Conclusions and Summary Report Environmental Life Cycle Assessment of Marine Pilings

ISO 14044 Compliant

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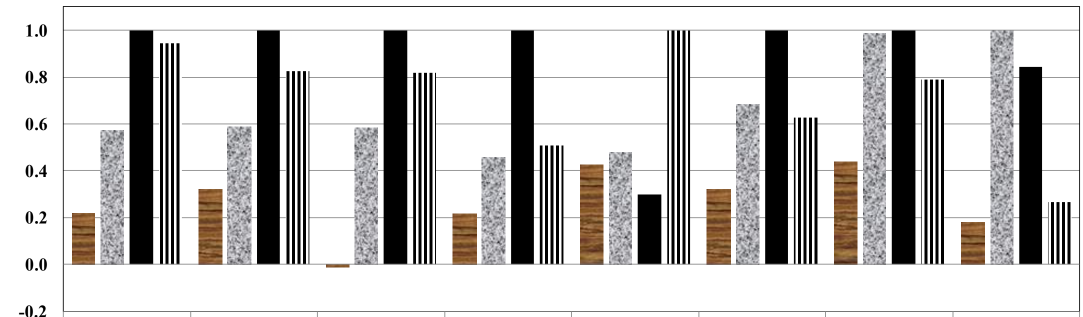
Conclusions and Summary Report

1. Conclusions & Executive Summary

The Treated Wood Council has completed a quantitative evaluation of the environmental impacts associated with the national production, use, and disposition of treated wood, concrete, galvanized steel, and plastic marine piles using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The results for treated wood piles are significant.

- **<u>Less Energy & Resource Use</u>:** Treated wood marine piles require less total energy and less fossil fuel than concrete, galvanized steel, and plastic marine piles. Treated wood marine piles require less water than concrete and plastic marine piles.
- **<u>Lower Environmental Impacts</u>:** Treated wood marine piles have lower environmental impacts than concrete, steel, and plastic marine piles in all six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, ecotoxicity, and eutrophication-causing emissions.
- **<u>Decreases Greenhouse Gas Levels</u>:** Use of treated wood marine piles lowers greenhouse gas levels in the atmosphere whereas concrete, galvanized steel, and plastic marine piles increase greenhouse gas levels in the atmosphere.
- **<u>Offsets Fossil Fuel Use</u>:** Reuse of treated wood marine piles 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)



	Fossil Fuel Use	Greenhouse Gas	Net GHG	Acid Rain	Water Use	Smog	Eutrophication	Ecotoxicity
Treated wood pile	0.22	0.32	-0.010	0.22	0.42	0.32	0.44	0.18
Concrete pile	0.57	0.59	0.58	0.46	0.48	0.69	0.99	1.0
Steel pile	1.0	1.0	1.0	1.0	0.30	1.0	1.0	0.84
Plastic pile	0.95	0.83	0.82	0.51	1.0	0.63	0.79	0.27

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.

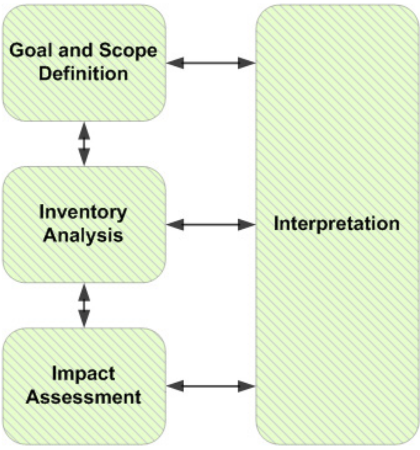
The carbon embodied in wood products, such as marine piles, is removed from the atmosphere during growth, stored for decades while the product is in use, and can be used for beneficial energy recovery at disposition. This temporary storage of carbon in the wood product reduces atmospheric levels of CO_2 because the service life of the pile exceeds the time required for tree growth.

2. 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 marine piles using LCA methodologies. The scope of this study includes:

- A life cycle inventory of four marine pile types: treated wood, concrete, galvanized steel, and plastic. Chromated copper arsenate (CCA) was chosen as a representative preservative for assessment of treated wood marine piles.
- 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.

3. Quality criteria



This LCA study was done in accordance with the principles and guidance provided by the International Organization for Standardization (ISO) in standards ISO/DIS 14040 and ISO/DIS 14044. The LCA procedures and findings were evaluated by a panel of external reviewers in accordance with Section 6 of ISO 14044. The external reviewers confirmed that the LCA followed the ISO standards and that the comparative assertions were done using equivalent functional units and equivalent methodological considerations.

4. Manufacturer Information

This LCA addresses products from multiple marine pile manufacturers.

- The LCA for treated wood marine piles includes weighted averages of primary data sources, including survey responses representing 14% of the total U.S. water-borne treated marine pile production.
- The LCAs for concrete, galvanized steel, and plastic marine piles 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.

5. Product Description and Functional Unit

For collection of LCA inventory inputs and outputs and comparative purposes, a 40-foot pile was chosen as a baseline product.

Scope: Cradle-to-grave

Functional unit: one 40-foot marine pile (wood product has a mid-point diameter of 12 inches).

Service life: 40 years

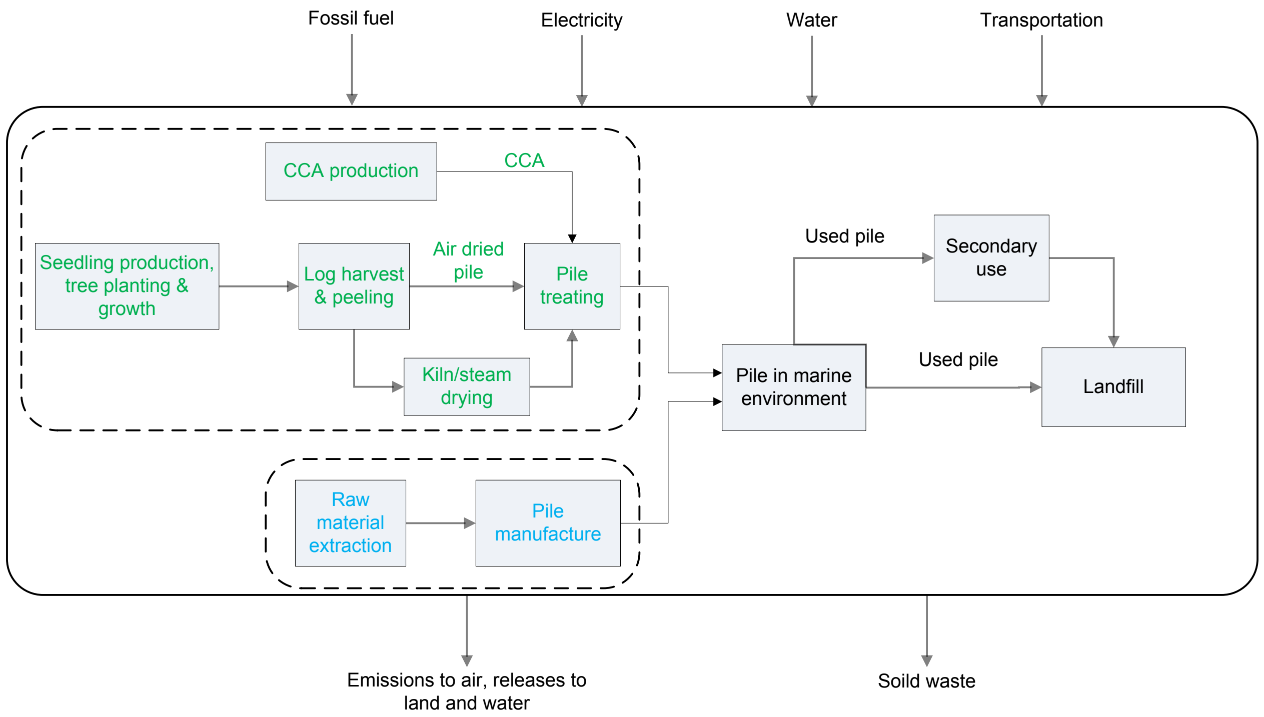
System boundary: from the extraction of the raw materials through processing, transport, primary service life, reuse, and disposal of the product.

Geographic boundary: U.S.

6. Life Cycle Inventory

The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the marine pile. 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.

Figure 2 System boundary and process flows for marine piles. Cradle-to-gate processes for treated wood are shown in green and non-wood products are shown in blue. Gate-to-grave processes are shown in black as combined.



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 marine piles assessed in this study.

The length of time a marine pile remains in marine service is dependent upon a number of factors. Often, piles are removed from service before the end of their useful service life, such as for marine upgrades. Assumptions used in this LCA for disposition of marine piles after service life include:

- Treated wood piles are recycled for secondary use or disposed in a solid waste landfill
- Concrete piles are recycled or disposed in a solid waste landfill
- Steel piles are recycled
- Plastic piles are recycled or disposed in solid waste landfills

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

Table 1 Environmental performance (per pile)

Impact category	Units	Treated wood pile	Concrete pile	Galvanized steel pile	Plastic pile
Energy use					
Energy input (technosphere)	MMBTU	2.8	4.6	7.3	3.85
Energy input (nature)	MMBTU	3.2	9	17.3	18
Biomass energy	MMBTU	0.73	0.086	0.29	0.073
Environmental indicators					
Anthropogenic greenhouse gas	lb-CO_2-eq	1,453	2,671	4,541	3,756
Total greenhouse gas	lb-CO_2-eq	-48	2,691	4,610	3,774
Acid rain air emissions	lb-H+ mole-eq	349	743	1,620	822
Smog potential	g NOx / m	1.7	3.6	5.3	3.3
Ecotoxicity air emissions	lb-2,4-D-eq	3.4	19	16.1	5.1
Eutrophication air emissions	lb-N-eq	0.097	0.22	0.22	0.17
Resource use					
Fossil fuel use	MMBTU	4.8	13	21.9	21
Water use	gal	236	267	167	556

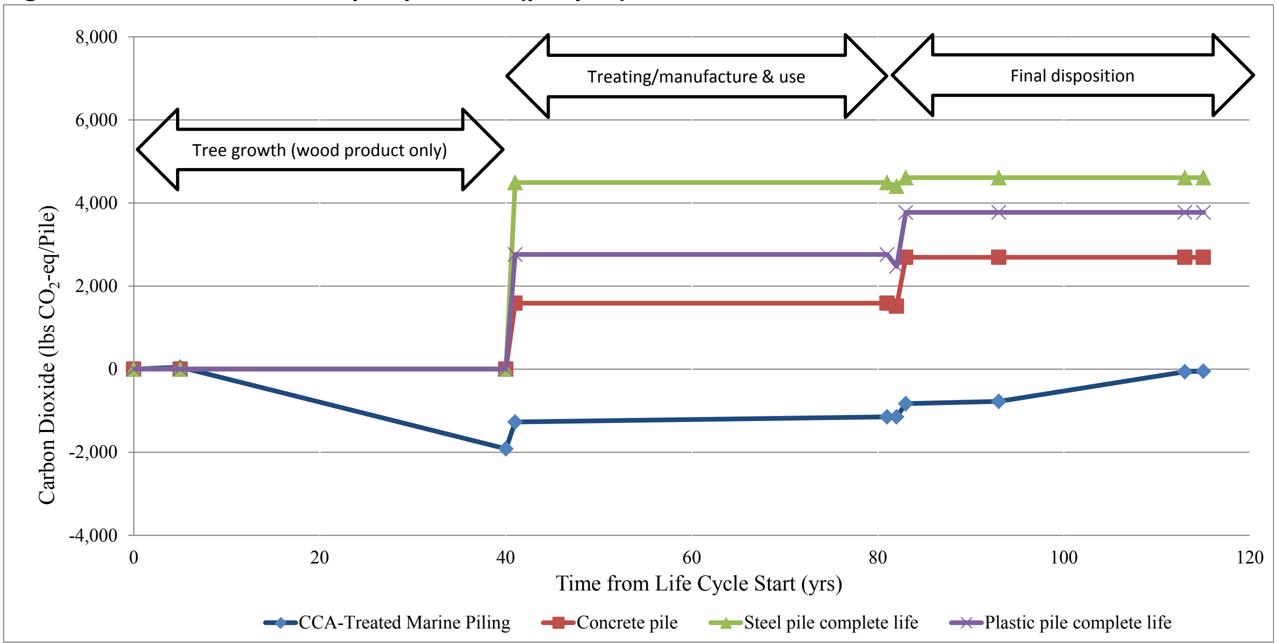
Treated wood piles result in releases that could impact highly localized marine ecological toxicity. The potential for such releases depends on numerous factors, including water flow or circulation rates, ambient levels of metals, and the number of piles in a row parallel to flow or current. A modeling tool, such as the peer-reviewed and National Oceanic and Atmospheric Administration (NOAA) Fisheries-recognized Preservative Risk Assessment Model, provides a tool to evaluate potential marine ecotoxicity for specific projects in which treated marine piles are being considered.

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 40-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.

Non-wood marine pile products begin their life cycle with the extraction of resources, such as limestone or silica sand or carbon-sequestered resources such as oil and coal, and require energy to convert resources into manufactured products.

Minimal impacts are required for both wood and non-wood products in the service life stage. Following the service life stage, wood piles are recycled for secondary uses or disposed in landfills. Non-wood material piles are recycled or disposed in landfills. The carbon balance of each marine pile product through the life cycle stages is shown in Figure 3.

Figure 3 Carbon balance for pile products (per pile)



Note: Net carbon less than zero is a reduction of greenhouse gas levels in the atmosphere because of the product's manufacture, use and disposal. Net carbon greater than zero is an increase of greenhouse gas levels in the atmosphere.

8. Additional Information

This study is further detailed in a Procedures and Findings Report completed September 28, 2012 and is available upon request from the Treated Wood Council at www.treated-wood.org/contactus.html.

This study has been published in the peer-reviewed *Journal of Marine Environmental Engineering* and is available at http://www.oldcitypublishing.com/JMEE/JMEEcontents/JMEEv9n3issuecontents.html.