

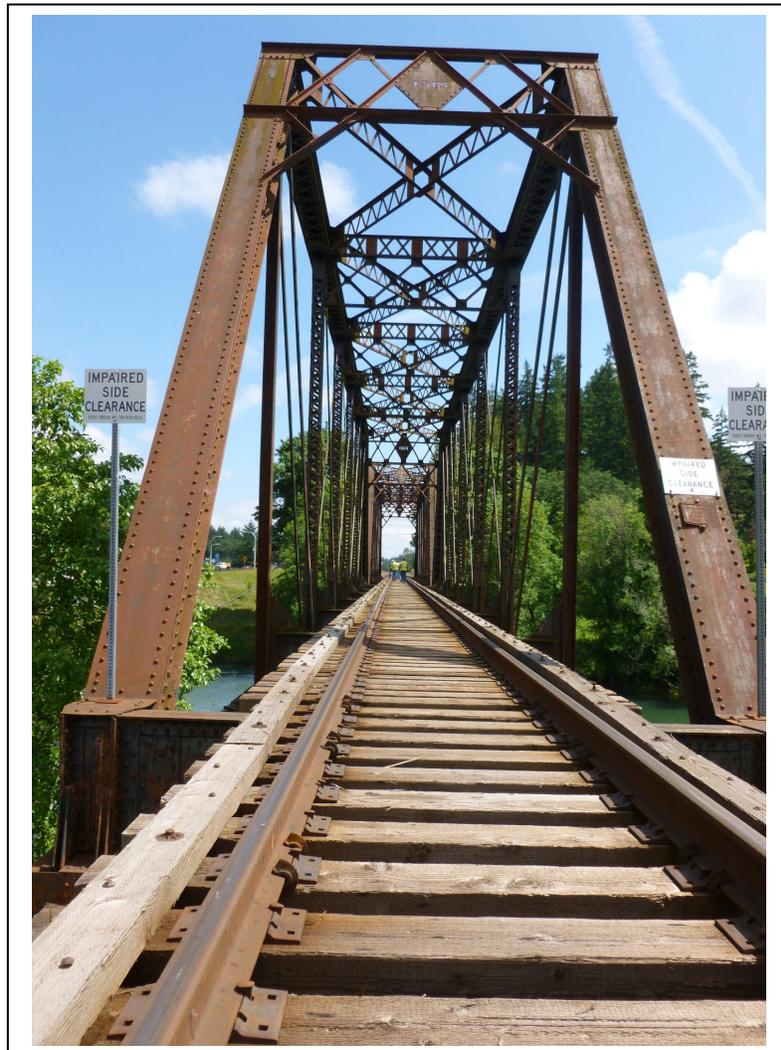
Conclusions and Summary Report

Environmental Life Cycle Assessment of Ammoniacal Copper Zinc Arsenate-Treated Railroad Ties with Comparisons to Concrete and Plastic/Composite Railroad Ties

ISO 14044 Compliant

Prepared by: AquAeTer, Inc.

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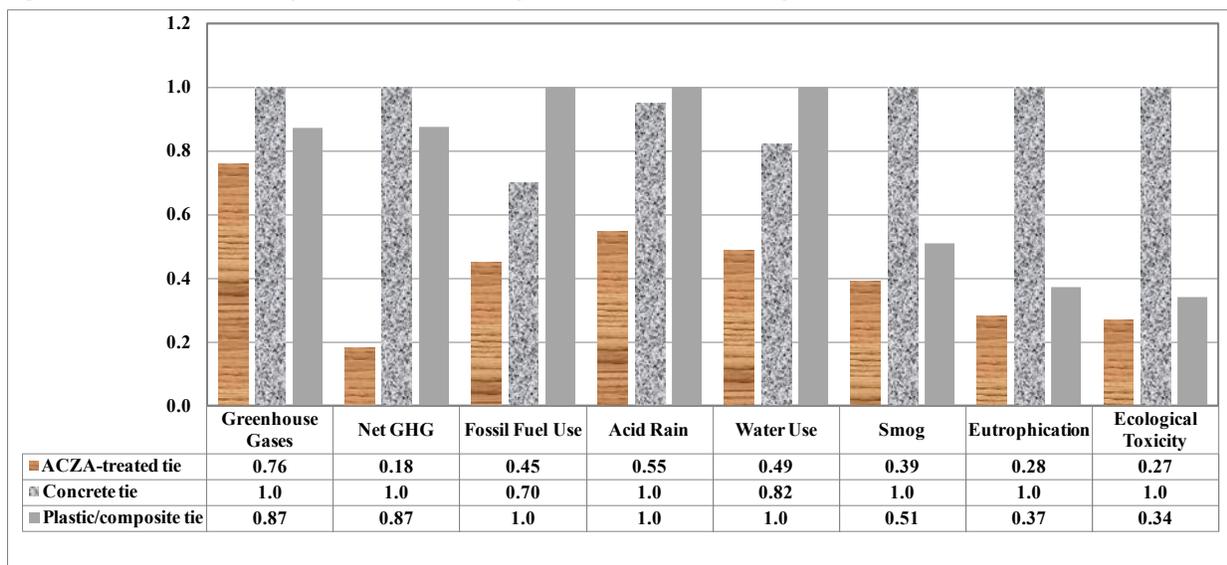
Conclusions and Summary Report

Lonza Wood Protection commissioned AquAeTer, Inc., an independent consulting firm, to prepare a quantitative evaluation of the environmental impacts associated with the national production, use, and disposition of ammoniacal copper zinc arsenate (ACZA)-treated, concrete, and plastic/composite (P/C) railroad ties, using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The comparative results confirm:

- **Less Energy & Resource Use:** ACZA-treated wood railroad ties require less total energy, less fossil fuel use, and less water than concrete and P/C railroad ties.
- **Lower Environmental Impacts:** ACZA-treated wood railroad ties have lower environmental impacts in comparison to concrete and P/C railroad ties for all six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, eutrophication, and ecotoxicity-causing emissions.
- **Greenhouse Gas Levels:** Compared to annual GHG emissions from national railroad fuel use, the net GHG “footprint” resulting from the railroads’ choice of tie materials is notable at 1.1% for ACZA-treated ties, 6.3% for concrete ties, and 5.5% for P/C ties.
- **Offsets Fossil Fuel Use:** Reuse of ACZA-treated railroad ties for energy recovery in permitted facilities with appropriate emission controls will further reduce greenhouse gas levels in the atmosphere, while offsetting the use of fossil fuel energy.



Figure 1 Normalized impact indicator comparison (maximum impact = 1.0)



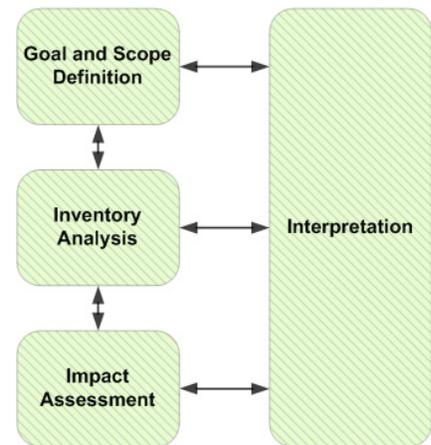
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Impact indicator values were normalized to better support comparisons between products and to understand the quantitative significance of indicators. Product normalization sets the cradle-to-grave life cycle value of maximum impact to 1.0, and all other values are a fraction of 1.0. The normalized results are provided in Figure 1.

Goal and Scope

The goal of this study is to provide a comprehensive, scientifically-based, fair, and accurate understanding of environmental burdens associated with the manufacture, use, and disposition of railroad ties using LCA methodologies. The scope of this study includes:

- A life cycle inventory of ACZA-treated, concrete, and P/C railroad ties modified from a life cycle inventory of creosote-treated railroad ties done for the Treated Wood Council.
- Calculation and comparison of life cycle impact assessment indicators: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, ecotoxicity, and waterborne eutrophication impacts potentially resulting from life cycle air emissions.
- Calculation of energy, fossil fuel, and water use.



Quality Criteria

This study was done as an extension of work performed by the Treated Wood Council and is not intended as a stand-alone LCA. The study includes most elements required for an LCA meeting the International Organization for Standardization (ISO) guidelines as defined in standards ISO/DIS 14040 “Environmental Management – Life Cycle Assessment – Principles and Framework” and ISO/DIS 14044 “Environmental Management – Life Cycle Assessment – Requirements and Guidelines”. However, there was no external peer review of the ACZA components of this LCA.

Manufacturer Information

ACZA is listed in the American Wood Protection Association (AWPA) Standard P22. ACZA can be used to treat numerous species of wood, however its ability to penetrate makes it particularly useful in the treatment of coastal Douglas fir and hardwood species.

The LCA for ACZA-treated railroad ties is based on Lonza Wood Protection-provided inventory data.



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Lonza Wood Protection supplies the ACZA preservative to wood treating companies treating ties in accordance with appropriate AWPA standards.

The LCAs for concrete and plastic/composite railroad ties represent general product categories, manufactured with different designs and material contents. These LCAs were prepared using secondary data sources and provide a basis for general comparison of products.

Product Description and Functional Unit

Railroads are a critical transportation element of the U.S. economy, distributing large quantities of material goods and oftentimes in a more efficient manner than road-based transportation. Railroad cross-ties are the base members, to which steel rails are attached to transfer load from the rails to the underlying ballast. The ties also provide the critical function of keeping the rails at the correct gauge and alignment. The railroad tie can be made of either wood, concrete, or plastic/composite materials.

Scope: Cradle-to-grave

Functional unit: one mile of Class 1 railroad per year of use. Tie size is 7 inch by 9 inch by 86 inch (or equivalent for non-wood product). Wood product treated with ACZA preservative.

Service life assumed for this LCA:

- sawn wood product - 35 years
- concrete product - 40 years
- plastic/composite product - 40 years

Tie spacing in Class 1 mainline railroads:

- sawn wood product - 19.5 inches
- concrete product - 24 inches
- plastic/composite product - 19.5 inches

System boundary: from the extraction of the raw materials through processing, transport, primary service life, reuse, and disposal of the product.

Geographic boundary: U.S.

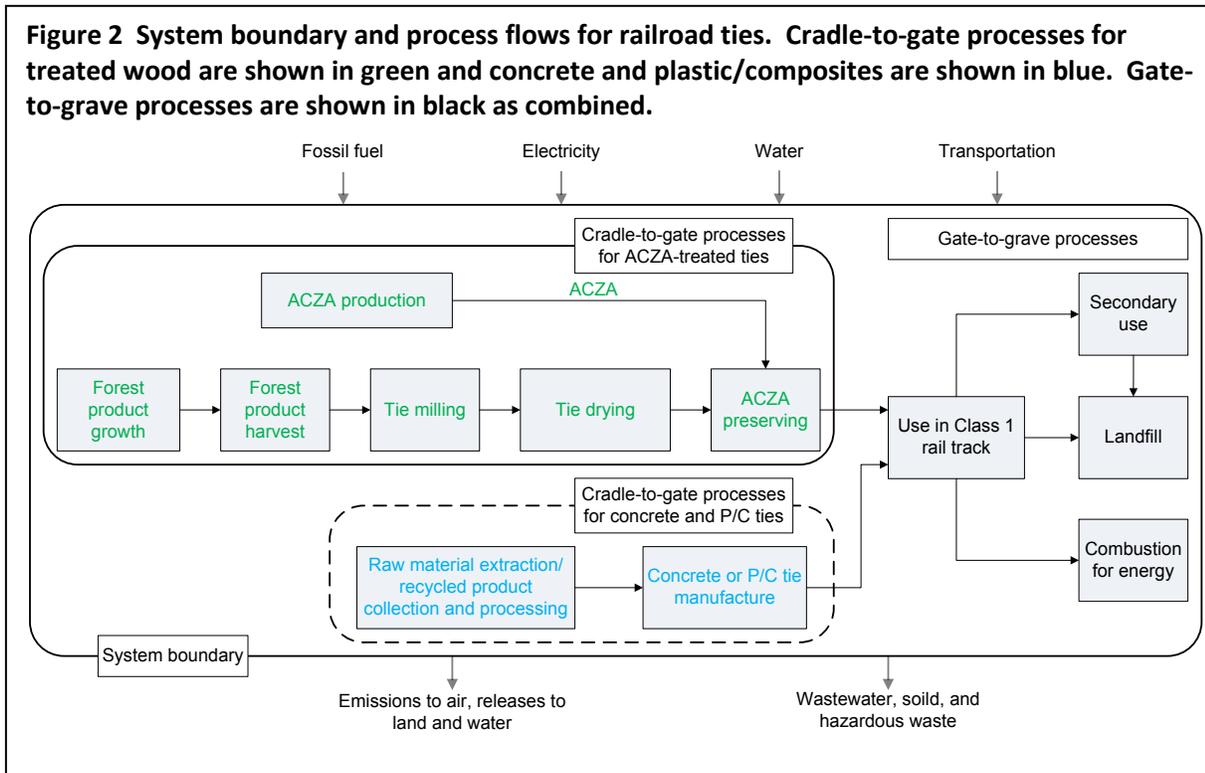
Life Cycle Inventory

For comparative purposes this LCA evaluates railroad ties that commonly are used. The products, ACZA-treated Douglas fir or hardwood species, treated in accordance with AWPA standards, concrete, and P/C railroad ties are compared at a functional unit of one mile of Class 1 railroad per year of use to account for tie spacing and expected service life.

The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the railroad tie. For each stage of the product life cycle, inputs of energy and raw materials, outputs of products, co-products and waste, and environmental releases to air, water, and soil are determined.

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The system boundaries include all the production steps from extraction of raw materials from the earth (cradle) through to final disposition after its service life (grave). Figure 2 illustrates the system boundaries and process flow for both wood and non-wood railroad ties assessed in this study.



The length of time a railroad tie remains in service is dependent upon a number of factors. For this assessment ACZA-treated railroad ties were assumed to remain in service for 35 years. Concrete ties and plastic/composite ties are assumed to provide 40 years of service.

Unlike ACZA-treated and plastic/composite ties installed with 19.5 inch spacing, concrete ties are installed at 24-inch spacing (2,640 ties per mile) and assumed to require nine-inches of additional rock ballast. Assumptions used in this LCA for disposition of railroad ties after service life include:

- Treated wood ties are recycled for secondary use or disposed in a solid waste landfill;
- Concrete ties are assumed either to be recycled or landfilled; and
- P/C ties are assumed either to be recycled or landfilled.

Environmental Performance

The assessment phase of the LCA uses the inventory results to calculate total energy use, impact indicators of interest, and resource use. For environmental indicators, USEPA’s Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) is used to assess anthropogenic and total greenhouse gas, acid rain, smog potential, ecotoxicity, and eutrophication impacts potentially resulting from air emissions. The categorized energy use, resource use, and impact indicators provide

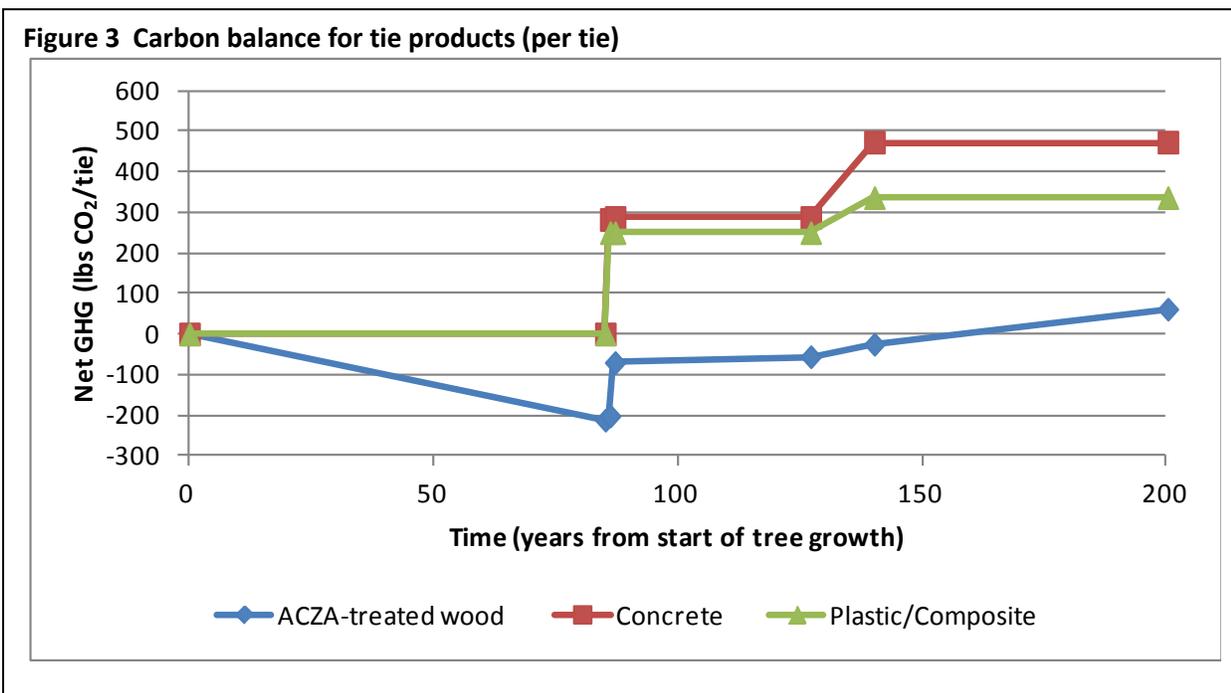
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general, but quantifiable, indications of environmental performance. The results of this impact assessment are used for comparison of railroad tie products as shown in Table 1.

Table 1 Environmental performance of railroad ties (per mile of track/year of railroad service)

Impact category	Units	ACZA-treated tie	Concrete tie	Plastic/composite tie
Energy use				
Energy input (technosphere)	MMBTU	34	53	90
Energy input (nature)	MMBTU	74	112	143
Biomass energy	MMBTU	0.97	1.0	1.2
Environmental indicators				
Anthropogenic greenhouse gas	lb-CO ₂ -eq	23,486	30,928	26,978
Total greenhouse gas	lb-CO ₂ -eq	5,662	31,175	27,268
Acid rain air emissions	lb-H+ mole-eq	5,615	9,783	10,277
Smog potential	g NOx / m	22	58	29
Ecotoxicity air emissions	lb-2,4-D-eq	51	188	64
Eutrophication air emissions	lb-N-eq	1.0	3.7	1.4
Resource use				
Fossil fuel use	MMBTU	100	154	220
Water use	gal	3,313	5,571	6,771

Wood products begin their life cycles removing carbon from the atmosphere (as carbon dioxide) and atmospheric carbon removal continues as trees grow during their approximate 80-year growth cycle, providing an initial life cycle carbon credit. Approximately half the mass of dry wood fiber is carbon. Transportation and treating operations are the primary sources of carbon emissions in the manufacture of treated wood products.



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The concrete and plastic/composite ties begin their life cycles either as raw materials or with the recycling of products. Both processes result in carbon emissions. Burdens associated with recycling, including transportation, sorting, cleaning, and melting, must be included in the manufacturing stage.

Minimal impacts are required for both treated wood, concrete, and P/C ties in the service life stage. Following the service life stage, ACZA-treated wood ties are recycled for secondary uses or disposed in landfills. Non-wood material ties are recycled or disposed in landfills. The carbon balance of railroad ties, through the life cycle stages, is shown in Figure 3. ACZA-treated wood products currently are not used as a combustion fuel for energy recovery; however, future procedures might make such recovery feasible.

Additional Information

This study is further detailed in a Life Cycle Assessment Report completed in April 2013 and is available upon request from Lonza Wood Protection at 5660 New Northside Dr., Suite 1100, Atlanta, GA 30328 (www.Chemonite.com).

This study is based on data collection and analysis done as part of an LCA on creosote-treated railroad ties. A manuscript of the creosote-treated railroad ties findings was published in the peer-reviewed *Journal of Transportation Technologies* (Vol. 3 No. 2, April 2013, pp 149-161) and is available at <http://www.scirp.org/journal/jtts>.

