data quality. Inputs and outputs were consistent for the four surveyed mills on a cubic meter basis. Difference for overall wood mass was less than 2%. A difference less than 10% would be good. Therefore, tracking of wood mass is excellent for this study.

Specific wood production LCA data such as those for I-joists can be used for several purposes. One purpose is to use the present cradle-to-gate LCAs to compare with LCAs of I-joists manufactured from different materials, i.e. steel I-joists. Secondly, production companies can explore potential process improvements in conjunction with new conversion technologies to identify potential environmental hotspots. Thirdly, other groups can use the data, such as LCA practitioners for their studies, customers needing to select products (perhaps eventually with an EPD), and building specifiers looking for green building products with documentation. Fourthly, developed wood product LCI data can contribute to product LCAs that are then incorporated into whole-building LCAs in environmental footprint software. Lastly, the gate-to-gate I-joist production data can be included or used to update current LCI data found in LCI databases.

Recommendations for future work on LCIA of I-joist manufacturing in the United States include expanding the system boundaries by including the use phase of the I-joist product. The cradle-to-grave analysis will allow a more comprehensive assessment of hotspots in the whole-product life cycle.

14 CRITICAL REVIEW

14.1 Internal Review

An internal critical review of the survey procedures, data, analysis, and report was completed by Dr. Maureen Puettmann, WoodLife Environmental Consultants (Corvallis, Oregon) to assess conformance with CORRIM guidelines, the PCR, and ISO 14040 standards.

The review provided assurances that the study methodology, data collection, and analyses were scientifically sound, and in conformance with internationally accepted standards and CORRIM research protocol (ISO 2006b; ILCD 2010; CORRIM 2014).

14.2 External Review

If an EPD is to be developed based on this LCA, an external review process is required. The external review process is intended to ensure consistency between the completed LCA and the principals and requirements of the international standards on LCA (ISO 2006a) and the PCR for North American structural and architectural wood products (FPInnovations 2015) by an independent third party. Following CORRIM's internal review, documents were submitted to UL Environment for independent external review.

15 REFERENCES

Aasestad K (2008) The Norwegian emission inventory 2008. Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants. Statistisk sentralbyrå. Reports 2008/48: 252 pp.

APA (2014) Engineered wood statistics: Third quarter 2014. APA—The Engineered Wood Association, Tacoma, WA. 9 pp.

ASMI (2016) Athena impact estimator for buildings. http://www.athenasmi.org/our-software-data/impact-estimator. Athena Sustainable Material Institute, Ottawa, Ontario, Canada. (1 March 2016).

ASTM (2010) ASTM D 7612-10. Standard practice for categorizing wood and wood-based products according to their fiber source. American Society for Testing and Materials, West Conshohocken, PA. pp. 783-793.

ASTM (2014) ASTM D 5456-14b. Standard specification for evaluation of structural composite lumber products. American Society for Testing and Materials, West Conshohocken, PA. 33 pp.

Bare JC (2011) TRACI 2.0: The tool for the reduction and assessment of chemical and other environmental impacts 2.0. Clean Technol Envir 13:687-696.

Bergman RD, Alanya-Rosenbaum S (2016) Cradle-to-gate life-cycle assessment of laminated veneer lumber produced in Southeast region of the United States. Consortium for Research on Renewable Industrial Materials (CORRIM), Inc., University of Washington, Seattle, WA.

Bergman RD, Taylor AM (2011) Environmental product declarations of wood products—An application of life cycle information about forest products. Forest Prod J 61(3):192-201.

CORRIM (2014) Research guidelines for life-cycle inventories (draft). Consortium for Research on Renewable Industrial Materials (CORRIM), Inc., University of Washington, Seattle, WA. 40 pp.

FPInnovations (2015) Product category rule (PCR): For preparing an environmental product declaration (EPD) for North American structural and architectural wood products. UN CPC 31. NAICS 321. https://fpinnovations.ca/ResearchProgram/environment-sustainability/epd-program/Documents/pcr-v2.pdf (15 July 2016).

Franklin Associates (2011) Life cycle inventory of nine plastic resins and four polyurethane precursors. Prepared for the Plastics Division of the American Chemistry Council. https://plastics.americanchemistry.com/LifeCycle-Inventory-of-9-Plastics-Resins-and-4-Polyurethane-Precursors-Rpt-Only (2 March 2016).

Goemans C (2010) US LCI Database – North American electricity generation by fuel type update and template methodology. Athena Institute, National Renewable Energy Laboratory, Golden, CO. http://www.nrel.gov/lci/database/.

Hodgman CD (1955) Handbook of chemistry and physics. 37th edition 1955-1956. Chemical Rubber Publishing Co., Cleveland, Ohio. 3156 pp.

ILCD (2010) International Reference Life Cycle Data System (ILCD) Handbook - General guide for life cycle assessment—Detailed guidance. EUR 24708 EN. European Commission–Joint Research Centre–Institute for Environment and Sustainability. Luxembourg. Publications Office of the European Union. 417 pp.

IPCC 2006. Task Force on National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/faq/faq.html (September 22, 2016). ISO (2006a) Environmental management—life-cycle assessment—requirements and guidelines. ISO 14044. International Organization for Standardization, Geneva, Switzerland. 46 pp.

ISO (2006a) Environmental management—Life-cycle assessment—Requirements and guidelines. ISO 14044. International Organization for Standardization, Geneva, Switzerland. 46 pp.

ISO (2006b) Environmental management—Life-cycle assessment—Principles and framework. ISO 14040. International Organization for Standardization, Geneva, Switzerland. 20 pp.

ISO (2006c) Environmental labels and declarations—Type III environmental declarations—Principles and procedures. ISO 14025. International Organization for Standardization, Geneva, Switzerland. 25 pp.
Johnson LR, Lippke BR, Marshall JD, Comnick J (2005) Life-cycle impacts of forest resource activities in the Pacific Northwest and southeast United States. Wood Fiber Sci 37(CORRIM Special Issue):30-46.
Kaestner D (2015) Life cycle assessment of the oriented strand board and plywood industries in the United States of America. Master's Thesis, University of Tennessee. 122 pp. http://trace.tennessee.edu/utk_gradthes/3376 (1 March 2016).
Kline ED (2005) Gate-to-gate life-cycle inventory of oriented strandboard production. Wood Fiber Sci 37 (Special Issue):74-84.
Milota MR (2004) Softwood lumber—Pacific Northwest Region. CORRIM Phase I Final Report Module B. University of Washington, Seattle, WA. www.corrim.org/reports/. 75 pp.
Milota MR (2015) Softwood lumber production life-cycle inventory data. Oregon State University, Corvallis, OR. Personal communication with M Puettmann on 12 October 2015.
NIST ITL (1996) Weighted standard deviation. National Institute of Standards and Technology Information Technology Laboratory. www.itl.nist.gov/div898/software/dataplot/refman2/ch2/weightsd.pdf. (2 July 2015).
NREL (2012) Life-cycle inventory database project. National Renewable Energy Laboratory. www.lcacommons.gov/nrel/search. (1 March 2016).
PRé Consultants (2016) SimaPro 8 Life-cycle assessment software package, Version 8. Plotter 12, 3821 BB Amersfoort, the Netherlands. www.pre.nl/. (1 March 2016).
Puettmann ME, Bergman RD, Hubbard S, Johnson L, Lippke B, Wagner F (2010) Cradle-to-gate life-cycle inventories of US wood products production—CORRIM Phase I and Phase II Products. Wood Fiber Sci 42 (CORRIM Special Issue):15-28.
Puettmann M, Kaestner D, Taylor A (2015) Dry veneer and oriented strandboard production life-cycle inventory data. University of Tennessee, Knoxville, TN. Personal communication with M. Puettmann on 13 October 2015.
Puettmann ME, Oneil EE, Wilson J, Johnson L (2013) Cradle to gate life cycle assessment of engineered I-joists production from the Pacific Northwest. Consortium for Research on Renewable Industrial Materials. University of Washington, Seattle, WA. 24 pp.
Puettmann ME, Wilson JB (2005) Life-cycle analysis of wood products: Cradle-to-gate LCI of residential wood building materials. Wood Fiber Sci 37 (Special Issue):18-29.
Ritter MA, Skog KE, Bergman RD (2011) Science supporting the economic and environmental benefits of using wood and wood products in green building construction. Gen Tech Rep FPL-GTR-206. USDA For Serv Forest Products Laboratory, Madison, WI. 9 pp.
Salazar J, Meil J (2009) Franklin database. http://www.fal.com/lifecycle-services.html. (11 August 2015).
Silva DAL, Lahr FAR, Varanda LD, Christoforo AL, Ometto, AR (2015) Environmental performance assessment of the melamine-urea-formaldehyde (MUF) resin manufacture: A case study in Brazil. J Clean Prod 96: 299-307.
Stark NM, Cai Z, Carll C (2010) Wood-based composite materials: Panel products, glued-laminated timber, structural composite lumber, and wood–nonwood composite materials. In: Wood handbook—wood as an engineering material. Gen Tech Rep FPL–GTR–113. USDA For Serv Forest Products Laboratory, Madison, WI. pp. 11-1–11-28.
Starr C (1971) Energy and power. Sci Am 225(3):37-69.
Todreas NE, Kazimi MS (1990) Thermal hydraulics fundamentals: Nuclear system Volume I Page 2, Table 1-1. Taylor & Francis, New York.
USCB (2012) 2012 North American Industry Classification System Definitions. 321215 Structural wood product manufacturing. United States Census Bureau, Washington, DC. www.census.gov/eos/www/naics/. (1 March 2016).

USEPA (2002) AP 42 Section 10.9 Engineered wood products manufacturing. United States Environmental Protection Agency. pp. 10.9-1–24. http://www.epa.gov/ttnchie1/ap42/ch10/final/c10s09.pdf. (1 March 2016).
USEPA (2003a) Air pollution control technology fact sheet. EPA-452/F-03-021. Regenerative incinerator. United States Environmental Protection Agency, Washington, DC. 5 pp. http://www.epa.gov/ttn/catc/dir1/fregen.pdf. (1 March 2016).
USEPA (2003b) Air pollution control technology fact sheet. EPA-452/F-03-025. Fabric filter (baghouse). United States Environmental Protection Agency, Washington, DC. 6 pp. http://www.epa.gov/ttn/catc/dir1/ff-pulse.pdf. (1 March 2016).
USEPA (2003c) Air pollution control technology fact sheet. EPA-452/F-03-015. Packed-bed/packed-tower wet scrubber. United States Environmental Protection Agency, Washington, DC. 6 pp. http://www.epa.gov/ttn/catc/dir1/fpack.pdf. (1 March 2016).
USEPA (2015) Industrial commercial institutional boilers and process heaters. United States Environmental Protection Agency, Washington, DC. http://www.epa.gov/airtoxics/boiler/boilerpg.html. (1 March 2016).
Wilson JB (2009) Resins: A life cycle inventory of manufacturing resins used in the wood composites industry. In CORRIM Phase II Final Report Module H. January 2009. 103 pp. http://www.corrim.org/pubs/reports/2010/phase2/Module_H.pdf. (22 March 2016).
Wilson JB, Dancer ER (2004a) Composite I-joists–Pacific Northwest and Southeast. In CORRIM Phase I Final Report Module F. 122 pp. http://www.corrim.org/pubs/reports/2005/Phase1/Module_F_Final.pdf. (2 March 2016).
Wilson JB, Dancer ER (2004b) Laminated veneer lumber manufacturing. In CORRIM Phase I Final Report Module H. 87 pp. http://www.corrim.org/pubs/reports/2005/Phase1/Module_H_Final.pdf. (22 March 2016).
Wilson JB, Dancer ER (2005a) Gate-to-gate life-cycle inventory of I-joist production. Wood Fiber Sci 37 (Special Issue):85-98.
Wilson JB, Dancer ER (2005b) Gate-to-gate life-cycle inventory of laminated veneer lumber production. Wood Fiber Sci 37 (Special Issue):114-127.
Winistorfer P, Chen Z, Lippke B, Stevens N (2005) Energy consumption and greenhouse gas emissions related to use, maintenance, and disposal of a residential structure. Wood Fiber Sci 37(Special Issue):128-139.

16 APPENDIX A: CONVERSION FACTORS

Table 22. Common conversions from English to SI units.[a]

To convert from	to	multiply by
Cubic feet (ft^3)	Cubic meter (m^3)	0.02831685
Pounds (avdp) (lb)	Kilograms (kg)	0.4535924
Cubic inches (in^3)	Cubic centimeters (cm^3)	16.393
Btus	Joules (J)	1054
Cubic yards (yd^3)	Cubic meters (m^3)	0.7645549
Feet (ft)	Meters (m)	0.305
Gallons (US gal)	Liters (L)	3.785
Kilowatt hours (kWh)	Mega joules (MJ)	3.6
Miles (mi)	Kilometers (km)	1.609
Ounces (avdp)	Kilograms (kg)	0.028
Square feet (ft^2)	Square meters (m^2)	0.093
Tons (short)	Kilograms (kg)	907.185
Tons (short)	Metric ton (t)	0.9071847
Pounds (lb)	Metric ton (t)	0.0004
Watts (W)	Joules/sec (J/s)	1
Yards (yd)	Meters (m)	0.914
Acres	Hectares (ha)	0.405

[a] Source: Starr (1971).

Table 23. Electricity grids and dataset name by source.

Region	North American grid	Source
Southeast	Electricity, at grid, SERC, 2008/RNA U	U.S. LCI database

Table 24. Energy contents and densities of various fuels.

Fuel	HHV[a,b] MJ/kg	Density	Density units	HHV[a] Btu/lb
Coal	26.19			11,260
Distillate fuel oil[c]	45.54	0.85	kg/L	19,580
Liquid propane gas	54.05	0.49	kg/L	23,240
Natural gas	54.45	0.70	kg/m^3	23,410
Residual fuel oil	43.45	0.96	kg/L	18,680
Wood	20.93			9,000
Uranium	381,000.00			1.64E+08
Gasoline	48.36	0.72	kg/L	20,810
Diesel	44.00	0.88	kg/L	18,930

[a] Hodgman (1955); Salazar and Meil (2009); Todreas and Kazimi (1990).
[b] HHV: High heating value.
[c] Same as for crude oil.

17 APPENDIX B: SOUTHEAST I-JOIST LIFE-CYCLE INVENTORY FLOWS, MASS ALLOCATION

Table 25. Mass allocation inventory.

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Aluminium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.19E-05
Aluminium, 24% in bauxite, 11% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.57E-08	0.00E+00	9.59E-03
Anhydrite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E-06
Anhydrite, in ground	Raw	kg	0.00E+00	0.00E+00	5.32E-12	0.00E+00	3.28E-05
Barite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-04
Barite, 15% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.13E-09	0.00E+00	2.75E-02
Basalt	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-09
Basalt, in ground	Raw	kg	0.00E+00	0.00E+00	3.32E-11	0.00E+00	7.80E-07
Borax	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.67E-10
Borax, in ground	Raw	kg	0.00E+00	0.00E+00	2.91E-12	0.00E+00	7.22E-08
Bromine, 0.0023% in water	Raw	kg	0.00E+00	0.00E+00	6.34E-13	0.00E+00	3.97E-01
Cadmium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-13
Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground	Raw	kg	0.00E+00	0.00E+00	1.01E-13	0.00E+00	6.26E-10
Calcite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-01
Calcite, in ground	Raw	kg	0.00E+00	0.00E+00	1.78E-05	0.00E+00	8.58E-01
Carbon dioxide, in air	Raw	kg	1.24E+04	1.00E+02	3.17E-02	1.33E+02	1.84E+00
Carbon, in organic matter, in soil	Raw	kg	0.00E+00	0.00E+00	2.81E-10	0.00E+00	1.02E-04
Carbon, organic, in soil or biomass stock	Raw	kg	0.00E+00	0.00E+00	0.00E+00	4.21E+03	8.09E+03
Cerium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.94E-24
Chromium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-06
Chromium, 25.5% in chromite, 11.6% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.04E-09	0.00E+00	1.06E-04
Chrysotile	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.77E-09
Chrysotile, in ground	Raw	kg	0.00E+00	0.00E+00	1.04E-11	0.00E+00	3.04E-04
Cinnabar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.49E-07
Cinnabar, in ground	Raw	kg	0.00E+00	0.00E+00	9.78E-13	0.00E+00	2.79E-05
Clay, bentonite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E-05
Clay, bentonite, in ground	Raw	kg	0.00E+00	0.00E+00	4.57E-08	0.00E+00	1.34E-03
Clay, unspecified	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-03
Clay, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	2.32E-06	0.00E+00	1.97E-02
Coal, 26.4 MJ per kg	Raw	kg	2.20E+00	1.49E+02	1.15E+00	3.18E+02	8.16E+01
Coal, bituminous, 24.8 MJ per kg	Raw	kg	0.00E+00	1.10E-05	5.86E-06	1.12E-04	0.00E+00
Coal, bitumous, in ground	Raw	kg	0.00E+00	4.58E+00	0.00E+00	0.00E+00	0.00E+00
Coal, brown	Raw	kg	0.00E+00	9.90E-07	5.27E-07	1.01E-05	1.76E-02
Coal, brown, in ground	Raw	kg	0.00E+00	0.00E+00	2.60E-04	0.00E+00	5.71E+00
Coal, hard	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-01
Coal, hard, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	1.50E-04	0.00E+00	4.71E+00
Coal, lignite, in ground	Raw	kg	0.00E+00	3.80E-01	0.00E+00	0.00E+00	0.00E+00
Cobalt	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.71E-11
Cobalt, in ground	Raw	kg	0.00E+00	0.00E+00	3.63E-12	0.00E+00	2.32E-05
Colemanite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.32E-09
Colemanite, in ground	Raw	kg	0.00E+00	0.00E+00	8.20E-11	0.00E+00	6.47E-03
Copper ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E-04
Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-08
Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.56E-11	0.00E+00	1.16E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.44E-09
Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	7.91E-11	0.00E+00	3.65E-05
Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-09
Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.10E-11	0.00E+00	9.69E-06
Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.21E-09
Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.05E-10	0.00E+00	4.80E-05
Diatomite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-13
Diatomite, in ground	Raw	kg	0.00E+00	0.00E+00	3.61E-15	0.00E+00	8.06E-11
Dolomite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E-05
Dolomite, in ground	Raw	kg	0.00E+00	0.00E+00	1.50E-10	0.00E+00	2.88E-05
Energy, from biomass	Raw	MJ	0.00E+00	7.01E-01	9.73E-07	1.86E-05	0.00E+00
Energy, from gas, natural	Raw	MJ	0.00E+00	4.03E+01	0.00E+00	8.46E+00	0.00E+00
Energy, from hydro power	Raw	MJ	2.35E-01	3.21E+01	2.31E-01	7.74E+01	1.92E+01
Energy, from oil	Raw	MJ	0.00E+00	1.59E+01	0.00E+00	3.35E+00	0.00E+00
Energy, geothermal	Raw	MJ	0.00E+00	1.95E-01	2.71E-07	5.18E-06	0.00E+00
Energy, gross calorific value, in biomass	Raw	MJ	0.00E+00	0.00E+00	1.98E-04	0.00E+00	5.37E+00
Energy, gross calorific value, in biomass, primary forest	Raw	MJ	0.00E+00	0.00E+00	1.95E-08	0.00E+00	7.06E-03
Energy, kinetic (in wind), converted	Raw	MJ	0.00E+00	5.27E-01	3.38E-04	8.74E-01	2.56E+00
Energy, potential (in hydropower reservoir), converted	Raw	MJ	0.00E+00	0.00E+00	1.04E-03	0.00E+00	1.74E+01
Energy, recovered	Raw	MJ	0.00E+00	4.24E+01	7.47E-07	1.43E-05	0.00E+00
Energy, solar, converted	Raw	MJ	0.00E+00	2.41E-03	3.13E-06	6.08E-03	3.60E-02
Feldspar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-04
Feldspar, in ground	Raw	kg	0.00E+00	0.00E+00	1.81E-16	0.00E+00	1.91E-12
Fluorine	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.83E-09
Fluorine, 4.5% in apatite, 1% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.28E-09	0.00E+00	1.70E-02
Fluorine, 4.5% in apatite, 3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.32E-09
Fluorine, 4.5% in apatite, 3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.00E-09	0.00E+00	1.29E-02
Fluorspar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.15E-06
Fluorspar, 92%, in ground	Raw	kg	0.00E+00	0.00E+00	7.72E-08	0.00E+00	2.76E-01
Gadolinium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.22E-29
Gallium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.93E-17
Gallium, 0.014% in bauxite, in ground	Raw	kg	0.00E+00	0.00E+00	5.30E-19	0.00E+00	3.48E-15
Gas, mine, off-gas, process, coal mining/m3	Raw	m3	0.00E+00	0.00E+00	1.45E-06	0.00E+00	4.33E-02
Gas, natural, 36.6 MJ per m3	Raw	m3	0.00E+00	4.20E-05	2.24E-05	4.27E-04	0.00E+00
Gas, natural, 36.7 MJ per m3, in ground	Raw	kg	0.00E+00	9.97E+00	0.00E+00	0.00E+00	0.00E+00
Gas, natural, 46.8 MJ per kg	Raw	kg	0.00E+00	1.66E-01	5.02E-05	2.18E-01	1.63E-02
Gas, natural, 49.8 MJ per kg, in ground (EMR)	Raw	kg	0.00E+00	7.18E+00	0.00E+00	0.00E+00	0.00E+00
Gas, natural, in ground	Raw	m3	0.00E+00	0.00E+00	6.94E-03	0.00E+00	9.77E+00
Gas, natural/m3	Raw	m3	1.04E+01	1.21E+02	2.80E-01	3.34E+02	9.13E+01
Gold	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-14
Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.62E-14
Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.50E-16	0.00E+00	2.22E-12
Gold, Au 1.3E-4%, Ag 4.6E-5%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.63E-14
Gold, Au 1.3E-4%, Ag 4.6E-5%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	8.25E-16	0.00E+00	4.07E-12
Gold, Au 1.4E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.88E-16	0.00E+00	4.87E-12

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Gold, Au 2.1E-4%, Ag 2.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-13
Gold, Au 2.1E-4%, Ag 2.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.51E-15	0.00E+00	7.44E-12
Gold, Au 4.3E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.01E-14
Gold, Au 4.3E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.74E-16	0.00E+00	1.84E-12
Gold, Au 4.9E-5%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.20E-14
Gold, Au 4.9E-5%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	8.96E-16	0.00E+00	4.41E-12
Gold, Au 6.7E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-13
Gold, Au 6.7E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.39E-15	0.00E+00	6.83E-12
Gold, Au 7.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-13
Gold, Au 7.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.56E-15	0.00E+00	7.71E-12
Gold, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.53E-15
Gold, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.37E-17	0.00E+00	4.62E-13
Granite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E-14
Granite, in ground	Raw	kg	0.00E+00	0.00E+00	1.27E-16	0.00E+00	8.58E-13
Gravel	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-04
Gravel, in ground	Raw	kg	0.00E+00	0.00E+00	9.07E-05	0.00E+00	1.01E-01
Gypsum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-05
Gypsum, in ground	Raw	kg	0.00E+00	0.00E+00	3.08E-10	0.00E+00	1.86E-06
Helium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-16
Indium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-14
Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground	Raw	kg	0.00E+00	0.00E+00	1.71E-15	0.00E+00	1.03E-11
Iodine, 0.03% in water	Raw	kg	0.00E+00	0.00E+00	1.50E-13	0.00E+00	2.06E-01
Iron	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-03
Iron ore	Raw	kg	0.00E+00	1.91E-07	9.62E-06	2.24E-07	1.00E-04
Iron, 46% in ore, 25% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.31E-08	0.00E+00	1.57E-03
Kaolinite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-07
Kaolinite, 24% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.92E-09	0.00E+00	1.76E-05
Kieserite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.78E-10
Kieserite, 25% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	7.80E-12	0.00E+00	6.05E-08
Lanthanum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-23
Lead	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.68E-07
Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	2.12E-12	0.00E+00	1.20E-06
Limestone	Raw	kg	0.00E+00	6.18E+00	1.06E-03	8.08E+00	6.16E-01
Lithium, 0.15% in brine, in ground	Raw	kg	0.00E+00	0.00E+00	2.70E-15	0.00E+00	1.89E-11
Magnesite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-06
Magnesite, 60% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.31E-09	0.00E+00	2.32E-05
Magnesium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E-13
Magnesium, 0.13% in water	Raw	kg	0.00E+00	0.00E+00	2.50E-15	0.00E+00	1.41E-11
Manganese	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.22E-07
Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.14E-11	0.00E+00	2.95E-02
Metamorphous rock, graphite containing	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E-09
Metamorphous rock, graphite containing, in ground	Raw	kg	0.00E+00	0.00E+00	3.53E-11	0.00E+00	1.38E-05
Molybdenum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.89E-09
Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-10
Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.95E-12	0.00E+00	8.92E-07
Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-11

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.76E-13	0.00E+00	1.27E-07
Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-09
Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.57E-11	0.00E+00	7.84E-06
Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-11
Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.01E-12	0.00E+00	4.66E-07
Molybdenum, 0.11% in sulfide, Mo 4.1E-2% and Cu 0.36% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.16E-11	0.00E+00	1.58E-05
Neodymium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-9.98E-25
Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.47E-08
Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.12E-06	0.00E+00	4.43E-04
Nickel, 1.98% in silicates, 1.04% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-05
Nickel, 1.98% in silicates, 1.04% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.88E-09	0.00E+00	1.62E-04
Nitrogen	Raw	kg	0.00E+00	7.70E-01	0.00E+00	0.00E+00	2.63E-03
Occupation, arable, conservation tillage	Raw	m2a	0.00E+00	1.35E-03	8.07E-07	1.58E-03	0.00E+00
Occupation, arable, conventional tillage	Raw	m2a	0.00E+00	1.48E-03	8.84E-07	1.73E-03	0.00E+00
Occupation, arable, non-irrigated	Raw	m2a	0.00E+00	0.00E+00	6.12E-09	0.00E+00	6.91E-05
Occupation, arable, reduced tillage	Raw	m2a	0.00E+00	9.08E-04	5.41E-07	1.06E-03	0.00E+00
Occupation, construction site	Raw	m2a	0.00E+00	0.00E+00	2.00E-08	0.00E+00	1.78E-03
Occupation, dump site	Raw	m2a	0.00E+00	0.00E+00	1.11E-06	0.00E+00	2.85E-02
Occupation, dump site, benthos	Raw	m2a	0.00E+00	0.00E+00	2.20E-11	0.00E+00	1.59E-07
Occupation, forest, intensive	Raw	m2a	0.00E+00	0.00E+00	2.08E-07	0.00E+00	5.97E-03
Occupation, forest, intensive, normal	Raw	m2a	0.00E+00	0.00E+00	2.95E-06	0.00E+00	6.05E-02
Occupation, forest, intensive, short-cycle	Raw	m2a	0.00E+00	0.00E+00	4.88E-09	0.00E+00	1.77E-03
Occupation, industrial area	Raw	m2a	0.00E+00	0.00E+00	3.09E-07	0.00E+00	7.81E-03
Occupation, industrial area, benthos	Raw	m2a	0.00E+00	0.00E+00	2.01E-13	0.00E+00	1.46E-09
Occupation, industrial area, built up	Raw	m2a	0.00E+00	0.00E+00	2.23E-10	0.00E+00	1.41E-06
Occupation, industrial area, vegetation	Raw	m2a	0.00E+00	0.00E+00	1.03E-10	0.00E+00	1.12E-06
Occupation, mineral extraction site	Raw	m2a	0.00E+00	0.00E+00	6.14E-07	0.00E+00	2.12E-02
Occupation, permanent crop, fruit, intensive	Raw	m2a	0.00E+00	0.00E+00	6.83E-09	0.00E+00	1.67E-05
Occupation, shrub land, sclerophyllous	Raw	m2a	0.00E+00	0.00E+00	1.02E-08	0.00E+00	5.83E-04
Occupation, traffic area, rail embankment	Raw	m2a	0.00E+00	0.00E+00	9.17E-11	0.00E+00	4.77E-07
Occupation, traffic area, rail network	Raw	m2a	0.00E+00	0.00E+00	1.01E-10	0.00E+00	5.35E-07
Occupation, traffic area, rail/road embankment	Raw	m2a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.43E-09
Occupation, traffic area, road embankment	Raw	m2a	0.00E+00	0.00E+00	3.25E-08	0.00E+00	6.96E-04
Occupation, traffic area, road network	Raw	m2a	0.00E+00	0.00E+00	2.80E-10	0.00E+00	1.89E-06
Occupation, urban, discontinuously built	Raw	m2a	0.00E+00	0.00E+00	1.13E-14	0.00E+00	7.19E-11
Occupation, water bodies, artificial	Raw	m2a	0.00E+00	0.00E+00	1.55E-06	0.00E+00	2.85E-02
Occupation, water courses, artificial	Raw	m2a	0.00E+00	0.00E+00	6.07E-07	0.00E+00	1.22E-02
Oil, crude	Raw	kg	3.43E+01	2.29E+01	2.96E-01	7.84E+01	4.41E+01
Oil, crude, 41 MJ per kg	Raw	kg	0.00E+00	1.23E+01	0.00E+00	2.58E+00	0.00E+00
Oil, crude, 42 MJ per kg	Raw	kg	0.00E+00	7.49E-01	1.22E-04	9.81E-01	6.56E-02
Oil, crude, 42.7 MJ per kg	Raw	kg	0.00E+00	2.20E-05	1.17E-05	2.23E-04	0.00E+00
Oil, crude, 43.7 MJ per kg, in ground	Raw	kg	0.00E+00	1.39E+00	0.00E+00	0.00E+00	0.00E+00
Oil, crude, 43.7 MJ per kg, in ground (EMR)	Raw	kg	0.00E+00	6.63E+00	0.00E+00	0.00E+00	0.00E+00
Oil, crude, in ground	Raw	kg	0.00E+00	0.00E+00	1.65E-03	0.00E+00	6.29E+00
Olivine	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E-06
Olivine, in ground	Raw	kg	0.00E+00	0.00E+00	1.88E-12	0.00E+00	1.14E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Oxygen	Raw	kg	0.00E+00	1.08E+01	8.39E-05	8.59E+00	3.03E+00
Palladium, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.62E-12
Palladium, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-12
Pd, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.96E-12	0.00E+00	3.41E-09
Pd, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.70E-12	0.00E+00	8.18E-09
Peat	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-05
Peat, in ground	Raw	kg	0.00E+00	0.00E+00	5.29E-08	0.00E+00	8.97E-04
Pesticides	Raw	kg	0.00E+00	8.93E-07	4.39E-09	1.05E-06	2.40E-05
Phosphate ore	Raw	kg	0.00E+00	8.49E-05	4.17E-07	9.93E-05	2.34E-03
Phosphorus	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-04
Phosphorus, 18% in apatite, 12% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.02E-09	0.00E+00	5.24E-02
Phosphorus, 18% in apatite, 4% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E-08
Phosphorus, 18% in apatite, 4% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.13E-09	0.00E+00	6.79E-02
Platinum, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.36E-14
Platinum, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-13
Potassium chloride	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-03
Praseodymium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.06E-25
Pt, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.50E-14	0.00E+00	7.84E-11
Pt, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.61E-13	0.00E+00	2.81E-10
resin	Raw	kg	0.00E+00	5.78E+01	0.00E+00	0.00E+00	0.00E+00
Rh, Rh 2.0E-5%, Pt 2.5E-4%, Pd 7.3E-4%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.47E-14	0.00E+00	7.78E-11
Rh, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.40E-13	0.00E+00	2.44E-10
Rhenium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-13
Rhenium, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.04E-14	0.00E+00	1.46E-10
Rhodium, Rh 2.0E-5%, Pt 2.5E-4%, Pd 7.3E-4%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.26E-14
Rhodium, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E-13
Roundwood at forest road	Raw	m3	1.17E+01	5.30E+00	0.00E+00	0.00E+00	0.00E+00
Salt, unspecified	Raw	kg	0.00E+00	7.39E+00	0.00E+00	0.00E+00	0.00E+00
Samarium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-3.67E-27
Sand	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.12E-04
Sand, quartz, in ground	Raw	kg	0.00E+00	9.89E-06	4.86E-08	1.16E-05	2.66E-04
Sand, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	1.20E-09	0.00E+00	4.29E-03
Scrap, external	Raw	kg	0.00E+00	3.47E-01	9.74E-04	4.06E-01	4.77E+00
Seed corn	Raw	kg	0.00E+00	4.79E-06	2.35E-08	5.60E-06	1.29E-04
Shale	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.42E-06
Shale, in ground	Raw	kg	0.00E+00	0.00E+00	1.51E-11	0.00E+00	9.29E-05
Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.04E-13
Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	9.98E-15	0.00E+00	4.93E-11
Silver, 3.2ppm in sulfide, Ag 1.2ppm, Cu and Te, in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-13
Silver, 3.2ppm in sulfide, Ag 1.2ppm, Cu and Te, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	7.12E-15	0.00E+00	3.52E-11
Silver, Ag 2.1E-4%, Au 2.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.30E-14

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Silver, Ag 2.1E-4%, Au 2.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.57E-16	0.00E+00	3.25E-12
Silver, Ag 4.2E-3%, Au 1.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-13
Silver, Ag 4.2E-3%, Au 1.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.50E-15	0.00E+00	7.41E-12
Silver, Ag 4.6E-5%, Au 1.3E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-13
Silver, Ag 4.6E-5%, Au 1.3E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.47E-15	0.00E+00	7.27E-12
Silver, Ag 9.7E-4%, Au 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.82E-14
Silver, Ag 9.7E-4%, Au 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.71E-16	0.00E+00	4.80E-12
Sodium carbonate	Raw	kg	0.00E+00	1.15E-03	6.89E-07	1.35E-03	0.00E+00
Sodium chloride	Raw	kg	0.00E+00	2.12E+00	9.96E-05	5.37E+00	6.51E-01
Sodium chloride, in ground	Raw	kg	0.00E+00	0.00E+00	1.97E-05	0.00E+00	1.10E+01
Sodium nitrate	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E-13
Sodium nitrate, in ground	Raw	kg	0.00E+00	0.00E+00	6.74E-17	0.00E+00	3.47E-13
Sodium sulfate	Raw	kg	0.00E+00	6.27E-03	1.54E-05	7.34E-03	7.27E-02
Sodium sulphate, various forms, in ground	Raw	kg	0.00E+00	0.00E+00	1.90E-08	0.00E+00	3.81E-05
Stibnite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-14
Stibnite, in ground	Raw	kg	0.00E+00	0.00E+00	3.75E-16	0.00E+00	8.37E-12
Sulfur	Raw	kg	0.00E+00	3.38E-04	9.05E-07	3.95E-04	7.72E-03
Sulfur, in ground	Raw	kg	0.00E+00	0.00E+00	3.58E-10	0.00E+00	9.63E-02
Sylvinite, in ground	Raw	kg	0.00E+00	4.18E-05	2.06E-07	4.89E-05	1.12E-03
Sylvite, 25 % in sylvinite, in ground	Raw	kg	0.00E+00	0.00E+00	2.69E-10	0.00E+00	8.35E-02
Talc	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E-08
Talc, in ground	Raw	kg	0.00E+00	0.00E+00	3.74E-10	0.00E+00	4.08E-06
Tantalum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.34E-13
Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	7.87E-15	0.00E+00	3.89E-11
Tellurium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.60E-14
Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.07E-15	0.00E+00	5.27E-12
Tin	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.19E-11
Tin, 79% in cassiterite, 0.1% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.08E-13	0.00E+00	3.16E-09
TiO2, 54% in ilmenite, 2.6% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.13E-06
TiO2, 54% in ilmenite, 2.6% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.93E-08	0.00E+00	3.81E-04
TiO2, 95% in rutile, 0.40% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.96E-10
TiO2, 95% in rutile, 0.40% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.25E-16	0.00E+00	1.36E-12
Transformation, from arable	Raw	m2	0.00E+00	0.00E+00	1.36E-11	0.00E+00	3.64E-06
Transformation, from arable, non-irrigated	Raw	m2	0.00E+00	0.00E+00	1.13E-08	0.00E+00	1.27E-04
Transformation, from arable, non-irrigated, fallow	Raw	m2	0.00E+00	0.00E+00	4.33E-12	0.00E+00	1.16E-06
Transformation, from dump site, inert material landfill	Raw	m2	0.00E+00	0.00E+00	2.23E-12	0.00E+00	5.04E-05
Transformation, from dump site, residual material landfill	Raw	m2	0.00E+00	0.00E+00	1.94E-09	0.00E+00	6.52E-05
Transformation, from dump site, sanitary landfill	Raw	m2	0.00E+00	0.00E+00	1.03E-10	0.00E+00	6.51E-07
Transformation, from dump site, slag compartment	Raw	m2	0.00E+00	0.00E+00	2.54E-12	0.00E+00	2.60E-07
Transformation, from forest	Raw	m2	0.00E+00	0.00E+00	1.68E-10	0.00E+00	7.87E-05
Transformation, from forest, extensive	Raw	m2	0.00E+00	0.00E+00	2.44E-08	0.00E+00	5.13E-04
Transformation, from forest, intensive, clear-cutting	Raw	m2	0.00E+00	0.00E+00	1.74E-10	0.00E+00	6.32E-05
Transformation, from industrial area	Raw	m2	0.00E+00	0.00E+00	1.42E-09	0.00E+00	1.84E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Transformation, from industrial area, benthos	Raw	m2	0.00E+00	0.00E+00	1.86E-15	0.00E+00	1.37E-11
Transformation, from industrial area, built up	Raw	m2	0.00E+00	0.00E+00	3.26E-12	0.00E+00	2.75E-08
Transformation, from industrial area, vegetation	Raw	m2	0.00E+00	0.00E+00	5.56E-12	0.00E+00	4.69E-08
Transformation, from mineral extraction site	Raw	m2	0.00E+00	0.00E+00	1.16E-08	0.00E+00	5.73E-04
Transformation, from pasture and meadow	Raw	m2	0.00E+00	0.00E+00	6.54E-09	0.00E+00	4.42E-04
Transformation, from pasture and meadow, intensive	Raw	m2	0.00E+00	0.00E+00	9.19E-12	0.00E+00	1.04E-07
Transformation, from sea and ocean	Raw	m2	0.00E+00	0.00E+00	2.21E-11	0.00E+00	1.60E-07
Transformation, from shrub land, sclerophyllous	Raw	m2	0.00E+00	0.00E+00	5.83E-09	0.00E+00	1.93E-04
Transformation, from tropical rain forest	Raw	m2	0.00E+00	0.00E+00	1.74E-10	0.00E+00	6.32E-05
Transformation, from unknown	Raw	m2	0.00E+00	0.00E+00	3.75E-08	0.00E+00	7.85E-04
Transformation, to arable	Raw	m2	0.00E+00	0.00E+00	1.07E-08	0.00E+00	2.43E-04
Transformation, to arable, non-irrigated	Raw	m2	0.00E+00	0.00E+00	1.13E-08	0.00E+00	1.27E-04
Transformation, to arable, non-irrigated, fallow	Raw	m2	0.00E+00	0.00E+00	1.32E-11	0.00E+00	1.33E-06
Transformation, to dump site	Raw	m2	0.00E+00	0.00E+00	8.58E-09	0.00E+00	2.16E-04
Transformation, to dump site, benthos	Raw	m2	0.00E+00	0.00E+00	2.20E-11	0.00E+00	1.59E-07
Transformation, to dump site, inert material landfill	Raw	m2	0.00E+00	0.00E+00	2.23E-12	0.00E+00	5.04E-05
Transformation, to dump site, residual material landfill	Raw	m2	0.00E+00	0.00E+00	1.94E-09	0.00E+00	6.52E-05
Transformation, to dump site, sanitary landfill	Raw	m2	0.00E+00	0.00E+00	1.03E-10	0.00E+00	6.51E-07
Transformation, to dump site, slag compartment	Raw	m2	0.00E+00	0.00E+00	2.54E-12	0.00E+00	2.60E-07
Transformation, to forest	Raw	m2	0.00E+00	0.00E+00	2.92E-09	0.00E+00	1.60E-04
Transformation, to forest, intensive	Raw	m2	0.00E+00	0.00E+00	1.39E-09	0.00E+00	3.98E-05
Transformation, to forest, intensive, clear-cutting	Raw	m2	0.00E+00	0.00E+00	1.74E-10	0.00E+00	6.32E-05
Transformation, to forest, intensive, normal	Raw	m2	0.00E+00	0.00E+00	2.27E-08	0.00E+00	4.67E-04
Transformation, to forest, intensive, short-cycle	Raw	m2	0.00E+00	0.00E+00	1.74E-10	0.00E+00	6.32E-05
Transformation, to heterogeneous, agricultural	Raw	m2	0.00E+00	0.00E+00	2.00E-12	0.00E+00	1.39E-08
Transformation, to industrial area	Raw	m2	0.00E+00	0.00E+00	3.29E-09	0.00E+00	7.86E-05
Transformation, to industrial area, benthos	Raw	m2	0.00E+00	0.00E+00	3.22E-14	0.00E+00	2.08E-10
Transformation, to industrial area, built up	Raw	m2	0.00E+00	0.00E+00	1.89E-10	0.00E+00	3.49E-06
Transformation, to industrial area, vegetation	Raw	m2	0.00E+00	0.00E+00	4.68E-12	0.00E+00	3.95E-08
Transformation, to mineral extraction site	Raw	m2	0.00E+00	0.00E+00	1.58E-08	0.00E+00	6.37E-04
Transformation, to pasture and meadow	Raw	m2	0.00E+00	0.00E+00	3.41E-11	0.00E+00	2.85E-04
Transformation, to permanent crop, fruit, intensive	Raw	m2	0.00E+00	0.00E+00	9.61E-11	0.00E+00	2.35E-07
Transformation, to sea and ocean	Raw	m2	0.00E+00	0.00E+00	1.86E-15	0.00E+00	1.37E-11
Transformation, to shrub land, sclerophyllous	Raw	m2	0.00E+00	0.00E+00	2.04E-09	0.00E+00	1.17E-04
Transformation, to traffic area, rail embankment	Raw	m2	0.00E+00	0.00E+00	2.13E-13	0.00E+00	1.11E-09
Transformation, to traffic area, rail network	Raw	m2	0.00E+00	0.00E+00	2.35E-13	0.00E+00	1.24E-09
Transformation, to traffic area, rail/road embankment	Raw	m2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-11
Transformation, to traffic area, road embankment	Raw	m2	0.00E+00	0.00E+00	2.47E-10	0.00E+00	5.27E-06
Transformation, to traffic area, road network	Raw	m2	0.00E+00	0.00E+00	3.13E-12	0.00E+00	2.14E-08
Transformation, to unknown	Raw	m2	0.00E+00	0.00E+00	1.46E-09	0.00E+00	1.93E-05
Transformation, to urban, discontinuously built	Raw	m2	0.00E+00	0.00E+00	2.24E-16	0.00E+00	1.43E-12
Transformation, to water bodies, artificial	Raw	m2	0.00E+00	0.00E+00	1.06E-08	0.00E+00	1.86E-04
Transformation, to water courses, artificial	Raw	m2	0.00E+00	0.00E+00	7.51E-09	0.00E+00	1.52E-04

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Ulexite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-12
Ulexite, in ground	Raw	kg	0.00E+00	0.00E+00	2.75E-14	0.00E+00	1.74E-10
Uranium	Raw	kg	0.00E+00	3.25E-08	1.94E-11	3.81E-08	2.17E-04
Uranium oxide, 332 GJ per kg, in ore	Raw	kg	5.08E-05	4.37E-03	3.22E-05	8.97E-03	2.22E-03
Uranium, 2291 GJ per kg	Raw	kg	0.00E+00	2.52E-06	4.14E-10	3.30E-06	2.20E-07
Uranium, in ground	Raw	kg	0.00E+00	0.00E+00	1.04E-08	0.00E+00	2.51E-04
Vermiculite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.82E-13
Vermiculite, in ground	Raw	kg	0.00E+00	0.00E+00	1.83E-14	0.00E+00	7.71E-11
Volume occupied, final repository for low-active radioactive waste	Raw	m3	0.00E+00	0.00E+00	2.15E-11	0.00E+00	4.85E-07
Volume occupied, final repository for radioactive waste	Raw	m3	0.00E+00	0.00E+00	5.43E-12	0.00E+00	1.22E-07
Volume occupied, reservoir	Raw	m3y	0.00E+00	0.00E+00	2.37E-05	0.00E+00	3.16E-01
Volume occupied, underground deposit	Raw	m3	0.00E+00	0.00E+00	1.75E-10	0.00E+00	8.91E-06
Water, consumptive use, unspecified origin/m3	Raw	kg	0.00E+00	1.77E-01	0.00E+00	0.00E+00	0.00E+00
Water, cooling, unspecified natural origin/kg	Raw	kg	0.00E+00	6.21E-01	9.99E-06	1.57E+00	0.00E+00
Water, cooling, unspecified natural origin/m3	Raw	m3	0.00E+00	5.88E-01	1.15E-02	2.00E+00	3.45E+00
Water, lake	Raw	m3	0.00E+00	0.00E+00	2.36E-08	0.00E+00	1.11E-03
Water, process, surface	Raw	kg	0.00E+00	2.15E+02	1.14E+01	8.09E+02	0.00E+00
Water, process, unspecified natural origin/kg	Raw	kg	0.00E+00	1.15E+01	3.53E-02	2.92E+01	0.00E+00
Water, process, unspecified natural origin/m3	Raw	m3	0.00E+00	1.76E-05	9.40E-06	1.79E-04	0.00E+00
Water, process, well	Raw	kg	0.00E+00	3.20E+02	7.52E+00	3.54E+02	0.00E+00
Water, process, well, in ground	Raw	kg	0.00E+00	0.00E+00	5.26E-03	0.00E+00	5.95E+00
Water, river	Raw	m3	0.00E+00	1.52E-05	5.90E-06	1.78E-05	1.21E-01
Water, salt, ocean	Raw	m3	0.00E+00	0.00E+00	6.29E-06	0.00E+00	2.15E-02
Water, salt, sole	Raw	m3	0.00E+00	0.00E+00	1.32E-06	0.00E+00	1.33E+02
Water, turbine use, unspecified natural origin	Raw	m3	0.00E+00	0.00E+00	6.43E-03	0.00E+00	1.29E+02
Water, unspecified natural origin, RoW	Raw	m3	0.00E+00	9.85E-05	2.00E-05	1.14E-03	0.00E+00
Water, unspecified natural origin, US	Raw	m3	0.00E+00	7.57E-04	1.43E-03	1.90E+00	0.00E+00
Water, unspecified natural origin/kg	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E+01
Water, unspecified natural origin/m3	Raw	m3	4.22E-04	2.66E-01	4.01E-05	6.74E-01	9.82E-01
Water, well, in ground	Raw	m3	0.00E+00	8.78E-05	1.56E-06	1.03E-04	2.89E-02
Water, well, in ground, US	Raw	m3	0.00E+00	1.42E-04	2.68E-04	3.55E-01	0.00E+00
Wood and wood waste, 20.9 MJ per kg, ovendry basis	Raw	kg	0.00E+00	1.13E+02	8.92E-02	7.90E+02	0.00E+00
Wood and wood waste, 20.9 MJ/kg,ovendry (burned at kiln)	Raw	kg	0.00E+00	1.95E+00	3.70E+00	2.29E+00	0.00E+00
Wood and wood waste, 20.9 MJ/kg,ovendry (burned at sawmill boiler)	Raw	kg	0.00E+00	3.25E+00	6.15E+00	3.81E+00	0.00E+00
Wood and wood waste, 9.5 MJ per kg	Raw	kg	0.00E+00	3.41E-01	1.68E-03	4.00E-01	9.18E+00
Wood for fiber, feedstock	Raw	kg	0.00E+00	7.32E-01	3.60E-03	8.57E-01	1.97E+01
Wood into sawmill logyard	Raw	m3	0.00E+00	3.83E-02	7.24E-02	4.48E-02	0.00E+00
Wood, feedstock	Raw	kg	0.00E+00	7.78E-01	4.64E-04	9.11E-01	0.00E+00
Wood, hard, NE-NC, standing	Raw	m3	1.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wood, hard, standing	Raw	m3	0.00E+00	0.00E+00	5.33E-09	0.00E+00	1.07E-04
Wood, primary forest, standing	Raw	m3	0.00E+00	0.00E+00	1.81E-12	0.00E+00	6.55E-07
Wood, soft, standing	Raw	m3	0.00E+00	2.46E-03	4.65E-03	6.91E+00	2.84E-04
Wood, unspecified, standing/m3	Raw	m3	0.00E+00	0.00E+00	4.36E-14	0.00E+00	3.19E-07
Zinc	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-07
Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	5.38E-10	0.00E+00	1.33E-04
Zirconium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.67E-13
Zirconium, 50% in zircon, 0.39% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.08E-14	0.00E+00	5.31E-11
1-Butanol	Air	kg	0.00E+00	0.00E+00	5.40E-18	0.00E+00	8.75E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
1-Pentanol	Air	kg	0.00E+00	0.00E+00	5.11E-17	0.00E+00	3.57E-13
1-Pentene	Air	kg	0.00E+00	0.00E+00	3.86E-17	0.00E+00	2.70E-13
1-Propanol	Air	kg	0.00E+00	0.00E+00	3.82E-16	0.00E+00	2.91E-12
1,4-Butanediol	Air	kg	0.00E+00	0.00E+00	3.73E-17	0.00E+00	4.03E-04
2-Aminopropanol	Air	kg	0.00E+00	0.00E+00	7.67E-19	0.00E+00	5.11E-05
2-Butene, 2-methyl-	Air	kg	0.00E+00	0.00E+00	8.56E-21	0.00E+00	5.98E-17
2-Chloroacetophenone	Air	kg	2.32E-10	2.38E-09	3.45E-12	2.18E-09	7.72E-09
2-Methyl-1-propanol	Air	kg	0.00E+00	0.00E+00	9.26E-17	0.00E+00	7.81E-05
2-Methyl-4-chlorophenoxyacetic acid	Air	kg	0.00E+00	8.92E-11	5.32E-14	1.04E-10	0.00E+00
2-Nitrobenzoic acid	Air	kg	0.00E+00	0.00E+00	7.67E-19	0.00E+00	2.09E-04
2-Propanol	Air	kg	0.00E+00	0.00E+00	4.89E-14	0.00E+00	1.68E-04
2,4-D	Air	kg	0.00E+00	4.78E-09	2.85E-12	5.60E-09	0.00E+00
5-methyl Chrysene	Air	kg	2.12E-11	1.46E-09	1.09E-11	3.03E-09	7.74E-10
Acenaphthene	Air	kg	4.92E-10	3.39E-08	2.54E-10	7.02E-08	1.80E-08
Acenaphthylene	Air	kg	2.41E-10	1.66E-08	1.24E-10	3.44E-08	8.79E-09
Acetaldehyde	Air	kg	4.58E-04	2.27E-02	3.94E-04	6.77E-02	7.51E-04
Acetic acid	Air	kg	0.00E+00	0.00E+00	6.94E-08	0.00E+00	4.27E-03
Acetochlor	Air	kg	0.00E+00	6.63E-08	3.95E-11	7.76E-08	0.00E+00
Acetone	Air	kg	0.00E+00	6.78E-03	8.83E-09	0.00E+00	2.73E-04
Acetonitrile	Air	kg	0.00E+00	0.00E+00	1.90E-13	0.00E+00	6.87E-08
Acetophenone	Air	kg	4.98E-10	5.10E-09	7.40E-12	4.66E-09	1.65E-08
Acrolein	Air	kg	5.55E-05	6.69E-03	6.26E-05	6.82E-03	1.74E-05
Acrylic acid	Air	kg	0.00E+00	0.00E+00	1.27E-16	0.00E+00	6.34E-13
Actinides, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	1.74E-07	0.00E+00	3.20E-02
Aerosols, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	4.58E-06	0.00E+00	1.01E-01
Alachlor	Air	kg	0.00E+00	6.52E-09	3.89E-12	7.64E-09	0.00E+00
Aldehydes, unspecified	Air	kg	1.40E-03	1.00E-03	1.25E-05	3.32E-03	1.87E-03
Aluminium	Air	kg	0.00E+00	0.00E+00	6.90E-08	0.00E+00	7.61E-04
Ammonia	Air	kg	3.98E-03	6.83E-03	2.22E-04	1.27E-02	6.58E-03
Ammonium carbonate	Air	kg	0.00E+00	0.00E+00	1.01E-13	0.00E+00	1.16E-07
Ammonium chloride	Air	kg	2.70E-06	2.32E-04	1.71E-06	4.76E-04	1.18E-04
Aniline	Air	kg	0.00E+00	0.00E+00	2.96E-16	0.00E+00	3.19E-04
Anthracene	Air	kg	2.03E-10	1.40E-08	1.04E-10	2.89E-08	7.39E-09
Anthranilic acid	Air	kg	0.00E+00	0.00E+00	5.61E-19	0.00E+00	9.66E-05
Antimony	Air	kg	1.74E-08	1.24E-06	8.97E-09	2.50E-06	7.80E-07
Antimony-124	Air	Bq	0.00E+00	0.00E+00	2.05E-11	0.00E+00	8.63E-07
Antimony-125	Air	Bq	0.00E+00	0.00E+00	2.14E-10	0.00E+00	9.00E-06
Argon-41	Air	Bq	0.00E+00	0.00E+00	2.44E-03	0.00E+00	5.30E+01
Aromatics	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.01E-06
Arsenic	Air	kg	5.38E-07	2.85E-05	2.08E-07	5.84E-05	1.77E-05
Arsine	Air	kg	0.00E+00	0.00E+00	1.47E-21	0.00E+00	7.39E-18
Ash	Air	kg	0.00E+00	1.12E-04	0.00E+00	2.34E-05	0.00E+00
Atrazine	Air	kg	0.00E+00	1.29E-07	7.71E-11	1.51E-07	0.00E+00
Barium	Air	kg	0.00E+00	6.55E-03	5.45E-09	8.75E-07	2.62E-05
Barium-140	Air	Bq	0.00E+00	0.00E+00	1.39E-08	0.00E+00	5.86E-04
Bentazone	Air	kg	0.00E+00	5.27E-10	3.14E-13	6.17E-10	0.00E+00
Benzal chloride	Air	kg	0.00E+00	0.00E+00	2.74E-22	0.00E+00	1.48E-14
Benzaldehyde	Air	kg	0.00E+00	0.00E+00	7.62E-14	0.00E+00	6.61E-10
Benzene	Air	kg	5.62E-04	1.89E-02	4.10E-06	4.45E-02	2.53E-02
Benzene, 1-methyl-2-nitro-	Air	kg	0.00E+00	0.00E+00	6.62E-19	0.00E+00	1.81E-04
Benzene, 1,2-dichloro-	Air	kg	0.00E+00	0.00E+00	9.87E-17	0.00E+00	2.35E-04
Benzene, chloro-	Air	kg	7.31E-10	7.47E-09	1.09E-11	6.84E-09	2.43E-08
Benzene, ethyl-	Air	kg	3.12E-09	6.47E-07	9.46E-09	1.48E-05	5.68E-06
Benzene, hexachloro-	Air	kg	0.00E+00	0.00E+00	4.34E-16	0.00E+00	3.97E-11

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Benzene, pentachloro-	Air	kg	0.00E+00	0.00E+00	7.49E-16	0.00E+00	9.02E-11
Benzo(a)anthracene	Air	kg	7.72E-11	5.32E-09	3.98E-11	1.10E-08	2.81E-09
Benzo(a)pyrene	Air	kg	3.67E-11	2.53E-09	3.48E-11	5.23E-09	2.91E-07
Benzo(b,j,k)fluoranthene	Air	kg	1.06E-10	7.32E-09	5.47E-11	1.51E-08	3.87E-09
Benzo(g,h,i)perylene	Air	kg	2.61E-11	1.80E-09	1.34E-11	3.71E-09	9.50E-10
Benzyl chloride	Air	kg	2.32E-08	2.38E-07	3.45E-10	2.18E-07	7.72E-07
Beryllium	Air	kg	2.69E-08	1.57E-06	1.10E-08	3.26E-06	8.46E-07
Biphenyl	Air	kg	1.64E-09	1.13E-07	8.45E-10	2.34E-07	5.98E-08
Boron	Air	kg	0.00E+00	0.00E+00	6.72E-09	0.00E+00	1.58E-04
Boron trifluoride	Air	kg	0.00E+00	0.00E+00	2.02E-23	0.00E+00	1.00E-19
Bromine	Air	kg	0.00E+00	0.00E+00	7.39E-10	0.00E+00	1.64E-05
Bromoform	Air	kg	1.30E-09	1.33E-08	1.92E-11	1.21E-08	4.30E-08
Bromoxynil	Air	kg	0.00E+00	1.16E-09	6.89E-13	1.35E-09	0.00E+00
BTEX (Benzene, Toluene, Ethylbenzene, and Xylene), unspecified ratio	Air	kg	2.55E-03	2.98E-02	6.90E-05	8.24E-02	2.23E-02
Butadiene	Air	kg	2.33E-05	1.96E-07	4.71E-08	5.66E-06	3.07E-06
Butane	Air	kg	0.00E+00	0.00E+00	3.22E-07	0.00E+00	3.74E-04
Butene	Air	kg	0.00E+00	0.00E+00	2.22E-09	0.00E+00	1.20E-03
Butyrolactone	Air	kg	0.00E+00	0.00E+00	7.57E-19	0.00E+00	3.80E-15
Cadmium	Air	kg	1.37E-07	5.74E-06	3.25E-08	1.21E-05	3.86E-06
Calcium	Air	kg	0.00E+00	0.00E+00	1.13E-08	0.00E+00	1.17E-04
Carbofuran	Air	kg	0.00E+00	9.87E-10	5.89E-13	1.16E-09	0.00E+00
Carbon-14	Air	Bq	0.00E+00	0.00E+00	1.86E-02	0.00E+00	4.20E+02
Carbon dioxide	Air	kg	4.29E+00	8.27E+00	4.77E-03	2.62E+00	1.70E+00
Carbon dioxide, biogenic	Air	kg	8.72E-02	1.15E+02	1.31E+01	1.30E+03	1.15E+01
Carbon dioxide, fossil	Air	kg	1.11E+02	5.75E+02	3.60E+00	1.36E+03	4.12E+02
Carbon dioxide, land transformation	Air	kg	0.00E+00	0.00E+00	5.63E-08	0.00E+00	2.11E-03
Carbon disulfide	Air	kg	4.32E-09	2.75E-07	4.56E-07	3.10E-07	4.74E-06
Carbon monoxide	Air	kg	3.04E-04	1.59E-01	2.71E-05	2.17E-01	1.54E-01
Carbon monoxide, biogenic	Air	kg	0.00E+00	1.13E+00	2.36E-02	3.22E+00	1.27E-04
Carbon monoxide, fossil	Air	kg	1.43E+00	5.62E-01	8.26E-03	1.84E+00	1.02E+00
Cerium-141	Air	Bq	0.00E+00	0.00E+00	3.38E-09	0.00E+00	1.42E-04
Cesium-134	Air	Bq	0.00E+00	0.00E+00	1.62E-10	0.00E+00	6.80E-06
Cesium-137	Air	Bq	0.00E+00	0.00E+00	2.87E-09	0.00E+00	1.21E-04
Chloramine	Air	kg	0.00E+00	0.00E+00	1.80E-16	0.00E+00	1.31E-04
Chloride	Air	kg	6.68E-11	2.15E-09	1.28E-11	4.08E-09	1.06E-09
Chlorinated fluorocarbons and hydrochlorinated fluorocarbons, unspecified	Air	kg	0.00E+00	4.53E-07	4.58E-10	1.02E-06	2.50E-06
Chlorine	Air	kg	0.00E+00	2.11E-05	8.66E-09	1.54E-05	3.77E-02
Chloroacetic acid	Air	kg	0.00E+00	0.00E+00	4.30E-16	0.00E+00	6.60E-04
Chloroform	Air	kg	1.96E-09	2.01E-08	2.93E-11	1.83E-08	2.24E-03
Chlorosilane, trimethyl-	Air	kg	0.00E+00	0.00E+00	1.87E-17	0.00E+00	3.97E-13
Chlorosulfonic acid	Air	kg	0.00E+00	0.00E+00	5.45E-18	0.00E+00	9.95E-05
Chlorpyrifos	Air	kg	0.00E+00	7.60E-09	4.53E-12	8.90E-09	0.00E+00
Chromium	Air	kg	3.92E-07	2.02E-05	1.37E-07	4.23E-05	1.97E-05
Chromium-51	Air	Bq	0.00E+00	0.00E+00	2.17E-10	0.00E+00	9.10E-06
Chromium VI	Air	kg	7.62E-08	5.26E-06	3.93E-08	1.09E-05	3.01E-06
Chrysene	Air	kg	9.65E-11	6.66E-09	4.97E-11	1.38E-08	3.52E-09
Cobalt	Air	kg	7.06E-07	8.54E-06	6.54E-08	1.72E-05	6.92E-06
Cobalt-58	Air	Bq	0.00E+00	0.00E+00	3.02E-10	0.00E+00	1.27E-05
Cobalt-60	Air	Bq	0.00E+00	0.00E+00	2.67E-09	0.00E+00	1.12E-04
Copper	Air	kg	7.11E-09	1.20E-06	5.54E-09	6.03E-07	2.92E-05
Cumene	Air	kg	1.76E-10	2.54E-02	4.08E-07	6.43E-02	2.41E-02
Cyanazine	Air	kg	0.00E+00	1.14E-09	6.79E-13	1.33E-09	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Cyanide	Air	kg	8.30E-08	8.50E-07	1.24E-09	7.77E-07	1.29E-04
Cyanoacetic acid	Air	kg	0.00E+00	0.00E+00	4.46E-18	0.00E+00	8.15E-05
Dicamba	Air	kg	0.00E+00	6.71E-09	4.00E-12	7.86E-09	0.00E+00
Diethylamine	Air	kg	0.00E+00	0.00E+00	1.32E-16	0.00E+00	2.57E-04
Dimethenamid	Air	kg	0.00E+00	1.58E-08	9.46E-12	1.86E-08	0.00E+00
Dimethyl ether	Air	kg	0.00E+00	2.03E-04	1.18E-07	4.65E-04	2.00E-06
Dimethyl malonate	Air	kg	0.00E+00	0.00E+00	5.59E-18	0.00E+00	1.02E-04
Dinitrogen monoxide	Air	kg	2.54E-02	4.46E-03	4.36E-05	1.51E-02	1.37E-02
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	kg	2.29E-12	5.15E-09	3.46E-12	6.09E-09	3.28E-11
Dioxins (unspec.)	Air	kg	0.00E+00	1.28E-14	2.42E-14	1.50E-14	0.00E+00
Dipropylamine	Air	kg	0.00E+00	0.00E+00	8.39E-17	0.00E+00	1.15E-04
Dipropylthiocarbamic acid S-ethyl ester	Air	kg	0.00E+00	1.09E-08	6.47E-12	1.27E-08	0.00E+00
Ethane	Air	kg	0.00E+00	0.00E+00	1.17E-06	0.00E+00	1.19E-03
Ethane, 1,1-difluoro-, HFC-152a	Air	kg	0.00E+00	0.00E+00	6.88E-17	0.00E+00	4.60E-13
Ethane, 1,1,1-trichloro-, HCFC-140	Air	kg	3.89E-09	8.94E-09	3.77E-11	1.36E-08	2.65E-08
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Air	kg	0.00E+00	7.10E-07	6.22E-10	0.00E+00	6.90E-07
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	Air	kg	0.00E+00	0.00E+00	6.00E-18	0.00E+00	3.01E-14
Ethane, 1,2-dibromo-	Air	kg	3.99E-11	3.31E-08	6.40E-13	3.74E-10	1.32E-09
Ethane, 1,2-dichloro-	Air	kg	1.33E-09	1.36E-08	1.04E-10	1.24E-08	4.47E-04
Ethane, 1,2-dichloro-1,1,2-trifluoro-, HCFC-123	Air	kg	0.00E+00	7.10E-07	0.00E+00	0.00E+00	0.00E+00
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	Air	kg	0.00E+00	0.00E+00	7.63E-12	0.00E+00	1.77E-07
Ethane, chloro-	Air	kg	1.39E-09	1.43E-08	2.07E-11	1.31E-08	4.63E-08
Ethane, hexafluoro-, HFC-116	Air	kg	0.00E+00	0.00E+00	5.77E-13	0.00E+00	2.23E-07
Ethanol	Air	kg	0.00E+00	0.00E+00	1.76E-08	0.00E+00	5.21E-04
Ethene	Air	kg	0.00E+00	0.00E+00	4.81E-09	0.00E+00	1.08E-03
Ethene, chloro-	Air	kg	0.00E+00	0.00E+00	4.09E-11	0.00E+00	2.46E-07
Ethene, tetrachloro-	Air	kg	4.93E-08	2.91E-06	2.16E-08	6.01E-06	1.54E-06
Ethene, trichloro-	Air	kg	0.00E+00	2.15E-13	3.13E-14	2.52E-13	5.78E-12
Ethyl acetate	Air	kg	0.00E+00	0.00E+00	2.27E-13	0.00E+00	2.11E-06
Ethyl cellulose	Air	kg	0.00E+00	0.00E+00	4.59E-16	0.00E+00	2.30E-12
Ethylamine	Air	kg	0.00E+00	0.00E+00	5.93E-17	0.00E+00	2.37E-04
Ethylene diamine	Air	kg	0.00E+00	0.00E+00	1.24E-15	0.00E+00	8.42E-12
Ethylene oxide	Air	kg	0.00E+00	5.81E-09	3.10E-09	5.91E-08	4.61E-06
Ethyne	Air	kg	0.00E+00	0.00E+00	5.44E-11	0.00E+00	4.40E-04
Fluoranthene	Air	kg	6.85E-10	4.72E-08	3.53E-10	9.77E-08	2.50E-08
Fluorene	Air	kg	8.78E-10	6.06E-08	4.52E-10	1.25E-07	3.20E-08
Fluoride	Air	kg	5.00E-05	2.04E-05	6.04E-08	2.46E-05	5.18E-05
Fluorine	Air	kg	0.00E+00	0.00E+00	5.36E-10	0.00E+00	1.21E-05
Fluosilicic acid	Air	kg	0.00E+00	0.00E+00	6.74E-13	0.00E+00	2.61E-07
Formaldehyde	Air	kg	7.11E-04	5.31E-02	5.41E-04	8.20E-02	5.11E-03
Formamide	Air	kg	0.00E+00	0.00E+00	9.34E-17	0.00E+00	6.53E-13
Formic acid	Air	kg	0.00E+00	0.00E+00	1.27E-12	0.00E+00	4.60E-07
Furan	Air	kg	4.25E-12	3.22E-10	2.78E-12	6.73E-10	1.31E-07
Glyphosate	Air	kg	0.00E+00	1.42E-08	8.50E-12	1.67E-08	0.00E+00
HAPs	Air	kg	0.00E+00	3.93E-04	3.91E-05	4.55E-03	0.00E+00
Heat, waste	Air	MJ	0.00E+00	2.68E+01	4.16E-01	7.00E+01	7.47E+02
Helium	Air	kg	0.00E+00	0.00E+00	4.17E-09	0.00E+00	6.51E-06
Heptane	Air	kg	0.00E+00	0.00E+00	2.20E-08	0.00E+00	3.34E-05
Hexane	Air	kg	2.22E-09	5.55E-07	1.06E-06	6.44E-07	1.17E-04
Hydrazine, methyl-	Air	kg	5.65E-09	5.77E-08	8.39E-11	5.28E-08	1.87E-07
Hydrocarbons, aliphatic, alkanes, cyclic	Air	kg	0.00E+00	0.00E+00	2.01E-12	0.00E+00	1.37E-05
Hydrocarbons, aliphatic, alkanes, unspecified	Air	kg	0.00E+00	0.00E+00	1.07E-07	0.00E+00	5.41E-03

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Hydrocarbons, aliphatic, unsaturated	Air	kg	0.00E+00	0.00E+00	3.36E-09	0.00E+00	1.41E-04
Hydrocarbons, aromatic	Air	kg	0.00E+00	0.00E+00	4.40E-08	0.00E+00	1.60E-04
Hydrocarbons, chlorinated	Air	kg	0.00E+00	0.00E+00	8.24E-11	0.00E+00	2.16E-04
Hydrocarbons, unspecified	Air	kg	1.56E-05	1.34E-03	9.87E-06	2.75E-03	2.76E-03
Hydrogen	Air	kg	0.00E+00	2.72E-05	4.94E-09	3.40E-05	1.18E-02
Hydrogen-3, Tritium	Air	Bq	0.00E+00	0.00E+00	1.08E-01	0.00E+00	2.39E+03
Hydrogen chloride	Air	kg	1.22E-03	8.02E-02	6.07E-04	1.67E-01	4.41E-02
Hydrogen fluoride	Air	kg	1.43E-04	9.97E-03	7.46E-05	2.06E-02	5.50E-03
Hydrogen peroxide	Air	kg	0.00E+00	0.00E+00	3.40E-16	0.00E+00	1.70E-12
Hydrogen sulfide	Air	kg	2.16E-12	6.95E-11	1.69E-07	1.32E-10	2.32E-04
Indeno(1,2,3-cd)pyrene	Air	kg	5.89E-11	4.06E-09	3.03E-11	8.39E-09	2.15E-09
Iodine	Air	kg	0.00E+00	0.00E+00	3.93E-10	0.00E+00	8.86E-06
Iodine-129	Air	Bq	0.00E+00	0.00E+00	1.89E-05	0.00E+00	4.18E-01
Iodine-131	Air	Bq	0.00E+00	0.00E+00	9.65E-04	0.00E+00	2.09E+01
Iodine-133	Air	Bq	0.00E+00	0.00E+00	3.84E-08	0.00E+00	4.90E-03
Iodine-135	Air	Bq	0.00E+00	0.00E+00	4.70E-08	0.00E+00	9.12E-03
Iron	Air	kg	0.00E+00	7.46E-07	2.42E-08	8.74E-07	3.39E-04
Isocyanic acid	Air	kg	0.00E+00	0.00E+00	1.78E-05	0.00E+00	9.67E-12
Isophorone	Air	kg	1.93E-08	1.97E-07	2.86E-10	1.80E-07	6.40E-07
Isoprene	Air	kg	2.19E-03	7.05E-02	4.21E-04	1.34E-01	3.48E-02
Isopropylamine	Air	kg	0.00E+00	0.00E+00	4.75E-18	0.00E+00	1.48E-04
Kerosene	Air	kg	1.29E-06	1.11E-04	8.19E-07	2.28E-04	5.63E-05
Krypton-85	Air	Bq	0.00E+00	0.00E+00	7.62E-03	0.00E+00	1.66E+02
Krypton-85m	Air	Bq	0.00E+00	0.00E+00	3.23E-04	0.00E+00	1.11E+01
Krypton-87	Air	Bq	0.00E+00	0.00E+00	1.37E-04	0.00E+00	3.88E+00
Krypton-88	Air	Bq	0.00E+00	0.00E+00	1.32E-04	0.00E+00	4.05E+00
Krypton-89	Air	Bq	0.00E+00	0.00E+00	3.12E-05	0.00E+00	1.19E+00
Lactic acid	Air	kg	0.00E+00	0.00E+00	6.57E-17	0.00E+00	9.01E-05
Lanthanum-140	Air	Bq	0.00E+00	0.00E+00	1.19E-09	0.00E+00	5.00E-05
Lead	Air	kg	6.96E-07	4.36E-05	1.47E-06	1.90E-04	3.10E-05
Lead-210	Air	Bq	0.00E+00	0.00E+00	1.05E-04	0.00E+00	3.85E+00
m-Xylene	Air	kg	0.00E+00	0.00E+00	2.16E-11	0.00E+00	4.34E-07
Magnesium	Air	kg	1.06E-05	7.32E-04	5.47E-06	1.51E-03	4.96E-04
Manganese	Air	kg	7.92E-07	4.37E-05	5.84E-06	8.20E-05	6.57E-05
Manganese-54	Air	Bq	0.00E+00	0.00E+00	1.11E-10	0.00E+00	4.66E-06
Mercaptans, unspecified	Air	kg	7.20E-06	7.36E-05	1.06E-07	6.73E-05	2.39E-04
Mercury	Air	kg	1.46E-07	8.76E-06	6.73E-08	1.63E-05	1.30E-05
Metals, unspecified	Air	kg	2.48E-13	1.30E-04	7.79E-08	1.53E-04	4.28E-10
Methacrylic acid	Air	kg	0.00E+00	2.98E-09	0.00E+00	0.00E+00	0.00E+00
Methane	Air	kg	2.21E-01	1.67E+00	7.40E-03	4.31E+00	1.23E+00
Methane, biogenic	Air	kg	0.00E+00	1.39E-03	1.39E-04	1.61E-02	1.28E-03
Methane, bromo-, Halon 1001	Air	kg	5.31E-09	5.44E-08	7.89E-11	4.97E-08	1.76E-07
Methane, bromochlorodifluoro-, Halon 1211	Air	kg	0.00E+00	0.00E+00	3.54E-10	0.00E+00	2.92E-07
Methane, bromotrifluoro-, Halon 1301	Air	kg	0.00E+00	0.00E+00	5.77E-11	0.00E+00	8.80E-08
Methane, chlorodifluoro-, HCFC-22	Air	kg	0.00E+00	9.17E-06	1.22E-09	4.91E-13	1.11E-06
Methane, chlorotrifluoro-, CFC-13	Air	kg	0.00E+00	1.67E-07	2.44E-13	4.66E-12	0.00E+00
Methane, dichloro-, HCC-30	Air	kg	8.03E-07	2.31E-05	1.58E-07	4.66E-05	2.01E-04
Methane, dichlorodifluoro-, CFC-12	Air	kg	3.99E-09	2.65E-09	3.87E-11	9.09E-09	4.20E-06
Methane, dichlorofluoro-, HCFC-21	Air	kg	0.00E+00	0.00E+00	4.01E-20	0.00E+00	2.02E-16
Methane, fossil	Air	kg	2.47E-02	3.87E-01	5.57E-04	4.85E-01	2.95E-01
Methane, monochloro-, R-40	Air	kg	1.76E-08	1.80E-07	2.62E-10	1.65E-07	5.93E-07
Methane, tetrachloro-, CFC-10	Air	kg	3.99E-10	2.08E-06	2.49E-11	9.62E-07	2.28E-04
Methane, tetrafluoro-, CFC-14	Air	kg	0.00E+00	0.00E+00	5.19E-12	0.00E+00	2.01E-06
Methane, trichlorofluoro-, CFC-11	Air	kg	0.00E+00	0.00E+00	6.51E-20	0.00E+00	3.29E-16

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Methane, trifluoro-, HFC-23	Air	kg	0.00E+00	0.00E+00	1.28E-17	0.00E+00	6.44E-14
Methanesulfonic acid	Air	kg	0.00E+00	0.00E+00	4.51E-18	0.00E+00	8.24E-05
Methanol	Air	kg	0.00E+00	1.04E-01	2.47E-03	4.03E-01	3.98E-02
Methyl acetate	Air	kg	0.00E+00	0.00E+00	1.78E-19	0.00E+00	4.85E-05
Methyl acrylate	Air	kg	0.00E+00	0.00E+00	1.44E-16	0.00E+00	7.19E-13
Methyl amine	Air	kg	0.00E+00	0.00E+00	2.07E-17	0.00E+00	2.53E-05
Methyl borate	Air	kg	0.00E+00	0.00E+00	1.89E-17	0.00E+00	8.37E-06
Methyl ethyl ketone	Air	kg	1.30E-08	1.33E-07	1.93E-10	1.21E-07	4.31E-07
Methyl formate	Air	kg	0.00E+00	0.00E+00	4.74E-08	0.00E+00	1.75E-13
Methyl lactate	Air	kg	0.00E+00	0.00E+00	7.22E-17	0.00E+00	9.89E-05
Methyl methacrylate	Air	kg	6.64E-10	3.82E-09	9.87E-12	6.22E-09	2.21E-08
Methylamine	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-17
Methylene diisocyanate	Air	kg	0.00E+00	3.13E-04	0.00E+00	0.00E+00	0.00E+00
Metolachlor	Air	kg	0.00E+00	5.24E-08	3.12E-11	6.13E-08	0.00E+00
Metribuzin	Air	kg	0.00E+00	2.43E-10	1.45E-13	2.84E-10	0.00E+00
Molybdenum	Air	kg	0.00E+00	0.00E+00	9.73E-10	0.00E+00	1.01E-06
Monoethanolamine	Air	kg	0.00E+00	0.00E+00	1.24E-12	0.00E+00	2.80E-03
N-Nitrodimethylamine	Air	kg	0.00E+00	5.84E-03	7.00E-15	1.23E-03	1.29E-12
Naphthalene	Air	kg	1.50E-07	6.60E-06	3.73E-07	4.81E-05	1.23E-05
Nickel	Air	kg	8.86E-06	4.69E-05	3.37E-07	9.07E-05	6.51E-05
Nickel compounds	Air	kg	0.00E+00	9.17E-06	0.00E+00	0.00E+00	0.00E+00
Niobium-95	Air	Bq	0.00E+00	0.00E+00	1.32E-11	0.00E+00	5.53E-07
Nitrate	Air	kg	0.00E+00	0.00E+00	1.02E-10	0.00E+00	2.26E-06
Nitric oxide	Air	kg	0.00E+00	1.73E-04	0.00E+00	0.00E+00	0.00E+00
Nitrobenzene	Air	kg	0.00E+00	0.00E+00	3.97E-16	0.00E+00	8.57E-04
Nitrogen oxides	Air	kg	1.95E+00	2.37E+00	2.40E-02	4.87E+00	1.54E+00
Nitrogen, total	Air	kg	9.70E-04	6.41E-09	3.82E-12	7.50E-09	0.00E+00
Nitrous oxide	Air	kg	0.00E+00	9.03E-06	0.00E+00	0.00E+00	6.11E-02
NMVOC, non-methane volatile organic compounds, unspecified origin	Air	kg	6.78E-02	1.25E-01	7.55E-04	2.85E-01	1.34E-01
Noble gases, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	1.81E+02	0.00E+00	4.02E+06
Organic acids	Air	kg	9.92E-09	8.52E-07	6.28E-09	1.75E-06	4.32E-07
Organic substances, unspecified	Air	kg	5.98E-06	4.73E-03	5.23E-05	3.71E-03	1.20E-03
Other Organic	Air	kg	0.00E+00	1.32E-05	1.32E-06	1.53E-04	0.00E+00
Ozone	Air	kg	0.00E+00	0.00E+00	6.86E-09	0.00E+00	1.46E-04
PAH, polycyclic aromatic hydrocarbons	Air	kg	9.18E-05	7.89E-07	2.04E-07	2.32E-05	2.54E-05
Paraffins	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.36E-18
Paraquat	Air	kg	0.00E+00	1.06E-09	6.32E-13	1.24E-09	0.00E+00
Parathion, methyl	Air	kg	0.00E+00	8.01E-10	4.78E-13	9.37E-10	0.00E+00
Particulates	Air	kg	0.00E+00	8.97E-05	8.57E-08	2.27E-04	9.19E-05
Particulates, < 10 um	Air	kg	0.00E+00	4.35E-01	2.95E-03	1.07E+00	9.44E-02
Particulates, < 2.5 um	Air	kg	0.00E+00	2.47E-01	3.55E-03	7.52E-01	1.00E-01
Particulates, > 10 um	Air	kg	0.00E+00	2.47E-03	5.46E-03	4.55E-03	1.48E-02
Particulates, > 2.5 um, and < 10um	Air	kg	5.73E-02	3.62E-02	3.46E-04	1.00E-01	4.19E-02
Particulates, unspecified	Air	kg	1.35E-02	2.35E-01	1.74E-03	8.35E-01	1.37E-01
Pendimethalin	Air	kg	0.00E+00	5.45E-09	3.25E-12	6.38E-09	0.00E+00
Pentane	Air	kg	0.00E+00	0.00E+00	3.91E-07	0.00E+00	4.14E-04
Permethrin	Air	kg	0.00E+00	4.90E-10	2.92E-13	5.73E-10	0.00E+00
PFC (perfluorocarbons)	Air	kg	0.00E+00	9.17E-05	0.00E+00	0.00E+00	0.00E+00
Phenanthrene	Air	kg	2.61E-09	1.80E-07	1.34E-09	3.71E-07	9.50E-08
Phenol	Air	kg	5.31E-10	8.71E-03	6.22E-05	9.56E-03	8.73E-02
Phenol, 2,4-dichloro-	Air	kg	0.00E+00	0.00E+00	1.90E-17	0.00E+00	1.31E-04
Phenol, pentachloro-	Air	kg	0.00E+00	0.00E+00	5.20E-12	0.00E+00	1.13E-07
Phenols, unspecified	Air	kg	4.10E-07	3.39E-06	1.83E-08	6.66E-06	1.67E-06

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Phorate	Air	kg	0.00E+00	2.51E-10	1.50E-13	2.94E-10	0.00E+00
Phosphate	Air	kg	2.21E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Phosphine	Air	kg	0.00E+00	0.00E+00	1.09E-19	0.00E+00	5.48E-16
Phosphorus	Air	kg	0.00E+00	0.00E+00	7.67E-11	0.00E+00	5.76E-05
Phthalate, diisooctyl-	Air	kg	0.00E+00	1.09E-08	0.00E+00	0.00E+00	0.00E+00
Phthalate, dioctyl-	Air	kg	2.42E-09	1.40E-08	3.60E-11	2.27E-08	8.05E-08
Platinum	Air	kg	0.00E+00	0.00E+00	2.74E-16	0.00E+00	6.08E-12
Plutonium-238	Air	Bq	0.00E+00	0.00E+00	2.57E-12	0.00E+00	5.70E-08
Plutonium-alpha	Air	Bq	0.00E+00	0.00E+00	5.90E-12	0.00E+00	1.31E-07
Polonium-210	Air	Bq	0.00E+00	0.00E+00	1.85E-04	0.00E+00	6.42E+00
Polychlorinated biphenyls	Air	kg	0.00E+00	0.00E+00	3.78E-16	0.00E+00	1.36E-11
Polycyclic organic matter, unspecified	Air	kg	0.00E+00	4.26E-07	6.22E-13	1.19E-11	0.00E+00
Potassium	Air	kg	0.00E+00	1.32E-04	6.57E-07	1.55E-04	3.71E-03
Potassium-40	Air	Bq	0.00E+00	0.00E+00	2.38E-05	0.00E+00	8.13E-01
Propanal	Air	kg	1.26E-08	8.57E-06	1.03E-05	1.57E-02	1.39E-04
Propane	Air	kg	0.00E+00	0.00E+00	4.85E-07	0.00E+00	6.13E-04
Propene	Air	kg	1.54E-03	9.37E-03	3.26E-06	2.41E-02	9.71E-03
Propionic acid	Air	kg	0.00E+00	0.00E+00	4.51E-09	0.00E+00	4.15E-04
Propylamine	Air	kg	0.00E+00	0.00E+00	2.96E-17	0.00E+00	2.07E-13
Propylene glycol	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.36E-03
Propylene oxide	Air	kg	0.00E+00	2.60E-07	6.13E-09	1.34E-05	7.05E-05
Protactinium-234	Air	Bq	0.00E+00	0.00E+00	2.56E-06	0.00E+00	5.95E-02
Pyrene	Air	kg	3.18E-10	2.20E-08	1.64E-10	4.54E-08	1.16E-08
Radioactive species, other beta emitters	Air	Bq	0.00E+00	0.00E+00	5.89E-06	0.00E+00	1.32E-01
Radioactive species, unspecified	Air	Bq	5.28E+04	3.75E+06	2.81E+04	7.77E+06	1.93E+06
Radionuclides (Including Radon)	Air	kg	7.23E-05	6.21E-03	4.58E-05	1.27E-02	3.15E-03
Radium-226	Air	Bq	0.00E+00	0.00E+00	1.09E-04	0.00E+00	3.89E+00
Radium-228	Air	Bq	0.00E+00	0.00E+00	1.54E-05	0.00E+00	1.68E+00
Radon-220	Air	Bq	0.00E+00	0.00E+00	1.04E-03	0.00E+00	2.28E+01
Radon-222	Air	Bq	0.00E+00	0.00E+00	3.39E+02	0.00E+00	7.64E+06
Ruthenium-103	Air	Bq	0.00E+00	0.00E+00	2.89E-12	0.00E+00	1.21E-07
Scandium	Air	kg	0.00E+00	0.00E+00	3.11E-11	0.00E+00	7.27E-07
Selenium	Air	kg	1.34E-06	8.75E-05	6.51E-07	1.81E-04	4.79E-05
Silicon	Air	kg	0.00E+00	0.00E+00	3.64E-09	0.00E+00	4.13E-04
Silicon tetrafluoride	Air	kg	0.00E+00	0.00E+00	6.90E-14	0.00E+00	5.83E-10
Silver	Air	kg	0.00E+00	0.00E+00	1.61E-12	0.00E+00	2.92E-08
Silver-110	Air	Bq	0.00E+00	0.00E+00	2.87E-11	0.00E+00	1.20E-06
Simazine	Air	kg	0.00E+00	3.44E-09	2.05E-12	4.03E-09	0.00E+00
Sodium	Air	kg	0.00E+00	3.05E-06	6.02E-08	3.57E-06	1.31E-04
Sodium chlorate	Air	kg	0.00E+00	0.00E+00	9.84E-13	0.00E+00	6.81E-09
Sodium dichromate	Air	kg	0.00E+00	0.00E+00	1.01E-15	0.00E+00	3.18E-08
Sodium formate	Air	kg	0.00E+00	0.00E+00	4.69E-14	0.00E+00	1.40E-09
Sodium hydroxide	Air	kg	0.00E+00	0.00E+00	1.27E-15	0.00E+00	6.36E-12
Strontium	Air	kg	0.00E+00	0.00E+00	1.43E-10	0.00E+00	7.12E-06
Styrene	Air	kg	8.30E-10	8.50E-09	1.27E-11	7.77E-09	2.90E-07
Sulfate	Air	kg	0.00E+00	0.00E+00	1.17E-08	0.00E+00	1.26E-02
Sulfur	Air	kg	0.00E+00	1.61E-05	9.60E-09	1.88E-05	0.00E+00
Sulfur dioxide	Air	kg	2.30E-01	4.37E+00	2.13E-02	1.01E+01	3.16E+00
Sulfur hexafluoride	Air	kg	0.00E+00	0.00E+00	8.32E-11	0.00E+00	2.07E-06
Sulfur monoxide	Air	kg	1.02E-01	6.27E-02	3.92E-04	1.31E-01	1.13E-01
Sulfur oxides	Air	kg	1.02E-02	7.30E-02	7.27E-04	1.61E-01	8.53E-02
Sulfur trioxide	Air	kg	0.00E+00	0.00E+00	3.19E-15	0.00E+00	4.88E-03
Sulfur, total reduced	Air	kg	0.00E+00	9.44E-06	4.64E-08	1.11E-05	2.54E-04
Sulfuric acid	Air	kg	0.00E+00	9.17E-08	2.66E-16	0.00E+00	1.33E-12

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Sulfuric acid, dimethyl ester	Air	kg	1.59E-09	1.63E-08	2.37E-11	1.49E-08	5.29E-08
t-Butyl methyl ether	Air	kg	1.16E-09	1.19E-08	1.73E-11	1.09E-08	3.93E-08
t-Butylamine	Air	kg	0.00E+00	0.00E+00	8.29E-18	0.00E+00	1.43E-04
Tar	Air	kg	7.51E-11	2.42E-09	1.44E-11	4.58E-09	1.19E-09
Terbufos	Air	kg	0.00E+00	8.56E-09	5.11E-12	1.00E-08	0.00E+00
Terpenes	Air	kg	0.00E+00	0.00E+00	1.58E-13	0.00E+00	5.73E-08
Thallium	Air	kg	0.00E+00	0.00E+00	2.39E-13	0.00E+00	3.71E-08
Thorium	Air	kg	0.00E+00	0.00E+00	2.04E-13	0.00E+00	4.41E-08
Thorium-228	Air	Bq	0.00E+00	0.00E+00	5.14E-06	0.00E+00	2.28E-01
Thorium-230	Air	Bq	0.00E+00	0.00E+00	9.58E-06	0.00E+00	1.37E+00
Thorium-232	Air	Bq	0.00E+00	0.00E+00	7.52E-06	0.00E+00	2.56E-01
Thorium-234	Air	Bq	0.00E+00	0.00E+00	2.56E-06	0.00E+00	5.95E-02
Tin	Air	kg	0.00E+00	0.00E+00	1.69E-11	0.00E+00	6.61E-08
Titanium	Air	kg	0.00E+00	0.00E+00	6.05E-10	0.00E+00	2.15E-05
TOC, Total Organic Carbon	Air	kg	0.00E+00	1.41E-02	7.44E-09	1.46E-05	0.00E+00
Toluene	Air	kg	2.44E-04	2.08E-03	5.87E-07	1.17E-04	2.72E-03
Toluene, 2-chloro-	Air	kg	0.00E+00	0.00E+00	1.18E-16	0.00E+00	3.92E-04
Toluene, 2,4-dinitro-	Air	kg	9.30E-12	9.51E-11	1.38E-13	8.70E-11	3.09E-10
Trichloroethane	Air	kg	0.00E+00	7.25E-08	1.37E-07	8.49E-08	0.00E+00
Trimethylamine	Air	kg	0.00E+00	0.00E+00	3.17E-19	0.00E+00	9.76E-15
Tungsten	Air	kg	0.00E+00	0.00E+00	3.50E-12	0.00E+00	7.89E-08
Uranium	Air	kg	0.00E+00	0.00E+00	2.71E-13	0.00E+00	5.83E-08
Uranium-234	Air	Bq	0.00E+00	0.00E+00	2.99E-05	0.00E+00	1.83E+00
Uranium-235	Air	Bq	0.00E+00	0.00E+00	1.45E-06	0.00E+00	3.26E-02
Uranium-238	Air	Bq	0.00E+00	0.00E+00	4.85E-05	0.00E+00	2.45E+00
Uranium alpha	Air	Bq	0.00E+00	0.00E+00	1.39E-04	0.00E+00	3.14E+00
Vanadium	Air	kg	0.00E+00	0.00E+00	1.52E-07	0.00E+00	6.18E-05
Vinyl acetate	Air	kg	2.52E-10	2.58E-09	3.75E-12	2.36E-09	8.38E-09
VOC, volatile organic compounds	Air	kg	6.37E-02	1.00E+00	5.30E-02	3.18E+00	4.25E-01
Water	Air	kg	0.00E+00	0.00E+00	8.55E-08	0.00E+00	4.88E-04
Wood (dust)	Air	kg	0.00E+00	3.63E-02	5.86E-03	1.02E+00	0.00E+00
Xenon-131m	Air	Bq	0.00E+00	0.00E+00	6.25E-04	0.00E+00	1.83E+01
Xenon-133	Air	Bq	0.00E+00	0.00E+00	1.96E-02	0.00E+00	6.00E+02
Xenon-133m	Air	Bq	0.00E+00	0.00E+00	9.05E-05	0.00E+00	2.12E+00
Xenon-135	Air	Bq	0.00E+00	0.00E+00	8.07E-03	0.00E+00	2.45E+02
Xenon-135m	Air	Bq	0.00E+00	0.00E+00	4.73E-03	0.00E+00	1.46E+02
Xenon-137	Air	Bq	0.00E+00	0.00E+00	8.55E-05	0.00E+00	3.25E+00
Xenon-138	Air	Bq	0.00E+00	0.00E+00	7.75E-04	0.00E+00	2.72E+01
Xylene	Air	kg	1.70E-04	1.21E-03	3.74E-07	6.95E-05	1.35E-04
Zinc	Air	kg	1.79E-05	1.83E-06	7.52E-09	1.46E-06	5.06E-05
Zinc-65	Air	Bq	0.00E+00	0.00E+00	5.54E-10	0.00E+00	2.33E-05
Zirconium	Air	kg	0.00E+00	0.00E+00	7.75E-16	0.00E+00	5.53E-09
Zirconium-95	Air	Bq	0.00E+00	0.00E+00	5.42E-10	0.00E+00	2.27E-05
1-Butanol	Water	kg	0.00E+00	0.00E+00	5.02E-09	0.00E+00	3.65E-04
1-Pentanol	Water	kg	0.00E+00	0.00E+00	1.23E-16	0.00E+00	8.56E-13
1-Pentene	Water	kg	0.00E+00	0.00E+00	9.26E-17	0.00E+00	6.47E-13
1-Propanol	Water	kg	0.00E+00	0.00E+00	1.69E-16	0.00E+00	1.23E-12
1,4-Butanediol	Water	kg	0.00E+00	0.00E+00	1.49E-17	0.00E+00	1.61E-04
2-Aminopropanol	Water	kg	0.00E+00	0.00E+00	1.89E-18	0.00E+00	2.07E-04
2-Hexanone	Water	kg	1.01E-06	3.07E-06	1.27E-08	8.74E-06	2.89E-06
2-Methyl-1-propanol	Water	kg	0.00E+00	0.00E+00	2.22E-16	0.00E+00	1.87E-04
2-Methyl-2-butene	Water	kg	0.00E+00	0.00E+00	2.05E-20	0.00E+00	1.44E-16
2-Methyl-4-chlorophenoxyacetic acid	Water	kg	0.00E+00	3.82E-12	2.28E-15	4.48E-12	0.00E+00
2-Propanol	Water	kg	0.00E+00	8.88E-09	4.37E-11	1.04E-08	8.22E-04

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
2,4-D	Water	kg	0.00E+00	2.05E-10	1.22E-13	2.40E-10	0.00E+00
4-Methyl-2-pentanone	Water	kg	6.51E-07	1.96E-06	8.15E-09	5.62E-06	1.86E-06
Acenaphthene	Water	kg	0.00E+00	0.00E+00	6.55E-13	0.00E+00	9.87E-10
Acenaphthylene	Water	kg	0.00E+00	0.00E+00	4.09E-14	0.00E+00	6.18E-11
Acetaldehyde	Water	kg	0.00E+00	6.12E-09	1.13E-08	6.22E-08	5.89E-03
Acetic acid	Water	kg	0.00E+00	0.00E+00	2.10E-11	0.00E+00	2.22E-02
Acetochlor	Water	kg	0.00E+00	2.84E-09	1.69E-12	3.32E-09	0.00E+00
Acetone	Water	kg	1.55E-06	4.67E-06	1.94E-08	1.34E-05	4.49E-04
Acetonitrile	Water	kg	0.00E+00	0.00E+00	3.73E-18	0.00E+00	6.82E-05
Acetyl chloride	Water	kg	0.00E+00	0.00E+00	9.63E-17	0.00E+00	6.73E-13
Acidity, unspecified	Water	kg	0.00E+00	3.02E-04	5.43E-12	6.34E-05	4.37E-05
Acids, unspecified	Water	kg	1.40E-09	1.26E-05	2.59E-08	1.48E-05	1.58E-04
Acrylate	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.41E-14
Acrylate, ion	Water	kg	0.00E+00	0.00E+00	2.99E-16	0.00E+00	1.48E-12
Actinides, radioactive, unspecified	Water	Bq	0.00E+00	0.00E+00	3.06E-05	0.00E+00	6.79E-01
Alachlor	Water	kg	0.00E+00	2.80E-10	1.67E-13	3.27E-10	0.00E+00
Aluminium	Water	kg	1.16E-02	1.68E-02	1.26E-04	4.83E-02	5.13E-02
Ammonia	Water	kg	2.73E-03	6.97E-03	3.45E-05	1.87E-02	6.74E-03
Ammonia, as N	Water	kg	7.05E-10	2.27E-08	6.64E-06	4.30E-08	1.12E-08
Ammonium, ion	Water	kg	5.77E-07	1.21E-04	1.69E-05	9.32E-04	8.61E-02
Aniline	Water	kg	0.00E+00	0.00E+00	7.12E-16	0.00E+00	1.29E-03
Antimony	Water	kg	7.21E-06	9.16E-06	7.01E-08	2.75E-05	6.76E-05
Antimony-122	Water	Bq	0.00E+00	0.00E+00	8.28E-09	0.00E+00	3.48E-04
Antimony-124	Water	Bq	0.00E+00	0.00E+00	4.95E-06	0.00E+00	1.16E-01
Antimony-125	Water	Bq	0.00E+00	0.00E+00	4.53E-06	0.00E+00	1.06E-01
AOX, Adsorbable Organic Halogen as Cl	Water	kg	0.00E+00	0.00E+00	9.37E-11	0.00E+00	2.37E-05
Arsenic	Water	kg	8.26E-05	1.10E-04	4.98E-07	3.14E-04	1.07E-04
Arsenic, ion	Water	kg	0.00E+00	0.00E+00	5.07E-09	0.00E+00	7.60E-05
Atrazine	Water	kg	0.00E+00	5.54E-09	3.30E-12	6.48E-09	0.00E+00
Barite	Water	kg	0.00E+00	0.00E+00	1.37E-11	0.00E+00	9.93E-08
Barium	Water	kg	1.59E-01	2.15E-01	1.55E-03	6.44E-01	2.73E-01
Barium-140	Water	Bq	0.00E+00	0.00E+00	3.63E-08	0.00E+00	1.52E-03
Bentazone	Water	kg	0.00E+00	2.26E-11	1.35E-14	2.64E-11	0.00E+00
Benzene	Water	kg	2.60E-04	4.24E-02	3.93E-06	1.08E-01	7.21E-02
Benzene, 1-methyl-4-(1-methylethyl)-	Water	kg	1.55E-08	4.67E-08	1.94E-10	1.34E-07	4.42E-08
Benzene, 1,2-dichloro-	Water	kg	0.00E+00	0.00E+00	1.02E-15	0.00E+00	1.95E-03
Benzene, chloro-	Water	kg	0.00E+00	0.00E+00	1.64E-14	0.00E+00	2.90E-02
Benzene, ethyl-	Water	kg	1.46E-05	4.42E-05	1.86E-07	1.26E-04	4.56E-05
Benzene, pentamethyl-	Water	kg	1.16E-08	3.50E-08	1.45E-10	1.00E-07	3.31E-08
Benzenes, alkylated, unspecified	Water	kg	6.32E-06	8.75E-06	6.05E-08	2.41E-05	1.05E-05
Benzo(a)pyrene	Water	kg	0.00E+00	8.35E-13	4.20E-11	9.78E-13	0.00E+00
Benzoic acid	Water	kg	1.57E-04	4.77E-04	1.97E-06	1.36E-03	4.48E-04
Beryllium	Water	kg	2.22E-06	5.16E-06	2.64E-08	1.49E-05	2.64E-05
Biphenyl	Water	kg	4.09E-07	5.67E-07	3.92E-09	1.56E-06	6.77E-07
BOD5, Biological Oxygen Demand	Water	kg	2.81E-02	4.83E-01	5.19E-04	1.23E+00	7.99E-01
Borate	Water	kg	0.00E+00	0.00E+00	9.35E-15	0.00E+00	1.18E-02
Boron	Water	kg	4.86E-04	1.47E-03	6.16E-06	4.20E-03	1.88E-03
Bromate	Water	kg	0.00E+00	0.00E+00	5.51E-11	0.00E+00	1.60E-03
Bromide	Water	kg	3.32E-02	1.00E-01	4.16E-04	2.87E-01	3.94E-01
Bromine	Water	kg	0.00E+00	0.00E+00	7.42E-08	0.00E+00	1.68E-04
Bromoxynil	Water	kg	0.00E+00	2.99E-11	1.78E-14	3.50E-11	0.00E+00
Butene	Water	kg	0.00E+00	0.00E+00	5.55E-11	0.00E+00	5.90E-04
Butyl acetate	Water	kg	0.00E+00	0.00E+00	6.53E-09	0.00E+00	1.96E-05
Butyrolactone	Water	kg	0.00E+00	0.00E+00	1.82E-18	0.00E+00	9.11E-15

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Cadmium	Water	kg	1.99E-05	1.66E-05	7.71E-08	4.70E-05	1.60E-05
Cadmium, ion	Water	kg	0.00E+00	0.00E+00	1.72E-09	0.00E+00	1.01E-05
Calcium	Water	kg	4.98E-01	1.50E+00	6.23E-03	4.30E+00	1.45E+00
Calcium, ion	Water	kg	0.00E+00	0.00E+00	1.89E-05	0.00E+00	4.21E-01
Carbofuran	Water	kg	0.00E+00	4.23E-11	2.52E-14	4.95E-11	0.00E+00
Carbon disulfide	Water	kg	0.00E+00	0.00E+00	5.90E-15	0.00E+00	4.17E-11
Carbonate	Water	kg	0.00E+00	0.00E+00	4.03E-10	0.00E+00	1.43E-01
Carboxylic acids, unspecified	Water	kg	0.00E+00	0.00E+00	4.53E-07	0.00E+00	6.81E-04
Cerium-141	Water	Bq	0.00E+00	0.00E+00	1.45E-08	0.00E+00	6.09E-04
Cerium-144	Water	Bq	0.00E+00	0.00E+00	4.42E-09	0.00E+00	1.85E-04
Cesium	Water	kg	0.00E+00	0.00E+00	1.05E-10	0.00E+00	1.59E-07
Cesium-134	Water	Bq	0.00E+00	0.00E+00	4.23E-06	0.00E+00	9.33E-02
Cesium-136	Water	Bq	0.00E+00	0.00E+00	2.57E-09	0.00E+00	1.08E-04
Cesium-137	Water	Bq	0.00E+00	0.00E+00	3.52E-03	0.00E+00	7.82E+01
CFCs, unspecified	Water	kg	0.00E+00	8.88E-09	4.37E-11	1.04E-08	2.45E-07
Chloramine	Water	kg	0.00E+00	0.00E+00	1.61E-15	0.00E+00	1.97E-03
Chlorate	Water	kg	0.00E+00	0.00E+00	4.72E-10	0.00E+00	1.23E-02
Chloride	Water	kg	5.60E+00	1.69E+01	7.01E-02	4.83E+01	2.20E+01
Chlorinated solvents, unspecified	Water	kg	0.00E+00	0.00E+00	1.85E-12	0.00E+00	8.84E-06
Chlorine	Water	kg	0.00E+00	0.00E+00	1.28E-11	0.00E+00	8.44E-07
Chloroacetic acid	Water	kg	0.00E+00	0.00E+00	8.23E-14	0.00E+00	5.29E-02
Chloroacetyl chloride	Water	kg	0.00E+00	0.00E+00	2.52E-18	0.00E+00	2.76E-04
Chloroform	Water	kg	0.00E+00	1.91E-08	6.81E-17	0.00E+00	2.42E-04
Chlorosulfonic acid	Water	kg	0.00E+00	0.00E+00	1.36E-17	0.00E+00	2.48E-04
Chlorpyrifos	Water	kg	0.00E+00	3.26E-10	1.94E-13	3.81E-10	0.00E+00
Chromate	Water	kg	0.00E+00	1.18E-12	3.38E-14	1.38E-12	3.18E-11
Chromium	Water	kg	3.56E-04	2.34E-04	2.75E-06	9.36E-04	4.64E-04
Chromium-51	Water	Bq	0.00E+00	0.00E+00	4.94E-06	0.00E+00	1.61E-01
Chromium III	Water	kg	3.35E-05	1.80E-04	3.83E-07	3.10E-04	7.89E-05
Chromium VI	Water	kg	1.23E-06	8.18E-07	1.57E-08	2.80E-06	1.42E-04
Chromium, ion	Water	kg	0.00E+00	0.00E+00	2.97E-10	0.00E+00	7.91E-06
Cobalt	Water	kg	3.43E-06	1.04E-05	6.38E-08	2.96E-05	3.26E-04
Cobalt-57	Water	Bq	0.00E+00	0.00E+00	8.17E-08	0.00E+00	3.43E-03
Cobalt-58	Water	Bq	0.00E+00	0.00E+00	3.82E-05	0.00E+00	1.05E+00
Cobalt-60	Water	Bq	0.00E+00	0.00E+00	2.97E-05	0.00E+00	8.47E-01
COD, Chemical Oxygen Demand	Water	kg	5.22E-02	5.56E-01	7.42E-04	1.41E+00	8.48E-01
Copper	Water	kg	6.94E-05	1.25E-04	7.66E-07	3.24E-04	1.27E-04
Copper, ion	Water	kg	0.00E+00	0.00E+00	2.15E-08	0.00E+00	2.63E-04
Cumene	Water	kg	0.00E+00	6.10E-02	9.81E-07	1.55E-01	5.78E-02
Cyanazine	Water	kg	0.00E+00	4.88E-11	2.91E-14	5.71E-11	0.00E+00
Cyanide	Water	kg	1.12E-08	5.31E-08	5.88E-09	9.70E-08	2.74E-04
Decane	Water	kg	4.52E-06	1.37E-05	5.65E-08	3.90E-05	1.29E-05
Detergent, oil	Water	kg	1.34E-04	4.50E-04	1.76E-06	1.29E-03	4.15E-04
Dibenzofuran	Water	kg	2.95E-08	8.89E-08	3.69E-10	2.54E-07	8.40E-08
Dibenzothiophene	Water	kg	2.51E-08	7.37E-08	3.11E-10	2.11E-07	7.02E-08
Dicamba	Water	kg	0.00E+00	2.88E-10	1.72E-13	3.37E-10	0.00E+00
Dichromate	Water	kg	0.00E+00	0.00E+00	1.13E-15	0.00E+00	1.43E-10
Diethylamine	Water	kg	0.00E+00	0.00E+00	3.17E-16	0.00E+00	6.16E-04
Dimethenamid	Water	kg	0.00E+00	6.79E-10	4.05E-13	7.95E-10	0.00E+00
Dimethylamine	Water	kg	0.00E+00	0.00E+00	1.64E-16	0.00E+00	2.71E-03
Dipropylamine	Water	kg	0.00E+00	0.00E+00	2.01E-16	0.00E+00	2.76E-04
Dipropylthiocarbamic acid S-ethyl ester	Water	kg	0.00E+00	2.81E-10	1.67E-13	3.29E-10	0.00E+00
Dissolved organics	Water	kg	0.00E+00	1.93E-04	0.00E+00	4.05E-05	0.00E+00
Disulfoton	Water	kg	0.00E+00	1.68E-11	1.00E-14	1.96E-11	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Diuron	Water	kg	0.00E+00	4.71E-12	2.81E-15	5.51E-12	0.00E+00
DOC, Dissolved Organic Carbon	Water	kg	4.31E-12	1.12E-01	8.90E-06	2.85E-01	1.87E-01
Docosane	Water	kg	1.66E-07	5.00E-07	2.08E-09	1.43E-06	4.73E-07
Dodecane	Water	kg	8.57E-06	2.60E-05	1.07E-07	7.40E-05	2.44E-05
Eicosane	Water	kg	2.36E-06	7.15E-06	2.95E-08	2.04E-05	6.73E-06
Ethane, 1,2-dichloro-	Water	kg	0.00E+00	0.00E+00	1.60E-12	0.00E+00	1.07E-03
Ethanol	Water	kg	0.00E+00	0.00E+00	1.16E-08	0.00E+00	1.88E-02
Ethene	Water	kg	0.00E+00	0.00E+00	1.11E-10	0.00E+00	1.70E-04
Ethene, chloro-	Water	kg	0.00E+00	0.00E+00	1.25E-14	0.00E+00	3.13E-08
Ethyl acetate	Water	kg	0.00E+00	0.00E+00	3.36E-16	0.00E+00	8.44E-07
Ethylamine	Water	kg	0.00E+00	0.00E+00	1.42E-16	0.00E+00	5.70E-04
Ethylene diamine	Water	kg	0.00E+00	0.00E+00	2.98E-15	0.00E+00	2.02E-11
Ethylene oxide	Water	kg	0.00E+00	0.00E+00	2.27E-15	0.00E+00	9.23E-04
Fluorene	Water	kg	0.00E+00	2.69E-08	6.09E-14	1.16E-12	0.00E+00
Fluorene, 1-methyl-	Water	kg	1.76E-08	5.32E-08	2.21E-10	1.52E-07	5.03E-08
Fluorenes, alkylated, unspecified	Water	kg	3.66E-07	5.07E-07	3.50E-09	1.40E-06	6.06E-07
Fluoride	Water	kg	1.23E-01	8.06E-04	6.08E-06	1.65E-03	1.53E-02
Fluorine	Water	kg	1.83E-07	2.48E-07	1.79E-09	7.61E-07	3.18E-07
Fluosilicic acid	Water	kg	0.00E+00	0.00E+00	1.21E-12	0.00E+00	4.70E-07
Formaldehyde	Water	kg	0.00E+00	0.00E+00	4.01E-06	0.00E+00	1.10E-02
Formamide	Water	kg	0.00E+00	0.00E+00	2.24E-16	0.00E+00	1.57E-12
Formate	Water	kg	0.00E+00	0.00E+00	2.56E-15	0.00E+00	4.40E-02
Formic acid	Water	kg	0.00E+00	0.00E+00	6.51E-17	0.00E+00	4.55E-13
Furan	Water	kg	0.00E+00	3.26E-10	1.60E-12	3.81E-10	8.76E-09
Glutaraldehyde	Water	kg	0.00E+00	0.00E+00	1.69E-15	0.00E+00	1.23E-11
Glyphosate	Water	kg	0.00E+00	6.11E-10	3.64E-13	7.15E-10	0.00E+00
Heat, waste	Water	MJ	0.00E+00	0.00E+00	1.83E-03	0.00E+00	2.35E+01
Hexadecane	Water	kg	9.35E-06	2.84E-05	1.17E-07	8.08E-05	2.67E-05
Hexanoic acid	Water	kg	3.25E-05	9.87E-05	4.08E-07	2.81E-04	9.28E-05
Hydrocarbons, aliphatic, alkanes, unspecified	Water	kg	0.00E+00	0.00E+00	1.37E-08	0.00E+00	2.06E-05
Hydrocarbons, aliphatic, unsaturated	Water	kg	0.00E+00	0.00E+00	1.26E-09	0.00E+00	2.32E-04
Hydrocarbons, aromatic	Water	kg	0.00E+00	0.00E+00	5.56E-08	0.00E+00	8.43E-05
Hydrocarbons, unspecified	Water	kg	5.39E-12	3.26E-07	2.12E-09	3.81E-07	3.36E-04
Hydrogen-3, Tritium	Water	Bq	0.00E+00	0.00E+00	8.07E+00	0.00E+00	1.79E+05
Hydrogen peroxide	Water	kg	0.00E+00	0.00E+00	1.79E-13	0.00E+00	8.01E-06
Hydrogen sulfide	Water	kg	0.00E+00	0.00E+00	2.45E-10	0.00E+00	3.49E-06
Hydroxide	Water	kg	0.00E+00	0.00E+00	9.71E-15	0.00E+00	1.09E-04
Hypochlorite	Water	kg	0.00E+00	0.00E+00	4.37E-10	0.00E+00	9.59E-06
Iodide	Water	kg	0.00E+00	0.00E+00	1.06E-08	0.00E+00	1.17E-01
Iodine-131	Water	Bq	0.00E+00	0.00E+00	8.96E-07	0.00E+00	2.17E-02
Iodine-133	Water	Bq	0.00E+00	0.00E+00	2.28E-08	0.00E+00	9.56E-04
Iron	Water	kg	2.36E-02	4.17E-02	2.69E-04	1.19E-01	4.73E-02
Iron-59	Water	Bq	0.00E+00	0.00E+00	6.26E-09	0.00E+00	2.63E-04
Iron, ion	Water	kg	0.00E+00	0.00E+00	2.35E-06	0.00E+00	4.22E-02
Isopropylamine	Water	kg	0.00E+00	0.00E+00	1.14E-17	0.00E+00	3.56E-04
Lactic acid	Water	kg	0.00E+00	0.00E+00	1.58E-16	0.00E+00	2.16E-04
Lanthanum-140	Water	Bq	0.00E+00	0.00E+00	3.86E-08	0.00E+00	1.62E-03
Lead	Water	kg	1.03E-04	1.79E-04	9.53E-07	5.14E-04	2.38E-04
Lead-210	Water	Bq	0.00E+00	0.00E+00	7.11E-05	0.00E+00	1.22E+00
Lead-210/kg	Water	kg	1.61E-14	4.88E-14	2.02E-16	1.39E-13	4.59E-14
Lithium	Water	kg	3.54E-02	4.14E-01	9.53E-04	1.14E+00	3.08E-01
Lithium, ion	Water	kg	0.00E+00	0.00E+00	4.22E-13	0.00E+00	3.93E-08
m-Xylene	Water	kg	4.69E-06	1.42E-05	5.88E-08	4.05E-05	1.34E-05
Magnesium	Water	kg	9.73E-02	2.94E-01	1.23E-03	8.41E-01	5.60E-01

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Manganese	Water	kg	1.72E-04	1.78E-03	1.23E-05	4.06E-03	1.26E-02
Manganese-54	Water	Bq	0.00E+00	0.00E+00	2.36E-06	0.00E+00	6.46E-02
Mercury	Water	kg	7.50E-07	2.31E-07	1.87E-09	6.18E-07	7.32E-06
Metallic ions, unspecified	Water	kg	6.58E-11	9.28E-09	3.95E-11	1.24E-08	3.08E-04
Methane, dichloro-, HCC-30	Water	kg	0.00E+00	0.00E+00	2.40E-14	0.00E+00	3.01E-04
Methane, monochloro-, R-40	Water	kg	6.24E-09	1.88E-08	7.81E-11	5.39E-08	1.78E-08
Methanol	Water	kg	0.00E+00	0.00E+00	1.28E-08	0.00E+00	2.77E-03
Methyl acetate	Water	kg	0.00E+00	0.00E+00	4.26E-19	0.00E+00	1.16E-04
Methyl acrylate	Water	kg	0.00E+00	0.00E+00	2.80E-15	0.00E+00	1.40E-11
Methyl amine	Water	kg	0.00E+00	0.00E+00	4.96E-17	0.00E+00	6.06E-05
Methyl ethyl ketone	Water	kg	1.25E-08	3.76E-08	1.56E-10	1.08E-07	3.56E-08
Methyl formate	Water	kg	0.00E+00	0.00E+00	1.89E-08	0.00E+00	7.00E-14
Methylamine	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.27E-17
Metolachlor	Water	kg	0.00E+00	2.24E-09	1.34E-12	2.63E-09	0.00E+00
Metribuzin	Water	kg	0.00E+00	1.04E-11	6.21E-15	1.22E-11	0.00E+00
Molybdenum	Water	kg	3.56E-06	1.08E-05	4.93E-08	3.08E-05	9.01E-05
Molybdenum-99	Water	Bq	0.00E+00	0.00E+00	1.33E-08	0.00E+00	5.59E-04
n-Hexacosane	Water	kg	1.03E-07	3.12E-07	1.29E-09	8.93E-07	2.95E-07
Naphthalene	Water	kg	2.82E-06	8.54E-06	3.50E-08	2.43E-05	8.03E-06
Naphthalene, 2-methyl-	Water	kg	2.45E-06	7.44E-06	3.07E-08	2.12E-05	7.00E-06
Naphthalenes, alkylated, unspecified	Water	kg	1.04E-07	1.43E-07	9.91E-10	3.95E-07	1.71E-07
Nickel	Water	kg	6.01E-05	9.08E-05	4.45E-07	2.62E-04	9.59E-05
Nickel, ion	Water	kg	0.00E+00	0.00E+00	7.55E-08	0.00E+00	1.33E-03
Niobium-95	Water	Bq	0.00E+00	0.00E+00	3.84E-07	0.00E+00	9.14E-03
Nitrate	Water	kg	4.72E-13	1.06E-06	6.87E-07	1.24E-06	7.99E-02
Nitrate compounds	Water	kg	1.90E-11	8.03E-10	3.66E-12	1.16E-09	3.02E-10
Nitric acid	Water	kg	4.27E-08	1.37E-06	8.20E-09	2.60E-06	6.78E-07
Nitrite	Water	kg	0.00E+00	0.00E+00	1.40E-10	0.00E+00	2.84E-05
Nitrobenzene	Water	kg	0.00E+00	0.00E+00	1.59E-15	0.00E+00	3.43E-03
Nitrogen	Water	kg	0.00E+00	0.00E+00	7.18E-07	0.00E+00	1.03E-03
Nitrogen, organic bound	Water	kg	0.00E+00	0.00E+00	3.04E-08	0.00E+00	3.85E-05
Nitrogen, total	Water	kg	1.44E-06	1.60E-04	9.70E-07	2.96E-04	2.73E-04
o-Cresol	Water	kg	4.46E-06	1.35E-05	5.58E-08	3.85E-05	1.27E-05
o-Xylene	Water	kg	0.00E+00	5.67E-08	1.30E-13	2.47E-12	4.62E-10
Octadecane	Water	kg	2.31E-06	7.01E-06	2.89E-08	2.00E-05	6.59E-06
Oils, unspecified	Water	kg	3.47E-03	1.03E-02	5.35E-05	2.79E-02	2.10E-02
Organic substances, unspecified	Water	kg	0.00E+00	6.49E-09	1.32E-10	7.60E-09	2.14E-04
p-Cresol	Water	kg	4.81E-06	1.46E-05	6.02E-08	4.15E-05	1.37E-05
p-Xylene	Water	kg	0.00E+00	5.67E-08	1.30E-13	2.47E-12	0.00E+00
PAH, polycyclic aromatic hydrocarbons	Water	kg	0.00E+00	0.00E+00	6.14E-10	0.00E+00	9.36E-07
Paraffins	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-17
Paraquat	Water	kg	0.00E+00	4.54E-11	2.71E-14	5.32E-11	0.00E+00
Parathion, methyl	Water	kg	0.00E+00	3.43E-11	2.05E-14	4.02E-11	0.00E+00
Pendimethalin	Water	kg	0.00E+00	2.33E-10	1.39E-13	2.73E-10	0.00E+00
Permethrin	Water	kg	0.00E+00	2.10E-11	1.25E-14	2.46E-11	0.00E+00
Phenanthrene	Water	kg	3.90E-08	7.65E-08	4.14E-10	2.15E-07	8.10E-08
Phenanthrenes, alkylated, unspecified	Water	kg	4.30E-08	5.95E-08	4.11E-10	1.64E-07	7.10E-08
Phenol	Water	kg	5.44E-05	4.23E-05	4.82E-07	1.26E-04	5.59E-03
Phenol, 2,4-dimethyl-	Water	kg	4.34E-06	1.32E-05	5.43E-08	3.75E-05	1.24E-05
Phenols, unspecified	Water	kg	2.23E-05	1.80E-04	4.63E-07	4.93E-04	1.40E-04
Phorate	Water	kg	0.00E+00	6.49E-12	3.87E-15	7.60E-12	0.00E+00
Phosphate	Water	kg	9.27E-02	2.15E-04	2.59E-06	9.30E-05	5.11E-02
Phosphorus	Water	kg	0.00E+00	1.82E-05	1.14E-08	2.13E-05	1.65E-03
Phosphorus compounds, unspecified	Water	kg	0.00E+00	1.20E-07	7.18E-11	1.41E-07	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Phosphorus, total	Water	kg	0.00E+00	1.07E-05	5.28E-08	1.26E-05	2.89E-04
Polonium-210	Water	Bq	0.00E+00	0.00E+00	8.47E-05	0.00E+00	1.34E+00
Potassium	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-03
Potassium-40	Water	Bq	0.00E+00	0.00E+00	5.97E-05	0.00E+00	1.26E+00
Potassium, ion	Water	kg	0.00E+00	0.00E+00	4.93E-06	0.00E+00	1.34E-01
Process solvents, unspecified	Water	kg	0.00E+00	3.26E-08	1.60E-10	3.81E-08	8.76E-07
Propanal	Water	kg	0.00E+00	0.00E+00	1.77E-16	0.00E+00	1.24E-12
Propene	Water	kg	0.00E+00	2.25E-02	3.62E-07	5.69E-02	2.47E-02
Propionic acid	Water	kg	0.00E+00	0.00E+00	4.96E-17	0.00E+00	9.87E-04
Propylamine	Water	kg	0.00E+00	0.00E+00	7.10E-17	0.00E+00	4.96E-13
Propylene oxide	Water	kg	0.00E+00	0.00E+00	8.35E-12	0.00E+00	1.69E-04
Protactinium-234	Water	Bq	0.00E+00	0.00E+00	4.72E-05	0.00E+00	1.07E+00
Radioactive species, alpha emitters	Water	Bq	0.00E+00	0.00E+00	7.92E-08	0.00E+00	6.54E-01
Radioactive species, Nuclides, unspecified	Water	Bq	8.38E+01	7.20E+03	5.31E+01	1.48E+04	4.06E+03
Radium-224	Water	Bq	0.00E+00	0.00E+00	5.26E-03	0.00E+00	7.94E+00
Radium-226	Water	Bq	0.00E+00	0.00E+00	3.79E-02	0.00E+00	6.77E+02
Radium-226/kg	Water	kg	5.60E-12	1.70E-11	7.01E-14	4.84E-11	1.60E-11
Radium-228	Water	Bq	0.00E+00	0.00E+00	1.05E-02	0.00E+00	1.59E+01
Radium-228/kg	Water	kg	2.86E-14	8.69E-14	3.59E-16	2.47E-13	8.17E-14
Rubidium	Water	kg	0.00E+00	0.00E+00	1.05E-09	0.00E+00	1.59E-06
Ruthenium-103	Water	Bq	0.00E+00	0.00E+00	2.81E-09	0.00E+00	1.18E-04
Scandium	Water	kg	0.00E+00	0.00E+00	1.97E-09	0.00E+00	3.60E-05
Selenium	Water	kg	1.60E-06	1.91E-05	1.44E-07	4.10E-05	5.92E-05
Silicon	Water	kg	0.00E+00	0.00E+00	1.39E-05	0.00E+00	2.46E-01
Silver	Water	kg	3.25E-04	9.81E-04	4.07E-06	2.81E-03	9.27E-04
Silver-110	Water	Bq	0.00E+00	0.00E+00	2.76E-05	0.00E+00	7.95E-01
Silver, ion	Water	kg	0.00E+00	0.00E+00	1.81E-10	0.00E+00	7.40E-07
Simazine	Water	kg	0.00E+00	1.47E-10	8.79E-14	1.73E-10	0.00E+00
Sodium	Water	kg	1.58E+00	4.76E+00	1.98E-02	1.36E+01	4.62E+00
Sodium-24	Water	Bq	0.00E+00	0.00E+00	1.01E-07	0.00E+00	4.23E-03
Sodium formate	Water	kg	0.00E+00	0.00E+00	1.13E-13	0.00E+00	3.36E-09
Sodium, ion	Water	kg	0.00E+00	0.00E+00	3.86E-05	0.00E+00	3.51E+00
Solids, inorganic	Water	kg	1.08E-10	3.49E-09	1.31E-05	6.62E-09	3.36E-02
Solved solids	Water	kg	0.00E+00	0.00E+00	8.41E-07	0.00E+00	3.63E-03
Strontium	Water	kg	8.45E-03	2.56E-02	1.06E-04	7.29E-02	2.95E-02
Strontium-89	Water	Bq	0.00E+00	0.00E+00	4.92E-07	0.00E+00	1.51E-02
Strontium-90	Water	Bq	0.00E+00	0.00E+00	2.67E-02	0.00E+00	5.78E+02
Styrene	Water	kg	0.00E+00	3.42E-09	2.40E-13	1.97E-09	1.81E-09
Sulfate	Water	kg	1.25E-02	1.35E-01	9.45E-04	3.04E-01	1.85E+00
Sulfide	Water	kg	6.31E-06	1.24E-04	2.70E-07	1.56E-04	2.97E-03
Sulfite	Water	kg	0.00E+00	0.00E+00	1.19E-09	0.00E+00	2.60E-05
Sulfur	Water	kg	4.10E-04	1.24E-03	5.16E-06	3.54E-03	7.50E-03
Sulfuric acid	Water	kg	0.00E+00	2.85E-10	2.32E-11	3.34E-10	7.67E-09
Surfactants	Water	kg	0.00E+00	2.67E-06	6.00E-12	1.15E-10	0.00E+00
Suspended solids, inorganic	Water	kg	0.00E+00	0.00E+00	2.01E-05	0.00E+00	5.10E-03
Suspended solids, unspecified	Water	kg	7.26E+00	2.20E+01	9.04E-02	6.13E+01	2.04E+01
t-Butyl methyl ether	Water	kg	0.00E+00	0.00E+00	2.25E-10	0.00E+00	4.71E-07
t-Butylamine	Water	kg	0.00E+00	0.00E+00	1.99E-17	0.00E+00	3.43E-04
Tar	Water	kg	1.07E-12	3.46E-11	2.07E-13	6.56E-11	1.71E-11
Technetium-99m	Water	Bq	0.00E+00	0.00E+00	3.09E-07	0.00E+00	1.29E-02
Tellurium-123m	Water	Bq	0.00E+00	0.00E+00	5.44E-07	0.00E+00	1.21E-02
Tellurium-132	Water	Bq	0.00E+00	0.00E+00	7.71E-10	0.00E+00	3.24E-05
Terbufos	Water	kg	0.00E+00	2.21E-10	1.32E-13	2.59E-10	0.00E+00
Tetradecane	Water	kg	3.76E-06	1.14E-05	4.70E-08	3.24E-05	1.07E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Thallium	Water	kg	1.52E-06	1.93E-06	1.47E-08	5.81E-06	4.00E-06
Thorium-228	Water	Bq	0.00E+00	0.00E+00	2.11E-02	0.00E+00	3.18E+01
Thorium-230	Water	Bq	0.00E+00	0.00E+00	6.44E-03	0.00E+00	1.46E+02
Thorium-232	Water	Bq	0.00E+00	0.00E+00	1.06E-05	0.00E+00	2.29E-01
Thorium-234	Water	Bq	0.00E+00	0.00E+00	4.72E-05	0.00E+00	1.07E+00
Tin	Water	kg	3.11E-05	6.17E-05	3.34E-07	1.79E-04	6.75E-05
Tin, ion	Water	kg	0.00E+00	0.00E+00	1.57E-09	0.00E+00	9.60E-06
Titanium	Water	kg	1.11E-04	1.41E-04	1.06E-06	4.23E-04	1.88E-04
Titanium, ion	Water	kg	0.00E+00	0.00E+00	3.21E-08	0.00E+00	8.73E-04
TOC, Total Organic Carbon	Water	kg	0.00E+00	1.13E-01	8.91E-06	2.85E-01	1.88E-01
Toluene	Water	kg	2.46E-04	7.42E-04	3.09E-06	2.12E-03	2.62E-03
Toluene, 2-chloro-	Water	kg	0.00E+00	0.00E+00	2.47E-16	0.00E+00	6.89E-04
Tributyltin compounds	Water	kg	0.00E+00	0.00E+00	1.05E-10	0.00E+00	2.99E-07
Triethylene glycol	Water	kg	0.00E+00	0.00E+00	3.95E-09	0.00E+00	3.32E-06
Trimethylamine	Water	kg	0.00E+00	0.00E+00	7.62E-19	0.00E+00	2.34E-14
Tungsten	Water	kg	0.00E+00	0.00E+00	2.02E-09	0.00E+00	6.83E-06
Uranium-234	Water	Bq	0.00E+00	0.00E+00	5.67E-05	0.00E+00	1.28E+00
Uranium-235	Water	Bq	0.00E+00	0.00E+00	9.35E-05	0.00E+00	2.11E+00
Uranium-238	Water	Bq	0.00E+00	0.00E+00	1.78E-04	0.00E+00	3.82E+00
Uranium alpha	Water	Bq	0.00E+00	0.00E+00	2.72E-03	0.00E+00	6.15E+01
Urea	Water	kg	0.00E+00	0.00E+00	2.04E-16	0.00E+00	1.44E-12
Vanadium	Water	kg	4.21E-06	1.32E-05	5.27E-08	3.63E-05	1.34E-05
Vanadium, ion	Water	kg	0.00E+00	0.00E+00	5.31E-09	0.00E+00	1.22E-04
VOC, volatile organic compounds, unspecified origin	Water	kg	0.00E+00	0.00E+00	3.70E-08	0.00E+00	5.82E-05
Waste water/m3	Water	m3	0.00E+00	2.68E-03	2.73E-05	3.14E-03	0.00E+00
Xylene	Water	kg	1.31E-04	3.87E-04	1.64E-06	1.11E-03	3.84E-04
Yttrium	Water	kg	1.04E-06	3.17E-06	1.31E-08	9.02E-06	2.98E-06
Zinc	Water	kg	2.69E-04	4.47E-04	3.19E-06	1.26E-03	5.96E-04
Zinc-65	Water	Bq	0.00E+00	0.00E+00	1.37E-06	0.00E+00	5.74E-02
Zinc, ion	Water	kg	0.00E+00	0.00E+00	1.39E-07	0.00E+00	1.48E-03
Zirconium-95	Water	Bq	0.00E+00	0.00E+00	1.58E-08	0.00E+00	6.65E-04
Waste in inert landfill	Waste	kg	0.00E+00	0.00E+00	0.00E+00	1.91E+01	0.00E+00
Waste to recycling	Waste	kg	0.00E+00	0.00E+00	0.00E+00	1.26E+01	5.81E+00
Waste, solid	Waste	kg	0.00E+00	3.84E-02	1.89E-04	4.49E-02	1.03E+00
2,4-D	Soil	kg	0.00E+00	0.00E+00	6.36E-14	0.00E+00	2.31E-08
Aclonifen	Soil	kg	0.00E+00	0.00E+00	6.30E-15	0.00E+00	1.49E-10
Aldrin	Soil	kg	0.00E+00	0.00E+00	3.25E-18	0.00E+00	1.63E-14
Aluminium	Soil	kg	0.00E+00	0.00E+00	5.13E-10	0.00E+00	5.36E-05
Antimony	Soil	kg	0.00E+00	0.00E+00	7.35E-18	0.00E+00	1.59E-13
Arsenic	Soil	kg	0.00E+00	0.00E+00	1.60E-13	0.00E+00	8.95E-09
Atrazine	Soil	kg	0.00E+00	0.00E+00	8.54E-19	0.00E+00	4.28E-15
Barium	Soil	kg	0.00E+00	0.00E+00	1.39E-12	0.00E+00	4.32E-09
Benomyl	Soil	kg	0.00E+00	0.00E+00	4.06E-16	0.00E+00	1.47E-10
Bentazone	Soil	kg	0.00E+00	0.00E+00	3.21E-15	0.00E+00	7.61E-11
Boron	Soil	kg	0.00E+00	0.00E+00	2.72E-13	0.00E+00	3.95E-10
Cadmium	Soil	kg	0.00E+00	0.00E+00	8.73E-13	0.00E+00	1.15E-08
Calcium	Soil	kg	0.00E+00	0.00E+00	6.86E-09	0.00E+00	2.83E-04
Carbetamide	Soil	kg	0.00E+00	0.00E+00	2.52E-15	0.00E+00	3.66E-11
Carbofuran	Soil	kg	0.00E+00	0.00E+00	2.22E-13	0.00E+00	8.06E-08
Carbon	Soil	kg	0.00E+00	0.00E+00	6.00E-10	0.00E+00	5.19E-04
Chloride	Soil	kg	0.00E+00	0.00E+00	9.56E-11	0.00E+00	1.64E-06
Chlorothalonil	Soil	kg	0.00E+00	0.00E+00	1.36E-12	0.00E+00	9.49E-09
Chromium	Soil	kg	0.00E+00	0.00E+00	7.29E-12	0.00E+00	2.75E-07

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Chromium VI	Soil	kg	0.00E+00	0.00E+00	3.34E-14	0.00E+00	2.38E-10
Cobalt	Soil	kg	0.00E+00	0.00E+00	4.29E-13	0.00E+00	3.22E-08
Copper	Soil	kg	0.00E+00	0.00E+00	4.04E-11	0.00E+00	6.05E-06
Cypermethrin	Soil	kg	0.00E+00	0.00E+00	3.15E-14	0.00E+00	1.14E-08
Fenpiclonil	Soil	kg	0.00E+00	0.00E+00	5.39E-14	0.00E+00	3.79E-10
Fluoride	Soil	kg	0.00E+00	0.00E+00	6.94E-14	0.00E+00	4.90E-10
Glyphosate	Soil	kg	0.00E+00	0.00E+00	4.47E-13	0.00E+00	1.60E-07
Heat, waste	Soil	MJ	0.00E+00	0.00E+00	4.73E-05	0.00E+00	6.80E-01
Iron	Soil	kg	0.00E+00	0.00E+00	9.09E-07	0.00E+00	1.02E-03
Lead	Soil	kg	0.00E+00	0.00E+00	2.33E-11	0.00E+00	2.83E-07
Linuron	Soil	kg	0.00E+00	0.00E+00	4.85E-14	0.00E+00	1.15E-09
Magnesium	Soil	kg	0.00E+00	0.00E+00	7.70E-10	0.00E+00	3.19E-05
Mancozeb	Soil	kg	0.00E+00	0.00E+00	1.77E-12	0.00E+00	1.23E-08
Manganese	Soil	kg	0.00E+00	0.00E+00	4.76E-10	0.00E+00	1.03E-05
Mercury	Soil	kg	0.00E+00	0.00E+00	3.16E-15	0.00E+00	4.15E-09
Metaldehyde	Soil	kg	0.00E+00	0.00E+00	8.24E-16	0.00E+00	9.32E-12
Metolachlor	Soil	kg	0.00E+00	0.00E+00	3.51E-13	0.00E+00	8.32E-09
Metribuzin	Soil	kg	0.00E+00	0.00E+00	6.24E-14	0.00E+00	4.34E-10
Molybdenum	Soil	kg	0.00E+00	0.00E+00	8.91E-14	0.00E+00	1.57E-08
Napropamide	Soil	kg	0.00E+00	0.00E+00	1.46E-15	0.00E+00	1.65E-11
Nickel	Soil	kg	0.00E+00	0.00E+00	8.20E-12	0.00E+00	1.11E-07
Oils, biogenic	Soil	kg	0.00E+00	0.00E+00	3.37E-11	0.00E+00	7.00E-07
Oils, unspecified	Soil	kg	0.00E+00	0.00E+00	7.46E-06	0.00E+00	1.19E-02
Orbencarb	Soil	kg	0.00E+00	0.00E+00	3.37E-13	0.00E+00	2.34E-09
Phosphorus	Soil	kg	0.00E+00	0.00E+00	2.32E-10	0.00E+00	4.66E-06
Pirimicarb	Soil	kg	0.00E+00	0.00E+00	3.04E-16	0.00E+00	7.20E-12
Potassium	Soil	kg	0.00E+00	0.00E+00	1.29E-09	0.00E+00	2.59E-05
Silicon	Soil	kg	0.00E+00	0.00E+00	1.97E-09	0.00E+00	1.26E-04
Sodium	Soil	kg	0.00E+00	0.00E+00	1.98E-12	0.00E+00	1.37E-08
Solids	Soil	kg	0.00E+00	0.00E+00	2.60E-06	0.00E+00	5.04E-03
Strontium	Soil	kg	0.00E+00	0.00E+00	3.38E-12	0.00E+00	3.83E-09
Sulfur	Soil	kg	0.00E+00	0.00E+00	2.23E-10	0.00E+00	5.00E-05
Sulfuric acid	Soil	kg	0.00E+00	0.00E+00	1.64E-19	0.00E+00	8.22E-16
Tebutam	Soil	kg	0.00E+00	0.00E+00	3.45E-15	0.00E+00	3.91E-11
Teflubenzuron	Soil	kg	0.00E+00	0.00E+00	4.16E-15	0.00E+00	2.89E-11
Thiram	Soil	kg	0.00E+00	0.00E+00	7.20E-16	0.00E+00	2.61E-10
Tin	Soil	kg	0.00E+00	0.00E+00	6.00E-15	0.00E+00	5.87E-08
Titanium	Soil	kg	0.00E+00	0.00E+00	3.27E-11	0.00E+00	6.55E-07
Vanadium	Soil	kg	0.00E+00	0.00E+00	9.36E-13	0.00E+00	1.88E-08
Zinc	Soil	kg	0.00E+00	0.00E+00	1.53E-09	0.00E+00	4.68E-06

18 APPENDIX C: SOUTHEAST I-JOIST LIFE-CYCLE IMPACT ASSESSMENT, ECONOMIC ALLOCATION

Cradle-to-gate LCI and LCIA results of economic allocation are presented in this section. The results for SE I-joists were presented by five life stages, (1) forestry operations, (2) OSB production, (3) FJL production, (4) LVL production, and (5) I-joist production. The overall cumulative energy consumption obtained from impact assessment using economic allocation was about 3% higher compared with the mass allocation method. The difference between the contribution of the life-cycle stages to the CPEC in economic and mass allocation was minor. For the impact assessment results of selected impact categories, the difference was lower than 10% and ranged between 3% and 10%.

Raw material energy consumption and CPEC for economic allocation are presented in Table 26 and Table 27, respectively. The majority of raw material energy consumption occurs during LVL production followed by OSB and I-joist production with a small portion arising from FJL production and forestry operations. Wood fuel consumption had the greatest share, about 25%, which was dominated by the LVL stage resulting from veneer input to LVL production. For LVL production, wood and natural gas were used to generate thermal energy for log conditioning and for drying and pressing veneers. The LVL stage consumed the most primary energy, whereas its share in the CPEC was about 60% for cradle-to-gate production of SE I-joists. At the I-joist stage, the primary energy source used was natural gas, about 40.2%, which was used to generate thermal energy for resin curing.

Table 26. Raw material energy consumption per kilometer I-joist produced, cradle-to-gate, economic allocation.

Fuel	Unit	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Wood fuel, oven-dry	kg	0.00E+00	1.27E+02	1.31E+01	7.45E+02	1.01E+01
Gas, natural, in ground	kg	1.04E+01	1.57E+02	3.81E-01	3.43E+02	1.11E+02
Coal, in ground	kg	2.20E+00	1.67E+02	1.62E+00	3.25E+02	1.01E+02
Uranium oxide, in ore	kg	5.08E-05	4.72E-03	4.54E-05	9.16E-03	2.43E-03
Oil, crude, in ground	kg	3.43E+01	4.75E+01	4.58E-01	8.56E+01	5.54E+01

Table 32 (Appendix E) lists the air emissions and HAPs generated from I-joist production along with the ones reported by the mills themselves. Fossil and biogenic CO_2 released in the production of 1 km of I-joist were 1,371 and 2,601 kg, respectively. All waterborne emissions occurred off site (Table 32. Economic allocation inventory. Table 32, Appendix E). I-joist plants are zero-discharge facilities.

Table 27. Cumulative primary energy consumption per kilometer I-joist produced, cradle-to-gate, economic allocation.

Fuel	Percentage	Total	Forestry operations	OSB production	FJL production	LVL production	I-joist production
		MJ/km					
Wood fuel	25.1	1.87E+04	0.00E+00	2.66E+03	2.75E+02	1.56E+04	2.11E+02
Gas, natural, in ground	31.9	2.38E+04	3.97E+02	6.03E+03	1.46E+01	1.31E+04	4.25E+03
Coal, in ground	20.9	1.56E+04	5.77E+01	4.36E+03	4.24E+01	8.51E+03	2.65E+03
Oil, crude, in ground	13.6	1.02E+04	1.56E+03	2.16E+03	2.08E+01	3.89E+03	2.52E+03
Uranium oxide, in ore	8.4	6.25E+03	1.94E+01	1.80E+03	1.73E+01	3.49E+03	9.26E+02
Hydro	0.2	1.37E+02	2.35E-01	3.46E+01	2.96E-01	8.05E+01	2.11E+01
Wind	0.0	4.28E+00	0.00E+00	5.70E-01	2.58E-04	9.05E-01	2.81E+00
Solar	0.0	4.84E-02	0.00E+00	2.61E-03	2.76E-06	6.30E-03	3.95E-02
Geothermal	0.0	2.11E-01	0.00E+00	2.11E-01	3.87E-07	4.86E-06	0.00E+00
Total	100.0	7.47E+04	2.04E+03	1.70E+04	3.70E+02	4.47E+04	1.06E+04
Total, by percentage		100	2.7	22.8	0.5	59.8	14.2

Solid emissions were dominated by LVL and I-joist production stages. Solid emissions include ash generated at the wood boiler during veneer production for LVL production and primarily fuels and resins used (Table 28). A total of 108 kg/km solid waste was generated, which does not include the amount of recycled solid waste. Overall, 84% of the solid waste generated is landfilled.

Table 28. Waste to treatment (kg) per kilometer I-joist, cradle-to-gate, economic allocation.

Waste to treatment	Total	Forestry operations	OSB production	FJL production	LVL production	I-joist production
	kg/km					
Waste in inert landfill	9.06E+01	0.00E+00	1.17E+01	2.51E-04	7.77E+01	1.13E+00
Waste to recycling	1.76E+01	0.00E+00	0.00E+00	0.00E+00	1.12E+01	6.38E+00
Total waste	1.08E+02	0.00E+00	1.17E+01	2.51E-04	8.89E+01	7.51E+00

Table 29 shows environmental performance results for GWP, acidification, eutrophication, ozone depletion, and smog; energy consumption from nonrenewable and renewable sources; material resource consumption from renewable and nonrenewable resources; and solid waste. In addition, the contribution of major substances to the overall impact for eutrophication, acidification, smog, and global warming impact categories are provided in Appendix D. The data on solid waste generated during OSB and LVL production were obtained from Kaestner (2015) and Bergman and Alanya-Rosenbaum (2016), respectively.

Table 29. Environmental performance of 1 km of I-joist, cradle-to-gate, economic allocation.

Impact category	Unit	Total	Forestry operations	OSB production	FJL production	LVL production	I-joist production
Global warming	kg CO_2 eq	2.85E+03	1.29E+02	6.88E+02	5.47E+00	1.52E+03	5.01E+02
Acidification potential	kg SO_2 eq	2.78E+01	1.72E+00	6.77E+00	5.63E-02	1.43E+01	4.94E+00
Eutrophication potential	kg N eq	1.28E+00	3.14E-01	1.77E-01	1.69E-03	3.73E-01	4.15E-01
Ozone depletion potential	kg CFC-11 eq	1.95E-04	1.10E-08	2.39E-06	4.60E-09	8.23E-07	1.92E-04
Smog potential	kg O_3 eq	3.01E+02	4.87E+01	6.92E+01	1.11E+00	1.36E+02	4.55E+01
Total primary energy consumption	**MJ**	**7.47E+04**	**2.04E+03**	**1.70E+04**	**3.70E+02**	**4.47E+04**	**1.06E+04**
Nonrenewable fossil	MJ	4.96E+04	2.02E+03	1.26E+04	7.78E+01	2.55E+04	9.42E+03
Nonrenewable nuclear	MJ	6.25E+03	1.94E+01	1.80E+03	1.73E+01	3.49E+03	9.26E+02
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	1.41E+02	2.35E-01	3.54E+01	2.96E-01	8.14E+01	2.39E+01
Renewable, biomass	MJ	1.87E+04	0.00E+00	2.66E+03	2.75E+02	1.56E+04	2.11E+02
Material resources consumption (nonfuel resources)	**Unit**	**Total**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Nonrenewable materials	kg	1.49E+01	0.00E+00	6.67E+00	6.47E-04	7.57E+00	6.76E-01
Renewable materials	kg	3.98E+03	7.17E+02	2.40E+01	5.87E+01	3.16E+03	2.18E+01
Fresh water	L	1.24E+04	4.22E-01	1.52E+03	4.25E+01	5.80E+03	5.02E+03
Waste generated	**Unit**	**Total**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Solid waste	kg	1.08E+02	0.00E+00	1.17E+01	2.51E-04	8.89E+01	7.51E+00

19 APPENDIX D: SUBSTANCE CONTRIBUTION ANALYSIS

Table 30. Substance contribution analysis to acidification (kg SO_2 eq.) by life-cycle stage (total percentage basis and values are displayed).

		Mass allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartments		**100.00**	2%	9%	0.1%	19%	70%
Sulfur dioxide	Air	67	2.30E-01	4.37E+00	2.13E-02	1.01E+01	3.16E+00
Nitrogen oxides	Air	28	1.37E+00	1.66E+00	1.68E-02	3.41E+00	1.08E+00
Sulfur monoxide	Air	1.5	1.02E-01	6.27E-02	3.92E-04	1.31E-01	1.13E-01
Sulfur oxides	Air	1.2	1.02E-02	7.30E-02	7.27E-04	1.61E-01	8.53E-02
Other substances	Air	<1	8.77E-03	9.96E-02	1.07E-03	2.04E-01	6.43E-02
		Economic allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartments		**100.00**	6%	24%	0.2%	51%	18%
Sulfur dioxide	Air	68	2.30E-01	4.72E+00	2.95E-02	1.04E+01	3.47E+00
Nitrogen oxides	Air	28	1.37E+00	1.79E+00	2.37E-02	3.42E+00	1.18E+00
Sulfur monoxide	Air	1.5	1.02E-01	6.77E-02	5.18E-04	1.28E-01	1.24E-01
Sulfur oxides	Air	1.3	1.02E-02	7.85E-02	1.18E-03	1.76E-01	9.36E-02
Other substances	Air	<1	8.77E-03	1.08E-01	1.46E-03	2.06E-01	7.06E-02

Table 31. Substance contribution analysis to eutrophication (kg N eq.) by life-cycle stage (total percentage basis and values are displayed).

		Mass allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartments		**100.00**	26%	13%	0%	30%	31%
Nitrogen oxides	Air	39	8.65E-02	1.05E-01	1.06E-03	2.16E-01	6.83E-02
Phosphate	Air	28	2.21E-01	5.12E-04	6.16E-06	2.21E-04	1.22E-01
COD	Water	12	2.61E-03	2.78E-02	3.71E-05	7.05E-02	4.24E-02
BOD_5	Water	10	1.41E-03	2.41E-02	2.60E-05	6.15E-02	4.00E-02
Ammonium, ion	Water	6	4.50E-07	9.45E-05	1.32E-05	7.26E-04	6.71E-02
Ammonia	Water	2	2.13E-03	5.43E-03	2.68E-05	1.46E-02	5.25E-03
Nitrate	Water	2	1.12E-13	2.50E-07	1.63E-07	2.92E-07	1.89E-02
Other substances		<1	2.61E-03	6.50E-03	5.76E-05	1.70E-02	7.33E-03
		Economic allocation					
Substances	**Compartment type**	**Total (%)**	**Forestry operations**	**OSB production**	**FJL production**	**LVL production**	**I-joist production**
Total of all compartment		**100.00**	25%	14%	0.1%	29%	32%
Nitrogen oxides	Air	38	8.65E-02	1.13E-01	1.50E-03	2.16E-01	7.49E-02
Phosphate	Water	28	2.21E-01	5.38E-04	7.73E-06	2.49E-04	1.33E-01
COD	Water	12	2.61E-03	3.00E-02	5.26E-05	7.44E-02	4.65E-02
BOD_5	Water	11	1.41E-03	2.61E-02	3.64E-05	6.51E-02	4.38E-02
Ammonium, ion	Water	6	4.50E-07	1.02E-04	1.69E-05	6.86E-04	7.36E-02
Ammonia	Water	2	2.13E-03	5.87E-03	3.89E-05	1.50E-02	5.76E-03
Nitrate	Water	2	1.12E-13	2.50E-07	2.03E-07	3.30E-07	2.08E-02
Phosphorus	Water	1	0.00E+00	1.33E-04	1.11E-07	1.75E-04	1.32E-02
Other substances		<1	4.80E-04	9.22E-04	3.51E-05	1.48E-03	3.05E-03

20 APPENDIX E: SOUTHEAST I-JOIST LIFE-CYCLE INVENTORY FLOWS, ECONOMIC ALLOCATION

Table 32. Economic allocation inventory.

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Aluminium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.99E-05
Aluminium, 24% in bauxite, 11% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.46E-08	0.00E+00	1.05E-02
Anhydrite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.49E-06
Anhydrite, in ground	Raw	kg	0.00E+00	0.00E+00	6.65E-12	0.00E+00	3.60E-05
Barite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04
Barite, 15% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.41E-09	0.00E+00	3.02E-02
Basalt	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.34E-09
Basalt, in ground	Raw	kg	0.00E+00	0.00E+00	4.15E-11	0.00E+00	8.56E-07
Borax	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.22E-10
Borax, in ground	Raw	kg	0.00E+00	0.00E+00	3.64E-12	0.00E+00	7.92E-08
Bromine, 0.0023% in water	Raw	kg	0.00E+00	0.00E+00	7.93E-13	0.00E+00	4.36E-01
Cadmium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.85E-13
Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground	Raw	kg	0.00E+00	0.00E+00	1.26E-13	0.00E+00	6.87E-10
Calcite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-01
Calcite, in ground	Raw	kg	0.00E+00	0.00E+00	2.22E-05	0.00E+00	9.41E-01
Carbon dioxide, in air	Raw	kg	1.24E+04	1.08E+02	3.16E-02	1.25E+02	2.02E+00
Carbon, in organic matter, in soil	Raw	kg	0.00E+00	0.00E+00	3.51E-10	0.00E+00	1.12E-04
Carbon, organic, in soil or biomass stock	Raw	kg	0.00E+00	0.00E+00	0.00E+00	4.75E+03	8.88E+03
Cerium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-3.22E-24
Chromium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.62E-06
Chromium, 25.5% in chromite, 11.6% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.05E-09	0.00E+00	1.16E-04
Chrysotile	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.33E-09
Chrysotile, in ground	Raw	kg	0.00E+00	0.00E+00	1.30E-11	0.00E+00	3.33E-04
Cinnabar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.02E-07
Cinnabar, in ground	Raw	kg	0.00E+00	0.00E+00	1.22E-12	0.00E+00	3.07E-05
Clay, bentonite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.66E-05
Clay, bentonite, in ground	Raw	kg	0.00E+00	0.00E+00	5.71E-08	0.00E+00	1.47E-03
Clay, unspecified	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-03
Clay, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	2.90E-06	0.00E+00	2.16E-02
Coal, 26.4 MJ per kg	Raw	kg	2.20E+00	1.61E+02	1.62E+00	3.25E+02	8.95E+01
Coal, bituminous, 24.8 MJ per kg	Raw	kg	0.00E+00	1.18E-05	8.36E-06	1.05E-04	0.00E+00
Coal, bitumous, in ground	Raw	kg	0.00E+00	4.95E+00	0.00E+00	0.00E+00	0.00E+00
Coal, brown	Raw	kg	0.00E+00	1.07E-06	7.52E-07	9.45E-06	1.94E-02
Coal, brown, in ground	Raw	kg	0.00E+00	0.00E+00	3.25E-04	0.00E+00	6.26E+00
Coal, hard	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-01
Coal, hard, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	1.87E-04	0.00E+00	5.17E+00
Coal, lignite, in ground	Raw	kg	0.00E+00	4.11E-01	0.00E+00	0.00E+00	0.00E+00
Cobalt	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.26E-11
Cobalt, in ground	Raw	kg	0.00E+00	0.00E+00	4.54E-12	0.00E+00	2.55E-05
Colemanite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.64E-09
Colemanite, in ground	Raw	kg	0.00E+00	0.00E+00	1.03E-10	0.00E+00	7.10E-03
Copper ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.96E-04
Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.29E-08
Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.20E-11	0.00E+00	1.27E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.97E-09
Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.89E-11	0.00E+00	4.01E-05
Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-09
Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.62E-11	0.00E+00	1.06E-05
Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.91E-09
Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.31E-10	0.00E+00	5.27E-05
Diatomite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-13
Diatomite, in ground	Raw	kg	0.00E+00	0.00E+00	4.51E-15	0.00E+00	8.84E-11
Dolomite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.96E-05
Dolomite, in ground	Raw	kg	0.00E+00	0.00E+00	1.88E-10	0.00E+00	3.16E-05
Energy, from biomass	Raw	MJ	0.00E+00	7.58E-01	1.39E-06	1.75E-05	0.00E+00
Energy, from gas, natural	Raw	MJ	0.00E+00	4.36E+01	0.00E+00	9.54E+00	0.00E+00
Energy, from hydro power	Raw	MJ	2.35E-01	3.46E+01	2.96E-01	8.05E+01	2.11E+01
Energy, from oil	Raw	MJ	0.00E+00	1.72E+01	0.00E+00	3.77E+00	0.00E+00
Energy, geothermal	Raw	MJ	0.00E+00	2.11E-01	3.87E-07	4.86E-06	0.00E+00
Energy, gross calorific value, in biomass	Raw	MJ	0.00E+00	0.00E+00	2.47E-04	0.00E+00	5.90E+00
Energy, gross calorific value, in biomass, primary forest	Raw	MJ	0.00E+00	0.00E+00	2.43E-08	0.00E+00	7.74E-03
Energy, kinetic (in wind), converted	Raw	MJ	0.00E+00	5.70E-01	2.58E-04	9.05E-01	2.81E+00
Energy, potential (in hydropower reservoir), converted	Raw	MJ	0.00E+00	0.00E+00	1.29E-03	0.00E+00	1.91E+01
Energy, recovered	Raw	MJ	0.00E+00	4.58E+01	1.07E-06	1.34E-05	0.00E+00
Energy, solar, converted	Raw	MJ	0.00E+00	2.61E-03	2.76E-06	6.30E-03	3.95E-02
Feldspar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-04
Feldspar, in ground	Raw	kg	0.00E+00	0.00E+00	2.26E-16	0.00E+00	2.09E-12
Fluorine	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-08
Fluorine, 4.5% in apatite, 1% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.85E-09	0.00E+00	1.86E-02
Fluorine, 4.5% in apatite, 3% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.03E-09
Fluorine, 4.5% in apatite, 3% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.25E-09	0.00E+00	1.42E-02
Fluorspar	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-06
Fluorspar, 92%, in ground	Raw	kg	0.00E+00	0.00E+00	9.65E-08	0.00E+00	3.03E-01
Gadolinium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.34E-29
Gallium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-17
Gallium, 0.014% in bauxite, in ground	Raw	kg	0.00E+00	0.00E+00	6.63E-19	0.00E+00	3.82E-15
Gas, mine, off-gas, process, coal mining/m3	Raw	m3	0.00E+00	0.00E+00	1.82E-06	0.00E+00	4.75E-02
Gas, natural, 36.6 MJ per m3	Raw	m3	0.00E+00	4.52E-05	3.20E-05	4.02E-04	0.00E+00
Gas, natural, 36.7 MJ per m3, in ground	Raw	kg	0.00E+00	1.08E+01	0.00E+00	0.00E+00	0.00E+00
Gas, natural, 46.8 MJ per kg	Raw	kg	0.00E+00	1.79E-01	4.82E-05	2.04E-01	1.79E-02
Gas, natural, 49.8 MJ per kg, in ground (EMR)	Raw	kg	0.00E+00	7.76E+00	0.00E+00	0.00E+00	0.00E+00
Gas, natural, in ground	Raw	m3	0.00E+00	0.00E+00	8.68E-03	0.00E+00	1.07E+01
Gas, natural/m3	Raw	m3	1.04E+01	1.31E+02	3.73E-01	3.42E+02	1.00E+02
Gold	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-14
Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E-14
Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.62E-16	0.00E+00	2.43E-12
Gold, Au 1.3E-4%, Ag 4.6E-5%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.27E-14
Gold, Au 1.3E-4%, Ag 4.6E-5%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.03E-15	0.00E+00	4.46E-12
Gold, Au 1.4E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.23E-15	0.00E+00	5.34E-12

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Gold, Au 2.1E-4%, Ag 2.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-13
Gold, Au 2.1E-4%, Ag 2.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.89E-15	0.00E+00	8.16E-12
Gold, Au 4.3E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-14
Gold, Au 4.3E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	4.67E-16	0.00E+00	2.02E-12
Gold, Au 4.9E-5%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.90E-14
Gold, Au 4.9E-5%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.12E-15	0.00E+00	4.84E-12
Gold, Au 6.7E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-13
Gold, Au 6.7E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.73E-15	0.00E+00	7.50E-12
Gold, Au 7.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-13
Gold, Au 7.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.95E-15	0.00E+00	8.45E-12
Gold, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.26E-15
Gold, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.17E-16	0.00E+00	5.07E-13
Granite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-14
Granite, in ground	Raw	kg	0.00E+00	0.00E+00	1.59E-16	0.00E+00	9.42E-13
Gravel	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-04
Gravel, in ground	Raw	kg	0.00E+00	0.00E+00	1.13E-04	0.00E+00	1.11E-01
Gypsum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-05
Gypsum, in ground	Raw	kg	0.00E+00	0.00E+00	3.85E-10	0.00E+00	2.04E-06
Helium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.28E-16
Indium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-14
Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground	Raw	kg	0.00E+00	0.00E+00	2.13E-15	0.00E+00	1.14E-11
Iodine, 0.03% in water	Raw	kg	0.00E+00	0.00E+00	1.87E-13	0.00E+00	2.27E-01
Iron	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.94E-03
Iron ore	Raw	kg	0.00E+00	1.27E-08	1.28E-05	1.68E-08	1.10E-04
Iron, 46% in ore, 25% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.38E-08	0.00E+00	1.73E-03
Kaolinite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.89E-07
Kaolinite, 24% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.65E-09	0.00E+00	1.93E-05
Kieserite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.63E-10
Kieserite, 25% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.75E-12	0.00E+00	6.64E-08
Lanthanum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-23
Lead	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-07
Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	2.65E-12	0.00E+00	1.31E-06
Limestone	Raw	kg	0.00E+00	6.67E+00	6.47E-04	7.57E+00	6.76E-01
Lithium, 0.15% in brine, in ground	Raw	kg	0.00E+00	0.00E+00	3.38E-15	0.00E+00	2.07E-11
Magnesite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-06
Magnesite, 60% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.89E-09	0.00E+00	2.55E-05
Magnesium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-13
Magnesium, 0.13% in water	Raw	kg	0.00E+00	0.00E+00	3.13E-15	0.00E+00	1.55E-11
Manganese	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.63E-07
Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.43E-11	0.00E+00	3.24E-02
Metamorphous rock, graphite containing	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.49E-09
Metamorphous rock, graphite containing, in ground	Raw	kg	0.00E+00	0.00E+00	4.41E-11	0.00E+00	1.51E-05
Molybdenum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.26E-09
Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.47E-10
Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.43E-12	0.00E+00	9.79E-07
Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-11

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.45E-13	0.00E+00	1.40E-07
Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.11E-09
Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.96E-11	0.00E+00	8.60E-06
Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.63E-11
Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.26E-12	0.00E+00	5.11E-07
Molybdenum, 0.11% in sulfide, Mo 4.1E-2% and Cu 0.36% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.95E-11	0.00E+00	1.74E-05
Neodymium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.10E-24
Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-08
Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	3.90E-06	0.00E+00	4.87E-04
Nickel, 1.98% in silicates, 1.04% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-05
Nickel, 1.98% in silicates, 1.04% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	8.60E-09	0.00E+00	1.77E-04
Nitrogen	Raw	kg	0.00E+00	8.32E-01	0.00E+00	0.00E+00	2.88E-03
Occupation, arable, conservation tillage	Raw	m2a	0.00E+00	1.35E-03	1.07E-06	1.78E-03	0.00E+00
Occupation, arable, conventional tillage	Raw	m2a	0.00E+00	1.48E-03	1.18E-06	1.96E-03	0.00E+00
Occupation, arable, non-irrigated	Raw	m2a	0.00E+00	0.00E+00	7.65E-09	0.00E+00	7.58E-05
Occupation, arable, reduced tillage	Raw	m2a	0.00E+00	9.08E-04	7.20E-07	1.20E-03	0.00E+00
Occupation, construction site	Raw	m2a	0.00E+00	0.00E+00	2.50E-08	0.00E+00	1.95E-03
Occupation, dump site	Raw	m2a	0.00E+00	0.00E+00	1.38E-06	0.00E+00	3.13E-02
Occupation, dump site, benthos	Raw	m2a	0.00E+00	0.00E+00	2.75E-11	0.00E+00	1.75E-07
Occupation, forest, intensive	Raw	m2a	0.00E+00	0.00E+00	2.60E-07	0.00E+00	6.55E-03
Occupation, forest, intensive, normal	Raw	m2a	0.00E+00	0.00E+00	3.68E-06	0.00E+00	6.64E-02
Occupation, forest, intensive, short-cycle	Raw	m2a	0.00E+00	0.00E+00	6.11E-09	0.00E+00	1.94E-03
Occupation, industrial area	Raw	m2a	0.00E+00	0.00E+00	3.86E-07	0.00E+00	8.57E-03
Occupation, industrial area, benthos	Raw	m2a	0.00E+00	0.00E+00	2.52E-13	0.00E+00	1.60E-09
Occupation, industrial area, built up	Raw	m2a	0.00E+00	0.00E+00	2.79E-10	0.00E+00	1.55E-06
Occupation, industrial area, vegetation	Raw	m2a	0.00E+00	0.00E+00	1.28E-10	0.00E+00	1.23E-06
Occupation, mineral extraction site	Raw	m2a	0.00E+00	0.00E+00	7.67E-07	0.00E+00	2.33E-02
Occupation, permanent crop, fruit, intensive	Raw	m2a	0.00E+00	0.00E+00	8.53E-09	0.00E+00	1.83E-05
Occupation, shrub land, sclerophyllous	Raw	m2a	0.00E+00	0.00E+00	1.28E-08	0.00E+00	6.40E-04
Occupation, traffic area, rail embankment	Raw	m2a	0.00E+00	0.00E+00	1.15E-10	0.00E+00	5.23E-07
Occupation, traffic area, rail network	Raw	m2a	0.00E+00	0.00E+00	1.27E-10	0.00E+00	5.87E-07
Occupation, traffic area, rail/road embankment	Raw	m2a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.15E-09
Occupation, traffic area, road embankment	Raw	m2a	0.00E+00	0.00E+00	4.06E-08	0.00E+00	7.64E-04
Occupation, traffic area, road network	Raw	m2a	0.00E+00	0.00E+00	3.50E-10	0.00E+00	2.08E-06
Occupation, urban, discontinuously built	Raw	m2a	0.00E+00	0.00E+00	1.41E-14	0.00E+00	7.89E-11
Occupation, water bodies, artificial	Raw	m2a	0.00E+00	0.00E+00	1.94E-06	0.00E+00	3.13E-02
Occupation, water courses, artificial	Raw	m2a	0.00E+00	0.00E+00	7.59E-07	0.00E+00	1.34E-02
Oil, crude	Raw	kg	3.43E+01	2.47E+01	4.55E-01	8.17E+01	4.84E+01
Oil, crude, 41 MJ per kg	Raw	kg	0.00E+00	1.33E+01	0.00E+00	2.91E+00	0.00E+00
Oil, crude, 42 MJ per kg	Raw	kg	0.00E+00	8.09E-01	6.94E-05	9.16E-01	7.19E-02
Oil, crude, 42.7 MJ per kg	Raw	kg	0.00E+00	2.36E-05	1.67E-05	2.10E-04	0.00E+00
Oil, crude, 43.7 MJ per kg, in ground	Raw	kg	0.00E+00	1.51E+00	0.00E+00	0.00E+00	0.00E+00
Oil, crude, 43.7 MJ per kg, in ground (EMR)	Raw	kg	0.00E+00	7.16E+00	0.00E+00	0.00E+00	0.00E+00
Oil, crude, in ground	Raw	kg	0.00E+00	0.00E+00	2.07E-03	0.00E+00	6.90E+00
Olivine	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.36E-06
Olivine, in ground	Raw	kg	0.00E+00	0.00E+00	2.35E-12	0.00E+00	1.25E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Oxygen	Raw	kg	0.00E+00	1.17E+01	4.33E-05	9.16E+00	3.32E+00
Palladium, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E-12
Palladium, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-12
Pd, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.44E-12	0.00E+00	3.74E-09
Pd, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.87E-12	0.00E+00	8.98E-09
Peat	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-05
Peat, in ground	Raw	kg	0.00E+00	0.00E+00	6.61E-08	0.00E+00	9.85E-04
Pesticides	Raw	kg	0.00E+00	8.93E-07	5.84E-09	1.18E-06	2.64E-05
Phosphate ore	Raw	kg	0.00E+00	8.49E-05	5.55E-07	1.12E-04	2.57E-03
Phosphorus	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E-04
Phosphorus, 18% in apatite, 12% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.03E-09	0.00E+00	5.74E-02
Phosphorus, 18% in apatite, 4% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-08
Phosphorus, 18% in apatite, 4% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.14E-08	0.00E+00	7.45E-02
Platinum, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.17E-14
Platinum, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.29E-13
Potassium chloride	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-03
Praseodymium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.46E-25
Pt, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.62E-14	0.00E+00	8.60E-11
Pt, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.02E-13	0.00E+00	3.08E-10
resin	Raw	kg	0.00E+00	6.25E+01	0.00E+00	0.00E+00	0.00E+00
Rh, Rh 2.0E-5%, Pt 2.5E-4%, Pd 7.3E-4%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	5.59E-14	0.00E+00	8.54E-11
Rh, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.75E-13	0.00E+00	2.67E-10
Rhenium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-13
Rhenium, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.30E-14	0.00E+00	1.61E-10
Rhodium, Rh 2.0E-5%, Pt 2.5E-4%, Pd 7.3E-4%, Ni 2.3E+0%, Cu 3.2E+0% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.06E-14
Rhodium, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E-13
Roundwood at forest road	Raw	m3	1.17E+01	5.73E+00	0.00E+00	0.00E+00	0.00E+00
Salt, unspecified	Raw	kg	0.00E+00	7.99E+00	0.00E+00	0.00E+00	0.00E+00
Samarium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-4.02E-27
Sand	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E-04
Sand, quartz, in ground	Raw	kg	0.00E+00	9.89E-06	6.47E-08	1.31E-05	2.92E-04
Sand, unspecified, in ground	Raw	kg	0.00E+00	0.00E+00	1.50E-09	0.00E+00	4.70E-03
Scrap, external	Raw	kg	0.00E+00	3.47E-01	1.29E-03	4.58E-01	5.24E+00
Seed corn	Raw	kg	0.00E+00	4.79E-06	3.13E-08	6.32E-06	1.41E-04
Shale	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.05E-06
Shale, in ground	Raw	kg	0.00E+00	0.00E+00	1.88E-11	0.00E+00	1.02E-04
Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-13
Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	1.25E-14	0.00E+00	5.41E-11
Silver, 3.2ppm in sulfide, Ag 1.2ppm, Cu and Te, in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E-13
Silver, 3.2ppm in sulfide, Ag 1.2ppm, Cu and Te, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	8.90E-15	0.00E+00	3.86E-11
Silver, Ag 2.1E-4%, Au 2.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E-14

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Silver, Ag 2.1E-4%, Au 2.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	8.22E-16	0.00E+00	3.56E-12
Silver, Ag 4.2E-3%, Au 1.1E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-13
Silver, Ag 4.2E-3%, Au 1.1E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.88E-15	0.00E+00	8.13E-12
Silver, Ag 4.6E-5%, Au 1.3E-4%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-13
Silver, Ag 4.6E-5%, Au 1.3E-4%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.84E-15	0.00E+00	7.97E-12
Silver, Ag 9.7E-4%, Au 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.58E-14
Silver, Ag 9.7E-4%, Au 9.7E-4%, Zn 0.63%, Cu 0.38%, Pb 0.014%, in ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.21E-15	0.00E+00	5.26E-12
Sodium carbonate	Raw	kg	0.00E+00	1.15E-03	9.16E-07	1.52E-03	0.00E+00
Sodium chloride	Raw	kg	0.00E+00	2.29E+00	8.81E-05	5.72E+00	7.15E-01
Sodium chloride, in ground	Raw	kg	0.00E+00	0.00E+00	2.47E-05	0.00E+00	1.20E+01
Sodium nitrate	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-13
Sodium nitrate, in ground	Raw	kg	0.00E+00	0.00E+00	8.43E-17	0.00E+00	3.81E-13
Sodium sulfate	Raw	kg	0.00E+00	6.27E-03	2.05E-05	8.28E-03	7.97E-02
Sodium sulphate, various forms, in ground	Raw	kg	0.00E+00	0.00E+00	2.38E-08	0.00E+00	4.19E-05
Stibnite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-14
Stibnite, in ground	Raw	kg	0.00E+00	0.00E+00	4.68E-16	0.00E+00	9.18E-12
Sulfur	Raw	kg	0.00E+00	3.38E-04	1.20E-06	4.46E-04	8.47E-03
Sulfur, in ground	Raw	kg	0.00E+00	0.00E+00	4.47E-10	0.00E+00	1.06E-01
Sylvinite, in ground	Raw	kg	0.00E+00	4.18E-05	2.73E-07	5.52E-05	1.23E-03
Sylvite, 25 % in sylvinite, in ground	Raw	kg	0.00E+00	0.00E+00	3.36E-10	0.00E+00	9.16E-02
Talc	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.07E-08
Talc, in ground	Raw	kg	0.00E+00	0.00E+00	4.67E-10	0.00E+00	4.48E-06
Tantalum	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-13
Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	9.84E-15	0.00E+00	4.26E-11
Tellurium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.44E-14
Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.34E-15	0.00E+00	5.79E-12
Tin	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.59E-11
Tin, 79% in cassiterite, 0.1% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.35E-13	0.00E+00	3.47E-09
TiO2, 54% in ilmenite, 2.6% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.92E-06
TiO2, 54% in ilmenite, 2.6% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	6.16E-08	0.00E+00	4.18E-04
TiO2, 95% in rutile, 0.40% in crude ore	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.44E-10
TiO2, 95% in rutile, 0.40% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	2.82E-16	0.00E+00	1.49E-12
Transformation, from arable	Raw	m2	0.00E+00	0.00E+00	1.70E-11	0.00E+00	3.99E-06
Transformation, from arable, non-irrigated	Raw	m2	0.00E+00	0.00E+00	1.41E-08	0.00E+00	1.40E-04
Transformation, from arable, non-irrigated, fallow	Raw	m2	0.00E+00	0.00E+00	5.41E-12	0.00E+00	1.27E-06
Transformation, from dump site, inert material landfill	Raw	m2	0.00E+00	0.00E+00	2.79E-12	0.00E+00	5.53E-05
Transformation, from dump site, residual material landfill	Raw	m2	0.00E+00	0.00E+00	2.42E-09	0.00E+00	7.15E-05
Transformation, from dump site, sanitary landfill	Raw	m2	0.00E+00	0.00E+00	1.29E-10	0.00E+00	7.14E-07
Transformation, from dump site, slag compartment	Raw	m2	0.00E+00	0.00E+00	3.18E-12	0.00E+00	2.86E-07
Transformation, from forest	Raw	m2	0.00E+00	0.00E+00	2.10E-10	0.00E+00	8.63E-05
Transformation, from forest, extensive	Raw	m2	0.00E+00	0.00E+00	3.05E-08	0.00E+00	5.63E-04
Transformation, from forest, intensive, clear-cutting	Raw	m2	0.00E+00	0.00E+00	2.18E-10	0.00E+00	6.94E-05
Transformation, from industrial area	Raw	m2	0.00E+00	0.00E+00	1.77E-09	0.00E+00	2.02E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Transformation, from industrial area, benthos	Raw	m2	0.00E+00	0.00E+00	2.32E-15	0.00E+00	1.50E-11
Transformation, from industrial area, built up	Raw	m2	0.00E+00	0.00E+00	4.07E-12	0.00E+00	3.02E-08
Transformation, from industrial area, vegetation	Raw	m2	0.00E+00	0.00E+00	6.95E-12	0.00E+00	5.15E-08
Transformation, from mineral extraction site	Raw	m2	0.00E+00	0.00E+00	1.45E-08	0.00E+00	6.29E-04
Transformation, from pasture and meadow	Raw	m2	0.00E+00	0.00E+00	8.17E-09	0.00E+00	4.85E-04
Transformation, from pasture and meadow, intensive	Raw	m2	0.00E+00	0.00E+00	1.15E-11	0.00E+00	1.14E-07
Transformation, from sea and ocean	Raw	m2	0.00E+00	0.00E+00	2.76E-11	0.00E+00	1.75E-07
Transformation, from shrub land, sclerophyllous	Raw	m2	0.00E+00	0.00E+00	7.29E-09	0.00E+00	2.12E-04
Transformation, from tropical rain forest	Raw	m2	0.00E+00	0.00E+00	2.18E-10	0.00E+00	6.94E-05
Transformation, from unknown	Raw	m2	0.00E+00	0.00E+00	4.68E-08	0.00E+00	8.61E-04
Transformation, to arable	Raw	m2	0.00E+00	0.00E+00	1.34E-08	0.00E+00	2.67E-04
Transformation, to arable, non-irrigated	Raw	m2	0.00E+00	0.00E+00	1.41E-08	0.00E+00	1.40E-04
Transformation, to arable, non-irrigated, fallow	Raw	m2	0.00E+00	0.00E+00	1.65E-11	0.00E+00	1.46E-06
Transformation, to dump site	Raw	m2	0.00E+00	0.00E+00	1.07E-08	0.00E+00	2.37E-04
Transformation, to dump site, benthos	Raw	m2	0.00E+00	0.00E+00	2.75E-11	0.00E+00	1.75E-07
Transformation, to dump site, inert material landfill	Raw	m2	0.00E+00	0.00E+00	2.79E-12	0.00E+00	5.53E-05
Transformation, to dump site, residual material landfill	Raw	m2	0.00E+00	0.00E+00	2.42E-09	0.00E+00	7.15E-05
Transformation, to dump site, sanitary landfill	Raw	m2	0.00E+00	0.00E+00	1.29E-10	0.00E+00	7.14E-07
Transformation, to dump site, slag compartment	Raw	m2	0.00E+00	0.00E+00	3.18E-12	0.00E+00	2.86E-07
Transformation, to forest	Raw	m2	0.00E+00	0.00E+00	3.65E-09	0.00E+00	1.75E-04
Transformation, to forest, intensive	Raw	m2	0.00E+00	0.00E+00	1.73E-09	0.00E+00	4.36E-05
Transformation, to forest, intensive, clear-cutting	Raw	m2	0.00E+00	0.00E+00	2.18E-10	0.00E+00	6.94E-05
Transformation, to forest, intensive, normal	Raw	m2	0.00E+00	0.00E+00	2.84E-08	0.00E+00	5.13E-04
Transformation, to forest, intensive, short-cycle	Raw	m2	0.00E+00	0.00E+00	2.18E-10	0.00E+00	6.94E-05
Transformation, to heterogeneous, agricultural	Raw	m2	0.00E+00	0.00E+00	2.50E-12	0.00E+00	1.53E-08
Transformation, to industrial area	Raw	m2	0.00E+00	0.00E+00	4.11E-09	0.00E+00	8.62E-05
Transformation, to industrial area, benthos	Raw	m2	0.00E+00	0.00E+00	4.02E-14	0.00E+00	2.29E-10
Transformation, to industrial area, built up	Raw	m2	0.00E+00	0.00E+00	2.36E-10	0.00E+00	3.82E-06
Transformation, to industrial area, vegetation	Raw	m2	0.00E+00	0.00E+00	5.85E-12	0.00E+00	4.33E-08
Transformation, to mineral extraction site	Raw	m2	0.00E+00	0.00E+00	1.97E-08	0.00E+00	6.99E-04
Transformation, to pasture and meadow	Raw	m2	0.00E+00	0.00E+00	4.27E-11	0.00E+00	3.12E-04
Transformation, to permanent crop, fruit, intensive	Raw	m2	0.00E+00	0.00E+00	1.20E-10	0.00E+00	2.58E-07
Transformation, to sea and ocean	Raw	m2	0.00E+00	0.00E+00	2.32E-15	0.00E+00	1.50E-11
Transformation, to shrub land, sclerophyllous	Raw	m2	0.00E+00	0.00E+00	2.56E-09	0.00E+00	1.28E-04
Transformation, to traffic area, rail embankment	Raw	m2	0.00E+00	0.00E+00	2.67E-13	0.00E+00	1.22E-09
Transformation, to traffic area, rail network	Raw	m2	0.00E+00	0.00E+00	2.93E-13	0.00E+00	1.36E-09
Transformation, to traffic area, rail/road embankment	Raw	m2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-11
Transformation, to traffic area, road embankment	Raw	m2	0.00E+00	0.00E+00	3.09E-10	0.00E+00	5.78E-06
Transformation, to traffic area, road network	Raw	m2	0.00E+00	0.00E+00	3.91E-12	0.00E+00	2.35E-08
Transformation, to unknown	Raw	m2	0.00E+00	0.00E+00	1.83E-09	0.00E+00	2.12E-05
Transformation, to urban, discontinuously built	Raw	m2	0.00E+00	0.00E+00	2.80E-16	0.00E+00	1.57E-12
Transformation, to water bodies, artificial	Raw	m2	0.00E+00	0.00E+00	1.33E-08	0.00E+00	2.05E-04
Transformation, to water courses, artificial	Raw	m2	0.00E+00	0.00E+00	9.39E-09	0.00E+00	1.66E-04

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Ulexite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E-12
Ulexite, in ground	Raw	kg	0.00E+00	0.00E+00	3.44E-14	0.00E+00	1.91E-10
Uranium	Raw	kg	0.00E+00	3.25E-08	2.58E-11	4.30E-08	2.38E-04
Uranium oxide, 332 GJ per kg, in ore	Raw	kg	5.08E-05	4.72E-03	4.54E-05	9.16E-03	2.43E-03
Uranium, 2291 GJ per kg	Raw	kg	0.00E+00	2.72E-06	2.36E-10	3.08E-06	2.41E-07
Uranium, in ground	Raw	kg	0.00E+00	0.00E+00	1.30E-08	0.00E+00	2.75E-04
Vermiculite	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E-13
Vermiculite, in ground	Raw	kg	0.00E+00	0.00E+00	2.28E-14	0.00E+00	8.46E-11
Volume occupied, final repository for low-active radioactive waste	Raw	m3	0.00E+00	0.00E+00	2.69E-11	0.00E+00	5.32E-07
Volume occupied, final repository for radioactive waste	Raw	m3	0.00E+00	0.00E+00	6.79E-12	0.00E+00	1.33E-07
Volume occupied, reservoir	Raw	m3y	0.00E+00	0.00E+00	2.96E-05	0.00E+00	3.47E-01
Volume occupied, underground deposit	Raw	m3	0.00E+00	0.00E+00	2.19E-10	0.00E+00	9.78E-06
Water, consumptive use, unspecified origin/m3	Raw	kg	0.00E+00	1.91E-01	0.00E+00	0.00E+00	0.00E+00
Water, cooling, unspecified natural origin/kg	Raw	kg	0.00E+00	6.72E-01	2.56E-07	1.68E+00	0.00E+00
Water, cooling, unspecified natural origin/m3	Raw	m3	0.00E+00	6.35E-01	1.48E-02	2.04E+00	3.79E+00
Water, lake	Raw	m3	0.00E+00	0.00E+00	2.95E-08	0.00E+00	1.22E-03
Water, process, surface	Raw	kg	0.00E+00	2.32E+02	1.59E+01	7.59E+02	0.00E+00
Water, process, unspecified natural origin/kg	Raw	kg	0.00E+00	1.25E+01	4.39E-02	3.11E+01	0.00E+00
Water, process, unspecified natural origin/m3	Raw	m3	0.00E+00	1.90E-05	1.34E-05	1.69E-04	0.00E+00
Water, process, well	Raw	kg	0.00E+00	3.46E+02	1.10E+01	3.32E+02	0.00E+00
Water, process, well, in ground	Raw	kg	0.00E+00	0.00E+00	6.58E-03	0.00E+00	6.53E+00
Water, river	Raw	m3	0.00E+00	1.52E-05	7.38E-06	2.00E-05	1.33E-01
Water, salt, ocean	Raw	m3	0.00E+00	0.00E+00	7.86E-06	0.00E+00	2.36E-02
Water, salt, sole	Raw	m3	0.00E+00	0.00E+00	1.64E-06	0.00E+00	1.46E+02
Water, turbine use, unspecified natural origin	Raw	m3	0.00E+00	0.00E+00	8.03E-03	0.00E+00	1.42E+02
Water, unspecified natural origin, RoW	Raw	m3	0.00E+00	1.06E-04	2.56E-05	1.07E-03	0.00E+00
Water, unspecified natural origin, US	Raw	m3	0.00E+00	2.83E-04	7.38E-04	1.91E+00	0.00E+00
Water, unspecified natural origin/kg	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E+01
Water, unspecified natural origin/m3	Raw	m3	4.22E-04	2.88E-01	4.48E-05	7.19E-01	1.08E+00
Water, well, in ground	Raw	m3	0.00E+00	8.78E-05	1.95E-06	1.16E-04	3.17E-02
Water, well, in ground, US	Raw	m3	0.00E+00	5.30E-05	1.38E-04	3.57E-01	0.00E+00
Wood and wood waste, 20.9 MJ per kg, ovendry basis	Raw	kg	0.00E+00	1.22E+02	4.32E-02	7.38E+02	0.00E+00
Wood and wood waste, 20.9 MJ/kg,ovendry (burned at kiln)	Raw	kg	0.00E+00	1.89E+00	4.91E+00	2.49E+00	0.00E+00
Wood and wood waste, 20.9 MJ/kg,ovendry (burned at sawmill boiler)	Raw	kg	0.00E+00	3.14E+00	8.18E+00	4.14E+00	0.00E+00
Wood and wood waste, 9.5 MJ per kg	Raw	kg	0.00E+00	3.41E-01	2.23E-03	4.50E-01	1.01E+01
Wood for fiber, feedstock	Raw	kg	0.00E+00	7.32E-01	4.79E-03	9.67E-01	2.16E+01
Wood into sawmill logyard	Raw	m3	0.00E+00	4.69E-02	1.22E-01	6.19E-02	0.00E+00
Wood, feedstock	Raw	kg	0.00E+00	7.78E-01	6.17E-04	1.03E+00	0.00E+00
Wood, hard, NE-NC, standing	Raw	m3	1.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wood, hard, standing	Raw	m3	0.00E+00	0.00E+00	6.67E-09	0.00E+00	1.17E-04
Wood, primary forest, standing	Raw	m3	0.00E+00	0.00E+00	2.26E-12	0.00E+00	7.18E-07
Wood, soft, standing	Raw	m3	0.00E+00	9.82E-04	2.56E-03	6.65E+00	3.12E-04
Wood, unspecified, standing/m3	Raw	m3	0.00E+00	0.00E+00	5.45E-14	0.00E+00	3.50E-07
Zinc	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-07
Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground	Raw	kg	0.00E+00	0.00E+00	6.73E-10	0.00E+00	1.46E-04
Zirconium	Raw	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.51E-13
Zirconium, 50% in zircon, 0.39% in crude ore, in ground	Raw	kg	0.00E+00	0.00E+00	1.35E-14	0.00E+00	5.83E-11
1-Butanol	Air	kg	0.00E+00	0.00E+00	6.74E-18	0.00E+00	9.60E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
1-Pentanol	Air	kg	0.00E+00	0.00E+00	6.38E-17	0.00E+00	3.91E-13
1-Pentene	Air	kg	0.00E+00	0.00E+00	4.82E-17	0.00E+00	2.96E-13
1-Propanol	Air	kg	0.00E+00	0.00E+00	4.78E-16	0.00E+00	3.19E-12
1,4-Butanediol	Air	kg	0.00E+00	0.00E+00	4.66E-17	0.00E+00	4.42E-04
2-Aminopropanol	Air	kg	0.00E+00	0.00E+00	9.58E-19	0.00E+00	5.61E-05
2-Butene, 2-methyl-	Air	kg	0.00E+00	0.00E+00	1.07E-20	0.00E+00	6.56E-17
2-Chloroacetophenone	Air	kg	2.32E-10	2.50E-09	4.72E-12	2.36E-09	8.47E-09
2-Methyl-1-propanol	Air	kg	0.00E+00	0.00E+00	1.16E-16	0.00E+00	8.57E-05
2-Methyl-4-chlorophenoxyacetic acid	Air	kg	0.00E+00	8.92E-11	7.08E-14	1.18E-10	0.00E+00
2-Nitrobenzoic acid	Air	kg	0.00E+00	0.00E+00	9.59E-19	0.00E+00	2.30E-04
2-Propanol	Air	kg	0.00E+00	0.00E+00	6.11E-14	0.00E+00	1.84E-04
2,4-D	Air	kg	0.00E+00	4.78E-09	3.79E-12	6.31E-09	0.00E+00
5-methyl Chrysene	Air	kg	2.12E-11	1.58E-09	1.54E-11	3.09E-09	8.49E-10
Acenaphthene	Air	kg	4.92E-10	3.67E-08	3.57E-10	7.16E-08	1.97E-08
Acenaphthylene	Air	kg	2.41E-10	1.80E-08	1.75E-10	3.51E-08	9.65E-09
Acetaldehyde	Air	kg	4.58E-04	2.45E-02	5.23E-04	6.25E-02	8.24E-04
Acetic acid	Air	kg	0.00E+00	0.00E+00	8.68E-08	0.00E+00	4.69E-03
Acetochlor	Air	kg	0.00E+00	6.63E-08	5.26E-11	8.75E-08	0.00E+00
Acetone	Air	kg	0.00E+00	7.33E-03	1.10E-08	0.00E+00	3.00E-04
Acetonitrile	Air	kg	0.00E+00	0.00E+00	2.37E-13	0.00E+00	7.54E-08
Acetophenone	Air	kg	4.98E-10	5.37E-09	1.01E-11	5.05E-09	1.81E-08
Acrolein	Air	kg	5.55E-05	7.23E-03	8.32E-05	5.77E-03	1.90E-05
Acrylic acid	Air	kg	0.00E+00	0.00E+00	1.58E-16	0.00E+00	6.95E-13
Actinides, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	2.18E-07	0.00E+00	3.51E-02
Aerosols, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	5.72E-06	0.00E+00	1.11E-01
Alachlor	Air	kg	0.00E+00	6.52E-09	5.17E-12	8.61E-09	0.00E+00
Aldehydes, unspecified	Air	kg	1.40E-03	1.08E-03	1.92E-05	3.46E-03	2.05E-03
Aluminium	Air	kg	0.00E+00	0.00E+00	8.63E-08	0.00E+00	8.35E-04
Ammonia	Air	kg	3.98E-03	7.38E-03	2.86E-04	1.21E-02	7.22E-03
Ammonium carbonate	Air	kg	0.00E+00	0.00E+00	1.26E-13	0.00E+00	1.27E-07
Ammonium chloride	Air	kg	2.70E-06	2.50E-04	2.41E-06	4.86E-04	1.29E-04
Aniline	Air	kg	0.00E+00	0.00E+00	3.71E-16	0.00E+00	3.50E-04
Anthracene	Air	kg	2.03E-10	1.51E-08	1.47E-10	2.95E-08	8.10E-09
Anthranilic acid	Air	kg	0.00E+00	0.00E+00	7.01E-19	0.00E+00	1.06E-04
Antimony	Air	kg	1.74E-08	1.34E-06	1.26E-08	2.56E-06	8.56E-07
Antimony-124	Air	Bq	0.00E+00	0.00E+00	2.57E-11	0.00E+00	9.46E-07
Antimony-125	Air	Bq	0.00E+00	0.00E+00	2.68E-10	0.00E+00	9.88E-06
Argon-41	Air	Bq	0.00E+00	0.00E+00	3.05E-03	0.00E+00	5.81E+01
Aromatics	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.50E-06
Arsenic	Air	kg	5.38E-07	3.08E-05	2.94E-07	5.97E-05	1.95E-05
Arsine	Air	kg	0.00E+00	0.00E+00	1.84E-21	0.00E+00	8.10E-18
Ash	Air	kg	0.00E+00	1.21E-04	0.00E+00	2.64E-05	0.00E+00
Atrazine	Air	kg	0.00E+00	1.29E-07	1.02E-10	1.70E-07	0.00E+00
Barium	Air	kg	0.00E+00	7.08E-03	7.23E-09	9.86E-07	2.87E-05
Barium-140	Air	Bq	0.00E+00	0.00E+00	1.74E-08	0.00E+00	6.42E-04
Bentazone	Air	kg	0.00E+00	5.27E-10	4.18E-13	6.95E-10	0.00E+00
Benzal chloride	Air	kg	0.00E+00	0.00E+00	3.43E-22	0.00E+00	1.62E-14
Benzaldehyde	Air	kg	0.00E+00	0.00E+00	9.53E-14	0.00E+00	7.25E-10
Benzene	Air	kg	5.62E-04	2.04E-02	5.16E-06	4.75E-02	2.78E-02
Benzene, 1-methyl-2-nitro-	Air	kg	0.00E+00	0.00E+00	8.28E-19	0.00E+00	1.98E-04
Benzene, 1,2-dichloro-	Air	kg	0.00E+00	0.00E+00	1.23E-16	0.00E+00	2.58E-04
Benzene, chloro-	Air	kg	7.31E-10	7.87E-09	1.48E-11	7.41E-09	2.66E-08
Benzene, ethyl-	Air	kg	3.12E-09	6.96E-07	6.92E-09	1.46E-05	6.23E-06
Benzene, hexachloro-	Air	kg	0.00E+00	0.00E+00	5.42E-16	0.00E+00	4.35E-11

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Benzene, pentachloro-	Air	kg	0.00E+00	0.00E+00	9.37E-16	0.00E+00	9.90E-11
Benzo(a)anthracene	Air	kg	7.72E-11	5.75E-09	5.60E-11	1.12E-08	3.09E-09
Benzo(a)pyrene	Air	kg	3.67E-11	2.73E-09	4.65E-11	5.34E-09	3.19E-07
Benzo(b,j,k)fluoranthene	Air	kg	1.06E-10	7.91E-09	7.70E-11	1.55E-08	4.24E-09
Benzo(g,h,i)perylene	Air	kg	2.61E-11	1.94E-09	1.89E-11	3.79E-09	1.04E-09
Benzyl chloride	Air	kg	2.32E-08	2.50E-07	4.72E-10	2.36E-07	8.47E-07
Beryllium	Air	kg	2.69E-08	1.70E-06	1.55E-08	3.34E-06	9.28E-07
Biphenyl	Air	kg	1.64E-09	1.22E-07	1.19E-09	2.39E-07	6.56E-08
Boron	Air	kg	0.00E+00	0.00E+00	8.41E-09	0.00E+00	1.74E-04
Boron trifluoride	Air	kg	0.00E+00	0.00E+00	2.52E-23	0.00E+00	1.10E-19
Bromine	Air	kg	0.00E+00	0.00E+00	9.23E-10	0.00E+00	1.80E-05
Bromoform	Air	kg	1.30E-09	1.40E-08	2.63E-11	1.31E-08	4.72E-08
Bromoxynil	Air	kg	0.00E+00	1.16E-09	9.16E-13	1.52E-09	0.00E+00
BTEX (Benzene, Toluene, Ethylbenzene, and Xylene), unspecified ratio	Air	kg	2.55E-03	3.22E-02	9.18E-05	8.43E-02	2.44E-02
Butadiene	Air	kg	2.33E-05	2.10E-07	6.48E-08	5.49E-06	3.37E-06
Butane	Air	kg	0.00E+00	0.00E+00	4.03E-07	0.00E+00	4.10E-04
Butene	Air	kg	0.00E+00	0.00E+00	2.78E-09	0.00E+00	1.31E-03
Butyrolactone	Air	kg	0.00E+00	0.00E+00	9.47E-19	0.00E+00	4.16E-15
Cadmium	Air	kg	1.37E-07	6.20E-06	4.54E-08	1.24E-05	4.23E-06
Calcium	Air	kg	0.00E+00	0.00E+00	1.42E-08	0.00E+00	1.28E-04
Carbofuran	Air	kg	0.00E+00	9.87E-10	7.83E-13	1.30E-09	0.00E+00
Carbon-14	Air	Bq	0.00E+00	0.00E+00	2.32E-02	0.00E+00	4.61E+02
Carbon dioxide	Air	kg	4.29E+00	8.94E+00	6.12E-03	2.86E+00	1.86E+00
Carbon dioxide, biogenic	Air	kg	8.72E-02	1.23E+02	1.73E+01	1.22E+03	1.26E+01
Carbon dioxide, fossil	Air	kg	1.11E+02	6.22E+02	5.17E+00	1.39E+03	4.52E+02
Carbon dioxide, land transformation	Air	kg	0.00E+00	0.00E+00	7.04E-08	0.00E+00	2.31E-03
Carbon disulfide	Air	kg	4.32E-09	2.69E-07	6.04E-07	3.37E-07	5.20E-06
Carbon monoxide	Air	kg	3.04E-04	1.71E-01	3.38E-05	2.41E-01	1.69E-01
Carbon monoxide, biogenic	Air	kg	0.00E+00	1.22E+00	3.11E-02	3.00E+00	1.39E-04
Carbon monoxide, fossil	Air	kg	1.43E+00	6.08E-01	1.22E-02	1.91E+00	1.12E+00
Cerium-141	Air	Bq	0.00E+00	0.00E+00	4.23E-09	0.00E+00	1.56E-04
Cesium-134	Air	Bq	0.00E+00	0.00E+00	2.02E-10	0.00E+00	7.46E-06
Cesium-137	Air	Bq	0.00E+00	0.00E+00	3.59E-09	0.00E+00	1.32E-04
Chloramine	Air	kg	0.00E+00	0.00E+00	2.25E-16	0.00E+00	1.43E-04
Chloride	Air	kg	6.68E-11	2.32E-09	1.82E-11	4.16E-09	1.16E-09
Chlorinated fluorocarbons and hydrochlorinated fluorocarbons, unspecified	Air	kg	0.00E+00	4.82E-07	6.02E-10	1.10E-06	2.74E-06
Chlorine	Air	kg	0.00E+00	2.26E-05	1.14E-08	1.67E-05	4.14E-02
Chloroacetic acid	Air	kg	0.00E+00	0.00E+00	5.38E-16	0.00E+00	7.24E-04
Chloroform	Air	kg	1.96E-09	2.11E-08	4.01E-11	1.99E-08	2.46E-03
Chlorosilane, trimethyl-	Air	kg	0.00E+00	0.00E+00	2.34E-17	0.00E+00	4.35E-13
Chlorosulfonic acid	Air	kg	0.00E+00	0.00E+00	6.81E-18	0.00E+00	1.09E-04
Chlorpyrifos	Air	kg	0.00E+00	7.60E-09	6.03E-12	1.00E-08	0.00E+00
Chromium	Air	kg	3.92E-07	2.18E-05	1.93E-07	4.33E-05	2.16E-05
Chromium-51	Air	Bq	0.00E+00	0.00E+00	2.71E-10	0.00E+00	9.98E-06
Chromium VI	Air	kg	7.62E-08	5.68E-06	5.53E-08	1.11E-05	3.30E-06
Chrysene	Air	kg	9.65E-11	7.19E-09	7.00E-11	1.40E-08	3.86E-09
Cobalt	Air	kg	7.06E-07	9.23E-06	9.18E-08	1.76E-05	7.59E-06
Cobalt-58	Air	Bq	0.00E+00	0.00E+00	3.77E-10	0.00E+00	1.39E-05
Cobalt-60	Air	Bq	0.00E+00	0.00E+00	3.33E-09	0.00E+00	1.23E-04
Copper	Air	kg	7.11E-09	1.29E-06	7.08E-09	6.49E-07	3.20E-05
Cumene	Air	kg	1.76E-10	2.74E-02	1.06E-08	6.86E-02	2.64E-02
Cyanazine	Air	kg	0.00E+00	1.14E-09	9.03E-13	1.50E-09	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Cyanide	Air	kg	8.30E-08	8.95E-07	1.70E-09	8.42E-07	1.42E-04
Cyanoacetic acid	Air	kg	0.00E+00	0.00E+00	5.57E-18	0.00E+00	8.94E-05
Dicamba	Air	kg	0.00E+00	6.71E-09	5.32E-12	8.86E-09	0.00E+00
Diethylamine	Air	kg	0.00E+00	0.00E+00	1.65E-16	0.00E+00	2.82E-04
Dimethenamid	Air	kg	0.00E+00	1.58E-08	1.26E-11	2.09E-08	0.00E+00
Dimethyl ether	Air	kg	0.00E+00	2.19E-04	1.44E-07	4.96E-04	2.20E-06
Dimethyl malonate	Air	kg	0.00E+00	0.00E+00	6.99E-18	0.00E+00	1.12E-04
Dinitrogen monoxide	Air	kg	2.54E-02	4.66E-03	6.25E-05	1.60E-02	1.50E-02
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	kg	2.29E-12	5.16E-09	4.64E-12	6.85E-09	3.60E-11
Dioxins (unspec.)	Air	kg	0.00E+00	1.23E-14	3.21E-14	1.63E-14	0.00E+00
Dipropylamine	Air	kg	0.00E+00	0.00E+00	1.05E-16	0.00E+00	1.26E-04
Dipropylthiocarbamic acid S-ethyl ester	Air	kg	0.00E+00	1.09E-08	8.61E-12	1.43E-08	0.00E+00
Ethane	Air	kg	0.00E+00	0.00E+00	1.46E-06	0.00E+00	1.31E-03
Ethane, 1,1-difluoro-, HFC-152a	Air	kg	0.00E+00	0.00E+00	8.60E-17	0.00E+00	5.05E-13
Ethane, 1,1,1-trichloro-, HCFC-140	Air	kg	3.89E-09	9.48E-09	5.62E-11	1.44E-08	2.90E-08
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Air	kg	0.00E+00	7.68E-07	7.78E-10	0.00E+00	7.57E-07
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	Air	kg	0.00E+00	0.00E+00	7.51E-18	0.00E+00	3.30E-14
Ethane, 1,2-dibromo-	Air	kg	3.99E-11	3.57E-08	8.78E-13	4.05E-10	1.45E-09
Ethane, 1,2-dichloro-	Air	kg	1.33E-09	1.43E-08	1.32E-10	1.35E-08	4.91E-04
Ethane, 1,2-dichloro-1,1,2-trifluoro-, HCFC-123	Air	kg	0.00E+00	7.68E-07	0.00E+00	0.00E+00	0.00E+00
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	Air	kg	0.00E+00	0.00E+00	9.54E-12	0.00E+00	1.94E-07
Ethane, chloro-	Air	kg	1.39E-09	1.50E-08	2.83E-11	1.41E-08	5.08E-08
Ethane, hexafluoro-, HFC-116	Air	kg	0.00E+00	0.00E+00	7.21E-13	0.00E+00	2.45E-07
Ethanol	Air	kg	0.00E+00	0.00E+00	2.20E-08	0.00E+00	5.71E-04
Ethene	Air	kg	0.00E+00	0.00E+00	6.02E-09	0.00E+00	1.19E-03
Ethene, chloro-	Air	kg	0.00E+00	0.00E+00	5.11E-11	0.00E+00	2.70E-07
Ethene, tetrachloro-	Air	kg	4.93E-08	3.14E-06	3.04E-08	6.14E-06	1.69E-06
Ethene, trichloro-	Air	kg	0.00E+00	2.15E-13	4.17E-14	2.84E-13	6.34E-12
Ethyl acetate	Air	kg	0.00E+00	0.00E+00	2.84E-13	0.00E+00	2.32E-06
Ethyl cellulose	Air	kg	0.00E+00	0.00E+00	5.74E-16	0.00E+00	2.52E-12
Ethylamine	Air	kg	0.00E+00	0.00E+00	7.41E-17	0.00E+00	2.61E-04
Ethylene diamine	Air	kg	0.00E+00	0.00E+00	1.55E-15	0.00E+00	9.23E-12
Ethylene oxide	Air	kg	0.00E+00	6.26E-09	4.42E-09	5.55E-08	5.06E-06
Ethyne	Air	kg	0.00E+00	0.00E+00	6.79E-11	0.00E+00	4.83E-04
Fluoranthene	Air	kg	6.85E-10	5.11E-08	4.97E-10	9.97E-08	2.74E-08
Fluorene	Air	kg	8.78E-10	6.54E-08	6.37E-10	1.28E-07	3.51E-08
Fluoride	Air	kg	5.00E-05	2.16E-05	8.43E-08	2.60E-05	5.69E-05
Fluorine	Air	kg	0.00E+00	0.00E+00	6.70E-10	0.00E+00	1.33E-05
Fluosilicic acid	Air	kg	0.00E+00	0.00E+00	8.42E-13	0.00E+00	2.86E-07
Formaldehyde	Air	kg	7.11E-04	5.74E-02	7.17E-04	7.60E-02	5.60E-03
Formamide	Air	kg	0.00E+00	0.00E+00	1.17E-16	0.00E+00	7.16E-13
Formic acid	Air	kg	0.00E+00	0.00E+00	1.59E-12	0.00E+00	5.04E-07
Furan	Air	kg	4.25E-12	3.48E-10	3.87E-12	6.87E-10	1.43E-07
Glyphosate	Air	kg	0.00E+00	1.42E-08	1.13E-11	1.88E-08	0.00E+00
HAPs	Air	kg	0.00E+00	4.22E-04	5.16E-05	4.25E-03	0.00E+00
Heat, waste	Air	MJ	0.00E+00	2.90E+01	5.21E-01	7.43E+01	8.20E+02
Helium	Air	kg	0.00E+00	0.00E+00	5.21E-09	0.00E+00	7.14E-06
Heptane	Air	kg	0.00E+00	0.00E+00	2.75E-08	0.00E+00	3.66E-05
Hexane	Air	kg	2.22E-09	5.37E-07	1.40E-06	7.00E-07	1.28E-04
Hydrazine, methyl-	Air	kg	5.65E-09	6.07E-08	1.15E-10	5.72E-08	2.06E-07
Hydrocarbons, aliphatic, alkanes, cyclic	Air	kg	0.00E+00	0.00E+00	2.51E-12	0.00E+00	1.50E-05
Hydrocarbons, aliphatic, alkanes, unspecified	Air	kg	0.00E+00	0.00E+00	1.33E-07	0.00E+00	5.93E-03

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Hydrocarbons, aliphatic, unsaturated	Air	kg	0.00E+00	0.00E+00	4.20E-09	0.00E+00	1.55E-04
Hydrocarbons, aromatic	Air	kg	0.00E+00	0.00E+00	5.51E-08	0.00E+00	1.76E-04
Hydrocarbons, chlorinated	Air	kg	0.00E+00	0.00E+00	1.03E-10	0.00E+00	2.37E-04
Hydrocarbons, unspecified	Air	kg	1.56E-05	1.45E-03	1.39E-05	2.81E-03	3.03E-03
Hydrogen	Air	kg	0.00E+00	2.94E-05	6.11E-09	3.63E-05	1.29E-02
Hydrogen-3, Tritium	Air	Bq	0.00E+00	0.00E+00	1.35E-01	0.00E+00	2.62E+03
Hydrogen chloride	Air	kg	1.22E-03	8.67E-02	8.55E-04	1.70E-01	4.84E-02
Hydrogen fluoride	Air	kg	1.43E-04	1.08E-02	1.05E-04	2.11E-02	6.03E-03
Hydrogen peroxide	Air	kg	0.00E+00	0.00E+00	4.25E-16	0.00E+00	1.87E-12
Hydrogen sulfide	Air	kg	2.16E-12	7.51E-11	2.11E-07	1.34E-10	2.54E-04
Indeno(1,2,3-cd)pyrene	Air	kg	5.89E-11	4.39E-09	4.27E-11	8.57E-09	2.35E-09
Iodine	Air	kg	0.00E+00	0.00E+00	4.91E-10	0.00E+00	9.72E-06
Iodine-129	Air	Bq	0.00E+00	0.00E+00	2.36E-05	0.00E+00	4.59E-01
Iodine-131	Air	Bq	0.00E+00	0.00E+00	1.21E-03	0.00E+00	2.29E+01
Iodine-133	Air	Bq	0.00E+00	0.00E+00	4.79E-08	0.00E+00	5.38E-03
Iodine-135	Air	Bq	0.00E+00	0.00E+00	5.88E-08	0.00E+00	1.00E-02
Iron	Air	kg	0.00E+00	7.46E-07	3.05E-08	9.85E-07	3.71E-04
Isocyanic acid	Air	kg	0.00E+00	0.00E+00	2.23E-05	0.00E+00	1.06E-11
Isophorone	Air	kg	1.93E-08	2.08E-07	3.91E-10	1.95E-07	7.02E-07
Isoprene	Air	kg	2.19E-03	7.62E-02	5.96E-04	1.36E-01	3.82E-02
Isopropylamine	Air	kg	0.00E+00	0.00E+00	5.94E-18	0.00E+00	1.63E-04
Kerosene	Air	kg	1.29E-06	1.20E-04	1.15E-06	2.33E-04	6.18E-05
Krypton-85	Air	Bq	0.00E+00	0.00E+00	9.53E-03	0.00E+00	1.82E+02
Krypton-85m	Air	Bq	0.00E+00	0.00E+00	4.04E-04	0.00E+00	1.22E+01
Krypton-87	Air	Bq	0.00E+00	0.00E+00	1.72E-04	0.00E+00	4.26E+00
Krypton-88	Air	Bq	0.00E+00	0.00E+00	1.65E-04	0.00E+00	4.44E+00
Krypton-89	Air	Bq	0.00E+00	0.00E+00	3.90E-05	0.00E+00	1.30E+00
Lactic acid	Air	kg	0.00E+00	0.00E+00	8.22E-17	0.00E+00	9.88E-05
Lanthanum-140	Air	Bq	0.00E+00	0.00E+00	1.49E-09	0.00E+00	5.49E-05
Lead	Air	kg	6.96E-07	4.70E-05	1.96E-06	1.83E-04	3.40E-05
Lead-210	Air	Bq	0.00E+00	0.00E+00	1.31E-04	0.00E+00	4.22E+00
m-Xylene	Air	kg	0.00E+00	0.00E+00	2.70E-11	0.00E+00	4.76E-07
Magnesium	Air	kg	1.06E-05	7.91E-04	7.71E-06	1.55E-03	5.44E-04
Manganese	Air	kg	7.92E-07	4.64E-05	7.79E-06	8.48E-05	7.21E-05
Manganese-54	Air	Bq	0.00E+00	0.00E+00	1.39E-10	0.00E+00	5.11E-06
Mercaptans, unspecified	Air	kg	7.20E-06	7.75E-05	1.45E-07	7.29E-05	2.62E-04
Mercury	Air	kg	1.46E-07	9.45E-06	9.28E-08	1.67E-05	1.42E-05
Metals, unspecified	Air	kg	2.48E-13	1.30E-04	1.04E-07	1.72E-04	4.70E-10
Methacrylic acid	Air	kg	0.00E+00	3.22E-09	0.00E+00	0.00E+00	0.00E+00
Methane	Air	kg	2.21E-01	1.80E+00	1.04E-02	4.41E+00	1.35E+00
Methane, biogenic	Air	kg	0.00E+00	1.50E-03	1.83E-04	1.51E-02	1.40E-03
Methane, bromo-, Halon 1001	Air	kg	5.31E-09	5.73E-08	1.08E-10	5.39E-08	1.94E-07
Methane, bromochlorodifluoro-, Halon 1211	Air	kg	0.00E+00	0.00E+00	4.43E-10	0.00E+00	3.21E-07
Methane, bromotrifluoro-, Halon 1301	Air	kg	0.00E+00	0.00E+00	7.22E-11	0.00E+00	9.66E-08
Methane, chlorodifluoro-, HCFC-22	Air	kg	0.00E+00	9.91E-06	1.52E-09	4.62E-13	1.22E-06
Methane, chlorotrifluoro-, CFC-13	Air	kg	0.00E+00	1.81E-07	3.49E-13	4.38E-12	0.00E+00
Methane, dichloro-, HCC-30	Air	kg	8.03E-07	2.49E-05	2.23E-07	4.79E-05	2.21E-04
Methane, dichlorodifluoro-, CFC-12	Air	kg	3.99E-09	2.87E-09	5.82E-11	9.48E-09	4.61E-06
Methane, dichlorofluoro-, HCFC-21	Air	kg	0.00E+00	0.00E+00	5.01E-20	0.00E+00	2.22E-16
Methane, fossil	Air	kg	2.47E-02	4.18E-01	7.46E-04	4.96E-01	3.23E-01
Methane, monochloro-, R-40	Air	kg	1.76E-08	1.90E-07	3.58E-10	1.78E-07	6.50E-07
Methane, tetrachloro-, CFC-10	Air	kg	3.99E-10	2.24E-06	2.56E-11	1.03E-06	2.50E-04
Methane, tetrafluoro-, CFC-14	Air	kg	0.00E+00	0.00E+00	6.49E-12	0.00E+00	2.20E-06
Methane, trichlorofluoro-, CFC-11	Air	kg	0.00E+00	0.00E+00	8.14E-20	0.00E+00	3.61E-16

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Methane, trifluoro-, HFC-23	Air	kg	0.00E+00	0.00E+00	1.60E-17	0.00E+00	7.07E-14
Methanesulfonic acid	Air	kg	0.00E+00	0.00E+00	5.63E-18	0.00E+00	9.04E-05
Methanol	Air	kg	0.00E+00	1.12E-01	3.29E-03	4.12E-01	4.36E-02
Methyl acetate	Air	kg	0.00E+00	0.00E+00	2.22E-19	0.00E+00	5.32E-05
Methyl acrylate	Air	kg	0.00E+00	0.00E+00	1.79E-16	0.00E+00	7.89E-13
Methyl amine	Air	kg	0.00E+00	0.00E+00	2.58E-17	0.00E+00	2.77E-05
Methyl borate	Air	kg	0.00E+00	0.00E+00	2.37E-17	0.00E+00	9.19E-06
Methyl ethyl ketone	Air	kg	1.30E-08	1.40E-07	2.63E-10	1.31E-07	4.73E-07
Methyl formate	Air	kg	0.00E+00	0.00E+00	5.92E-08	0.00E+00	1.92E-13
Methyl lactate	Air	kg	0.00E+00	0.00E+00	9.02E-17	0.00E+00	1.08E-04
Methyl methacrylate	Air	kg	6.64E-10	3.94E-09	1.35E-11	6.73E-09	2.42E-08
Methylamine	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.41E-17
Methylene diisocyanate	Air	kg	0.00E+00	3.39E-04	0.00E+00	0.00E+00	0.00E+00
Metolachlor	Air	kg	0.00E+00	5.24E-08	4.15E-11	6.91E-08	0.00E+00
Metribuzin	Air	kg	0.00E+00	2.43E-10	1.93E-13	3.20E-10	0.00E+00
Molybdenum	Air	kg	0.00E+00	0.00E+00	1.22E-09	0.00E+00	1.11E-06
Monoethanolamine	Air	kg	0.00E+00	0.00E+00	1.55E-12	0.00E+00	3.07E-03
N-Nitrodimethylamine	Air	kg	0.00E+00	6.32E-03	9.30E-15	1.38E-03	1.42E-12
Naphthalene	Air	kg	1.50E-07	7.05E-06	4.93E-07	4.56E-05	1.35E-05
Nickel	Air	kg	8.86E-06	5.07E-05	4.74E-07	9.34E-05	7.15E-05
Nickel compounds	Air	kg	0.00E+00	9.91E-06	0.00E+00	0.00E+00	0.00E+00
Niobium-95	Air	Bq	0.00E+00	0.00E+00	1.65E-11	0.00E+00	6.07E-07
Nitrate	Air	kg	0.00E+00	0.00E+00	1.28E-10	0.00E+00	2.48E-06
Nitric oxide	Air	kg	0.00E+00	1.88E-04	0.00E+00	0.00E+00	0.00E+00
Nitrobenzene	Air	kg	0.00E+00	0.00E+00	4.96E-16	0.00E+00	9.40E-04
Nitrogen oxides	Air	kg	1.95E+00	2.56E+00	3.38E-02	4.88E+00	1.69E+00
Nitrogen, total	Air	kg	9.70E-04	6.41E-09	5.08E-12	8.45E-09	0.00E+00
Nitrous oxide	Air	kg	0.00E+00	9.77E-06	0.00E+00	0.00E+00	6.71E-02
NMVOC, non-methane volatile organic compounds, unspecified origin	Air	kg	6.78E-02	1.35E-01	1.12E-03	2.99E-01	1.47E-01
Noble gases, radioactive, unspecified	Air	Bq	0.00E+00	0.00E+00	2.27E+02	0.00E+00	4.41E+06
Organic acids	Air	kg	9.92E-09	9.20E-07	8.86E-09	1.79E-06	4.74E-07
Organic substances, unspecified	Air	kg	5.98E-06	5.11E-03	6.76E-05	3.55E-03	1.32E-03
Other Organic	Air	kg	0.00E+00	1.42E-05	1.74E-06	1.43E-04	0.00E+00
Ozone	Air	kg	0.00E+00	0.00E+00	8.58E-09	0.00E+00	1.60E-04
PAH, polycyclic aromatic hydrocarbons	Air	kg	9.18E-05	8.45E-07	2.80E-07	2.24E-05	2.79E-05
Paraffins	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-18
Paraquat	Air	kg	0.00E+00	1.06E-09	8.41E-13	1.40E-09	0.00E+00
Parathion, methyl	Air	kg	0.00E+00	8.01E-10	6.35E-13	1.06E-09	0.00E+00
Particulates	Air	kg	0.00E+00	9.70E-05	1.05E-07	2.42E-04	1.01E-04
Particulates, < 10 um	Air	kg	0.00E+00	4.70E-01	3.88E-03	1.02E+00	1.04E-01
Particulates, < 2.5 um	Air	kg	0.00E+00	2.67E-01	4.86E-03	7.32E-01	1.10E-01
Particulates, > 10 um	Air	kg	0.00E+00	2.58E-03	7.77E-03	4.90E-03	1.63E-02
Particulates, > 2.5 um, and < 10um	Air	kg	5.73E-02	3.90E-02	4.96E-04	1.02E-01	4.59E-02
Particulates, unspecified	Air	kg	1.35E-02	2.54E-01	2.46E-03	8.91E-01	1.51E-01
Pendimethalin	Air	kg	0.00E+00	5.45E-09	4.32E-12	7.19E-09	0.00E+00
Pentane	Air	kg	0.00E+00	0.00E+00	4.89E-07	0.00E+00	4.54E-04
Permethrin	Air	kg	0.00E+00	4.90E-10	3.88E-13	6.46E-10	0.00E+00
PFC (perfluorocarbons)	Air	kg	0.00E+00	9.91E-05	0.00E+00	0.00E+00	0.00E+00
Phenanthrene	Air	kg	2.61E-09	1.94E-07	1.89E-09	3.79E-07	1.04E-07
Phenol	Air	kg	5.31E-10	9.41E-03	8.24E-05	8.42E-03	9.58E-02
Phenol, 2,4-dichloro-	Air	kg	0.00E+00	0.00E+00	2.37E-17	0.00E+00	1.44E-04
Phenol, pentachloro-	Air	kg	0.00E+00	0.00E+00	6.50E-12	0.00E+00	1.24E-07
Phenols, unspecified	Air	kg	4.10E-07	3.65E-06	2.60E-08	6.98E-06	1.84E-06

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Phorate	Air	kg	0.00E+00	2.51E-10	1.99E-13	3.31E-10	0.00E+00
Phosphate	Air	kg	2.21E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Phosphine	Air	kg	0.00E+00	0.00E+00	1.37E-19	0.00E+00	6.01E-16
Phosphorus	Air	kg	0.00E+00	0.00E+00	9.59E-11	0.00E+00	6.32E-05
Phthalate, diisooctyl-	Air	kg	0.00E+00	1.17E-08	0.00E+00	0.00E+00	0.00E+00
Phthalate, dioctyl-	Air	kg	2.42E-09	1.44E-08	4.93E-11	2.46E-08	8.83E-08
Platinum	Air	kg	0.00E+00	0.00E+00	3.43E-16	0.00E+00	6.67E-12
Plutonium-238	Air	Bq	0.00E+00	0.00E+00	3.22E-12	0.00E+00	6.26E-08
Plutonium-alpha	Air	Bq	0.00E+00	0.00E+00	7.37E-12	0.00E+00	1.43E-07
Polonium-210	Air	Bq	0.00E+00	0.00E+00	2.31E-04	0.00E+00	7.04E+00
Polychlorinated biphenyls	Air	kg	0.00E+00	0.00E+00	4.72E-16	0.00E+00	1.49E-11
Polycyclic organic matter, unspecified	Air	kg	0.00E+00	4.60E-07	8.88E-13	1.12E-11	0.00E+00
Potassium	Air	kg	0.00E+00	1.32E-04	8.73E-07	1.75E-04	4.07E-03
Potassium-40	Air	Bq	0.00E+00	0.00E+00	2.97E-05	0.00E+00	8.92E-01
Propanal	Air	kg	1.26E-08	8.64E-06	1.37E-05	1.77E-02	1.53E-04
Propane	Air	kg	0.00E+00	0.00E+00	6.06E-07	0.00E+00	6.72E-04
Propene	Air	kg	1.54E-03	1.01E-02	4.28E-06	2.56E-02	1.06E-02
Propionic acid	Air	kg	0.00E+00	0.00E+00	5.64E-09	0.00E+00	4.55E-04
Propylamine	Air	kg	0.00E+00	0.00E+00	3.70E-17	0.00E+00	2.27E-13
Propylene glycol	Air	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-03
Propylene oxide	Air	kg	0.00E+00	2.78E-07	3.14E-09	1.32E-05	7.74E-05
Protactinium-234	Air	Bq	0.00E+00	0.00E+00	3.20E-06	0.00E+00	6.53E-02
Pyrene	Air	kg	3.18E-10	2.37E-08	2.31E-10	4.64E-08	1.27E-08
Radioactive species, other beta emitters	Air	Bq	0.00E+00	0.00E+00	7.37E-06	0.00E+00	1.45E-01
Radioactive species, unspecified	Air	Bq	5.28E+04	4.05E+06	3.96E+04	7.93E+06	2.12E+06
Radionuclides (Including Radon)	Air	kg	7.23E-05	6.71E-03	6.46E-05	1.30E-02	3.46E-03
Radium-226	Air	Bq	0.00E+00	0.00E+00	1.36E-04	0.00E+00	4.27E+00
Radium-228	Air	Bq	0.00E+00	0.00E+00	1.93E-05	0.00E+00	1.84E+00
Radon-220	Air	Bq	0.00E+00	0.00E+00	1.29E-03	0.00E+00	2.50E+01
Radon-222	Air	Bq	0.00E+00	0.00E+00	4.23E+02	0.00E+00	8.39E+06
Ruthenium-103	Air	Bq	0.00E+00	0.00E+00	3.62E-12	0.00E+00	1.33E-07
Scandium	Air	kg	0.00E+00	0.00E+00	3.89E-11	0.00E+00	7.98E-07
Selenium	Air	kg	1.34E-06	9.45E-05	9.17E-07	1.85E-04	5.25E-05
Silicon	Air	kg	0.00E+00	0.00E+00	4.55E-09	0.00E+00	4.54E-04
Silicon tetrafluoride	Air	kg	0.00E+00	0.00E+00	8.63E-14	0.00E+00	6.39E-10
Silver	Air	kg	0.00E+00	0.00E+00	2.01E-12	0.00E+00	3.21E-08
Silver-110	Air	Bq	0.00E+00	0.00E+00	3.58E-11	0.00E+00	1.32E-06
Simazine	Air	kg	0.00E+00	3.44E-09	2.73E-12	4.54E-09	0.00E+00
Sodium	Air	kg	0.00E+00	3.05E-06	7.65E-08	4.03E-06	1.44E-04
Sodium chlorate	Air	kg	0.00E+00	0.00E+00	1.23E-12	0.00E+00	7.47E-09
Sodium dichromate	Air	kg	0.00E+00	0.00E+00	1.26E-15	0.00E+00	3.49E-08
Sodium formate	Air	kg	0.00E+00	0.00E+00	5.87E-14	0.00E+00	1.53E-09
Sodium hydroxide	Air	kg	0.00E+00	0.00E+00	1.59E-15	0.00E+00	6.97E-12
Strontium	Air	kg	0.00E+00	0.00E+00	1.79E-10	0.00E+00	7.81E-06
Styrene	Air	kg	8.30E-10	8.95E-09	1.73E-11	8.42E-09	3.19E-07
Sulfate	Air	kg	0.00E+00	0.00E+00	1.46E-08	0.00E+00	1.39E-02
Sulfur	Air	kg	0.00E+00	1.61E-05	1.28E-08	2.12E-05	0.00E+00
Sulfur dioxide	Air	kg	2.30E-01	4.72E+00	2.95E-02	1.04E+01	3.47E+00
Sulfur hexafluoride	Air	kg	0.00E+00	0.00E+00	1.04E-10	0.00E+00	2.28E-06
Sulfur monoxide	Air	kg	1.02E-01	6.77E-02	5.18E-04	1.28E-01	1.24E-01
Sulfur oxides	Air	kg	1.02E-02	7.85E-02	1.18E-03	1.76E-01	9.36E-02
Sulfur trioxide	Air	kg	0.00E+00	0.00E+00	3.99E-15	0.00E+00	5.35E-03
Sulfur, total reduced	Air	kg	0.00E+00	9.44E-06	6.17E-08	1.25E-05	2.79E-04
Sulfuric acid	Air	kg	0.00E+00	9.91E-08	3.32E-16	0.00E+00	1.46E-12

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Sulfuric acid, dimethyl ester	Air	kg	1.59E-09	1.72E-08	3.24E-11	1.62E-08	5.81E-08
t-Butyl methyl ether	Air	kg	1.16E-09	1.25E-08	2.37E-11	1.18E-08	4.32E-08
t-Butylamine	Air	kg	0.00E+00	0.00E+00	1.04E-17	0.00E+00	1.57E-04
Tar	Air	kg	7.51E-11	2.61E-09	2.04E-11	4.67E-09	1.31E-09
Terbufos	Air	kg	0.00E+00	8.56E-09	6.79E-12	1.13E-08	0.00E+00
Terpenes	Air	kg	0.00E+00	0.00E+00	1.98E-13	0.00E+00	6.29E-08
Thallium	Air	kg	0.00E+00	0.00E+00	2.99E-13	0.00E+00	4.07E-08
Thorium	Air	kg	0.00E+00	0.00E+00	2.55E-13	0.00E+00	4.84E-08
Thorium-228	Air	Bq	0.00E+00	0.00E+00	6.43E-06	0.00E+00	2.50E-01
Thorium-230	Air	Bq	0.00E+00	0.00E+00	1.20E-05	0.00E+00	1.50E+00
Thorium-232	Air	Bq	0.00E+00	0.00E+00	9.40E-06	0.00E+00	2.81E-01
Thorium-234	Air	Bq	0.00E+00	0.00E+00	3.20E-06	0.00E+00	6.53E-02
Tin	Air	kg	0.00E+00	0.00E+00	2.12E-11	0.00E+00	7.25E-08
Titanium	Air	kg	0.00E+00	0.00E+00	7.57E-10	0.00E+00	2.36E-05
TOC, Total Organic Carbon	Air	kg	0.00E+00	1.53E-02	9.90E-09	1.65E-05	0.00E+00
Toluene	Air	kg	2.44E-04	2.25E-03	7.77E-07	1.15E-04	2.98E-03
Toluene, 2-chloro-	Air	kg	0.00E+00	0.00E+00	1.48E-16	0.00E+00	4.30E-04
Toluene, 2,4-dinitro-	Air	kg	9.30E-12	1.00E-10	1.89E-13	9.43E-11	3.39E-10
Trichloroethane	Air	kg	0.00E+00	7.00E-08	1.82E-07	9.23E-08	0.00E+00
Trimethylamine	Air	kg	0.00E+00	0.00E+00	3.97E-19	0.00E+00	1.07E-14
Tungsten	Air	kg	0.00E+00	0.00E+00	4.38E-12	0.00E+00	8.65E-08
Uranium	Air	kg	0.00E+00	0.00E+00	3.39E-13	0.00E+00	6.40E-08
Uranium-234	Air	Bq	0.00E+00	0.00E+00	3.74E-05	0.00E+00	2.01E+00
Uranium-235	Air	Bq	0.00E+00	0.00E+00	1.81E-06	0.00E+00	3.58E-02
Uranium-238	Air	Bq	0.00E+00	0.00E+00	6.06E-05	0.00E+00	2.69E+00
Uranium alpha	Air	Bq	0.00E+00	0.00E+00	1.74E-04	0.00E+00	3.45E+00
Vanadium	Air	kg	0.00E+00	0.00E+00	1.90E-07	0.00E+00	6.77E-05
Vinyl acetate	Air	kg	2.52E-10	2.72E-09	5.13E-12	2.56E-09	9.20E-09
VOC, volatile organic compounds	Air	kg	6.37E-02	1.08E+00	7.12E-02	3.18E+00	4.66E-01
Water	Air	kg	0.00E+00	0.00E+00	1.07E-07	0.00E+00	5.36E-04
Wood (dust)	Air	kg	0.00E+00	3.89E-02	8.04E-03	8.34E-01	0.00E+00
Xenon-131m	Air	Bq	0.00E+00	0.00E+00	7.81E-04	0.00E+00	2.01E+01
Xenon-133	Air	Bq	0.00E+00	0.00E+00	2.45E-02	0.00E+00	6.58E+02
Xenon-133m	Air	Bq	0.00E+00	0.00E+00	1.13E-04	0.00E+00	2.33E+00
Xenon-135	Air	Bq	0.00E+00	0.00E+00	1.01E-02	0.00E+00	2.68E+02
Xenon-135m	Air	Bq	0.00E+00	0.00E+00	5.91E-03	0.00E+00	1.61E+02
Xenon-137	Air	Bq	0.00E+00	0.00E+00	1.07E-04	0.00E+00	3.56E+00
Xenon-138	Air	Bq	0.00E+00	0.00E+00	9.69E-04	0.00E+00	2.98E+01
Xylene	Air	kg	1.70E-04	1.31E-03	5.01E-07	6.77E-05	1.48E-04
Zinc	Air	kg	1.79E-05	1.91E-06	9.79E-09	1.63E-06	5.56E-05
Zinc-65	Air	Bq	0.00E+00	0.00E+00	6.93E-10	0.00E+00	2.55E-05
Zirconium	Air	kg	0.00E+00	0.00E+00	9.69E-16	0.00E+00	6.06E-09
Zirconium-95	Air	Bq	0.00E+00	0.00E+00	6.77E-10	0.00E+00	2.49E-05
1-Butanol	Water	kg	0.00E+00	0.00E+00	6.28E-09	0.00E+00	4.01E-04
1-Pentanol	Water	kg	0.00E+00	0.00E+00	1.53E-16	0.00E+00	9.39E-13
1-Pentene	Water	kg	0.00E+00	0.00E+00	1.16E-16	0.00E+00	7.10E-13
1-Propanol	Water	kg	0.00E+00	0.00E+00	2.11E-16	0.00E+00	1.35E-12
1,4-Butanediol	Water	kg	0.00E+00	0.00E+00	1.86E-17	0.00E+00	1.77E-04
2-Aminopropanol	Water	kg	0.00E+00	0.00E+00	2.36E-18	0.00E+00	2.27E-04
2-Hexanone	Water	kg	1.01E-06	3.32E-06	1.83E-08	8.98E-06	3.17E-06
2-Methyl-1-propanol	Water	kg	0.00E+00	0.00E+00	2.78E-16	0.00E+00	2.06E-04
2-Methyl-2-butene	Water	kg	0.00E+00	0.00E+00	2.57E-20	0.00E+00	1.57E-16
2-Methyl-4-chlorophenoxyacetic acid	Water	kg	0.00E+00	3.82E-12	3.03E-15	5.05E-12	0.00E+00
2-Propanol	Water	kg	0.00E+00	8.88E-09	5.81E-11	1.17E-08	9.02E-04

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
2,4-D	Water	kg	0.00E+00	2.05E-10	1.63E-13	2.70E-10	0.00E+00
4-Methyl-2-pentanone	Water	kg	6.51E-07	2.12E-06	1.18E-08	5.78E-06	2.04E-06
Acenaphthene	Water	kg	0.00E+00	0.00E+00	8.18E-13	0.00E+00	1.08E-09
Acenaphthylene	Water	kg	0.00E+00	0.00E+00	5.12E-14	0.00E+00	6.78E-11
Acetaldehyde	Water	kg	0.00E+00	6.58E-09	1.47E-08	5.84E-08	6.47E-03
Acetic acid	Water	kg	0.00E+00	0.00E+00	2.62E-11	0.00E+00	2.44E-02
Acetochlor	Water	kg	0.00E+00	2.84E-09	2.25E-12	3.75E-09	0.00E+00
Acetone	Water	kg	1.55E-06	5.05E-06	2.80E-08	1.37E-05	4.93E-04
Acetonitrile	Water	kg	0.00E+00	0.00E+00	4.67E-18	0.00E+00	7.49E-05
Acetyl chloride	Water	kg	0.00E+00	0.00E+00	1.20E-16	0.00E+00	7.38E-13
Acidity, unspecified	Water	kg	0.00E+00	3.26E-04	6.78E-12	7.14E-05	4.80E-05
Acids, unspecified	Water	kg	1.40E-09	1.26E-05	3.45E-08	1.67E-05	1.74E-04
Acrylate	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-14
Acrylate, ion	Water	kg	0.00E+00	0.00E+00	3.74E-16	0.00E+00	1.62E-12
Actinides, radioactive, unspecified	Water	Bq	0.00E+00	0.00E+00	3.83E-05	0.00E+00	7.45E-01
Alachlor	Water	kg	0.00E+00	2.80E-10	2.22E-13	3.69E-10	0.00E+00
Aluminium	Water	kg	1.16E-02	1.81E-02	1.88E-04	5.00E-02	5.63E-02
Ammonia	Water	kg	2.73E-03	7.53E-03	4.99E-05	1.92E-02	7.39E-03
Ammonia, as N	Water	kg	7.05E-10	2.45E-08	8.30E-06	4.38E-08	1.23E-08
Ammonium, ion	Water	kg	5.77E-07	1.31E-04	2.17E-05	8.80E-04	9.44E-02
Aniline	Water	kg	0.00E+00	0.00E+00	8.90E-16	0.00E+00	1.42E-03
Antimony	Water	kg	7.21E-06	9.90E-06	1.05E-07	2.85E-05	7.42E-05
Antimony-122	Water	Bq	0.00E+00	0.00E+00	1.04E-08	0.00E+00	3.82E-04
Antimony-124	Water	Bq	0.00E+00	0.00E+00	6.19E-06	0.00E+00	1.27E-01
Antimony-125	Water	Bq	0.00E+00	0.00E+00	5.67E-06	0.00E+00	1.16E-01
AOX, Adsorbable Organic Halogen as Cl	Water	kg	0.00E+00	0.00E+00	1.17E-10	0.00E+00	2.60E-05
Arsenic	Water	kg	8.26E-05	1.19E-04	7.25E-07	3.23E-04	1.18E-04
Arsenic, ion	Water	kg	0.00E+00	0.00E+00	6.34E-09	0.00E+00	8.34E-05
Atrazine	Water	kg	0.00E+00	5.54E-09	4.39E-12	7.31E-09	0.00E+00
Barite	Water	kg	0.00E+00	0.00E+00	1.72E-11	0.00E+00	1.09E-07
Barium	Water	kg	1.59E-01	2.33E-01	2.32E-03	6.65E-01	2.99E-01
Barium-140	Water	Bq	0.00E+00	0.00E+00	4.54E-08	0.00E+00	1.67E-03
Bentazone	Water	kg	0.00E+00	2.26E-11	1.79E-14	2.98E-11	0.00E+00
Benzene	Water	kg	2.60E-04	4.59E-02	4.72E-06	1.15E-01	7.91E-02
Benzene, 1-methyl-4-(1-methylethyl)-	Water	kg	1.55E-08	5.05E-08	2.80E-10	1.37E-07	4.84E-08
Benzene, 1,2-dichloro-	Water	kg	0.00E+00	0.00E+00	1.27E-15	0.00E+00	2.14E-03
Benzene, chloro-	Water	kg	0.00E+00	0.00E+00	2.04E-14	0.00E+00	3.18E-02
Benzene, ethyl-	Water	kg	1.46E-05	4.78E-05	2.67E-07	1.30E-04	5.01E-05
Benzene, pentamethyl-	Water	kg	1.16E-08	3.78E-08	2.10E-10	1.03E-07	3.63E-08
Benzenes, alkylated, unspecified	Water	kg	6.32E-06	9.46E-06	9.12E-08	2.49E-05	1.15E-05
Benzo(a)pyrene	Water	kg	0.00E+00	5.56E-14	5.58E-11	7.34E-14	0.00E+00
Benzoic acid	Water	kg	1.57E-04	5.15E-04	2.84E-06	1.39E-03	4.92E-04
Beryllium	Water	kg	2.22E-06	5.58E-06	3.84E-08	1.54E-05	2.90E-05
Biphenyl	Water	kg	4.09E-07	6.13E-07	5.90E-09	1.61E-06	7.42E-07
BOD5, Biological Oxygen Demand	Water	kg	2.81E-02	5.22E-01	7.27E-04	1.30E+00	8.77E-01
Borate	Water	kg	0.00E+00	0.00E+00	1.17E-14	0.00E+00	1.29E-02
Boron	Water	kg	4.86E-04	1.59E-03	8.87E-06	4.32E-03	2.07E-03
Bromate	Water	kg	0.00E+00	0.00E+00	6.89E-11	0.00E+00	1.76E-03
Bromide	Water	kg	3.32E-02	1.08E-01	6.00E-04	2.95E-01	4.32E-01
Bromine	Water	kg	0.00E+00	0.00E+00	9.28E-08	0.00E+00	1.84E-04
Bromoxynil	Water	kg	0.00E+00	2.99E-11	2.37E-14	3.94E-11	0.00E+00
Butene	Water	kg	0.00E+00	0.00E+00	6.94E-11	0.00E+00	6.48E-04
Butyl acetate	Water	kg	0.00E+00	0.00E+00	8.16E-09	0.00E+00	2.15E-05
Butyrolactone	Water	kg	0.00E+00	0.00E+00	2.27E-18	0.00E+00	9.99E-15

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Cadmium	Water	kg	1.99E-05	1.79E-05	1.12E-07	4.84E-05	1.76E-05
Cadmium, ion	Water	kg	0.00E+00	0.00E+00	2.16E-09	0.00E+00	1.10E-05
Calcium	Water	kg	4.98E-01	1.63E+00	9.00E-03	4.42E+00	1.59E+00
Calcium, ion	Water	kg	0.00E+00	0.00E+00	2.36E-05	0.00E+00	4.62E-01
Carbofuran	Water	kg	0.00E+00	4.23E-11	3.36E-14	5.59E-11	0.00E+00
Carbon disulfide	Water	kg	0.00E+00	0.00E+00	7.38E-15	0.00E+00	4.58E-11
Carbonate	Water	kg	0.00E+00	0.00E+00	5.04E-10	0.00E+00	1.56E-01
Carboxylic acids, unspecified	Water	kg	0.00E+00	0.00E+00	5.66E-07	0.00E+00	7.47E-04
Cerium-141	Water	Bq	0.00E+00	0.00E+00	1.81E-08	0.00E+00	6.68E-04
Cerium-144	Water	Bq	0.00E+00	0.00E+00	5.52E-09	0.00E+00	2.03E-04
Cesium	Water	kg	0.00E+00	0.00E+00	1.32E-10	0.00E+00	1.74E-07
Cesium-134	Water	Bq	0.00E+00	0.00E+00	5.29E-06	0.00E+00	1.02E-01
Cesium-136	Water	Bq	0.00E+00	0.00E+00	3.22E-09	0.00E+00	1.19E-04
Cesium-137	Water	Bq	0.00E+00	0.00E+00	4.40E-03	0.00E+00	8.58E+01
CFCs, unspecified	Water	kg	0.00E+00	8.88E-09	5.81E-11	1.17E-08	2.68E-07
Chloramine	Water	kg	0.00E+00	0.00E+00	2.01E-15	0.00E+00	2.16E-03
Chlorate	Water	kg	0.00E+00	0.00E+00	5.90E-10	0.00E+00	1.34E-02
Chloride	Water	kg	5.60E+00	1.83E+01	1.01E-01	4.97E+01	2.41E+01
Chlorinated solvents, unspecified	Water	kg	0.00E+00	0.00E+00	2.31E-12	0.00E+00	9.70E-06
Chlorine	Water	kg	0.00E+00	0.00E+00	1.61E-11	0.00E+00	9.26E-07
Chloroacetic acid	Water	kg	0.00E+00	0.00E+00	1.03E-13	0.00E+00	5.81E-02
Chloroacetyl chloride	Water	kg	0.00E+00	0.00E+00	3.15E-18	0.00E+00	3.03E-04
Chloroform	Water	kg	0.00E+00	2.06E-08	8.52E-17	0.00E+00	2.66E-04
Chlorosulfonic acid	Water	kg	0.00E+00	0.00E+00	1.70E-17	0.00E+00	2.72E-04
Chlorpyrifos	Water	kg	0.00E+00	3.26E-10	2.58E-13	4.30E-10	0.00E+00
Chromate	Water	kg	0.00E+00	1.18E-12	4.49E-14	1.56E-12	3.49E-11
Chromium	Water	kg	3.56E-04	2.53E-04	4.20E-06	9.88E-04	5.09E-04
Chromium-51	Water	Bq	0.00E+00	0.00E+00	6.17E-06	0.00E+00	1.76E-01
Chromium III	Water	kg	3.35E-05	1.94E-04	5.23E-07	3.02E-04	8.66E-05
Chromium VI	Water	kg	1.23E-06	8.84E-07	2.27E-08	2.92E-06	1.56E-04
Chromium, ion	Water	kg	0.00E+00	0.00E+00	3.72E-10	0.00E+00	8.68E-06
Cobalt	Water	kg	3.43E-06	1.12E-05	8.80E-08	3.05E-05	3.58E-04
Cobalt-57	Water	Bq	0.00E+00	0.00E+00	1.02E-07	0.00E+00	3.76E-03
Cobalt-58	Water	Bq	0.00E+00	0.00E+00	4.78E-05	0.00E+00	1.16E+00
Cobalt-60	Water	Bq	0.00E+00	0.00E+00	3.72E-05	0.00E+00	9.29E-01
COD, Chemical Oxygen Demand	Water	kg	5.22E-02	6.00E-01	1.05E-03	1.49E+00	9.30E-01
Copper	Water	kg	6.94E-05	1.35E-04	1.11E-06	3.33E-04	1.39E-04
Copper, ion	Water	kg	0.00E+00	0.00E+00	2.69E-08	0.00E+00	2.89E-04
Cumene	Water	kg	0.00E+00	6.60E-02	2.55E-08	1.65E-01	6.34E-02
Cyanazine	Water	kg	0.00E+00	4.88E-11	3.87E-14	6.44E-11	0.00E+00
Cyanide	Water	kg	1.12E-08	5.73E-08	7.76E-09	9.96E-08	3.01E-04
Decane	Water	kg	4.52E-06	1.48E-05	8.16E-08	4.01E-05	1.41E-05
Detergent, oil	Water	kg	1.34E-04	4.86E-04	2.52E-06	1.32E-03	4.55E-04
Dibenzofuran	Water	kg	2.95E-08	9.60E-08	5.32E-10	2.61E-07	9.22E-08
Dibenzothiophene	Water	kg	2.51E-08	7.96E-08	4.50E-10	2.17E-07	7.70E-08
Dicamba	Water	kg	0.00E+00	2.88E-10	2.28E-13	3.80E-10	0.00E+00
Dichromate	Water	kg	0.00E+00	0.00E+00	1.42E-15	0.00E+00	1.57E-10
Diethylamine	Water	kg	0.00E+00	0.00E+00	3.96E-16	0.00E+00	6.76E-04
Dimethenamid	Water	kg	0.00E+00	6.79E-10	5.39E-13	8.96E-10	0.00E+00
Dimethylamine	Water	kg	0.00E+00	0.00E+00	2.04E-16	0.00E+00	2.98E-03
Dipropylamine	Water	kg	0.00E+00	0.00E+00	2.52E-16	0.00E+00	3.03E-04
Dipropylthiocarbamic acid S-ethyl ester	Water	kg	0.00E+00	2.81E-10	2.23E-13	3.70E-10	0.00E+00
Dissolved organics	Water	kg	0.00E+00	2.09E-04	0.00E+00	4.57E-05	0.00E+00
Disulfoton	Water	kg	0.00E+00	1.68E-11	1.33E-14	2.21E-11	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Diuron	Water	kg	0.00E+00	4.71E-12	3.73E-15	6.21E-12	0.00E+00
DOC, Dissolved Organic Carbon	Water	kg	4.31E-12	1.22E-01	8.91E-06	3.04E-01	2.06E-01
Docosane	Water	kg	1.66E-07	5.40E-07	3.00E-09	1.47E-06	5.19E-07
Dodecane	Water	kg	8.57E-06	2.81E-05	1.55E-07	7.60E-05	2.68E-05
Eicosane	Water	kg	2.36E-06	7.73E-06	4.26E-08	2.09E-05	7.38E-06
Ethane, 1,2-dichloro-	Water	kg	0.00E+00	0.00E+00	2.00E-12	0.00E+00	1.18E-03
Ethanol	Water	kg	0.00E+00	0.00E+00	1.44E-08	0.00E+00	2.06E-02
Ethene	Water	kg	0.00E+00	0.00E+00	1.39E-10	0.00E+00	1.86E-04
Ethene, chloro-	Water	kg	0.00E+00	0.00E+00	1.56E-14	0.00E+00	3.44E-08
Ethyl acetate	Water	kg	0.00E+00	0.00E+00	4.20E-16	0.00E+00	9.26E-07
Ethylamine	Water	kg	0.00E+00	0.00E+00	1.78E-16	0.00E+00	6.25E-04
Ethylene diamine	Water	kg	0.00E+00	0.00E+00	3.72E-15	0.00E+00	2.22E-11
Ethylene oxide	Water	kg	0.00E+00	0.00E+00	2.83E-15	0.00E+00	1.01E-03
Fluorene	Water	kg	0.00E+00	2.91E-08	8.69E-14	1.09E-12	0.00E+00
Fluorene, 1-methyl-	Water	kg	1.76E-08	5.75E-08	3.19E-10	1.56E-07	5.52E-08
Fluorenes, alkylated, unspecified	Water	kg	3.66E-07	5.48E-07	5.28E-09	1.45E-06	6.64E-07
Fluoride	Water	kg	1.23E-01	8.71E-04	8.55E-06	1.69E-03	1.68E-02
Fluorine	Water	kg	1.83E-07	2.68E-07	2.68E-09	7.86E-07	3.49E-07
Fluosilicic acid	Water	kg	0.00E+00	0.00E+00	1.52E-12	0.00E+00	5.15E-07
Formaldehyde	Water	kg	0.00E+00	0.00E+00	5.01E-06	0.00E+00	1.21E-02
Formamide	Water	kg	0.00E+00	0.00E+00	2.80E-16	0.00E+00	1.72E-12
Formate	Water	kg	0.00E+00	0.00E+00	3.19E-15	0.00E+00	4.83E-02
Formic acid	Water	kg	0.00E+00	0.00E+00	8.14E-17	0.00E+00	4.99E-13
Furan	Water	kg	0.00E+00	3.26E-10	2.13E-12	4.30E-10	9.61E-09
Glutaraldehyde	Water	kg	0.00E+00	0.00E+00	2.12E-15	0.00E+00	1.34E-11
Glyphosate	Water	kg	0.00E+00	6.11E-10	4.84E-13	8.06E-10	0.00E+00
Heat, waste	Water	MJ	0.00E+00	0.00E+00	2.29E-03	0.00E+00	2.58E+01
Hexadecane	Water	kg	9.35E-06	3.06E-05	1.69E-07	8.30E-05	2.93E-05
Hexanoic acid	Water	kg	3.25E-05	1.07E-04	5.88E-07	2.89E-04	1.02E-04
Hydrocarbons, aliphatic, alkanes, unspecified	Water	kg	0.00E+00	0.00E+00	1.71E-08	0.00E+00	2.26E-05
Hydrocarbons, aliphatic, unsaturated	Water	kg	0.00E+00	0.00E+00	1.58E-09	0.00E+00	2.54E-04
Hydrocarbons, aromatic	Water	kg	0.00E+00	0.00E+00	6.94E-08	0.00E+00	9.25E-05
Hydrocarbons, unspecified	Water	kg	5.39E-12	3.26E-07	2.78E-09	4.30E-07	3.69E-04
Hydrogen-3, Tritium	Water	Bq	0.00E+00	0.00E+00	1.01E+01	0.00E+00	1.96E+05
Hydrogen peroxide	Water	kg	0.00E+00	0.00E+00	2.24E-13	0.00E+00	8.79E-06
Hydrogen sulfide	Water	kg	0.00E+00	0.00E+00	3.06E-10	0.00E+00	3.83E-06
Hydroxide	Water	kg	0.00E+00	0.00E+00	1.21E-14	0.00E+00	1.20E-04
Hypochlorite	Water	kg	0.00E+00	0.00E+00	5.46E-10	0.00E+00	1.05E-05
Iodide	Water	kg	0.00E+00	0.00E+00	1.32E-08	0.00E+00	1.28E-01
Iodine-131	Water	Bq	0.00E+00	0.00E+00	1.12E-06	0.00E+00	2.38E-02
Iodine-133	Water	Bq	0.00E+00	0.00E+00	2.85E-08	0.00E+00	1.05E-03
Iron	Water	kg	2.36E-02	4.51E-02	3.99E-04	1.23E-01	5.19E-02
Iron-59	Water	Bq	0.00E+00	0.00E+00	7.83E-09	0.00E+00	2.88E-04
Iron, ion	Water	kg	0.00E+00	0.00E+00	2.94E-06	0.00E+00	4.63E-02
Isopropylamine	Water	kg	0.00E+00	0.00E+00	1.43E-17	0.00E+00	3.91E-04
Lactic acid	Water	kg	0.00E+00	0.00E+00	1.97E-16	0.00E+00	2.37E-04
Lanthanum-140	Water	Bq	0.00E+00	0.00E+00	4.83E-08	0.00E+00	1.78E-03
Lead	Water	kg	1.03E-04	1.93E-04	1.40E-06	5.29E-04	2.61E-04
Lead-210	Water	Bq	0.00E+00	0.00E+00	8.88E-05	0.00E+00	1.34E+00
Lead-210/kg	Water	kg	1.61E-14	5.28E-14	2.91E-16	1.43E-13	5.04E-14
Lithium	Water	kg	3.54E-02	4.47E-01	1.27E-03	1.16E+00	3.38E-01
Lithium, ion	Water	kg	0.00E+00	0.00E+00	5.27E-13	0.00E+00	4.31E-08
m-Xylene	Water	kg	4.69E-06	1.54E-05	8.48E-08	4.17E-05	1.47E-05
Magnesium	Water	kg	9.73E-02	3.18E-01	1.77E-03	8.64E-01	6.14E-01

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Manganese	Water	kg	1.72E-04	1.92E-03	1.73E-05	4.16E-03	1.38E-02
Manganese-54	Water	Bq	0.00E+00	0.00E+00	2.95E-06	0.00E+00	7.09E-02
Mercury	Water	kg	7.50E-07	2.50E-07	2.72E-09	6.38E-07	8.03E-06
Metallic ions, unspecified	Water	kg	6.58E-11	9.45E-09	5.36E-11	1.35E-08	3.38E-04
Methane, dichloro-, HCC-30	Water	kg	0.00E+00	0.00E+00	3.00E-14	0.00E+00	3.31E-04
Methane, monochloro-, R-40	Water	kg	6.24E-09	2.03E-08	1.13E-10	5.53E-08	1.95E-08
Methanol	Water	kg	0.00E+00	0.00E+00	1.60E-08	0.00E+00	3.04E-03
Methyl acetate	Water	kg	0.00E+00	0.00E+00	5.33E-19	0.00E+00	1.28E-04
Methyl acrylate	Water	kg	0.00E+00	0.00E+00	3.51E-15	0.00E+00	1.54E-11
Methyl amine	Water	kg	0.00E+00	0.00E+00	6.20E-17	0.00E+00	6.65E-05
Methyl ethyl ketone	Water	kg	1.25E-08	4.07E-08	2.25E-10	1.11E-07	3.90E-08
Methyl formate	Water	kg	0.00E+00	0.00E+00	2.36E-08	0.00E+00	7.68E-14
Methylamine	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.78E-17
Metolachlor	Water	kg	0.00E+00	2.24E-09	1.78E-12	2.96E-09	0.00E+00
Metribuzin	Water	kg	0.00E+00	1.04E-11	8.25E-15	1.37E-11	0.00E+00
Molybdenum	Water	kg	3.56E-06	1.17E-05	7.02E-08	3.16E-05	9.88E-05
Molybdenum-99	Water	Bq	0.00E+00	0.00E+00	1.67E-08	0.00E+00	6.14E-04
n-Hexacosane	Water	kg	1.03E-07	3.37E-07	1.87E-09	9.18E-07	3.24E-07
Naphthalene	Water	kg	2.82E-06	9.23E-06	5.05E-08	2.50E-05	8.81E-06
Naphthalene, 2-methyl-	Water	kg	2.45E-06	8.04E-06	4.43E-08	2.18E-05	7.68E-06
Naphthalenes, alkylated, unspecified	Water	kg	1.04E-07	1.55E-07	1.49E-09	4.09E-07	1.88E-07
Nickel	Water	kg	6.01E-05	9.82E-05	6.52E-07	2.70E-04	1.05E-04
Nickel, ion	Water	kg	0.00E+00	0.00E+00	9.44E-08	0.00E+00	1.46E-03
Niobium-95	Water	Bq	0.00E+00	0.00E+00	4.80E-07	0.00E+00	1.00E-02
Nitrate	Water	kg	4.72E-13	1.06E-06	8.59E-07	1.39E-06	8.77E-02
Nitrate compounds	Water	kg	1.90E-11	8.68E-10	5.18E-12	1.18E-09	3.31E-10
Nitric acid	Water	kg	4.27E-08	1.48E-06	1.16E-08	2.65E-06	7.43E-07
Nitrite	Water	kg	0.00E+00	0.00E+00	1.75E-10	0.00E+00	3.11E-05
Nitrobenzene	Water	kg	0.00E+00	0.00E+00	1.99E-15	0.00E+00	3.77E-03
Nitrogen	Water	kg	0.00E+00	0.00E+00	8.97E-07	0.00E+00	1.13E-03
Nitrogen, organic bound	Water	kg	0.00E+00	0.00E+00	3.80E-08	0.00E+00	4.22E-05
Nitrogen, total	Water	kg	1.44E-06	1.70E-04	1.36E-06	3.07E-04	2.99E-04
o-Cresol	Water	kg	4.46E-06	1.46E-05	8.05E-08	3.96E-05	1.39E-05
o-Xylene	Water	kg	0.00E+00	6.13E-08	1.85E-13	2.32E-12	5.07E-10
Octadecane	Water	kg	2.31E-06	7.57E-06	4.18E-08	2.05E-05	7.23E-06
Oils, unspecified	Water	kg	3.47E-03	1.12E-02	7.57E-05	2.87E-02	2.31E-02
Organic substances, unspecified	Water	kg	0.00E+00	6.49E-09	1.75E-10	8.56E-09	2.35E-04
p-Cresol	Water	kg	4.81E-06	1.58E-05	8.69E-08	4.27E-05	1.50E-05
p-Xylene	Water	kg	0.00E+00	6.13E-08	1.85E-13	2.32E-12	0.00E+00
PAH, polycyclic aromatic hydrocarbons	Water	kg	0.00E+00	0.00E+00	7.67E-10	0.00E+00	1.03E-06
Paraffins	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-17
Paraquat	Water	kg	0.00E+00	4.54E-11	3.60E-14	6.00E-11	0.00E+00
Parathion, methyl	Water	kg	0.00E+00	3.43E-11	2.72E-14	4.53E-11	0.00E+00
Pendimethalin	Water	kg	0.00E+00	2.33E-10	1.85E-13	3.08E-10	0.00E+00
Permethrin	Water	kg	0.00E+00	2.10E-11	1.66E-14	2.77E-11	0.00E+00
Phenanthrene	Water	kg	3.90E-08	8.27E-08	6.13E-10	2.22E-07	8.89E-08
Phenanthrenes, alkylated, unspecified	Water	kg	4.30E-08	6.43E-08	6.19E-10	1.69E-07	7.79E-08
Phenol	Water	kg	5.44E-05	4.57E-05	7.37E-07	1.31E-04	6.13E-03
Phenol, 2,4-dimethyl-	Water	kg	4.34E-06	1.42E-05	7.84E-08	3.85E-05	1.36E-05
Phenols, unspecified	Water	kg	2.23E-05	1.95E-04	6.30E-07	5.05E-04	1.53E-04
Phorate	Water	kg	0.00E+00	6.49E-12	5.15E-15	8.57E-12	0.00E+00
Phosphate	Water	kg	9.27E-02	2.26E-04	3.25E-06	1.05E-04	5.61E-02
Phosphorus	Water	kg	0.00E+00	1.82E-05	1.52E-08	2.40E-05	1.81E-03
Phosphorus compounds, unspecified	Water	kg	0.00E+00	1.20E-07	9.54E-11	1.59E-07	0.00E+00

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Phosphorus, total	Water	kg	0.00E+00	1.07E-05	7.02E-08	1.42E-05	3.17E-04
Polonium-210	Water	Bq	0.00E+00	0.00E+00	1.06E-04	0.00E+00	1.47E+00
Potassium	Water	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-03
Potassium-40	Water	Bq	0.00E+00	0.00E+00	7.47E-05	0.00E+00	1.38E+00
Potassium, ion	Water	kg	0.00E+00	0.00E+00	6.16E-06	0.00E+00	1.47E-01
Process solvents, unspecified	Water	kg	0.00E+00	3.26E-08	2.13E-10	4.30E-08	9.61E-07
Propanal	Water	kg	0.00E+00	0.00E+00	2.22E-16	0.00E+00	1.36E-12
Propene	Water	kg	0.00E+00	2.43E-02	9.68E-09	6.07E-02	2.71E-02
Propionic acid	Water	kg	0.00E+00	0.00E+00	6.20E-17	0.00E+00	1.08E-03
Propylamine	Water	kg	0.00E+00	0.00E+00	8.87E-17	0.00E+00	5.44E-13
Propylene oxide	Water	kg	0.00E+00	0.00E+00	1.04E-11	0.00E+00	1.85E-04
Protactinium-234	Water	Bq	0.00E+00	0.00E+00	5.90E-05	0.00E+00	1.17E+00
Radioactive species, alpha emitters	Water	Bq	0.00E+00	0.00E+00	9.90E-08	0.00E+00	7.17E-01
Radioactive species, Nuclides, unspecified	Water	Bq	8.38E+01	7.78E+03	7.49E+01	1.51E+04	4.45E+03
Radium-224	Water	Bq	0.00E+00	0.00E+00	6.58E-03	0.00E+00	8.71E+00
Radium-226	Water	Bq	0.00E+00	0.00E+00	4.73E-02	0.00E+00	7.43E+02
Radium-226/kg	Water	kg	5.60E-12	1.84E-11	1.01E-13	4.97E-11	1.75E-11
Radium-228	Water	Bq	0.00E+00	0.00E+00	1.32E-02	0.00E+00	1.75E+01
Radium-228/kg	Water	kg	2.86E-14	9.39E-14	5.18E-16	2.54E-13	8.96E-14
Rubidium	Water	kg	0.00E+00	0.00E+00	1.32E-09	0.00E+00	1.74E-06
Ruthenium-103	Water	Bq	0.00E+00	0.00E+00	3.51E-09	0.00E+00	1.30E-04
Scandium	Water	kg	0.00E+00	0.00E+00	2.46E-09	0.00E+00	3.95E-05
Selenium	Water	kg	1.60E-06	2.07E-05	2.04E-07	4.19E-05	6.49E-05
Silicon	Water	kg	0.00E+00	0.00E+00	1.73E-05	0.00E+00	2.70E-01
Silver	Water	kg	3.25E-04	1.06E-03	5.87E-06	2.88E-03	1.02E-03
Silver-110	Water	Bq	0.00E+00	0.00E+00	3.44E-05	0.00E+00	8.72E-01
Silver, ion	Water	kg	0.00E+00	0.00E+00	2.26E-10	0.00E+00	8.12E-07
Simazine	Water	kg	0.00E+00	1.47E-10	1.17E-13	1.95E-10	0.00E+00
Sodium	Water	kg	1.58E+00	5.15E+00	2.85E-02	1.40E+01	5.07E+00
Sodium-24	Water	Bq	0.00E+00	0.00E+00	1.26E-07	0.00E+00	4.64E-03
Sodium formate	Water	kg	0.00E+00	0.00E+00	1.41E-13	0.00E+00	3.68E-09
Sodium, ion	Water	kg	0.00E+00	0.00E+00	4.82E-05	0.00E+00	3.85E+00
Solids, inorganic	Water	kg	1.08E-10	3.77E-09	1.64E-05	6.75E-09	3.69E-02
Solved solids	Water	kg	0.00E+00	0.00E+00	1.05E-06	0.00E+00	3.98E-03
Strontium	Water	kg	8.45E-03	2.77E-02	1.53E-04	7.50E-02	3.24E-02
Strontium-89	Water	Bq	0.00E+00	0.00E+00	6.15E-07	0.00E+00	1.66E-02
Strontium-90	Water	Bq	0.00E+00	0.00E+00	3.33E-02	0.00E+00	6.34E+02
Styrene	Water	kg	0.00E+00	3.69E-09	3.06E-13	2.11E-09	1.99E-09
Sulfate	Water	kg	1.25E-02	1.46E-01	1.33E-03	3.12E-01	2.03E+00
Sulfide	Water	kg	6.31E-06	1.26E-04	3.70E-07	1.73E-04	3.26E-03
Sulfite	Water	kg	0.00E+00	0.00E+00	1.48E-09	0.00E+00	2.86E-05
Sulfur	Water	kg	4.10E-04	1.34E-03	7.44E-06	3.64E-03	8.23E-03
Sulfuric acid	Water	kg	0.00E+00	2.85E-10	3.08E-11	3.76E-10	8.41E-09
Surfactants	Water	kg	0.00E+00	2.89E-06	8.56E-12	1.08E-10	0.00E+00
Suspended solids, inorganic	Water	kg	0.00E+00	0.00E+00	2.52E-05	0.00E+00	5.59E-03
Suspended solids, unspecified	Water	kg	7.26E+00	2.38E+01	1.31E-01	6.31E+01	2.24E+01
t-Butyl methyl ether	Water	kg	0.00E+00	0.00E+00	2.82E-10	0.00E+00	5.17E-07
t-Butylamine	Water	kg	0.00E+00	0.00E+00	2.49E-17	0.00E+00	3.76E-04
Tar	Water	kg	1.07E-12	3.74E-11	2.93E-13	6.69E-11	1.87E-11
Technetium-99m	Water	Bq	0.00E+00	0.00E+00	3.86E-07	0.00E+00	1.42E-02
Tellurium-123m	Water	Bq	0.00E+00	0.00E+00	6.80E-07	0.00E+00	1.33E-02
Tellurium-132	Water	Bq	0.00E+00	0.00E+00	9.64E-10	0.00E+00	3.55E-05
Terbufos	Water	kg	0.00E+00	2.21E-10	1.76E-13	2.92E-10	0.00E+00
Tetradecane	Water	kg	3.76E-06	1.23E-05	6.79E-08	3.33E-05	1.18E-05

Substance	Compart-ment	Unit	Forest operations	OSB	FJL	LVL	I-joists
Thallium	Water	kg	1.52E-06	2.09E-06	2.21E-08	6.01E-06	4.39E-06
Thorium-228	Water	Bq	0.00E+00	0.00E+00	2.63E-02	0.00E+00	3.48E+01
Thorium-230	Water	Bq	0.00E+00	0.00E+00	8.05E-03	0.00E+00	1.60E+02
Thorium-232	Water	Bq	0.00E+00	0.00E+00	1.32E-05	0.00E+00	2.51E-01
Thorium-234	Water	Bq	0.00E+00	0.00E+00	5.90E-05	0.00E+00	1.17E+00
Tin	Water	kg	3.11E-05	6.66E-05	4.94E-07	1.85E-04	7.40E-05
Tin, ion	Water	kg	0.00E+00	0.00E+00	1.97E-09	0.00E+00	1.05E-05
Titanium	Water	kg	1.11E-04	1.52E-04	1.60E-06	4.37E-04	2.07E-04
Titanium, ion	Water	kg	0.00E+00	0.00E+00	4.02E-08	0.00E+00	9.58E-04
TOC, Total Organic Carbon	Water	kg	0.00E+00	1.22E-01	8.92E-06	3.04E-01	2.07E-01
Toluene	Water	kg	2.46E-04	8.02E-04	4.45E-06	2.18E-03	2.88E-03
Toluene, 2-chloro-	Water	kg	0.00E+00	0.00E+00	3.09E-16	0.00E+00	7.56E-04
Tributyltin compounds	Water	kg	0.00E+00	0.00E+00	1.31E-10	0.00E+00	3.29E-07
Triethylene glycol	Water	kg	0.00E+00	0.00E+00	4.94E-09	0.00E+00	3.64E-06
Trimethylamine	Water	kg	0.00E+00	0.00E+00	9.52E-19	0.00E+00	2.57E-14
Tungsten	Water	kg	0.00E+00	0.00E+00	2.53E-09	0.00E+00	7.50E-06
Uranium-234	Water	Bq	0.00E+00	0.00E+00	7.08E-05	0.00E+00	1.40E+00
Uranium-235	Water	Bq	0.00E+00	0.00E+00	1.17E-04	0.00E+00	2.32E+00
Uranium-238	Water	Bq	0.00E+00	0.00E+00	2.23E-04	0.00E+00	4.19E+00
Uranium alpha	Water	Bq	0.00E+00	0.00E+00	3.40E-03	0.00E+00	6.74E+01
Urea	Water	kg	0.00E+00	0.00E+00	2.55E-16	0.00E+00	1.58E-12
Vanadium	Water	kg	4.21E-06	1.42E-05	7.60E-08	3.73E-05	1.47E-05
Vanadium, ion	Water	kg	0.00E+00	0.00E+00	6.64E-09	0.00E+00	1.34E-04
VOC, volatile organic compounds, unspecified origin	Water	kg	0.00E+00	0.00E+00	4.62E-08	0.00E+00	6.39E-05
Waste water/m3	Water	m3	0.00E+00	2.68E-03	3.63E-05	3.54E-03	0.00E+00
Xylene	Water	kg	1.31E-04	4.18E-04	2.36E-06	1.14E-03	4.22E-04
Yttrium	Water	kg	1.04E-06	3.42E-06	1.89E-08	9.27E-06	3.27E-06
Zinc	Water	kg	2.69E-04	4.83E-04	4.74E-06	1.30E-03	6.54E-04

21 APPENDIX F: PRODUCTION FACILITY SURVEY QUESTIONNAIRES

CORRIM SURVEY

The Consortium for Research on Renewable Industrial Materials (CORRIM)

Laminated Veneer Lumber (LVL) and Composite I-Joist Plants

2014

The information from this survey will be used in a project by CORRIM, a consortium of universities, industry, and government groups. In collaboration with the USDA Forest Service Forest Products Laboratory, APA-The Engineered Wood Association, and the American Wood Council, CORRIM is updating life-cycle assessment data that describes environmental impacts of building materials. This CORRIM survey is designed specifically for LVL and composite I-joist plants. There are three sections for this survey. The three sections are the LVL plant (pg. 3-11), the veneer mill (pg. 12-19), and the I-joist plant (pg. 20-29). Please complete the section(s) that apply to your facilities. Emission data are requested for each section.

Questions will be concentrated on **annual production**, electricity production and usage, fuel consumption, material flows, and environmental emissions. We realize that you may not have all the information requested, especially when it comes to specific equipment/processing groups or what we call 'machine centers'. The data you are able to provide will be appreciated.

Your data will be confidential; only weight-averaged values based on production for the industry will be reported.

Company: _____

Facility Site (city, state): _____

Should we have a follow-up question about the data, please provide the name and the following information for the contact in your company.

Name: _____ Title: _____

Telephone: _____ Email: _____

Please send the complete survey to the following email or address by March 3rd. If you have questions about the survey, contact:

Rick Bergman
Research Forest Products Technologist,
USDA Forest Service Forest Products Laboratory
One Gifford Pinchot Dr,
Madison, WI 53726-2398
(608) 231-9477 (ph) / (608) 231-9508 (fax)
rbergman@fs.fed.us

General Plant Information

Yes	No	Equipment in mill
O	O	Veneer dryer (for redry)
O	O	conventional steam, #: _____
O	O	high temp (>212F) steam # _____
O	O	direct fire, # _____
O	O	continuous, # _____
O	O	other:_____
O	O	Hot pressing
O	O	Hot press(es), #_____
		year built or updated:_____
O	O	heating system
O	O	hot oil (fired by nat. gas)
O	O	microwave
O	O	radio-frequency
		pressure (psig) _____
		temperature (°F) _____
		press time (min:sec) _____
O	O	Precipitator
O	O	Bag house
O	O	Other pollution controls?
O	O	Layup of LVL billets
O	O	Resin
O	O	phenol-formaldehyde
O	O	other _____
O	O	other _____
		Inputs
O	O	PLV
O	O	veneer
O	O	Sawing/trimming of LVL
O	O	Resaw
O	O	Rip saw
O	O	In-line moisture meter
O	O	Automatic grading (visual grades)
O	O	Manual grading (visual grades)
O	O	Machine grading (MSR grades)
O	O	End Trim
O	O	Wrap LVL, material _____
O	O	Steel strapping
O	O	Plastic strapping
O	O	Cardboard corners
O	O	other:_____
O	O	other:_____
O	O	other:_____
O	O	Bag house
O	O	Other pollution control

Yes	No	Equipment in mill (continued)
O	O	Boiler / cogen
O	O	wood boiler(s), #_____
O	O	gas boiler(s), #_____
O	O	oil boiler(s), #_____
O	O	propane boiler(s), #_____
O	O	Cogeneration unit
O	O	Bag house
O	O	Other pollution control?
O	O	Precipitator
O	O	other:_____
O	O	other:_____
O	O	other:_____
O	O	Buy steam
O	O	Sell electricity
O	O	Routing/shaping of web and flanges
O	O	Router(s), # _____
		Flanges
O	O	LSL
O	O	LVL
O	O	Lumber
O	O	Lumber (finger-jointed)
O	O	Assembly of I-joist
O	O	Resin
O	O	phenol-resorcinol-formaldehyde
O	O	emulsified polyurethane
O	O	other _____
		% MC (dry basis) _____
O	O	Sawing/curing of I-joists
O	O	Ripsaw
O	O	Oven(s), # _____
		Fuel source_____
O	O	Wrap LVL, material _____
O	O	Steel strapping
O	O	Plastic strapping
O	O	Cardboard corners
O	O	other:_____
O	O	Bag house
O	O	Other pollution control

LVL Plant Annual Wood Production Data

Reporting year _____ **Starting month** _____ **Ending month** _____

LVL Annual Production				
(Please provide units of measurement if different than stated)				Total Production
1.	Annual LVL production, 2012		ft^3	
	Annual LVL production, 2012		MSF 3/8 in. basis	
	Annual LVL production, 2012		Tons (%MC)	
2.	Veneer			
	a. Produced Veneer:			
	i. Used in Mill		MSF 3/8 in. basis	
	ii. Sold		MSF 3/8 in. basis	
	b. Purchased Veneer:			
	i. Dry		MSF 3/8 in. basis	
	ii. Green		MSF 3/8 in. basis	
	c. Sold Veneer			
	i. Dry		MSF 3/8 in. basis	
	ii. Green		MSF 3/8 in. basis	
	d. Purchased Parallel Laminated Veneer (PLV)		MSF 3/8 in. basis	
Transportation method(s) and average delivery distance for purchased veneer				
	Truck (% of total)		Average delivery miles	
	Rail (% of total)		Average delivery miles	
	Other (% of total)		Average delivery miles	
	Total (%)	100%		
Transportation method(s) and average delivery distance for purchased PLV				
	Truck (% of total)		Average delivery miles	
	Rail (% of total)		Average delivery miles	
	Other (% of total)		Average delivery miles	
	Total (%)	100%		

3. If you either peel/dry or dry veneer on-site, please be sure to complete the next section on veneer mills.

LVL Plant Annual Power and Fuel Consumption

If you have completed a 2012 Annual Fuel and Energy Survey for AF&PA, you may want to attach the survey and skip to the next section entitled "Other Annual Production." The first section refers to energy generation (non-transport fuel). (Please provide units of measurement if different)

Fuel	Unit	Quantity
Purchased electricity	kWh	
Purchased steam	lbs (°F)	
Wood Fuel *Self-generated*	Tons / (%MC)	/
Wood Fuel *Purchased*	Tons / (%MC)	/
Natural Gas	1000 ft^3	
Kerosene (fuel oil #1)	Gallons	
Fuel oil #2	Gallons	
Residual fuel oil #6 (Bunker C)	Gallons	
Diesel	Gallons	
Gasoline	Gallons	
Liquid Propane Gas	Gallons	
Total electricity for LVL plant	kWh	

If your facility produces any of the following for use on-site or for sale, please fill out the table. Enter N/A if not applicable.

Energy	Unit	Quantity (used on-site)	Quantity (sold off-site)
Electricity	kWh		
Steam	lbs (°F)		

If your facility has a boiler, please provide the following. Otherwise, enter N/A as applicable.

Boiler	Boiler size (million BTU/hr)	Boiler fuel	Boiler fuel unit	Quantity	Electricity to operate boiler (kWh)
#1					
#2					
#3					
#4					

LVL Plant Annual Transportation Fuel Use On-site

(includes all fuels for yard equipment, forklifts, and carriers)

Type	Total Quantity	Percent of total by unit process (percentage or volume)					Units	
		Veneer / PLV prep	Layup	Boiler	Hot press	Saw/ trimmer	Support vehicles	
Off-road diesel								Gallons
On-road diesel								Gallons
Propane								Gallons
Gasoline								Gallons
Electricity								kWh
Other								

Other LVL Plant Annual Use Data

Formulation and usage of resin, fillers, and other components			
Component Type	Percent of Solid by Weight (range is ok)		Total annual use (lbs.)
Phenol formaldehyde			
Extender and filler			
Catalyst (NaOH)			
Water			
Other (please specify)			
Other (please specify)			
Transportation method and distance for resin			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		
Transportation method and distance for extender and filler			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		
Transportation method and distance for catalysts			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	

Other (% of total)		Average delivery miles	
Total (%)	100%		

Source of Heat for Press: direct or in-direct (circle one)			
Thermal Fluid (Hot Oil) heated by	Units		
Natural Gas	1000 ft^3		
Electricity	kWh		
Steam	lbs		
Radio Frequency	kWh		
Microwave Frequency	kWh		
Other	?		

LVL Plant Annual Wood Residue Production

Wood residues are any wood material produced in conjunction with making LVL and are called co-products in this survey. For each of the co-products produced at your plant, please indicate the weight (tons) of **annual** wood residue production for the reporting period that are shipped to other users, used internally as fuel or for the production of another co-product at your facility, stockpiled for future use or land filled (estimates are acceptable). If zero, enter a dash (-). Please state units if other than tons like cubic yards. The final column (Total Quantity) should equal the sum of the individual rows.

Estimate amount of wood residue produced per Msf of LVL_____tons/Msf LVL

Wood residue	**Moisture Content (wet basis)**	**Sold (Shipped)**	**Used Internally (as fuel)**	**Used Internally (other uses)**	**Landfill**	**Inventory**	**Total Quantity**
	(%)	tons	tons	tons	tons	tons	Tons
Veneer loss							
PLV loss							
Lay-up scrap							
Panel trim							
Sawdust (sawing and trimming)							
Sawdust (rip saw)							
Tested LVL, used							
Other							

LVL Plant Ancillary Material Inputs

Ancillary Material	Used		Amount	How amount was found? Mark one[1]		Where the ancillary material is emitted as a percent (estimation is ok)					
	Yes	No		M	E	Veneer / PLV prep	Layup	Boiler	Hot press	Saw/ trimmer	Comments
Hydraulic fluids	O	O	lb/yr	O	O	%	%	%	%	%	
Greases	O	O	lb/yr	O	O	%	%	%	%	%	
Motor Oil	O	O	lb/yr	O	O	%	%	%	%	%	
Plastic wrapping	O	O	lb/yr	O	O	%	%	%	%	%	
Cardboard packaging	O	O	lb/yr	O	O	%	%	%	%	%	
Steel strapping	O	O	lb/yr	O	O	%	%	%	%	%	
Plastic strapping	O	O	lb/yr	O	O	%	%	%	%	%	
Potable water	O	O	gal/yr	O	O	%	%	%	%	%	
Paints	O	O	lb/yr	O	O	%	%	%	%	%	
Waxes	O	O	lb/yr	O	O	%	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	%	

[1] Estimated (E) / Measured (M)

LVL Plant Air Emissions

If air emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount	How amount was found?[1]			Sampling method or source[2]	Where the substance is emitted as a percent (estimation is ok)				
	Yes	No		M	E	PV		Veneer / PLV prep	Layup	Boiler	Hot press	Saw/ trimmer
Dust	O	O	lb/yr	O	O	O		%	%	%	%	%
Particulate	O	O	lb/yr	O	O	O		%	%	%	%	%
Particulate, PM10[3]	O	O	lb/yr	O	O	O		%	%	%	%	%
Particulate, PM2.5[4]	O	O	lb/yr	O	O	O		%	%	%	%	%
VOC	O	O	lb/yr	O	O	O		%	%	%	%	%
Sulfur dioxide	O	O	lb/yr	O	O	O		%	%	%	%	%
Carbon monoxide	O	O	lb/yr	O	O	O		%	%	%	%	%
Nitrous oxide	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Total	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Methanol	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Formaldehyde	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Acetaldehyde	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Propionaldehyde	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Acrolein	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Phenol	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: Acetone	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
HAP: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other organic[5]: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other inorganic[6]: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement

[2] Sampling methods might be Method 25A, Method 5, NCASI 105. Estimates might be based on AP42, Standard Air Contaminate Discharge Permit or other source.

[3] PM10 is particulate matter up to 10 micrometers in size

[4] PM2.5 is particulate matter up to 2.5 micrometers in size

[5] Non-HAP organics that are not included in VOC value.

[6] Inorganics such as chlorine, mercury sulfur.

LVL Plant Water Emissions

If water emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount[2]	How amount was found Mark one[3]			Sampling method or source[1]	Where the substance is emitted as a percent (estimation is ok)				
	Yes	No		M	E	PV		Veneer / PLV prep	Layup	Boiler	Hot press	Saw/ trimmer
Suspended solids	O	O	lb/yr	O	O	O		%	%	%	%	%
BOD	O	O	lb/yr	O	O	O		%	%	%	%	%
COD	O	O	lb/yr	O	O	O		%	%	%	%	%
Oil and grease	O	O	lb/yr	O	O	O		%	%	%	%	%
HAPs	O	O	lb/yr	O	O	O		%	%	%	%	%
Chemicals in boiler blowdown (if not included above)	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%	%

[1] Sampling methods is type of water test or how estimate was obtained.

[2] Report the mass of material, not the mass of material and water.

[3] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

LVL Plant Solid Waste Production

If annual solid waste summary is available, please provide as an alternative to the following table.

Check here if summary is attached ☐

Material	Amount[2] (lb/yr)	Where material is going? Landfill (L) or recycled (R) Mark one	How amount was found? Mark one[1]			Where the solid waste is emitted as a percent (estimation is ok)				
			M	E	PV	Veneer / LVL prep	Layup	Boiler	Hot press	Saw/ trimmer
Discarded Wood		L / R	O	O	O	%	%	%	%	%
Discarded Bark		L / R	O	O	O	%	%	%	%	%
Dirt and rocks		L / R	O	O	O	%	%	%	%	%
Ash		L / R	O	O	O	%	%	%	%	%
Plastic wrap		L / R	O	O	O	%	%	%	%	%
Metal strapping		L / R	O	O	O	%	%	%	%	%
Plastic strapping		L / R	O	O	O	%	%	%	%	%
Other metals		L / R	O	O	O	%	%	%	%	%
Other organics		L / R	O	O	O	%	%	%	%	%
Other non-organics		L / R	O	O	O	%	%	%	%	%
Other: _____		L / R	O	O	O	%	%	%	%	%
Other: _____		L / R	O	O	O	%	%	%	%	%
Other: _____		L / R	O	O	O	%	%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

[2] Report the mass of material, for example, report wood separately from dirt and rocks.

LVL Plant Annual Water Use

Type	Total Quantity	Percent of total by unit process (percentage or volume; estimation is ok)					Units
		Veneer / LVL prep	Layup	Boiler	Hot press	Saw/ trimmer	
Input							
Surface water							Gallons
Groundwater							Gallons
Municipal water							Gallons
Output							
Water discharged							Gallons
Water recycled							Gallons

Recycling rate of water helps reduce the water footprint.

What percent of water is recycled?		%
Was water measured or estimated?		

LVL Plant Emission Control Device (ECD)

The following is a chart of emission control devices. Please fill in all information related to the control devices.

Emission Control Device (ECD)- Type, Electricity, Fuel Usage					
	ECD 1	ECD 2	ECD 3	ECD 4	ECD 5
Equipment controlled (i.e., boiler, press, dryer, etc.)					
Type					
Model					
Year Installed					
Electricity used to operate ECD; either kWh or % of total plant use					
Natural Gas used to operate ECD; either $ft.^3$ or % of total plant use					

Machine Center Breakdown for Electricity and Fuel Use

Fill in all that apply and for which you have data. If you **do not** have given machines center such as the co-generator, either draw **a line** through that row and **write N/A**.

Machine Center	**Model/Type** **Year Installed**	**Annual electricity** **kWh or % of the total use for mill**	**Fuel Usage** **% of total use for mill**
Co-generator			
Lay-up			
Press(es)			
#1			
#2			
#3			
#4			
Billet Cuts			
Rip Saw			

If you do not peel or dry veneer or produce I-joists, congratulations you have completed the survey! However, if you do, please complete the following pages.

Veneer Mill Annual Wood Production Data

Please fill in all the information that pertains just to your plant.

Type of veneer dryer: Longitudinal, Cross flow, Jet, Rotary (circle one)

Log scale: Dolye, International, Scribner, Weight base (circle one)

Total volume of incoming softwood logs	_____	thousand BF/year
Total volume of incoming green veneer	_____	thousand ft^2 3/8" basis/year
Total volume of veneer produced on-site	_____	thousand ft^2 3/8" basis/year
Total volume of veneer produced on-site used on-site	_____	thousand ft^2 3/8" basis/year

Please complete the following table showing the breakdown of the ***individual tree species*** and approximate ***sizes*** processed by your mill by species and the average log diameter. If less than 2% of total, use category labeled "Other".

Species	% of total log input into veneer mill	Log Diameter* (in)
Total	100%	

*Please provide individual log diameters if known otherwise please state the average or range of logs processed at your facility in bottom row under Log Diameter

Wood species processed into veneer and approximate percentage of total:

Species	Volume (Msf 3/8")	%MC (wet basis)	Percent
Total			100%

MILEAGE: Over the Road_____% By Rail_____%

Total number of log deliveries made to this facility annually	_____	# per year
Average one-way mileage travel to this facility to deliver logs	_____	miles

Veneer Mill Annual Transportation Fuel Use On-site

(includes all fuels for yard equipment, forklifts, and carriers)

Type	Total Quantity	Percent of total by unit process (percentage or volume)					Units
		Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying	Support Vehicle	
Off-road diesel							Gallons
On-road diesel							Gallons
Propane							Gallons
Gasoline							Gallons
Electricity							kWh
Other							

Veneer Mill Annual (Non-Transportation) Fuel Use

(boilers, cogeneration units, etc.)

Fuel	Unit	Quantity
Total electricity for veneer mill	kWh	
Purchased steam	lbs (°F)	
Wood Fuel *Self-generated*	Tons / (%MC)	/
Wood Fuel *Purchased*	Tons / (%MC)	/
Natural Gas	1000 ft^3	
Kerosene (fuel oil #1)	Gallons	
Fuel oil #2	Gallons	
Residual fuel oil #6 (Bunker C)	Gallons	
Diesel	Gallons	
Gasoline	Gallons	
Liquid Propane Gas	Gallons	

If your facility has a boiler, please provide the following. Otherwise, enter N/A as applicable.

Boiler	Boiler size (million BTU/hr)	Boiler Fuel	Boiler Fuel Unit	Quantity	Electricity to operate boiler (kWh)
#1					
#2					
#3					
#4					

Veneer Mill Machine Center Breakdown

Fill in all that apply and for which you have data. If you do not have a given machine center, draw a line through that row and write None. Please provide units.

Machine Center	Model/Type Year Installed	Annual Electricity Usage kWh or % of total electricity use for mill **(Estimation is ok)**	Fuel Usage % of total use for mill **(Estimation is ok)**
Bucking & Debarking			
Log Conditioning			
Peeling & Clipping			
Drying			
Energy Generation			
Emissions control			
Total veneer mill			

Veneer Mill Annual Wood Residue Production

This is a general material flow survey for veneer mills. Wood residues are any wood material produced in conjunction with making LVL and are called co-products in this survey. This survey is designed to trace all wood components generated during production.

Estimate amount of wood residue produced per Msf of veneer_____tons/Msf veneer

Wood residue	Moisture Content (wet basis) (%)	Sold (Shipped) tons	Used Internally (as fuel) tons	Used Internally (other uses) tons	Landfill tons	Total Quantity Tons
Bark, green						
Roundup wood, green						
Peeler core, green						
Clippings, green						
Veneer downfall						
Trim , green						
Chips, green						
Hogged material						
Waste gate material						
Clippings, green						
Other						

For dryer(s), check heat source and give the annual fuel consumption: indirect or direct (circle one)		
Heat source		
□ Steam	lbs	
□ Natural gas direct-fired	ft^3	
□ Wood fuel	Tons (%MC)	/
□ Other		

Veneer moisture content information		
Average moisture content into dryer	% ovendry basis	
Average moisture content out of dryer	% ovendry basis	
Redry rate	%	

Transportation method and distance for veneer logs			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Veneer Mill Ancillary Material Inputs

Ancillary Material	Used		Amount	How amount was found? Mark one[1]		Where the ancillary material is emitted as a percent (estimation is ok)				
	Yes	No		M	E	Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying	Comments
Hydraulic fluids	O	O	lb/yr	O	O	%	%	%	%	
Greases	O	O	lb/yr	O	O	%	%	%	%	
Motor Oil	O	O	lb/yr	O	O	%	%	%	%	
Plastic wrapping	O	O	lb/yr	O	O	%	%	%	%	
Cardboard packaging	O	O	lb/yr	O	O	%	%	%	%	
Steel strapping	O	O	lb/yr	O	O	%	%	%	%	
Plastic strapping	O	O	lb/yr	O	O	%	%	%	%	
Potable water	O	O	gal/yr	O	O	%	%	%	%	
Paints	O	O	lb/yr	O	O	%	%	%	%	
Waxes	O	O	lb/yr	O	O	%	%	%	%	
Runners	O	O	lb/yr	O	O	%	%	%	%	
Boiler chemicals	O	O	lb/yr	O	O	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	
Other: _____	O	O	lb/yr	O	O	%	%	%	%	

[1] Estimated (E) / Measured (M)

Veneer Mill Air Emissions

If air emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount	How amount was found? Mark one[1]			Sampling method or source[2]	Where the substance is emitted as a percent (estimation is ok)			
	Yes	No		M	E	PV		Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying
Dust	O	O	lb/yr	O	O	O		%	%	%	%
Particulate	O	O	lb/yr	O	O	O		%	%	%	%
Particulate, PM10[3]	O	O	lb/yr	O	O	O		%	%	%	%
Particulate, PM2.5[4]	O	O	lb/yr	O	O	O		%	%	%	%
VOC	O	O	lb/yr	O	O	O		%	%	%	%
Sulfur dioxide	O	O	lb/yr	O	O	O		%	%	%	%
Carbon monoxide	O	O	lb/yr	O	O	O		%	%	%	%
Nitrous oxide	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Total	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Methanol	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Formaldehyde	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Acetaldehyde	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Propionaldehyde	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Acrolein	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Phenol	O	O	lb/yr	O	O	O		%	%	%	%
HAP: Acetone	O	O	lb/yr	O	O	O		%	%	%	%
HAP: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other organic[5]: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other inorganic[6]: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement

[2] Sampling methods might be Method 25A, Method 5, NCASI 105. Estimates might be based on AP42, Standard Air Contaminate Discharge Permit or other source.

[3] PM10 is particulate matter up to 10 micrometers in size

[4] PM2.5 is particulate matter up to 2.5 micrometers in size

[5] Non-HAP organics that are not included in VOC value.

[6] Inorganics such as chlorine, mercury sulfur.

Veneer Mill Water Emissions

If water emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount[2]	How amount was found? Mark one[3]			Sampling method or source[1]	Where the substance is emitted as a percent (Estimation is ok)			
	Yes	No		M	E	PV		Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying
Suspended solids	O	O	lb/yr	O	O	O		%	%	%	%
BOD	O	O	lb/yr	O	O	O		%	%	%	%
COD	O	O	lb/yr	O	O	O		%	%	%	%
Oil and grease	O	O	lb/yr	O	O	O		%	%	%	%
HAPs	O	O	lb/yr	O	O	O		%	%	%	%
Chemicals in boiler blowdown (if not included above)	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%
Other: _____	O	O	lb/yr	O	O	O		%	%	%	%

[1] Sampling methods is type of water test or how estimate was obtained.

[2] Report the mass of material, not the mass of material and water.

[3] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

Veneer Mill Solid waste

If annual solid waste summary is available, please provide as an alternative to the following table. Check here if summary is attached □

Material	Amount[2] (lb/yr)	Where material is going? Landfill (L) or recycled (R)	How amount was found? Mark one[1]	Where the solid waste is emitted as a percent (estimation is ok)			
				Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying
Discarded Wood		L / R	M / E / PV	%	%	%	%
Discarded Bark		L / R	M / E / PV	%	%	%	%
Dirt and rocks		L / R	M / E / PV	%	%	%	%
Ash		L / R	M / E / PV	%	%	%	%
Plastic wrap		L / R	M / E / PV	%	%	%	%
Plastic strapping		L / R	M / E / PV	%	%	%	%
Metal strapping		L / R	M / E / PV	%	%	%	%
Plastic bags		L / R	M / E / PV	%	%	%	%
Other metals		L / R	M / E / PV	%	%	%	%
Other organics		L / R	M / E / PV	%	%	%	%
Other non organics		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

[2] Report the mass of material, for example, report wood separately from dirt and rocks.

Veneer Mill Annual Water Use

Type	Total Quantity	Percent of total by unit process (percentage or volume)				Units
		Bucking & Debarking	Block Conditioning	Peeling & Clipping	Drying	
Input						
Surface water						Gallons
Groundwater						Gallons
Municipal water						Gallons
Output						
Water discharged						Gallons
Water recycled						Gallons

Recycling rate of water helps reduce the water footprint.

What percent of water is recycled?		%
Was water measured or estimated?		

2012 Composite I-joists Annual Production Plant Data

Please fill in all information relevant to producing I-joists. Please provide the data on an annual basis for the year which the data is reported.

Annual I-Joists Production for 2012			
Product (Series)	Amount (lin.ft.)	Joist Depth (in.)	Flange dim. (in. x in.)

I-joists Construction-Web		
Material	Percent of total	Annual consumption (MSF 3/8")
OSB		
Plywood		
Total	100%	

Transportation Method and Delivery Distance for OSB			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Transportation Method and Delivery Distance for plywood			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Estimate amount of wood residue produced per Msf of I-joist_____tons/Msf I-joist

Wood residue	**Moisture Content (wet basis)** (%)	**Sold (Shipped)** tons	**Used Internally (as fuel)** tons	**Used Internally (other uses)** tons	**Landfill** tons	**Inventory** tons	**Total Quantity** Tons
Sawdust, dry							
Other							
Other							

I-joists Construction-Flange		
Material	Percent of total	Annual consumption (MSF 3/8")
LVL		
LSL		
Lumber (finger-jointed)		
Total	100%	

Transportation Method and Delivery Distance for LVL			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Transportation Method and Delivery Distance for LSL			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Transportation Method and Delivery Distance for lumber (finger-jointed)			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Annual Resin Consumption Data

Resin consumption is comprised of three different scenarios: 1) web-joint, 2) flange finger-joint, and 3) I-joist (web to flange)

1. Web-joint resin consumption	
Resin type	
Percent water	

Transportation Method and Delivery Distance for web-joint resin			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

- Please include the amount of resin used in the web-joints of the I-joist in this section. Please state whether weight is given as wet or dry weight.

- If you use the same resin for the web-joint, finger-joint, and web to flange-joint, complete the following table with total resin use and check this box ☐ ☐

- Otherwise, fill in resin use for web-joint only and then proceed to fill out resin data for flange finger-joints and I-joist (web to flange).

Formulation and usage of web-joint resin, fillers, and other components			
Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)	Circle one
Resin			Wet or dry
Extender and filler			Wet or dry
Catalyst (NaOH)			Wet or dry
Water			
Other (please specify)			Wet or dry
Resin loss (lbs)			Wet or dry

2. Flange finger-joint resin consumption			
Resin type			
Percent water			
Transportation Method and Delivery Distance for flange finger-joint resin			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Formulation and usage of flange finger-joint resin, fillers, and other components			
Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)	Circle one
Resin			Wet or dry
Extender and filler			Wet or dry
Catalyst (NaOH)			Wet or dry
Water			
Other (please specify)			Wet or dry
Resin loss (lbs)			Wet or dry

3. I-joist (web-to-flange) resin consumption	
Resin type	
Percent water	

Transportation Method and Delivery Distance for I-joist (web-to-flange) resin			
Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100%		

Formulation and usage of I-joist (web-to-flange) resin, fillers, and other components			
Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)	Circle one
Resin			Wet or dry
Extender and filler			Wet or dry
Catalyst (NaOH)			Wet or dry
Water			
Other (please specify)			Wet or dry
Resin loss (lbs)			Wet or dry

I-joist Plant Annual (Non-Transportation) Fuel Use

(boilers, cogeneration units, etc.)

Fuel	Unit	Quantity
Total electricity for I-joist plant	kWh	
Purchased steam	lbs (°F)	
Wood Fuel *Self-generated*	Tons / (%MC)	/
Wood Fuel *Purchased*	Tons / (%MC)	/
Natural Gas	1000 ft^3	
Kerosene (fuel oil #1)	Gallons	
Fuel oil #2	Gallons	
Residual fuel oil #6 (Bunker C)	Gallons	
Diesel	Gallons	
Gasoline	Gallons	
Liquid Propane Gas	Gallons	

If your facility has a boiler, please provide the following. Otherwise, enter N/A as applicable.

Boiler	Boiler size (million BTU/hr)	Boiler Fuel	Boiler Fuel Unit	Quantity	Electricity to operate boiler (kWh)
#1					
#2					
#3					

For oven(s), check heat source and give the annual fuel consumption: indirect or direct (circle one)		
Heat source		
□ Steam	lbs	
□ Natural gas direct-fired	ft^3	
□ Wood fuel	Tons (%MC)	/
□ Other		

I-Joist Plant Annual Transportation Fuel Use On-site

(includes all fuels for yard equipment, forklifts, and carriers)

Type	Total Quantity	Percent of total by unit process (percentage or volume)					Units
		Routing / shaping	Assembly	Sawing	Curing	Support vehicles	
Off-road diesel							Gallons
On-road diesel							Gallons
Propane							Gallons
Gasoline							Gallons
Electricity							kWh
Other							

Machine Center Breakdown for Electricity and Fuel Use

Fill in all that apply and for which you have data. If you **do not** have a given machine center that is listed here, either **draw a line** through that row and **write N/A**.

Machine Center	Model/Type Year Installed	Annual Electricity kWh or % of the Total Use for Mill	Fuel Usage % of Total Use for Mill
OSB/Plywood saws			
LVL/FJ lumber saws			
Web joint shaper/router			
I-joist assembler			
I-joist saw			
Other (please specify)			
Curing Oven			
Steam			
Electricity			
Natural Gas			

I-joist Plant Ancillary Material Inputs

Ancillary Material	Used		Amount	How amount was found? Circle one[1]	Where the ancillary material is emitted as a percent (estimation is ok)				
	Yes	No			Routing / shaping	Assembly	Sawing	Curing	Comments
Hydraulic fluids	O	O	lb/yr	M / E	%	%	%	%	
Greases	O	O	lb/yr	M / E	%	%	%	%	
Motor Oil	O	O	lb/yr	M / E	%	%	%	%	
Plastic wrapping	O	O	lb/yr	M / E	%	%	%	%	
Cardboard packaging	O	O	lb/yr	M / E	%	%	%	%	
Steel strapping	O	O	lb/yr	M / E	%	%	%	%	
Plastic strapping	O	O	lb/yr	M / E	%	%	%	%	
Potable water	O	O	gal/yr	M / E	%	%	%	%	
Paints	O	O	lb/yr	M / E	%	%	%	%	
Waxes	O	O	lb/yr	M / E	%	%	%	%	
Plastic strapping	O	O	lb/yr	M / E	%	%	%	%	
Runners	O	O	lb/yr	M / E	%	%	%	%	
Boiler chemicals	O	O	lb/yr	M / E	%	%	%	%	
Other: _____	O	O	lb/yr	M / E	%	%	%	%	
Other: _____	O	O	lb/yr	M / E	%	%	%	%	
Other: _____	O	O	lb/yr	M / E	%	%	%	%	

[1] Estimated (E) / Measured (M)

I-joist Plant Air Emissions

If air emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount	How amount was found? Circle one[1]	Sampling method or source[2]	Where the substance is emitted as a percent (estimation is ok)			
	Yes	No				Routing / shaping	Assembly	Sawing	Curing
Dust	O	O	lb/yr	M / E / PV		%	%	%	%
Particulate	O	O	lb/yr	M / E / PV		%	%	%	%
Particulate, PM10[3]	O	O	lb/yr	M / E / PV		%	%	%	%
Particulate, PM2.5[4]	O	O	lb/yr	M / E / PV		%	%	%	%
VOC	O	O	lb/yr	M / E / PV		%	%	%	%
Sulfur dioxide	O	O	lb/yr	M / E / PV		%	%	%	%
Carbon monoxide	O	O	lb/yr	M / E / PV		%	%	%	%
Nitrous oxide	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Total	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Methanol	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Formaldehyde	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Acetaldehyde	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Propionaldehyde	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Acrolein	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Phenol	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: Acetone	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: _____	O	O	lb/yr	M / E / PV		%	%	%	%
HAP: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other organic[5]: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other inorganic[6]: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement

[2] Sampling methods might be Method 25A, Method 5, NCASI 105. Estimates might be based on AP42, Standard Air Contaminate Discharge Permit or other source.

[3] PM10 is particulate matter up to 10 micrometers in size

[4] PM2.5 is particulate matter up to 2.5 micrometers in size

[5] Non-HAP organics that are not included in VOC value.

[6] Inorganics such as chlorine, mercury sulfur.

I-joist Plant Water Emissions

If water emission inventories are available, please provide as an alternative to the following table. Check here if inventory is attached ☐

Substance	Emit		Amount[2]	How amount was found? Circle one[3]	Sampling method or source[1]	Where the substance is emitted as a percent (estimation is ok)			
	Yes	No				Routing / shaping	Assembly	Sawing	Curing
Suspended solids	O	O	lb/yr	M / E / PV		%	%	%	%
BOD	O	O	lb/yr	M / E / PV		%	%	%	%
COD	O	O	lb/yr	M / E / PV		%	%	%	%
Oil and grease	O	O	lb/yr	M / E / PV		%	%	%	%
HAPs	O	O	lb/yr	M / E / PV		%	%	%	%
Chemicals in boiler blowdown (if not included above)	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%
Other: _____	O	O	lb/yr	M / E / PV		%	%	%	%

[1] Sampling methods is type of water test or how estimate was obtained.

[2] Report the mass of material, not the mass of material and water.

[3] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

I-joist Plant Solid waste

If annual solid waste summary is available, please provide as an alternative to the following table. Check here if summary is attached ☐

Material	Amount[2] (lb/yr)	Where material is going? Landfill (L) or recycled (R)	How amount was found? Circle one[1]	Where the solid waste is emitted as a percent (estimation is ok)			
				Routing / shaping	Assembly	Sawing	Curing
Discarded Wood		L / R	M / E / PV	%	%	%	%
Discarded Bark		L / R	M / E / PV	%	%	%	%
Dirt and rocks		L / R	M / E / PV	%	%	%	%
Ash		L / R	M / E / PV	%	%	%	%
Plastic wrap		L / R	M / E / PV	%	%	%	%
Metal strapping		L / R	M / E / PV	%	%	%	%
Cardboard packaging		L / R	M / E / PV	%	%	%	%
Plastic bags		L / R	M / E / PV	%	%	%	%
Other metals		L / R	M / E / PV	%	%	%	%
Other organics		L / R	M / E / PV	%	%	%	%
Other non organics		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%
Other: _____		L / R	M / E / PV	%	%	%	%

[1] Estimated (E) / Measured (M)/ Permit value (PV): For example, from landfill fees, a permit, or measurement.

[2] Report the mass of material, for example, report wood separately from dirt and rocks.

I-joist Plant Annual Water Use

Type	Total Quantity	Percent of total by unit process (percentage or volume)				Units
		Routing / shaping	Assembly	Sawing	Curing	
Input						
Surface water						Gallons
Groundwater						Gallons
Municipal water						Gallons
Output						
Water discharged						Gallons
Water recycled						Gallons

Recycling rate of water helps reduce the water footprint.

What percent of water is recycled?		%
Was water measured or estimated? M/E		

Annual Emission Control Device and Environmental Emission

The following is a chart of emission control devices and a listing of chemical compounds that are observed and/or permitted. Please fill in all information related to the control devices. Then list all compounds that are collected and known for the mill for all control device sources. If you recently applied for air permit, use those numbers. Fill in all that apply and for which you have data.

Annual Emission Control Device (ECD)- Electricity and Fuel Usage					
	ECD 1	ECD 2	ECD 3	ECD 4	ECD 5
Equipment controlled (i.e., boiler, press, dryer, etc.)					
Type					
Model					
Year Installed					
Electricity used to operate ECD; either kWh or % of total plant use					
Natural gas used to operate ECD; either ft^3 or % of total plant use					