



Biodiesel as a Carrier Agent for Preservative Applications

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Contents

List of Figures Error! Bookmark not defined.

1 Forward.....5

2 Executive Summary6

3 Laboratory Leachability Test of Pentachlorophenol Formulations8

 3.1 Summary.....8

 3.2 Introduction8

 3.3 Experimental.....8

 3.4 Results & Discussion10

 3.5 Conclusions.....11

 Figure 3.1. Leachability of southern pine treated with pentachlorophenol (target retention = 7.2 kg/m3) in different carrier systems.12

 Figure 3.2. Leachability of southern pine treated with pentachlorophenol (target retention = 6.1 kg/m3) in different carrier systems.12

 Figure 3.3. Leachability of Western red cedar treated with pentachlorophenol (target retention = 12.8 kg/m3) in different carrier systems.....13

 Figure 3.4. Leachability of Western red cedar treated with pentachlorophenol (target retention = 16.0 kg/m3) in different carrier systems.....13

 Figure 3.5. Leachability of Douglas---fir treated with pentachlorophenol (target retention = 9.6 kg/m3) in different carrier systems.14

 Figure 3.6. Leachability of red pine treated with pentachlorophenol (target retention = 8.5 kg/m3) in different carrier systems.....14

Appendix A: Treatment Data15

Appendix B: Leachability Test Data23

Appendix C: Leachate Chemical Analysis Report.....3

4 Laboratory Soil Block Decay Test of Pentachlorophenol Formulations.....4

 4.1 Summary.....4

 4.2 Introduction4

 4.3 Experimental.....4

 4.4 Results and Discussion5

 4.5 Conclusions7

Appendix A: Soil Block Treatment Data8

Appendix B: Soil Block Decay Test Data.....12

1 Forward

Utility pole manufacturers have supplied North American utility markets for more than 95 years, but the utility pole industry has received complaints about strong odors coming from their production sites. These odors are related to a wood treatment co-solvent known as DT-40, which has unusual concentrations of butyl butyrate and 2-ethylhexanol—compounds that tend to produce high odor levels.

To reduce these odor levels, one pole manufacturer implemented use of biodiesel as a treatment co-solvent. The poles are treated with a preservative using a B20 biodiesel mixture, which has demonstrated lower odor problems. Previously, they used a mixture of the preservative and a carrier consisting of 100% diesel fuel in their treatment process.

Members of the American Wood Preservers Association (AWPA) have challenged the use of biodiesel as a carrier for the preservative treatment, prompting debate in the trade organization about the utilization of biodiesel as a co-solvent. There is no extensive testing to support or oppose the use of biodiesel in this application. Therefore, AURI and the Minnesota Soybean Research & Promotion Council funded this research to investigate biodiesel as a co-solvent for this wood treatment.

The research addresses the following questions:

- What is the leaching rate at various Bxx levels vs. DT40?
- Does biodiesel hold PENTA better?
- Is biodiesel leaching out of the wood over time?
- Does the biodiesel break down over time?
- What is the optimal biodiesel blend rate? (B20, B30, B40, B50)

Project Outcomes

This research demonstrated support for usage of biodiesel as a preservative carrier. This usage diversifies the market base for biodiesel beyond that of just the transportation industry and improves the overall financial stability of the industry, representing a new and substantial non-fuel market for the industry.

Currently, one pole manufacturer uses 5 loads of B20/week in their preservative application or 390,000 gallons of biodiesel annually. Every additional 10% increase in percentage of biodiesel in the carrier mixture will increase the market for biodiesel by 195,000 gallons annually. Industry sources expect that usage of biodiesel as a preservative carrier will continue to expand the market for biodiesel well beyond original usage estimates.

AURI will share this research with preservative treatment processors, electrical utilities and Minnesota biodiesel producers. The report's findings will also be disseminated to utilities and members of the construction industry having need or the capacity to utilize treated poles.

Denny Timmerman
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2 Executive Summary

Project Objectives:

A national utility pole manufacturer began using biodiesel as a treatment co-solvent to treat wood poles with the intention of reducing odor. Within their trade organization, AWWPA (American Wood Preservers Association), there has been opposition to the use of biodiesel in this application. There is no extensive testing to support those that are using biodiesel as a co-solvent. The utility pole manufacturer was interested in testing that could help determine if biodiesel could be substituted for conventional petroleum based co-solvents without adversely affecting pentachlorophenol leachability or decay resistance.

Description of Work Performed & Conclusions:

Michigan Technological University's School of Forest Resources and Environmental Science was chosen to conduct the testing because they have credibility in the industry and the capabilities to carry out the testing. Attached is the final report for Project No. AIC-100, Laboratory Soil Block Decay Test and Laboratory Leachability Test of Pentachlorophenol Formulations. A summary of the testing is as follows:

Laboratory Leachability Test of Pentachlorophenol Formulations

- Leachability of southern pine, western red cedar, Douglas-fir, and red pine treated with biodiesel blends and conventional wood preservative treatments.
- Blends of B20, B30, B40, B50 and B100 were tested.
- The purpose: to compare the leachability of wood treated with biodiesel-based pentachlorophenol formulations vs. petroleum based formulations.
- Biodiesel substituted for petroleum-based co-solvents did not increase the leachability of pentachlorophenol.
- In regards to PCP leaching, biodiesel-based formulations performed at least as well as petroleum-based formulations.
- Increased biodiesel content may actually reduce PCP leaching.

Soil Block Decay Test of Pentachlorophenol Formulations

- The decay resistance of southern pine treated with B20 was exposed to 2 different common fungi (*Gloeophyllum trabeum* and *Neolentinus lepideus*)
- The purpose: compare decay resistance of the preservative treatment
- Only B20 was used as it is the most commercially viable blend being used in real world applications
- Biodiesel substituted for petroleum based co-solvents in pentachlorophenol wood preservative formulations did not reduce the decay resistance of treated southern pine in this test.
- Biodiesel substituted for petroleum diesel may have increased the protection against the fungal contamination.

Benefit to Minnesota Economic Development:

B20 was the most commonly used co-solvent blend level in this industry. These tests indicate that biodiesel blends perform at least as well as traditional petroleum based co-solvents and may even outperform in the areas tested in this project. Initially, the utility pole manufacturer was utilizing B20 (390,000 gallons annually) and the testing would protect that biodiesel usage. If they increase the biodiesel content of their co-solvent the impact on biodiesel usage would be as follows:

B30 – 585,000 gallons of biodiesel/year (+195,000)

B40 – 780,000 gallons of biodiesel/year (+390,000)

B50 – 975,000 gallons of biodiesel/year (+585,000)

Future Needs/Plans:

Based on the positive outcome of the Leachability testing, it is recommended to conduct Soil Block Decay testing with other fungi, wood species and higher biodiesel blends.

3 Laboratory Leachability Test of Pentachlorophenol Formulations

3.1 Summary

The leachability of southern pine, western red cedar, Douglas-fir, and red pine treated with biodiesel and conventional oilborne pentachlorophenol wood preservative formulations was evaluated in an AWWA E11--06 laboratory leachability test. Biodiesel formulations generally leached comparably to conventional petroleum-based formulations. Higher biodiesel content may lead to less pentachlorophenol leaching. Western red cedar and Douglas-fir leached more pentachlorophenol than the pine species.

3.2 Introduction

Oilborne pentachlorophenol is a wood preservative commonly used to treat utility poles. Biodiesel provides an alternative carrier system co-solvent that can be used in combination with fuel oil in these formulations. Substitution of biodiesel co-solvents may lower the dependence of wood treatment facilities on fossil fuels and reduce the environmental impact of the preservative treatment. The purpose of this study was to compare the leachability of wood treated with biodiesel-containing pentachlorophenol formulations to wood treated with a conventional petroleum-based formulation. Southern pine, western red cedar, Douglas-fir, and red pine are commonly used for utility poles and were chosen for this study. Biodiesel formulations are designated as B20, B30, B40, B50, and B100. The conventional co-solvent formulation was designated as Protreat. The leachability test was conducted from December 2010–June 2011 as MTU Project E44212.

3.3 Experimental

3.3.1 Materials

Wood

Southern pine (*Pinus* spp.), Western red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), and red pine (*Pinus resinosa*) were used.

Treating Chemicals

Wood preservative chemicals were received from a utility pole manufacturer. Biodiesel and conventional co-solvents were used as received. Pentachlorophenol (penta, PCP) was pulverized in a mortar and pestle to reduce particle size. Toluene was purchased from Sherwin Williams (Houghton, MI) and #2 off-road diesel was purchased from Sharon Avenue Express Mart (Houghton, MI).

3.3.2 Wood Specimen Selection and Preparation

Specimens were selected following the guidelines of AWWA E7-09¹ as much as possible. Boards for all wood species treated were clear, straight grained, and defect-free. Quarter-sawn southern pine boards were further selected to have 6–10 rings per inch and be entirely sapwood. Red pine boards were also selected to be 100% sapwood. Western red cedar and Douglas-fir boards were selected to maximize sapwood, and were approximately 50% and 90% sapwood, respectively.

Specimens were machined into 19 mm cubes and sorted to generate a narrow weight range to minimize density as a variable. Within each species, the mean weights of the leachability block sets were statistically identical as determined by Kruskal-Wallis One Way Analysis of Variance by Ranks test. There were 396 specimens selected for treatment and as controls. Outliers were discarded.

3.3.3 Preservative Treatment

Southern pine, western red cedar, Douglas-fir and red pine leachability blocks were treated at Michigan Tech in December 2010 in accordance with AWWA E7-09. The commercial empty cell treating process was mimicked. Toluene, a volatile solvent, was used as the diluent for an empty cell treating formulation. An initial vacuum of 84.7 kPa (25" Hg) was drawn for 30 minutes immediately followed by 758.4 kPa (110 PSI) pressure for 60 minutes. Preservative retentions were determined gravimetrically from the pre- and post-treatment specimen weights. Treated specimens were air-dried and conditioned until they reached constant weight before they were exposed to the leachability test. The experimental design is shown in Table 1, and the treatment data is attached as Appendix A.

Leachability Test

A laboratory leachability test was conducted in accordance with AWWA Standard E11-06.² In order to assure full saturation, the leachability blocks were initially pressure treated with water using the vacuum and pressure conditions described above. The leachate water was changed after 6, 18, 24, and 48 hours, and every 48 hours thereafter to a total leaching period of 336 hours. During each leachate water change, a 10 ml aliquot of leachate solution was collected and retained. All the leachate collected for a given treatment was pooled into a separate composite sample. There were a total of 48 composite samples generated during the test, each composed of nine leachate aliquots. These were refrigerated between leachate collections and after completion of the test. They were then sent to the Laboratory for Environmental Analysis (University of Georgia) for pentachlorophenol analysis.

Chemical Analysis

Pentachlorophenol analysis was conducted at the University of Georgia using gas chromatography-mass spectrometry (GC-MS). The analytical results were then provided to Michigan Tech for inclusion in this report.

¹ AWWA Standard E7-09, Standard Method of Testing Wood Preservatives by Field Tests with Stakes, American Wood Protection Association (2011)

² AWWA Standard E11-06, STANDARD METHOD OF DETERMINING THE LEACHABILITY OF WOOD PRESERVATIVES American Wood Protection Association (2011) Birmingham, AL USA

Specimen		Preservative&System		Specimen		Preservative&System	
Number	Species	Formulation	Target&Retention&(Kg/m³)	Number	Species	Formulation	Target&Retention&(Kg/m³)
1	Southern*Pine	B20	6.1	26	Western*Red*Cedar	B20	12.8
2	Southern*Pine	B20	7.2	27	Western*Red*Cedar	B20	16.0
3	Southern*Pine	B20	7.2	28	Western*Red*Cedar	B30	12.8
4	Southern*Pine	B20	7.2	29	Western*Red*Cedar	B30	16.0
5	Southern*Pine	B30	6.1	30	Western*Red*Cedar	B40	12.8
6	Southern*Pine	B30	7.2	31	Western*Red*Cedar	B40	16.0
7	Southern*Pine	B30	7.2	32	Western*Red*Cedar	B50	12.8
8	Southern*Pine	B30	7.2	33	Western*Red*Cedar	B50	16.0
9	Southern*Pine	B40	6.1	34	Western*Red*Cedar	Protreat	12.8
10	Southern*Pine	B40	7.2	35	Western*Red*Cedar	Protreat	16.0
11	Southern*Pine	B40	7.2	36	Western*Red*Cedar	Untreated	???
12	Southern*Pine	B40	7.2	37	Douglas?fir	B20	9.6
13	Southern*Pine	B50	6.1	38	Douglas?fir	B30	9.6
14	Southern*Pine	B50	7.2	39	Douglas?fir	B40	9.6
15	Southern*Pine	B50	7.2	40	Douglas?fir	B50	9.6
16	Southern*Pine	B50	7.2	41	Douglas?fir	Protreat	9.6
17	Southern*Pine	B100	6.1	42	Douglas?fir	Untreated	???
18	Southern*Pine	B100	7.2	43	Red*Pine	B20	8.5
19	Southern*Pine	B100	7.2	44	Red*Pine	B30	8.5
20	Southern*Pine	B100	7.2	45	Red*Pine	B40	8.5
21	Southern*Pine	Protreat	6.1	46	Red*Pine	B50	8.5
22	Southern*Pine	Protreat	7.2	47	Red*Pine	Protreat	8.5
23	Southern*Pine	Protreat	7.2	48	Red*Pine	Untreated	???
24	Southern*Pine	Protreat	7.2	49	Water*Blank		
25	Southern*Pine	Untreated	???				

Statistical Analysis

All statistical analysis was performed using One Way Analysis of Variance ($\alpha = 0.05$) using SigmaPlot 12 statistical software.³ When a statistically significant difference was found, a Sidak-Holm-All-Pairwise-Comparison ($\alpha = 0.05$) was used to determine which groups were different from each other.

3.4 Results & Discussion

Leachability of Treated Wood

Overall results are graphically summarized in Figures 1 through 6, and tabulated in Appendix B. The University of Georgia chemical analysis report is attached as Appendix C.

Biodiesel-based and conventional petroleum-based preservative formulations generally leached comparably to one another in this test. Higher content biodiesel formulations leached less pentachlorophenol than the Protreat formulations for the pines and for Douglas-fir. Western red cedar exhibited no clear trend for the effect of biodiesel content and leachability.

For southern pine treated to a 7.2 kg/m³ target retention, the B100 (100% biodiesel formulation) leached significantly less pentachlorophenol than the conventional and B20 formulations (CI=0.95, $p < 0.001$). The PCP leachability of the B20, B30, B40, and B50 formulations were not

³ SigmaPlot 12, Systat Software, Inc. (2010) San Jose, CA, USA

significantly different from one another (Figure 1). Although no statistics were performed because only one leachate replicate was tested, the lower southern pine retention behaved similarly to the higher retention (Figure 2). The leachate penta concentrations were comparable for the B20 and conventional formulations, and PCP leaching was inversely proportionate to formulation biodiesel content,

Although pentachlorophenol leachability from Western red cedar treated with biodiesel formulations was quite variable at both of the studied retentions (Figures 3 and 4), the interpretation is that it is comparable to the conventional formulation. The B20 and B50 leachate PCP concentrations are 15% to 20% greater than the Protreat at the lower retention and less than 10% greater at the higher retention. Similar differences were not statistically significant in the analysis of the southern pine data. These differences are likely within experimental error. They may arise from the large amount (50%) of heartwood content in the Western red cedar leachability blocks, leading to uneven penetration of PCP and possible higher concentrations at the specimen surfaces. Additional study may help to better clarify the behavior of the preservative formulations with respect to Western red cedar.

The leachability of penta from Douglas---fir (Figure 5) was inversely proportional to biodiesel content in the formulation. The B20 formulation leached comparably to the Protreat formulation, whereas the B50 formulation appears to have leached considerably less PCP. The leachability of pentachlorophenol from red pine (Figure 6) was comparable for all tested formulations.

3.5 Conclusions

Substitution of biodiesel co-solvents for conventional petroleum based co-solvents in pentachlorophenol wood preservative formulations did not increase the leachability of pentachlorophenol. The biodiesel---based formulations generally performed at least as well as the conventional petroleum-based formulations with respect to PCP leaching. In fact, increased biodiesel content may reduce pentachlorophenol leachability. Further study is needed to definitively establish if this is the case.

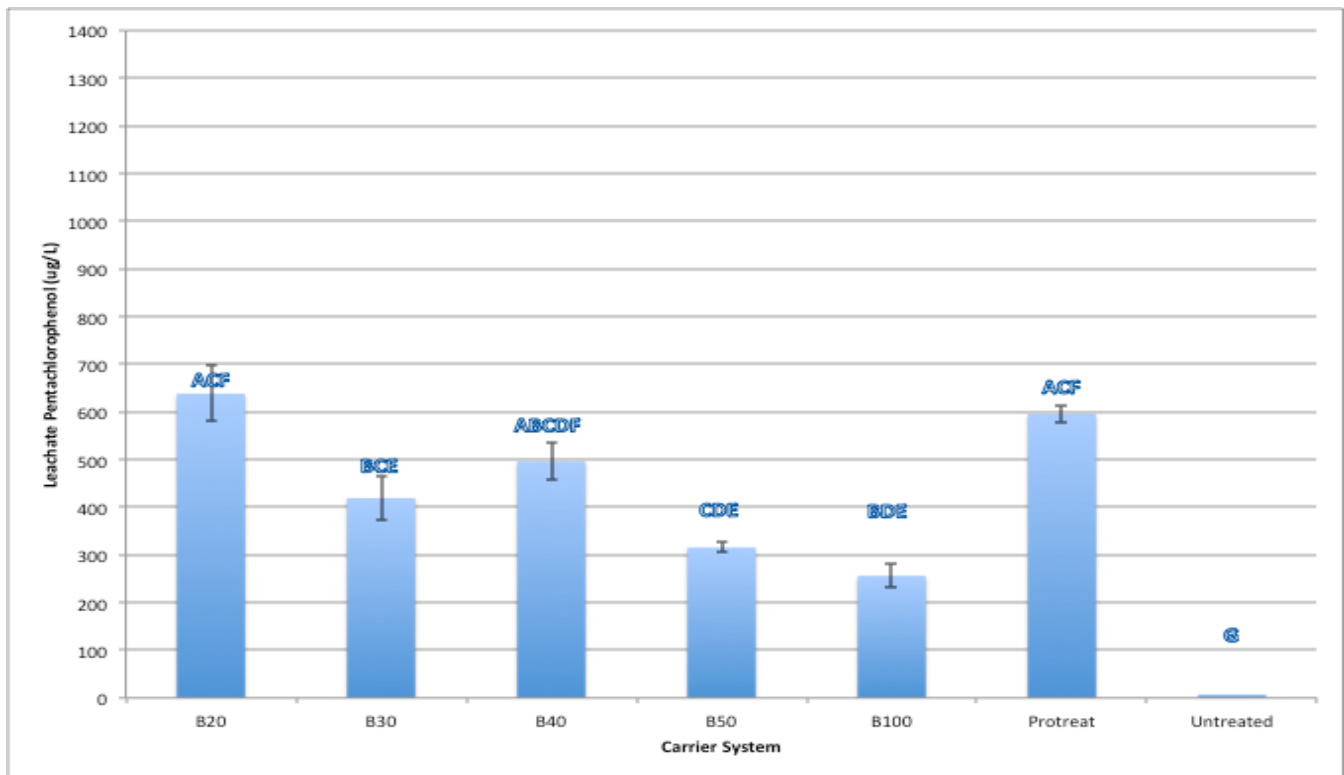


Figure 3.1. Leachability of southern pine treated with pentachlorophenol (target retention = 7.2 kg/m³) in different carrier systems. There were three replicate leachate solutions assayed for each specimen type. The error bars are standard error and like letters indicate treatments that are statistically identical (CI=0.95).

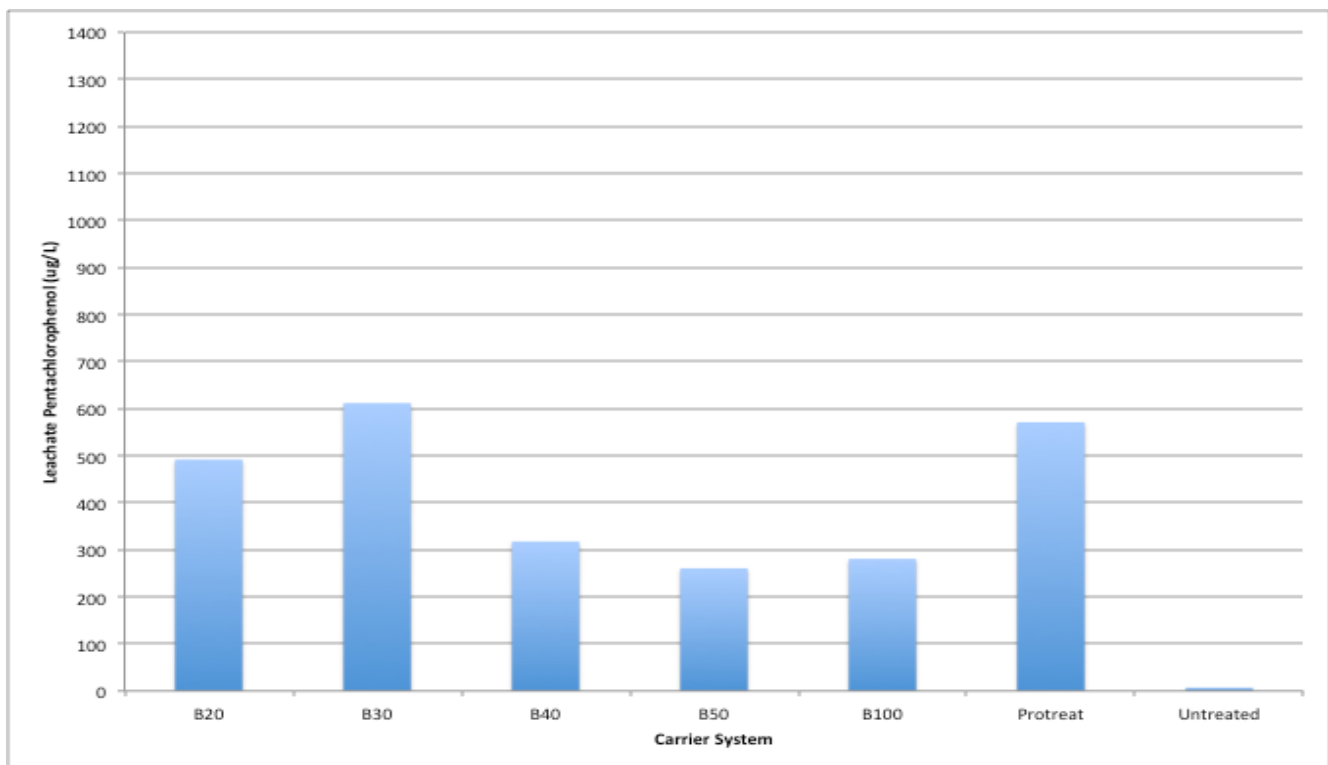


Figure 3.2. Leachability of southern pine treated with pentachlorophenol (target retention = 6.1 kg/m³) in different carrier systems. There was one replicate leachate solution assayed for each specimen type.

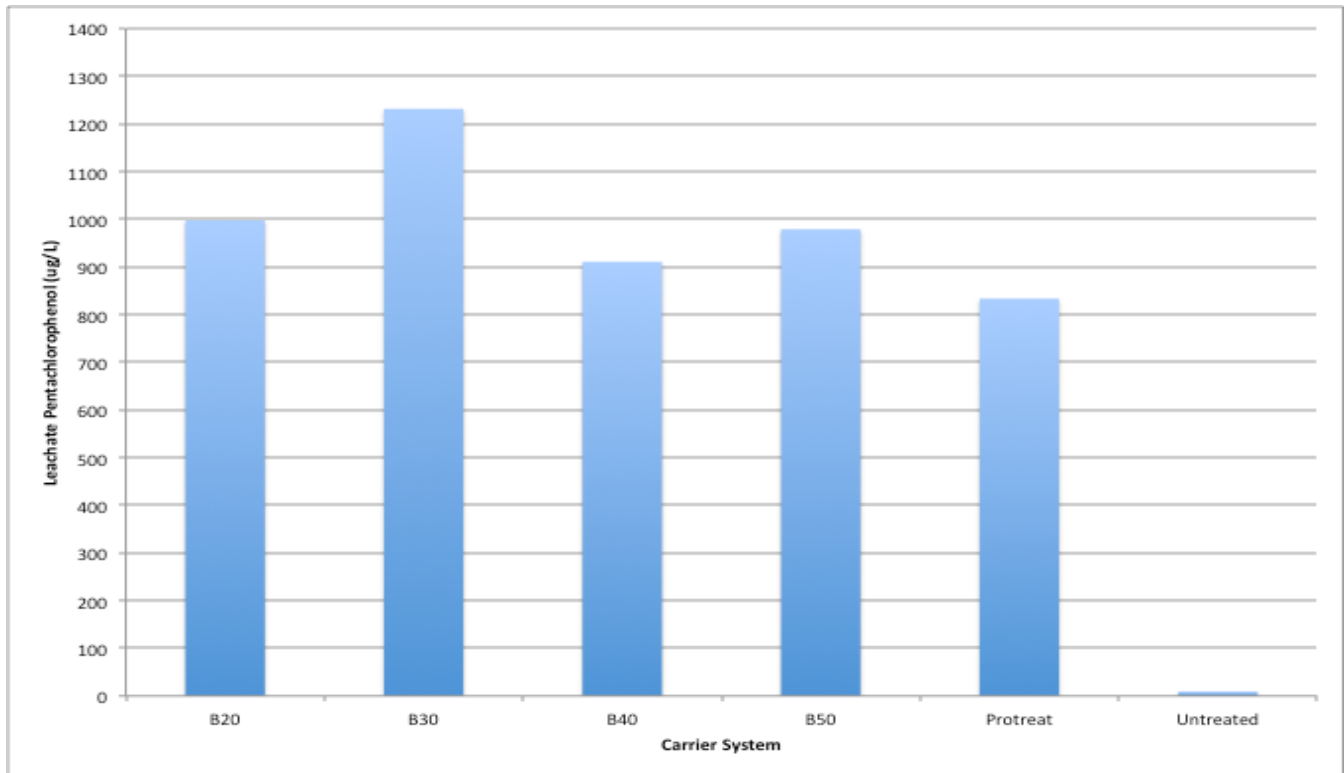


Figure 3.3. Leachability of Western red cedar treated with pentachlorophenol (target retention = 12.8 kg/m³) in different carrier systems. There was one replicate leachate solution assayed for each specimen type.

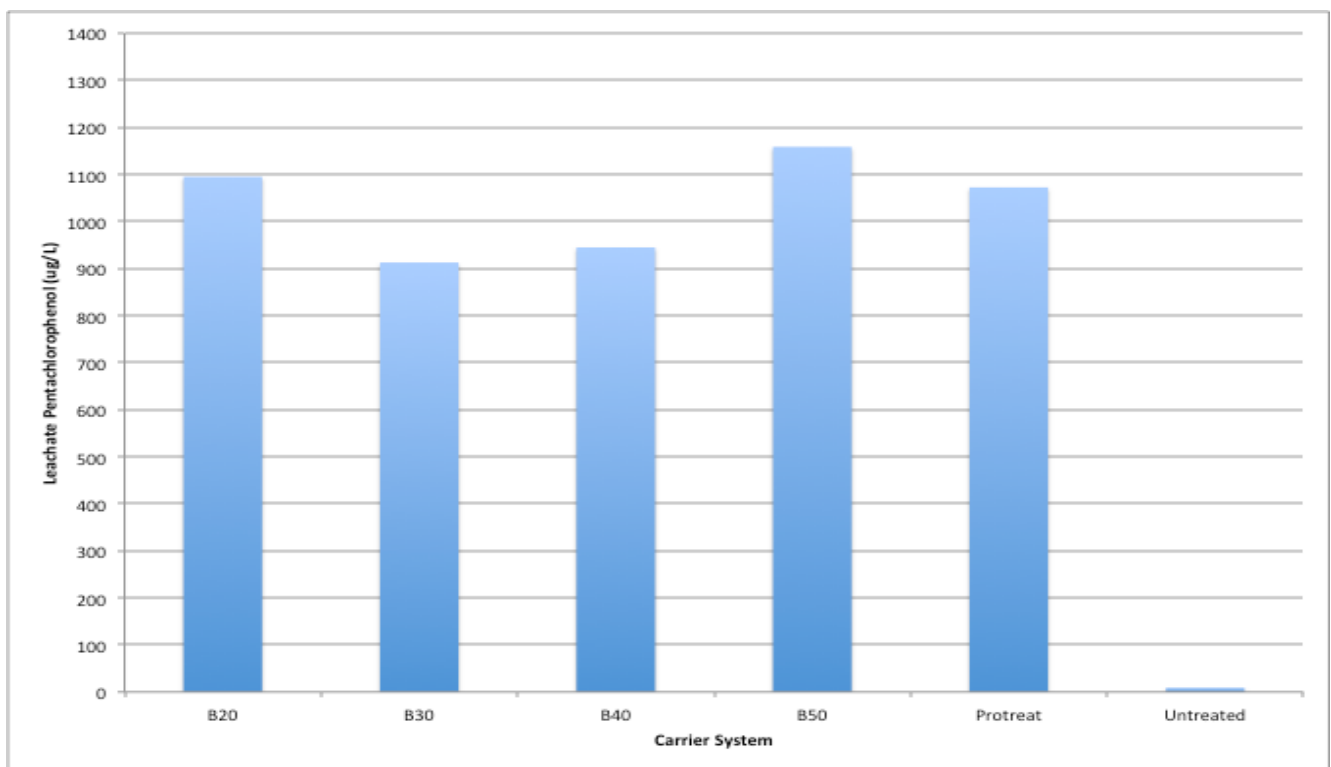


Figure 3.4. Leachability of Western red cedar treated with pentachlorophenol (target retention = 16.0 kg/m³) in different carrier systems. There was one replicate leachate solution assayed for each specimen type.

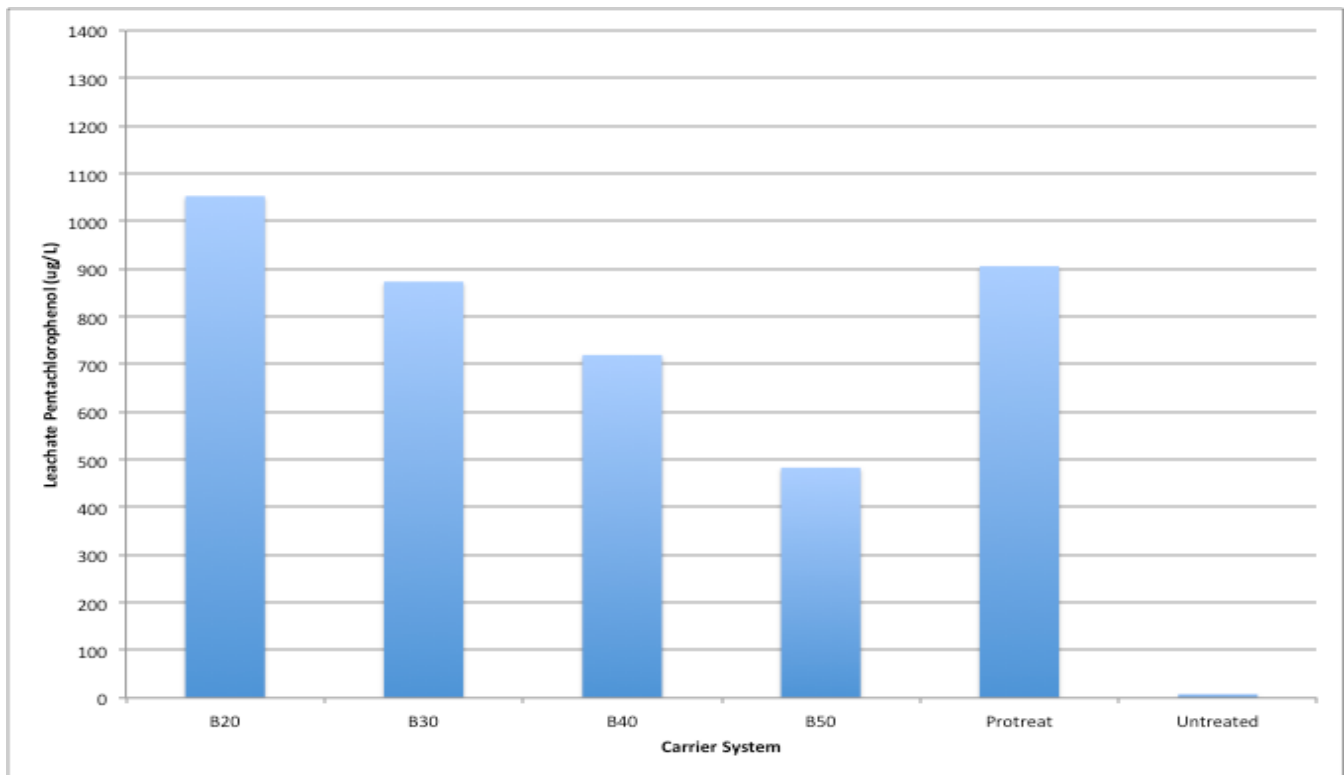


Figure 3.5. Leachability of Douglas---fir treated with pentachlorophenol (target retention = 9.6 kg/m³) in different carrier systems. There was one replicate leachate solution assayed for each specimen type.

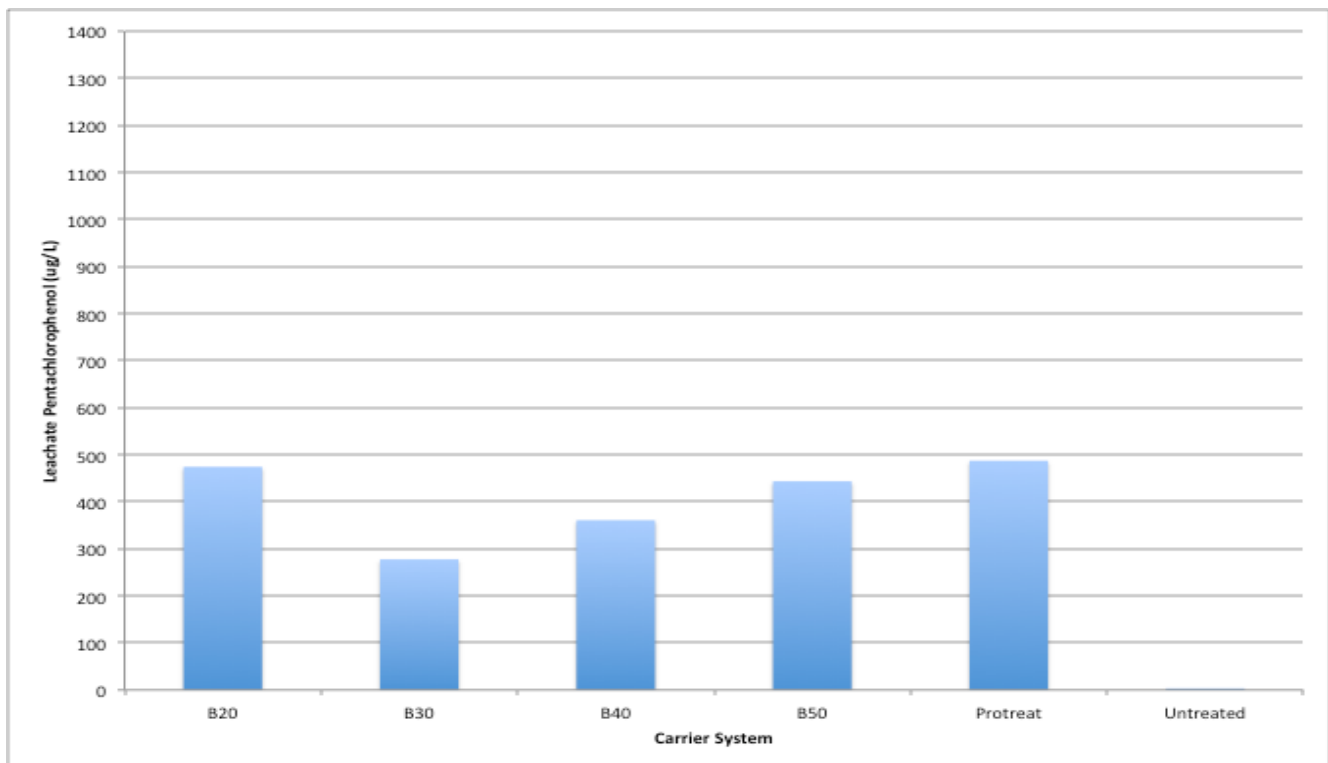


Figure 3.6. Leachability of red pine treated with pentachlorophenol (target retention = 8.5 kg/m³) in different carrier systems. There was one replicate leachate solution assayed for each specimen type.

Appendix A: Treatment Data

Table A1. Summary Table of Pentachlorophenol Pressure Treatment for the AWP A E11---06 Laboratory Leachability Test

Treatment					Calculated Retention (Kg/m ³)			Deviation From Target
Type	Wood Species	Date	Formulation*	Target Retention (Kg/m ³)	Average	STDEV	STDERR	(%)
1	Southern Pine	12/2/10	B20	6.10	6.13	0.10	0.03	0.51
2	Southern Pine	12/2/10	B20	7.20	7.11	0.23	0.08	---1.26
3	Southern Pine	12/2/10	B20	7.20	7.12	0.18	0.07	---1.18
4	Southern Pine	12/2/10	B20	7.20	7.08	0.19	0.08	---1.73
5	Southern Pine	12/3/10	B30	6.10	6.18	0.12	0.04	1.24
6	Southern Pine	12/3/10	B30	7.20	7.21	0.24	0.08	0.12
7	Southern Pine	12/3/10	B30	7.20	7.24	0.21	0.08	0.51
8	Southern Pine	12/3/10	B30	7.20	7.16	0.08	0.03	---0.59
9	Southern Pine	12/3/10	B40	6.10	6.09	0.15	0.05	---0.12
10	Southern Pine	12/3/10	B40	7.20	7.26	0.23	0.08	0.85
11	Southern Pine	12/3/10	B40	7.20	7.15	0.14	0.06	---0.74
12	Southern Pine	12/3/10	B40	7.20	7.07	0.14	0.06	---1.79
13	Southern Pine	12/7/10	B50	6.10	6.23	0.14	0.05	2.17
14	Southern Pine	12/7/10	B50	7.20	6.99	0.34	0.11	---2.90
15	Southern Pine	12/7/10	B50	7.20	6.99	0.23	0.09	---2.96
16	Southern Pine	12/7/10	B50	7.20	6.86	0.23	0.09	---4.68
17	Southern Pine	12/7/10	B100	6.10	6.30	0.07	0.02	3.33
18	Southern Pine	12/7/10	B100	7.20	7.53	0.17	0.06	4.57
19	Southern Pine	12/7/10	B100	7.20	7.39	0.31	0.13	2.63
20	Southern Pine	12/7/10	B100	7.20	7.20	0.25	0.10	---0.06
21	Southern Pine	12/8/10	Protreat	6.10	6.27	0.15	0.05	2.79
22	Southern Pine	12/8/10	Protreat	7.20	7.27	0.24	0.08	0.93
23	Southern Pine	12/8/10	Protreat	7.20	7.11	0.20	0.08	---1.24
24	Southern Pine	12/8/10	Protreat	7.20	7.05	0.17	0.07	---2.03
25	Southern Pine	NA	Untreated	0.00	-----	-----	-----	-----
26	Western Red Cedar	12/8/11	B20	12.80	13.11	0.13	0.04	2.43
27	Western Red Cedar	12/8/11	B20	16.00	16.49	0.12	0.04	3.05
28	Western Red Cedar	12/9/11	B30	12.80	13.12	0.15	0.05	2.47
29	Western Red Cedar	12/9/11	B30	16.00	16.30	0.18	0.06	1.90
30	Western Red Cedar	12/9/11	B40	12.80	13.00	0.13	0.04	1.60
31	Western Red Cedar	12/9/11	B40	16.00	16.33	0.28	0.09	2.07
32	Western Red Cedar	12/9/11	B50	12.80	12.96	0.32	0.11	1.25
33	Western Red Cedar	12/9/11	B50	16.00	16.42	0.36	0.12	2.61
34	Western Red Cedar	12/9/11	Protreat	12.80	12.91	0.12	0.04	0.87
35	Western Red Cedar	12/9/11	Protreat	16.00	16.31	0.19	0.06	1.95
36	Western Red Cedar	NA	Untreated	0.00	-----	-----	-----	-----
37	Douglas Fir	12/10/11	B20	9.60	9.67	0.38	0.13	0.76
38	Douglas Fir	12/10/11	B30	9.60	9.63	0.38	0.13	0.29
39	Douglas Fir	12/10/11	B40	9.60	9.66	0.48	0.16	0.63
40	Douglas Fir	12/10/11	B50	9.60	9.47	0.27	0.09	---1.38
41	Douglas Fir	12/10/11	Protreat	9.60	9.67	0.49	0.16	0.70
42	Douglas Fir	NA	Untreated	0.00	-----	-----	-----	-----
43	Red Pine	12/13/11	B20	8.50	8.29	0.28	0.09	---2.51
44	Red Pine	12/13/11	B30	8.50	8.38	0.26	0.09	---1.42
45	Red Pine	12/13/11	B40	8.50	8.28	0.36	0.12	---2.60
46	Red Pine	12/13/11	B50	8.50	8.30	0.45	0.15	---2.30
47	Red Pine	12/13/11	Protreat	8.50	8.39	0.19	0.06	---1.26
48	Red Pine	NA	Untreated	8.50	-----	-----	-----	-----

Table A2. Pentachlorophenol Pressure Treatment of Southern Pine for the AWP A E11--06 Laboratory Leachability Test

Type	Wood Species	Date	Specimen			Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation	Target Retention (Kg/m ³)	Label #	Length	Width	Thick	Initial	Final	Gross	Net
1	Southern Pine	12/2/10	B20	6.10	1	19.21	19.43	20.18	4.31	7.86	471.3	6.25
					2	19.37	19.84	19.37	4.40	7.76	451.4	5.99
					3	19.55	20.14	19.39	4.26	7.87	472.8	6.27
					4	19.28	20.11	19.06	4.26	7.71	466.8	6.19
					5	19.32	19.35	19.91	4.46	7.85	455.4	6.04
					6	19.45	18.90	20.23	4.20	7.68	468.0	6.21
					7	19.75	19.39	19.26	4.42	7.79	456.9	6.06
					8	20.01	19.30	19.61	4.44	7.89	455.6	6.04
					9	19.30	19.84	18.85	4.28	7.62	462.7	6.14
2	Southern Pine	12/2/10	B20	7.20	Average	19.47	19.59	19.54	4.34	7.78	462.3	6.13
					Std Dev	0.26	0.42	0.48	0.09	0.10	7.80	0.10
					Std Error	0.09	0.14	0.16	0.03	0.03	2.60	0.03
					10	19.39	18.91	19.14	4.37	7.33	421.8	6.60
					11	19.26	19.99	19.11	4.45	7.73	445.8	6.98
					12	19.34	19.52	19.41	4.36	7.68	453.1	7.09
					13	19.43	20.33	19.35	4.47	7.92	451.4	7.06
					14	19.51	20.27	19.35	4.25	7.83	467.8	7.32
					15	19.32	19.26	19.99	4.33	7.75	459.8	7.20
3	Southern Pine	12/2/10	B20	7.20	16	19.42	19.54	19.41	4.37	7.72	454.8	7.12
					17	19.48	19.55	19.43	4.21	7.63	462.2	7.23
					18	19.34	20.12	19.04	4.26	7.75	471.1	7.37
					Average	19.39	19.72	19.36	4.34	7.70	454.2	7.11
					Std Dev	0.08	0.48	0.28	0.09	0.16	14.56	0.23
					Std Error	0.03	0.16	0.09	0.03	0.05	4.85	0.08
					19	19.37	20.10	19.48	4.41	7.87	456.2	7.14
					20	19.47	19.98	19.39	4.19	7.75	472.0	7.39
					21	19.14	20.04	19.60	4.36	7.69	442.9	6.93
4	Southern Pine	12/2/10	B20	7.20	22	19.38	20.03	19.99	4.44	8.02	461.4	7.22
					23	19.28	19.95	19.50	4.39	7.80	454.6	7.12
					24	19.27	20.04	19.17	4.41	7.67	440.4	6.89
					Average	19.32	20.02	19.52	4.37	7.80	454.6	7.12
					Std Dev	0.11	0.05	0.27	0.09	0.13	11.73	0.18
					Std Error	0.05	0.02	0.11	0.04	0.05	4.79	0.07
					25	19.34	19.38	19.53	4.17	7.45	448.1	7.01
					26	19.39	19.12	20.18	4.27	7.77	467.8	7.32
					27	18.94	19.56	19.83	4.41	7.73	451.9	7.07
5	Southern Pine	12/3/10	B30	6.10	28	19.35	19.91	18.75	4.19	7.52	461.0	7.22
					29	19.32	19.96	19.40	4.32	7.70	451.8	7.07
					30	19.12	20.19	19.33	4.48	7.70	431.5	6.75
					Average	19.24	19.69	19.50	4.31	7.65	452.0	7.08
					Std Dev	0.18	0.40	0.48	0.12	0.13	12.38	0.19
					Std Error	0.07	0.16	0.20	0.05	0.05	5.05	0.08
					31	19.55	19.05	18.93	4.33	7.52	452.5	6.00
					32	19.28	19.75	19.34	4.38	7.79	463.0	6.14
					33	19.22	19.41	20.32	4.25	7.92	484.1	6.42
6	Southern Pine	12/3/10	B30	7.20	34	19.39	19.45	19.20	4.29	7.64	462.6	6.14
					35	19.42	19.81	19.37	4.42	7.86	461.6	6.12
					36	19.33	19.68	19.19	4.26	7.69	469.9	6.23
					37	19.33	19.55	19.26	4.27	7.70	471.3	6.25
					38	19.31	19.99	19.21	4.40	7.86	466.6	6.19
					39	19.09	19.47	19.84	4.26	7.64	459.5	6.09
					Average	19.32	19.57	19.41	4.32	7.74	465.7	6.18
					Std Dev	0.13	0.28	0.42	0.07	0.13	8.91	0.12
					Std Error	0.04	0.09	0.14	0.02	0.04	2.97	0.04
7	Southern Pine	12/3/10	B30	7.20	40	19.01	19.38	19.16	4.38	7.36	422.2	6.61
					41	19.42	19.90	19.31	4.39	7.85	463.7	7.26
					42	19.63	20.27	19.34	4.34	7.97	471.7	7.38
					43	19.37	19.75	19.40	4.38	7.82	463.5	7.25
					44	19.40	20.20	19.00	4.24	7.72	467.4	7.32
					45	19.23	19.29	20.04	4.32	7.74	460.1	7.20
					46	19.41	19.81	19.46	4.42	7.82	454.4	7.11
					47	19.51	20.08	19.48	4.26	7.87	473.0	7.40
					48	19.40	18.98	20.27	4.25	7.75	468.9	7.34
8	Southern Pine	12/3/10	B30	7.20	Average	19.38	19.74	19.50	4.33	7.77	460.5	7.21
					Std Dev	0.17	0.44	0.41	0.07	0.17	15.52	0.24
					Std Error	0.06	0.15	0.14	0.02	0.06	5.17	0.08
					49	19.40	19.35	19.97	4.41	7.83	456.2	7.14
					50	20.06	19.45	19.21	4.26	7.70	459.0	7.18
					51	19.40	19.13	20.17	4.25	7.75	467.6	7.32
					52	19.39	19.00	19.76	4.40	7.61	440.9	6.90
					53	19.51	19.93	19.39	4.25	7.84	476.2	7.45
					54	19.42	20.30	19.47	4.28	7.92	474.2	7.42
9	Southern Pine	12/3/10	B30	7.20	Average	19.53	19.53	19.66	4.31	7.78	462.3	7.24
					Std Dev	0.26	0.50	0.37	0.08	0.11	13.16	0.21
					Std Error	0.11	0.20	0.15	0.03	0.05	5.37	0.08
					55	19.34	19.86	19.41	4.43	7.85	458.7	7.18
					56	19.39	20.36	19.18	4.32	7.83	463.6	7.26
					57	19.28	19.67	19.52	4.42	7.80	456.6	7.15
					58	19.39	19.05	19.56	4.19	7.51	459.5	7.19
					59	19.42	20.02	19.73	4.30	7.81	457.6	7.16
					60	19.40	19.98	19.65	4.45	7.86	447.7	7.01
10	Southern Pine	12/3/10	B30	7.20	Average	19.37	19.82	19.51	4.35	7.78	457.3	7.16
					Std Dev	0.05	0.44	0.19	0.10	0.13	5.27	0.08
					Std Error	0.02	0.18	0.08	0.04	0.05	2.15	0.03

Table A2. Pentachlorophenol Pressure Treatment of Southern Pine for the AWWA E11-06 Laboratory Leachability Test (con...)

Specimen						Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)					
Type	Wood Species	Date	Formulation	Target Retention (Kg/m ³)	Label #	Length	Width	Thick	Initial	Final	Gross	Net				
9	Southern Pine	12/3/10	B40	6.10	61	19.40	19.81	19.86	4.33	7.92	470.4	6.24				
					62	19.51	19.39	19.86	4.40	7.89	464.5	6.16				
					63	19.31	19.09	19.71	4.20	7.60	468.0	6.21				
					64	19.27	19.91	19.36	4.31	7.74	461.8	6.12				
					65	19.34	19.43	19.35	4.42	7.66	445.6	5.91				
					66	19.50	19.55	19.40	4.13	7.62	471.9	6.26				
					67	19.44	19.34	18.34	4.26	7.29	439.4	5.83				
					68	19.41	19.55	19.68	4.44	7.82	452.6	6.00				
					69	19.37	20.01	19.09	4.12	7.53	460.9	6.11				
									Average	19.39	19.56	19.41	4.29	7.67	459.4	6.09
				Std Dev	0.08	0.30	0.48	0.12	0.20	11.29	0.15					
				Std Error	0.03	0.10	0.16	0.04	0.07	3.76	0.05					
10	Southern Pine	12/3/10	B40	7.20	70	19.55	19.68	19.62	4.32	7.90	474.3	7.42				
					71	19.37	20.13	19.49	4.42	7.96	465.8	7.29				
					72	19.48	20.29	19.26	4.34	7.92	470.3	7.36				
					73	19.25	19.21	19.14	4.47	7.53	432.3	6.77				
					74	19.47	19.39	19.43	4.21	7.70	475.8	7.45				
					75	19.24	20.39	19.47	4.35	7.90	464.8	7.27				
					76	19.30	19.81	19.33	4.39	7.80	461.4	7.22				
					77	19.39	20.23	19.38	4.20	7.85	480.1	7.52				
					78	19.44	19.75	19.38	4.33	7.68	450.7	7.05				
									Average	19.39	19.88	19.39	4.34	7.80	463.9	7.26
				Std Dev	0.11	0.41	0.14	0.09	0.14	14.78	0.23					
				Std Error	0.04	0.14	0.05	0.03	0.05	4.93	0.08					
11	Southern Pine	12/3/10	B40	7.20	79	19.42	19.76	18.83	4.42	7.62	442.9	6.93				
					80	19.33	19.87	19.22	4.25	7.69	466.0	7.29				
					81	19.50	19.75	19.04	4.36	7.73	459.6	7.19				
					82	19.33	19.48	19.72	4.40	7.80	457.9	7.17				
					83	19.35	19.74	19.09	4.25	7.53	449.8	7.04				
					84	19.53	19.92	19.36	4.32	7.81	463.4	7.25				
									Average	19.41	19.75	19.21	4.33	7.70	456.6	7.15
									Std Dev	0.09	0.15	0.31	0.07	0.11	8.71	0.14
									Std Error	0.04	0.06	0.13	0.03	0.04	3.56	0.06
					12	Southern Pine	12/3/10	B40	7.20	85	19.36	19.60	19.84	4.42	7.80	449.0
86	19.36	19.77	18.75	4.17						7.49	462.6	7.24				
87	19.23	20.07	19.40	4.29						7.76	463.4	7.25				
88	19.49	20.05	19.41	4.46						7.82	443.0	6.93				
89	18.91	19.48	19.94	4.27						7.56	447.9	7.01				
90	19.48	18.91	20.15	4.32						7.62	444.6	6.96				
				Average						19.31	19.65	19.58	4.32	7.68	451.8	7.07
				Std Dev						0.22	0.43	0.50	0.11	0.14	9.01	0.14
				Std Error						0.09	0.18	0.21	0.04	0.06	3.68	0.06
13	Southern Pine	12/7/10	B50	6.10						91	19.35	20.04	19.30	4.36	7.81	461.0
					92	19.39	20.24	19.80	4.45	8.09	468.4	6.21				
					93	19.49	19.72	19.32	4.17	7.69	474.0	6.29				
					94	19.49	19.38	19.87	4.30	7.90	479.7	6.36				
					95	19.44	20.22	19.70	4.40	8.05	471.4	6.25				
					96	19.36	19.86	19.67	4.17	7.84	485.3	6.44				
					97	19.34	19.14	19.94	4.33	7.64	448.4	5.95				
					98	19.40	19.71	20.21	4.40	8.05	472.3	6.26				
					99	19.36	19.86	19.73	4.21	7.77	469.3	6.22				
									Average	19.40	19.80	19.73	4.31	7.87	470.0	6.23
				Std Dev	0.06	0.36	0.29	0.10	0.16	10.60	0.14					
				Std Error	0.02	0.12	0.10	0.03	0.05	3.53	0.05					
14	Southern Pine	12/7/10	B50	7.20	100	19.44	19.28	19.94	4.29	7.69	454.9	7.12				
					101	19.37	19.09	19.95	4.39	7.77	458.2	7.17				
					102	19.33	19.36	18.58	4.28	7.34	440.1	6.89				
					103	19.38	19.07	19.02	4.44	7.36	415.4	6.50				
					104	19.18	19.84	19.43	4.18	7.67	472.0	7.39				
					105	19.39	18.85	19.15	4.33	7.27	420.0	6.57				
					106	19.30	19.40	19.05	4.39	7.45	429.0	6.71				
					107	19.37	19.87	19.36	4.41	7.80	455.0	7.12				
					108	19.35	19.88	19.30	4.20	7.73	475.5	7.44				
									Average	19.35	19.40	19.31	4.32	7.56	446.7	6.99
				Std Dev	0.07	0.38	0.44	0.09	0.21	21.75	0.34					
				Std Error	0.02	0.13	0.15	0.03	0.07	7.25	0.11					
15	Southern Pine	12/7/10	B50	7.20	109	19.50	19.86	19.51	4.35	7.71	444.7	6.96				
					110	19.36	19.56	19.03	4.44	7.65	445.4	6.97				
					111	19.26	19.30	18.93	4.35	7.30	419.2	6.56				
					112	19.37	19.45	19.83	4.39	7.81	457.8	7.17				
					113	19.40	19.96	19.13	4.17	7.51	450.9	7.06				
					114	19.46	19.68	19.34	4.31	7.72	460.4	7.21				
				Average	19.39	19.64	19.30	4.34	7.62	446.4	6.99					
				Std Dev	0.08	0.25	0.34	0.09	0.18	14.75	0.23					
				Std Error	0.03	0.10	0.14	0.04	0.08	6.02	0.09					
16	Southern Pine	12/7/10	B50	7.20	115	19.47	19.33	19.98	4.34	7.55	426.9	6.68				
					116	19.41	19.94	19.06	4.18	7.56	458.2	7.17				
					117	19.35	19.37	19.89	4.31	7.61	442.7	6.93				
					118	19.35	19.72	19.53	4.42	7.73	444.2	6.95				
					119	19.39	19.94	18.72	4.18	7.38	442.1	6.92				
					120	19.37	18.96	19.20	4.36	7.30	416.9	6.53				
									Average	19.39	19.54	19.40	4.30	7.52	438.5	6.86
				Std Dev	0.05	0.39	0.49	0.10	0.16	14.49	0.23					
				Std Error	0.02	0.16	0.20	0.04	0.06	5.91	0.09					

Table A2. Pentachlorophenol Pressure Treatment of Southern Pine for the AWP A E11--06 Laboratory Leachability Test (con...)

Type	Wood Species	Date	Specimen			Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation	Target Retention (Kg/m ³)	Label #	Length	Width	Thick	Initial	Final	Gross	Net
17	Southern Pine	12/7/10	B100	6.10	121	19.31	19.40	19.50	4.43	7.85	468.2	6.21
					122	19.15	19.35	19.67	4.32	7.78	474.7	6.29
					123	19.36	19.77	19.95	4.42	8.05	475.4	6.30
					124	19.42	19.05	19.77	4.21	7.72	479.9	6.36
					125	19.35	19.66	19.14	4.29	7.75	475.2	6.30
					126	19.34	19.94	19.27	4.48	8.02	476.4	6.32
					127	18.85	19.16	19.64	4.19	7.63	485.0	6.43
					128	19.88	19.36	19.21	4.34	7.82	470.7	6.24
					129	19.23	19.29	19.92	4.48	7.97	472.3	6.26
					Average	19.32	19.44	19.56	4.35	7.84	475.3	6.30
					Std Dev	0.27	0.29	0.30	0.11	0.14	4.96	0.07
					Std Error	0.09	0.10	0.10	0.04	0.05	1.65	0.02
18	Southern Pine	12/7/10	B100	7.20	130	19.77	19.33	19.02	4.16	7.74	492.5	7.71
					131	19.49	20.03	19.19	4.24	7.93	492.6	7.71
					132	19.90	19.36	19.83	4.44	8.16	486.9	7.62
					133	19.37	19.34	19.14	4.22	7.62	474.2	7.42
					134	19.04	19.39	19.75	4.28	7.70	469.0	7.34
					135	19.28	19.42	19.66	4.46	7.93	471.4	7.38
					136	19.45	19.40	19.14	4.23	7.77	490.2	7.67
					137	19.53	20.06	19.28	4.34	8.01	485.9	7.61
					138	19.43	19.28	19.12	4.40	7.74	466.3	7.30
					Average	19.47	19.51	19.35	4.31	7.84	481.0	7.53
					Std Dev	0.25	0.30	0.31	0.11	0.17	10.65	0.17
					Std Error	0.08	0.10	0.10	0.04	0.06	3.55	0.06
19	Southern Pine	12/7/10	B100	7.20	139	19.35	19.68	19.20	4.20	7.75	485.5	7.60
					140	18.81	19.37	19.54	4.27	7.60	467.7	7.32
					141	19.35	19.29	19.45	4.39	7.80	469.7	7.35
					142	19.45	19.77	19.31	4.19	7.83	490.2	7.67
					143	19.32	18.66	18.98	4.36	7.34	435.5	6.82
					144	19.99	19.30	19.50	4.43	8.07	483.8	7.57
					Average	19.38	19.35	19.33	4.31	7.73	472.1	7.39
					Std Dev	0.38	0.39	0.21	0.10	0.24	20.05	0.31
					Std Error	0.15	0.16	0.09	0.04	0.10	8.19	0.13
20	Southern Pine	12/7/10	B100	7.20	145	19.17	19.35	19.65	4.19	7.70	481.6	7.54
					146	19.25	19.16	18.44	4.32	7.44	458.7	7.18
					147	19.20	19.01	18.97	4.45	7.49	439.1	6.87
					148	19.41	19.77	18.89	4.26	7.66	469.0	7.34
					149	18.78	19.39	19.03	4.34	7.41	443.0	6.93
					150	19.79	19.31	19.17	4.35	7.77	466.8	7.31
					Average	19.27	19.33	19.03	4.32	7.58	459.7	7.20
					Std Dev	0.33	0.26	0.39	0.09	0.15	16.25	0.25
					Std Error	0.13	0.10	0.16	0.04	0.06	6.64	0.10
21	Southern Pine	12/8/10	Protreat	6.10	151	19.36	19.75	19.49	4.21	7.91	496.5	6.58
					152	19.43	20.06	19.05	4.26	7.79	475.4	6.30
					153	19.25	19.56	19.54	4.37	7.75	459.4	6.09
					154	19.78	19.38	18.85	4.17	7.56	469.1	6.22
					155	19.32	19.05	19.90	4.29	7.69	464.2	6.16
					156	19.67	19.39	19.15	4.42	7.84	468.2	6.21
					157	19.36	18.97	19.95	4.20	7.72	480.4	6.37
					158	20.06	19.54	19.28	4.34	7.94	476.4	6.32
					159	19.33	19.98	19.17	4.40	7.85	466.0	6.18
					Average	19.51	19.52	19.38	4.30	7.78	472.9	6.27
					Std Dev	0.27	0.37	0.38	0.09	0.12	11.03	0.15
					Std Error	0.09	0.12	0.13	0.03	0.04	3.68	0.05
22	Southern Pine	12/8/10	Protreat	7.20	160	19.75	19.34	19.31	4.40	7.80	461.0	7.22
					161	19.95	19.20	19.35	4.16	7.80	491.1	7.69
					162	20.05	19.52	19.25	4.34	7.86	467.2	7.31
					163	20.20	19.43	19.65	4.46	8.13	475.9	7.45
					164	18.97	19.33	18.86	4.25	7.41	456.9	7.15
					165	19.40	19.23	18.50	4.33	7.35	437.6	6.85
					166	19.42	18.47	19.54	4.39	7.54	449.4	7.03
					167	19.50	19.57	19.33	4.16	7.62	469.0	7.34
					168	18.80	19.46	19.65	4.27	7.65	470.2	7.36
					Average	19.56	19.28	19.27	4.31	7.68	464.3	7.27
					Std Dev	0.48	0.33	0.38	0.11	0.24	15.48	0.24
					Std Error	0.16	0.11	0.13	0.04	0.08	5.16	0.08
23	Southern Pine	12/8/10	Protreat	7.20	169	19.60	19.48	18.61	4.34	7.55	451.8	7.07
					170	19.42	18.94	19.75	4.15	7.60	474.9	7.43
					171	19.24	19.28	18.44	4.35	7.33	435.7	6.82
					172	19.45	19.22	19.91	4.47	7.82	450.1	7.04
					173	19.81	19.41	19.13	4.23	7.60	458.1	7.17
					174	19.40	20.02	19.23	4.31	7.71	455.2	7.13
					Average	19.49	19.39	19.18	4.31	7.60	454.3	7.11
					Std Dev	0.20	0.36	0.59	0.11	0.16	12.75	0.20
					Std Error	0.08	0.15	0.24	0.04	0.07	5.20	0.08
24	Southern Pine	12/8/10	Protreat	7.20	175	19.56	19.78	18.79	4.45	7.63	437.4	6.85
					176	19.50	19.34	19.04	4.18	7.41	449.8	7.04
					177	19.40	19.74	18.84	4.29	7.51	446.3	6.99
					178	19.31	19.45	19.33	4.38	7.60	443.5	6.94
					179	19.78	19.37	18.98	4.21	7.58	463.4	7.25
					180	20.11	19.45	19.31	4.33	7.83	463.4	7.25
					Average	19.61	19.52	19.05	4.31	7.59	450.7	7.05
					Std Dev	0.29	0.19	0.23	0.10	0.14	10.68	0.17
					Std Error	0.12	0.08	0.09	0.04	0.06	4.36	0.07
25	Southern Pine	NA	Untreated	0.00	181	19.50	18.65	19.12	4.30	---	---	---
					182	19.43	19.00	19.19	4.33	---	---	---
					183	19.42	18.79	19.34	4.32	---	---	---
					184	19.95	19.39	18.85	4.30	---	---	---
					185	19.38	19.25	19.29	4.26	---	---	---
					186	19.67	18.83	19.32	4.28	---	---	---
					187	19.71	18.89	19.35	4.32	---	---	---
					188	19.39	18.90	19.51	4.32	---	---	---
					189	19.38	18.97	19.50	4.28	---	---	---
					Average	19.54	18.96	19.27	4.30	---	---	---
					Std Dev	0.20	0.23	0.20	0.02	---	---	---
					Std Error	0.07	0.08	0.07	0.01	---	---	---

Table A3. Pentachlorophenol Pressure Treatment of Western Red Cedar for the AWP A E11--06 Laboratory Leachability Test

Type	Wood Species	Date	Specimen			Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation	Target Retention (Kg/m ³)	Label #	Length	Width	Thick	Initial	Final	Gross	Net
26	Western Red Cedar	12/8/11	B20	12.80	190	19.06	18.10	18.48	2.25	6.33	640.0	13.11
					191	19.03	18.54	18.44	2.30	6.47	641.0	13.13
					192	19.27	18.81	18.26	2.41	6.59	631.5	12.93
					193	19.23	18.42	18.44	2.30	6.58	655.3	13.42
					194	19.24	18.68	18.42	2.36	6.59	639.0	13.09
					195	19.18	18.13	18.31	2.26	6.31	636.1	13.03
					196	18.96	18.18	18.40	2.23	6.31	643.3	13.17
					197	19.23	18.02	18.24	2.27	6.31	639.2	13.09
					198	19.47	18.01	18.37	2.30	6.39	636.6	13.04
					Average	19.18	18.32	18.37	2.30	6.43	640.2	13.11
27	Western Red Cedar	12/8/11	B20	16.00	Std Dev	0.14	0.30	0.09	0.06	0.13	6.56	0.13
					Std Error	0.05	0.10	0.03	0.02	0.04	2.19	0.04
					199	19.04	18.95	18.42	2.35	6.65	647.0	16.56
					200	19.18	18.06	18.33	2.29	6.33	636.3	16.29
					201	19.15	18.33	18.36	2.25	6.44	650.1	16.64
					202	18.85	18.50	18.38	2.23	6.39	649.0	16.62
					203	19.02	18.42	18.43	2.34	6.49	642.7	16.45
					204	19.23	18.01	18.27	2.23	6.30	643.2	16.47
					205	19.21	18.42	18.37	2.31	6.51	646.1	16.54
					206	19.26	18.35	18.31	2.31	6.48	644.4	16.50
28	Western Red Cedar	12/9/11	B30	12.80	207	19.31	18.49	18.18	2.42	6.56	637.8	16.33
					Average	19.14	18.39	18.34	2.30	6.46	644.1	16.49
					Std Dev	0.14	0.27	0.08	0.06	0.11	4.70	0.12
					Std Error	0.05	0.09	0.03	0.02	0.04	1.57	0.04
					208	18.97	19.03	18.37	2.41	6.72	649.9	13.31
					209	19.30	18.82	18.56	2.31	6.65	643.8	13.18
					210	19.14	18.71	18.42	2.42	6.61	635.2	13.01
					211	18.88	18.76	18.26	2.37	6.44	629.3	12.89
					212	19.14	18.42	18.32	2.28	6.43	642.5	13.16
					213	19.25	18.95	18.42	2.36	6.73	650.4	13.32
29	Western Red Cedar	12/9/11	B30	16.00	214	19.29	18.07	18.43	2.25	6.37	641.3	13.13
					215	18.93	18.26	18.42	2.28	6.32	634.5	12.99
					216	19.32	18.71	18.41	2.34	6.58	637.1	13.05
					Average	19.14	18.64	18.40	2.34	6.54	640.5	13.12
					Std Dev	0.17	0.32	0.08	0.06	0.15	7.09	0.15
					Std Error	0.06	0.11	0.03	0.02	0.05	2.36	0.05
					217	18.75	18.74	18.37	2.26	6.39	639.8	16.38
					218	19.17	18.89	18.23	2.42	6.59	631.7	16.17
					219	19.28	18.10	18.52	2.26	6.43	645.2	16.52
					220	19.23	18.21	18.31	2.33	6.44	641.0	16.41
30	Western Red Cedar	12/9/11	B40	12.80	221	19.16	18.06	18.32	2.25	6.26	632.6	16.19
					222	19.22	18.11	18.49	2.26	6.41	644.8	16.51
					223	19.32	18.09	18.44	2.32	6.41	634.6	16.25
					224	19.29	18.36	18.19	2.37	6.49	639.5	16.37
					225	19.31	18.59	18.25	2.41	6.49	622.8	15.94
					Average	19.19	18.35	18.35	2.32	6.43	636.9	16.30
					Std Dev	0.18	0.31	0.12	0.07	0.09	7.20	0.18
					Std Error	0.06	0.10	0.04	0.02	0.03	2.40	0.06
					226	19.28	18.26	18.26	2.37	6.44	633.1	12.97
					227	19.03	17.93	18.27	2.22	6.24	644.9	13.21
31	Western Red Cedar	12/9/11	B40	16.00	228	19.28	18.47	18.51	2.33	6.50	632.6	12.96
					229	19.17	18.97	18.41	2.38	6.68	642.3	13.15
					230	19.31	18.41	18.41	2.41	6.54	631.0	12.92
					231	19.33	18.83	18.41	2.33	6.62	640.2	13.11
					232	19.34	17.91	18.36	2.24	6.28	635.3	13.01
					233	19.34	18.32	18.26	2.38	6.42	624.5	12.79
					234	19.30	18.20	18.36	2.31	6.38	631.1	12.92
					Average	19.26	18.37	18.36	2.33	6.46	635.0	13.00
					Std Dev	0.10	0.36	0.09	0.06	0.15	6.41	0.13
					Std Error	0.03	0.12	0.03	0.02	0.05	2.14	0.04
32	Western Red Cedar	12/9/11	B40	16.00	235	19.33	18.55	18.42	2.28	6.57	649.5	16.63
					236	19.39	18.56	18.41	2.29	6.53	640.0	16.38
					237	19.38	18.08	18.40	2.31	6.36	628.2	16.08
					238	19.28	18.20	18.37	2.28	6.41	640.7	16.40
					239	19.29	18.20	18.33	2.28	6.41	641.8	16.43
					240	19.24	18.28	18.32	2.30	6.48	648.7	16.61
					241	19.05	18.31	18.47	2.24	6.35	638.0	16.33
					242	19.31	17.79	18.20	2.49	6.33	614.2	15.72
					243	19.01	18.21	18.32	2.28	6.34	640.2	16.30
					Average	19.25	18.24	18.36	2.31	6.42	637.9	16.33
33	Western Red Cedar	12/9/11	B40	16.00	Std Dev	0.14	0.23	0.08	0.07	0.09	10.85	0.28
					Std Error	0.05	0.08	0.03	0.02	0.03	3.62	0.09

Table A3. Pentachlorophenol Pressure Treatment of Western Red Cedar for the AWWA E11-06 Laboratory Leachability Test (con...)

Type	Wood Species	Date	Specimen		Target Retention (Kg/m3)	Label #	Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation				Length	Width	Thick	Initial	Final	Gross	Net
32	Western Red Cedar	12/9/11	B50	12.80		244	18.82	19.06	18.38	2.30	6.59	650.7	13.33
						245	19.26	18.13	18.45	2.26	6.39	641.1	13.13
						246	18.87	18.93	18.22	2.39	6.48	628.4	12.87
						247	19.22	18.65	18.44	2.36	6.56	635.4	13.01
						248	19.37	18.54	18.44	2.30	6.53	638.8	13.08
						249	19.24	18.90	18.43	2.40	6.69	640.1	13.11
						250	18.99	18.18	18.42	2.23	6.27	635.3	13.01
						251	19.36	18.34	18.47	2.43	6.33	594.7	12.18
						252	19.33	18.04	18.41	2.29	6.34	630.9	12.92
						Average	19.16	18.53	18.41	2.33	6.46	632.8	12.96
						Std Dev	0.21	0.38	0.07	0.07	0.14	15.67	0.32
						Std Error	0.07	0.13	0.02	0.02	0.05	5.22	0.11
33	Western Red Cedar	12/9/11	B50	16.00		253	19.33	18.46	18.43	2.30	6.59	652.3	16.70
						254	19.05	18.95	18.52	2.34	6.69	650.6	16.66
						255	19.19	18.02	18.48	2.27	6.43	651.0	16.66
						256	19.31	18.89	18.17	2.50	6.65	626.2	16.03
						257	19.31	18.99	18.42	2.42	6.78	645.5	16.52
						258	19.28	18.70	18.41	2.30	6.65	655.4	16.78
						259	19.18	18.18	18.50	2.35	6.41	629.4	16.11
						260	19.41	18.72	18.41	2.32	6.64	645.8	16.53
						261	18.95	18.89	18.29	2.40	6.43	615.5	15.76
						Average	19.22	18.64	18.40	2.36	6.59	641.3	16.42
						Std Dev	0.15	0.35	0.11	0.07	0.13	14.03	0.36
						Std Error	0.05	0.12	0.04	0.02	0.04	4.68	0.12
34	Western Red Cedar	12/9/11	Protreat	12.80		262	19.33	18.80	18.42	2.35	6.56	628.9	12.88
						263	19.36	18.74	18.46	2.31	6.59	639.1	13.09
						264	19.31	18.25	18.26	2.36	6.37	623.2	12.76
						265	19.36	18.29	18.34	2.32	6.43	632.9	12.96
						266	19.29	18.28	18.25	2.40	6.42	624.7	12.79
						267	18.94	18.75	18.46	2.31	6.44	630.0	12.90
						268	19.20	18.05	18.29	2.25	6.23	627.9	12.86
						269	19.39	18.19	18.47	2.28	6.37	627.8	12.86
						270	18.91	19.07	18.38	2.29	6.53	639.7	13.10
						Average	19.23	18.49	18.37	2.32	6.44	630.5	12.91
						Std Dev	0.18	0.35	0.09	0.05	0.11	5.79	0.12
						Std Error	0.06	0.12	0.03	0.02	0.04	1.93	0.04
35	Western Red Cedar	12/9/11	Protreat	16.00		271	19.32	18.61	18.37	2.30	6.55	643.5	16.47
						272	19.27	18.27	18.38	2.27	6.44	644.4	16.50
						273	19.33	18.44	18.26	2.39	6.44	622.2	15.93
						274	19.29	18.68	18.38	2.29	6.55	643.2	16.47
						275	19.01	18.46	18.49	2.26	6.41	639.6	16.37
						276	19.20	18.80	18.44	2.36	6.59	635.5	16.27
						277	19.31	17.96	18.29	2.29	6.32	635.3	16.26
						278	19.25	17.98	18.51	2.25	6.28	629.0	16.10
						279	19.26	18.68	18.45	2.31	6.57	641.8	16.43
						Average	19.25	18.43	18.40	2.30	6.46	637.2	16.31
						Std Dev	0.10	0.31	0.08	0.05	0.11	7.51	0.19
						Std Error	0.03	0.10	0.03	0.02	0.04	2.50	0.06
36	Western Red Cedar	NA	Untreated	0.00		280	19.33	19.15	18.34	2.44	—	—	—
						281	19.27	18.10	18.40	2.27	—	—	—
						282	19.29	18.52	18.37	2.39	—	—	—
						283	19.37	18.21	18.35	2.29	—	—	—
						284	19.33	18.73	18.41	2.39	—	—	—
						285	19.20	18.01	18.44	2.22	—	—	—
						286	19.30	18.80	18.29	2.44	—	—	—
						287	19.31	18.33	18.28	2.36	—	—	—
						288	19.11	18.87	18.51	2.30	—	—	—
						Average	19.28	18.52	18.38	2.34	—	—	—
						Std Dev	0.08	0.39	0.07	0.08	—	—	—
						Std Error	0.03	0.13	0.02	0.03	—	—	—

Table A4. Pentachlorophenol Pressure Treatment of Douglas---fir for the AWP A E11---06 Laboratory Leachability Test

Type	Wood Species	Date	Specimen			Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation	Target Retention (Kg/m ³)	Label #	Length	Width	Thick	Initial	Final	Gross	Net
37	Douglas Fir	12/10/11	B20	9.60	289	19.04	18.91	18.55	3.91	7.07	473.1	10.09
					290	18.73	19.11	18.70	3.84	7.03	476.6	10.17
					291	19.27	18.55	18.92	3.83	6.86	448.0	9.56
					292	19.05	18.92	18.67	3.77	6.71	436.9	9.32
					293	19.06	18.77	18.66	3.92	6.91	447.9	9.56
					294	18.99	18.94	18.68	3.80	6.95	468.8	10.00
					295	19.02	18.50	18.74	3.78	6.84	464.1	9.90
					296	18.95	18.85	18.73	3.86	6.74	430.5	9.18
					297	19.13	18.90	18.69	3.90	6.84	435.1	9.28
					Average	19.03	18.83	18.70	3.85	6.88	453.4	9.67
					Std Dev	0.14	0.19	0.10	0.06	0.12	17.58	0.38
					Std Error	0.05	0.06	0.03	0.02	0.04	5.86	0.13
38	Douglas Fir	12/10/11	B30	9.60	298	19.05	18.82	18.64	3.90	6.89	447.4	9.54
					299	19.19	18.66	18.60	3.89	6.96	460.9	9.83
					300	19.21	18.76	18.52	3.97	6.87	434.5	9.27
					301	18.92	18.49	18.57	3.79	6.90	478.7	10.21
					302	19.21	18.86	18.88	3.88	7.03	460.5	9.82
					303	19.14	18.71	18.69	3.95	6.97	451.2	9.63
					304	18.22	18.46	18.48	3.78	6.39	419.9	8.96
					305	19.11	18.73	18.87	3.79	6.95	467.9	9.98
					306	19.12	19.01	18.80	3.89	6.90	440.5	9.40
					Average	19.02	18.72	18.67	3.87	6.87	451.3	9.63
					Std Dev	0.31	0.17	0.15	0.07	0.19	18.04	0.38
					Std Error	0.10	0.06	0.05	0.02	0.06	6.01	0.13
39	Douglas Fir	12/10/11	B40	9.60	307	19.02	18.43	18.60	3.92	6.86	450.9	9.62
					308	19.16	18.68	18.58	3.95	6.90	443.6	9.46
					309	19.17	18.42	18.60	3.76	6.54	423.3	9.03
					310	18.96	18.50	18.53	3.88	6.92	467.7	9.98
					311	19.10	18.73	18.54	3.86	7.03	477.9	10.20
					312	19.07	18.41	18.66	3.77	6.87	473.2	10.09
					313	19.11	18.71	18.71	3.98	6.96	445.5	9.50
					314	19.15	18.99	18.68	3.96	6.80	418.1	8.92
					315	18.93	18.70	18.60	3.84	6.97	475.4	10.14
					Average	19.07	18.62	18.61	3.88	6.87	452.8	9.66
					Std Dev	0.09	0.19	0.06	0.08	0.14	22.36	0.48
					Std Error	0.03	0.06	0.02	0.03	0.05	7.45	0.16
40	Douglas Fir	12/10/11	B50	9.60	316	18.87	18.47	18.71	3.85	6.80	452.4	9.65
					317	18.99	18.59	18.75	3.94	6.90	447.2	9.54
					318	18.93	18.85	18.73	3.82	6.77	441.4	9.42
					319	19.06	18.37	18.64	3.81	6.54	418.3	8.92
					320	18.96	18.92	18.55	3.82	6.84	453.8	9.68
					321	19.05	18.71	18.68	3.85	6.86	452.1	9.64
					322	19.21	18.87	18.66	3.81	6.89	455.3	9.71
					323	19.09	18.84	18.59	3.85	6.72	429.3	9.16
					324	19.07	18.71	18.60	3.85	6.80	444.5	9.48
					Average	19.03	18.70	18.66	3.84	6.79	443.8	9.47
					Std Dev	0.10	0.19	0.07	0.04	0.11	12.53	0.27
					Std Error	0.03	0.06	0.02	0.01	0.04	4.18	0.09
41	Douglas Fir	12/10/11	Protreat	9.60	325	19.05	18.69	18.47	3.93	6.96	460.8	9.83
					326	18.94	18.80	18.59	3.87	7.04	478.9	10.22
					327	18.84	19.01	18.15	3.93	6.67	421.5	8.99
					328	19.11	18.56	18.68	3.83	6.89	461.9	9.85
					329	19.05	18.56	18.74	3.96	6.99	457.3	9.76
					330	19.03	18.70	18.80	3.93	7.03	463.4	9.89
					331	19.17	18.97	18.78	3.95	7.23	480.3	10.25
					332	19.17	18.70	18.73	3.94	6.88	437.9	9.34
					333	19.34	18.57	18.45	3.83	6.59	416.5	8.89
					Average	19.08	18.73	18.60	3.91	6.92	453.2	9.67
					Std Dev	0.14	0.17	0.21	0.05	0.19	22.99	0.49
					Std Error	0.05	0.06	0.07	0.02	0.06	7.66	0.16
42	Douglas Fir	NA	Untreated	0.00	334	18.99	18.91	18.50	3.87	---	---	---
					335	18.98	18.92	18.65	3.90	---	---	---
					336	18.91	18.92	18.55	3.85	---	---	---
					337	18.97	18.41	18.71	3.80	---	---	---
					338	18.97	18.66	18.67	3.85	---	---	---
					339	18.74	18.65	18.42	3.84	---	---	---
					340	19.18	18.78	18.59	3.95	---	---	---
					341	18.94	19.00	18.62	3.78	---	---	---
					342	18.96	18.87	18.77	3.90	---	---	---
					Average	18.96	18.79	18.61	3.86	---	---	---
					Std Dev	0.11	0.19	0.11	0.05	---	---	---
					Std Error	0.04	0.06	0.04	0.02	---	---	---

Table A4. Pentachlorophenol Pressure Treatment of Red Pine for the AWP A E11--06 Laboratory Leachability Test

Type	Wood Species	Date	Specimen		Target Retention (Kg/m ³)	Label #	Dimensions (mm)			Weight (g)		Calculated Retention (Kg/m ³)	
			Formulation				Length	Width	Thick	Initial	Final	Gross	Net
43	Red Pine	12/13/11	B20	8.50		343	19.12	17.98	18.82	3.33	6.39	473.0	8.04
						344	19.14	17.84	18.73	3.20	6.29	483.2	8.21
						345	19.01	18.92	18.71	3.37	6.73	499.3	8.49
						346	18.96	18.67	18.72	3.25	6.55	498.0	8.47
						347	19.14	18.58	18.64	3.24	6.59	505.4	8.59
						348	19.04	18.73	18.56	3.30	6.59	497.1	8.45
						349	19.20	18.44	18.70	3.24	6.33	466.7	7.93
						350	19.26	18.95	18.75	3.34	6.77	501.2	8.52
						351	19.04	18.45	18.74	3.20	6.25	463.3	7.88
						Average	19.10	18.51	18.71	3.27	6.50	487.5	8.29
						Std Dev	0.10	0.38	0.07	0.06	0.19	16.19	0.28
						Std Error	0.03	0.13	0.02	0.02	0.06	5.40	0.09
44	Red Pine	12/13/11	B30	8.50		352	19.19	18.65	18.64	3.35	6.49	470.7	8.00
						353	19.11	18.81	18.55	3.34	6.70	503.9	8.57
						354	19.23	18.86	18.36	3.34	6.74	510.6	8.68
						355	19.10	18.87	18.66	3.37	6.71	496.6	8.44
						356	19.19	18.66	18.68	3.24	6.45	479.9	8.16
						357	19.13	17.79	18.77	3.25	6.35	485.3	8.25
						358	19.20	18.64	18.45	3.20	6.55	507.3	8.62
						359	19.20	18.13	18.92	3.34	6.47	475.3	8.08
						360	19.14	19.12	18.67	3.30	6.76	506.4	8.61
						Average	19.17	18.61	18.63	3.30	6.58	492.9	8.38
						Std Dev	0.05	0.41	0.17	0.06	0.15	15.30	0.26
						Std Error	0.02	0.14	0.06	0.02	0.05	5.10	0.09
45	Red Pine	12/13/11	B40	8.50		361	19.32	18.68	18.53	3.27	6.55	490.5	8.34
						362	19.18	18.75	18.64	3.35	6.72	502.7	8.55
						363	19.13	18.58	18.61	3.26	6.52	492.8	8.38
						364	19.20	18.54	18.74	3.25	6.39	470.7	8.00
						365	19.09	18.87	18.48	3.29	6.80	527.3	8.96
						366	18.86	18.81	18.47	3.23	6.47	494.5	8.41
						367	19.22	18.55	18.70	3.15	6.23	462.0	7.85
						368	18.56	18.53	18.76	3.24	6.22	461.9	7.85
						369	19.17	18.97	18.53	3.34	6.58	480.8	8.17
						Average	19.08	18.70	18.61	3.26	6.50	487.0	8.28
						Std Dev	0.23	0.16	0.11	0.06	0.20	21.01	0.36
						Std Error	0.08	0.05	0.04	0.02	0.07	7.00	0.12
46	Red Pine	12/13/11	B50	8.50		370	19.00	18.57	18.71	3.20	6.31	471.1	8.01
						371	19.21	19.04	18.54	3.24	6.75	517.6	8.80
						372	19.20	18.94	18.41	3.37	6.72	500.4	8.51
						373	19.29	18.69	18.56	3.20	6.60	508.1	8.64
						374	19.00	18.77	18.76	3.30	6.64	499.2	8.49
						375	19.21	19.01	18.55	3.21	6.69	513.7	8.73
						376	19.22	18.95	18.61	3.24	6.21	438.2	7.45
						377	19.09	18.86	18.64	3.32	6.57	484.3	8.23
						378	19.26	18.66	18.72	3.24	6.36	463.7	7.88
						Average	19.16	18.83	18.61	3.26	6.54	488.5	8.30
						Std Dev	0.11	0.17	0.11	0.06	0.20	26.43	0.45
						Std Error	0.04	0.06	0.04	0.02	0.07	8.81	0.15
47	Red Pine	12/13/11	Protreat	8.50		379	19.20	18.94	18.54	3.20	6.55	496.9	8.45
						380	19.28	18.46	18.70	3.19	6.56	506.3	8.61
						381	19.17	18.69	18.48	3.25	6.55	498.4	8.47
						382	19.21	18.67	18.51	3.25	6.52	492.6	8.37
						383	19.07	18.72	18.63	3.27	6.58	497.7	8.46
						384	19.04	18.80	18.52	3.31	6.58	493.3	8.39
						385	19.17	18.80	18.54	3.33	6.62	492.4	8.37
						386	19.11	17.94	18.81	3.17	6.18	466.8	7.93
						387	19.09	18.90	18.44	3.18	6.50	499.0	8.48
						Average	19.15	18.66	18.57	3.24	6.52	493.7	8.39
						Std Dev	0.08	0.30	0.12	0.06	0.13	10.98	0.19
						Std Error	0.03	0.10	0.04	0.02	0.04	3.66	0.06
48	Red Pine	NA	Untreated	8.50		388	19.23	18.50	18.59	3.23	---	---	---
						389	19.21	18.78	18.45	3.16	---	---	---
						390	19.16	18.85	18.56	3.30	---	---	---
						391	19.25	18.94	18.53	3.37	---	---	---
						392	19.05	18.09	18.73	3.18	---	---	---
						393	19.20	18.85	18.43	3.34	---	---	---
						394	19.19	19.06	18.55	3.37	---	---	---
						395	19.05	18.61	18.70	3.39	---	---	---
						396	19.21	18.54	18.54	3.20	---	---	---
						Average	19.17	18.69	18.56	3.28	---	---	---
						Std Dev	0.07	0.29	0.10	0.09	---	---	---
						Std Error	0.02	0.10	0.03	0.03	---	---	---

Appendix B: Leachability Test Data

Specimen		Preservative System		Pentachlorophenol Analysis (by GC---MS)			
Number	Species	Formulation	Target Retention (Kg/m ³)	(µg/L)	Average (µg/L)	STDEV	STDERR
1	Southern Pine	B20	6.1	491.8	491.8	—	-----
2	Southern Pine	B20	7.2	718.7			
3	Southern Pine	B20	7.2	670.5			
4	Southern Pine	B20	7.2	525.7	638.3	100.4	58.0
5	Southern Pine	B30	6.1	611.9	611.9	—	-----
6	Southern Pine	B30	7.2	506.4			
7	Southern Pine	B30	7.2	352.0			
8	Southern Pine	B30	7.2	398.6	419.0	79.2	45.7
9	Southern Pine	B40	6.1	317.6	317.6	—	-----
10	Southern Pine	B40	7.2	507.7			
11	Southern Pine	B40	7.2	556.5			
12	Southern Pine	B40	7.2	424.6	496.3	66.7	38.5
13	Southern Pine	B50	6.1	392.3	392.3	—	-----
14	Southern Pine	B50	7.2	337.3			
15	Southern Pine	B50	7.2	301.4			
16	Southern Pine	B50	7.2	308.2	315.6	19.0	11.0
17	Southern Pine	B100	6.1	280.8	280.8	—	-----
18	Southern Pine	B100	7.2	204.9			
19	Southern Pine	B100	7.2	281.6			
20	Southern Pine	B100	7.2	282.0	256.2	44.4	25.7
21	Southern Pine	Protreat	6.1	571.3	571.3	—	-----
22	Southern Pine	Protreat	7.2	619.4			
23	Southern Pine	Protreat	7.2	559.7			
24	Southern Pine	Protreat	7.2	608.4	595.8	31.8	18.3
25	Southern Pine	Untreated	-----	7.2	7.2	—	-----
26	Western Red Cedar	B20	12.8	997.8	997.8	—	-----
27	Western Red Cedar	B20	16.0	1,094.9	1,094.9	—	-----
28	Western Red Cedar	B30	12.8	1,231.5	1,231.5	—	-----
29	Western Red Cedar	B30	16.0	912.8	912.8	—	-----
30	Western Red Cedar	B40	12.8	910.7	910.7	—	-----
31	Western Red Cedar	B40	16.0	944.9	944.9	—	-----
32	Western Red Cedar	B50	12.8	978.9	978.9	—	-----
33	Western Red Cedar	B50	16.0	1,158.6	1,158.6	—	-----
34	Western Red Cedar	Protreat	12.8	833.6	833.6	—	-----
35	Western Red Cedar	Protreat	16.0	1,072.3	1,072.3	—	-----
36	Western Red Cedar	Untreated	-----	9.1	9.1	—	-----
37	Douglas---fir	B20	9.6	1,052.9	1,052.9	—	-----
38	Douglas---fir	B30	9.6	873.3	873.3	—	-----
39	Douglas---fir	B40	9.6	719.4	719.4	—	-----
40	Douglas---fir	B50	9.6	483.1	483.1	—	-----
41	Douglas---fir	Protreat	9.6	905.7	905.7	—	-----
42	Douglas---fir	Untreated	-----	8.2	8.2	—	-----
43	Red Pine	B20	8.5	474.4	474.4	—	-----
44	Red Pine	B30	8.5	277.7	277.7	—	-----
45	Red Pine	B40	8.5	360.9	360.9	—	-----
46	Red Pine	B50	8.5	443.6	443.6	—	-----
47	Red Pine	Protreat	8.5	487.2	487.2	—	-----
48	Red Pine	Untreated	-----	2.7	2.7	—	-----
49	Water Blank			16.3	16.3	—	-----

Appendix C: Leachate Chemical Analysis Report

The University of Georgia

College of Agricultural and Environmental Sciences
Department of Crop and Soil Sciences

Report of Analysis

Glenn Larkin
Michigan Tech University
Houghton, Michigan 49931-1295

Dear Dr. Larkin,

Enclosed are the results of the analysis of Pentachlorophenol (PCP) in the wood leachate samples. The method used is based on derivatization of PCP with acetic anhydride in presence of sodium borate followed by extraction of the acetate derivative with hexane containing 50 ppb concentration of hexachlorocyclohexane (internal standard). The hexane extract was then analyzed by GC/MS in the selected ion monitoring (SIM) mode.

Sample ID	Cone. (ug/l)	Sample ID	Cone. (ug/l)	Sample ID	Cone.
1	491.8	17	280.8	33	1,158.
2	718.7	18	204.9	34	833.6
3	670.5	19	281.6	35	1,072.
4	525.7	20	282.0	36	9.1
5	611.9	21	571.3	37	1,052.
6	506.4	22	619.4	38	873.
7	352.0	23	559.7	39	719.4
8	398.6	24	608.4	40	483.1
9	317.6	25	7.2	41	905.7
10	507.7	26	997.8	42	8.2
11	556.5	27	1,094.9	43	474.4
12	424.6	28	1,231.5	44	277.7
13	392.3	29	912.8	45	360.9
14	337.3	30	910.7	46	443.6
15	301.4	31	944.9	47	487.2
16	308.2	32	978.9	48	2.7
				49	16.3

Please feel free to call me if you have any question,

Sayed M. Hassan, Ph.D
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4 Laboratory Soil Block Decay Test of Pentachlorophenol Formulations

4.1 Summary

The decay resistance of southern pine treated with biodiesel (B20) and conventional oilborne pentachlorophenol (PCP) wood preservative formulations were evaluated in an AWP A E10-09 laboratory soil block decay test. The estimated activity thresholds for PCP in the biodiesel formulation were 0.328 kg/m³ (*Gloeophyllum trabeum*) and less than 0.30 kg/m³ (*Neolentinus lepideus*). The estimated activity thresholds for PCP in the conventional formulation were 0.375 kg/m³ (*Gloeophyllum trabeum*) and 0.43 kg/m³ (*Neolentinus lepideus*). The solvent blanks for the preservative systems performed comparably to one another.

4.2 Introduction

Oilborne pentachlorophenol (PCP) is a wood preservative commonly used to treat utility poles. A polar co-solvent is needed to dissolve PCP in the diesel fuel commonly used as the oil carrier. Substitution of conventional petroleum-based co-solvents with biodiesel co-solvent may lower the dependence of wood treatment facilities on fossil fuels and reduce the environmental impact of the preservative treatment. The purpose of this study was to compare the decay resistance of southern pine treated with a biodiesel-containing pentachlorophenol formulation to wood treated with a conventional petroleum-based formulation. The biodiesel-based carrier solvent was 20% biodiesel in #2 diesel fuel and was designated B20. The conventional co-solvent formulation was designated as Protreat. The soil block decay test was conducted from December 2010–April 2011 as MTU Project E44213.

4.3 Experimental

Wood and Treating Chemicals

Southern pine (*Pinus* spp.) was purchased from CzechMate Lumber (Mooresville, NC). Wood preservative chemicals were received from a utility pole manufacturer in November 2010. Biodiesel and conventional co-solvents were used as received. Pentachlorophenol was pulverized in a mortar and pestle to reduce particle size. Toluene was purchased from Sherwin Williams (Houghton, MI) and #2 off-road diesel was purchased from Sharon Avenue Express Mart (Houghton, MI).

Wood Specimen Selection and Preparation

Specimens were selected following the guidelines of AWP A E7-09¹. Boards for all wood species treated were clear, straight grained, and defect-free. Quarter-sawn southern pine boards were further selected to have 6–10 rings per inch and be entirely sapwood. Specimens were machined into 19 mm cubes and sorted to generate a narrow weight range to minimize density as a variable. The mean weights of the soil block sets were statistically identical as determined by a One Way Analysis of Variance test. There were 210 specimens selected for treatment and as controls.

¹ AWP A Standard E7-09, Standard Method of Testing Wood Preservatives by Field Tests with Stakes, American Wood Protection Association (2011) Birmingham, AL USA

Preservative Treatment

Southern pine soil blocks were treated at Michigan Tech during December of 2010 in accordance with AWWPA E7-09. Using toluene as a volatile diluent mimicked an empty cell treating process. An initial vacuum of 84.7 kPa (25" Hg) was drawn for 30 minutes immediately followed by 758.4 kPa (110 PSI) pressure for 60 minutes. Preservative retentions were determined gravimetrically from the pre- and post-treatment specimen weights. The experimental design is shown in Table 1, and the treatment data is attached as Appendix A. The treated blocks were conditioned at 20°C and 65% relative humidity, targeting an equilibrium moisture content of 12%, for 21 days prior to fungal exposure.

Soil Block Decay Test

Soil blocks were incubated according to AWWPA E10-09² for 12 weeks with either *Gloeophyllum trabeum* (ATCC 11539) or *Neolentinus lepideus* (ATCC 12653) as the exposure fungi. Decay was measured as the weight loss after fungal exposure. All test blocks were dried at 40°C in a forced air oven, then immediately weighed to obtain the initial weight prior to insertion into the soil block test jars. After fungal exposure, the test specimens were re-dried at 40°C in a forced air oven and re-weighed to obtain the post-exposure weights.

Statistical Analysis

All statistical analysis was performed using Analysis of Variance ($\alpha = 0.05$) with SigmaPlot 12 statistical software.³ When a statistically significant difference was found, a Sidak-Holm-All-Pairwise-Comparison ($\alpha = 0.05$) was used to determine which groups were different from each other.

4.4 Results and Discussion

Soil Block Decay Test

Soil block decay test results are presented in Table 2. The complete data set is contained in Appendix B.

Although the test fungi had colonized all soil jars feeder strips, and there was no evidence of contamination, variable colonization of specimens occurred at the lower pentachlorophenol retentions and various solvent blanks for both formulation types. The variable fungal colonization for the low retentions of the PCP treated soil blocks can be attributed to their nearness to the activity threshold. It is not uncommon to see large variability near the activity threshold, largely due to the differences in surface loading of the fungicide on the soil blocks. For the solvent blanks, the variable colonization may arise from incomplete removal of volatile organic solvents prior to fungal exposure or natural variability of the fungus.

² AWWPA Standard E10-09, Standard Method of Testing Wood Preservatives by Laboratory Soil Block Cultures, American Wood Protection Association (2010), Birmingham, AL USA

³ SigmaPlot 12, Systat Software, Inc. (2010) San Jose, CA, USA

Table 1. Experimental Design for AWP A E10-09 Soil Block Decay Test by Treatment/Retention/Replicate/Fungus Combination

Type	B20 Formulation				Protreat Formulation				Soil Block Replicates		
	Pentachlorophenol		Biodiesel Co-Solvent		Pentachlorophenol		Conventional Co-Solvent		Fungus Species		Total
	(kg/m ³)	(pcf)	(kg/m ³)	(pcf)	(kg/m ³)	(pcf)	(kg/m ³)	(pcf)	<i>G. trabeum</i>	<i>N. lepidus</i>	
1	0.3	0.02	4.7	0.29	---	---	---	---	5	5	10
2	0.6	0.04	9.4	0.59	---	---	---	---	5	5	10
3	1.2	0.08	18.7	1.17	---	---	---	---	5	5	10
4	2.4	0.15	37.4	2.34	---	---	---	---	5	5	10
5	4.8	0.30	74.9	4.68	---	---	---	---	5	5	10
6	---	---	4.7	0.29	---	---	---	---	5	5	10
7	---	---	9.4	0.59	---	---	---	---	5	5	10
8	---	---	18.7	1.17	---	---	---	---	5	5	10
9	---	---	37.4	2.34	---	---	---	---	5	5	10
10	---	---	74.9	4.68	---	---	---	---	5	5	10
11	---	---	---	---	0.3	0.02	4.7	0.29	5	5	10
12	---	---	---	---	0.6	0.04	9.4	0.59	5	5	10
13	---	---	---	---	1.2	0.08	18.7	1.17	5	5	10
14	---	---	---	---	2.4	0.15	37.4	2.34	5	5	10
15	---	---	---	---	4.8	0.30	74.9	4.68	5	5	10
16	---	---	---	---	---	---	4.7	0.29	5	5	10
17	---	---	---	---	---	---	9.4	0.59	5	5	10
18	---	---	---	---	---	---	18.7	1.17	5	5	10
19	---	---	---	---	---	---	37.4	2.34	5	5	10
20	---	---	---	---	---	---	74.9	4.68	5	5	10
21	---	---	---	---	---	---	---	---	5	5	10
Total									105	105	210

The untreated pine controls experienced 29.5% and 42.9% average weight loss for exposure to *Neolentinus lepidus* or *Gloeophyllum trabeum*, respectively, indicating acceptable fungal vigor. The minimum suggested acceptable average weight losses for untreated southern pine exposed to the fungi in this study are 25% (*N. lepidus*) and 40% (*G. trabeum*). Therefore, this was a valid soil block decay test.

The solvent blanks for the B20 and Protreat formulations were tested as a series of co-solvent retentions that are equal to the co-solvent loadings in the pentachlorophenol-treated blocks. They performed comparably and neither effectively protected the soil blocks from fungal attack. Average decay weight losses ranged from 8.5% to 17% with exposure to *Gloeophyllum trabeum*, and 15% to 30% with exposure to *Neolentinus lepidus*.

Both tested PCP formulations effectively controlled fungal decay at retentions of 0.6 kg/m³ with average weight losses of less than 3% after exposure to both test fungi. The B20 formulation also protected southern pine treated to target retention of 0.3 kg/m³ from decay by *Neolentinus lepidus*, with an average weight loss of 2%. Weight losses below five percent may arise from abiotic causes, so these results may be interpreted as effectively no decay.

The 0.3 kg/m³ retention of the biodiesel formulation had an average weight loss of almost 4.6% after *Gloeophyllum trabeum* exposure, with individual replicate weight losses between 1.6% and 7.3%. This variability is expected near the activity threshold. At the 0.30 kg/m³ pentachlorophenol retention, the B20 formulation had significantly more decay resistance than the Protreat formulation during exposure to *Gloeophyllum trabeum* ($p = 0.014$, $CI = 0.95$) and *Neolentinus lepidus* ($p < 0.001$, $CI = 0.95$). The conventional formulation had average weight losses between 9% and 10% after fungal exposure at this retention. Otherwise, the formulations performed

comparably against fungal attack in this study. Activity thresholds are presented in Table 2, and an example activity threshold calculation is shown in Figure 1.

Table 2. Estimated Activity Thresholds (kg/m³) for Pentachlorophenol Formulations

Wood Preservative Formulation	Test Fungus	
	<i>Gloeophyllum trabeum</i>	<i>Neolentinus lepideus</i>
Biodiesel Co-Solvent	0.328	< 0.30
Conventional Co-Solvent	0.375	0.43

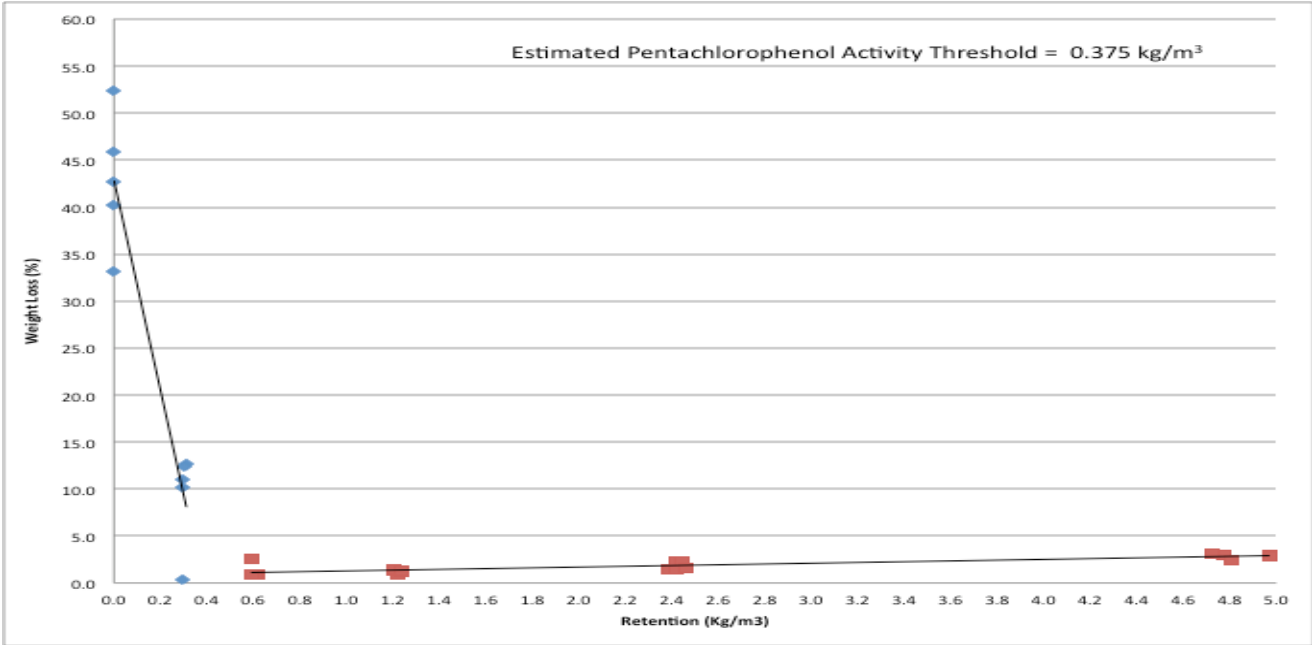


Figure 1. Estimated activity threshold of southern pine treated with a petroleum-based pentachlorophenol wood preservative formulation and exposed to a 12-week AWP A E10-09 soil block decay test with *Gloeophyllum trabeum*. The estimate was obtained by solving for the intercept of the two lines.

4.5 Conclusions

Substitution of biodiesel for conventional petroleum-based co-solvents in pentachlorophenol wood preservative formulations did not reduce the decay resistance of treated southern pine in this soil block decay test. In fact, the biodiesel-based formulation may have increased protection against fungal attack by *Gloeophyllum trabeum* and *Neolentinus lepideus*. Further study with other test fungi and wood species used as utility poles is advisable.

Appendix A: Soil Block Treatment Data

Table A1. Summary Table of Retentions for Southern Pine Soil Blocks Treated with Oilborne Pentachlorophenol Wood Preservative Formulations and their Solvent Blanks																		
Treatment		Specimen			Calculated Retention (Kg/m ³)													
		Target Retention (Kg/m ³)			Gross			Pentachlorophenol			Biodiesel Co-Solvent			Conventional Co-solvent				
Type	Date	Pentachlorophenol	Biodiesel Co-Solvent	Conventional Co-solvent	Average	STDEV	STDERR	Average	STDEV	STDERR	Average	STDEV	STDERR	Average	STDEV	STDERR	Deviation from Target (%)	
1	11/2/10	0.3	4.7	---	478.93	12.23	3.16	0.30	0.01	0.00	4.74	0.12	0.03	---	---	---	0.83	
2	11/2/10	0.6	9.4	---	478.77	12.69	3.28	0.60	0.02	0.00	9.47	0.25	0.06	---	---	---	0.79	
3	11/2/10	1.2	18.7	---	482.71	13.84	3.57	1.22	0.03	0.01	19.00	0.54	0.14	---	---	---	1.62	
4	11/2/10	2.4	37.4	---	470.29	13.69	3.53	2.38	0.07	0.02	37.03	1.08	0.28	---	---	---	--0.99	
5	11/2/10	4.8	74.9	---	481.29	11.33	2.93	4.86	0.11	0.03	75.89	1.79	0.46	---	---	---	1.32	
6	11/3/10	---	4.7	---	472.09	13.97	3.61	---	---	---	4.67	0.14	0.04	---	---	---	--0.61	
7	11/3/10	---	9.4	---	478.81	13.56	3.50	---	---	---	9.48	0.27	0.07	---	---	---	0.80	
8	11/3/10	---	18.7	---	476.46	13.30	3.43	---	---	---	18.76	0.52	0.14	---	---	---	0.31	
9	11/3/10	---	37.4	---	480.81	14.78	3.82	---	---	---	37.86	1.16	0.30	---	---	---	1.22	
10	11/3/10	---	74.9	---	489.28	9.52	2.46	---	---	---	77.15	1.50	0.39	---	---	---	3.01	
11	11/4/10	0.3	---	4.7	465.56	14.48	3.74	0.29	0.01	0.00	---	---	---	4.61	0.14	0.04	--1.99	
12	11/4/10	0.6	---	9.4	473.08	14.13	3.65	0.60	0.02	0.00	---	---	---	9.36	0.28	0.07	--0.40	
13	11/4/10	1.2	---	18.7	480.25	12.89	3.33	1.21	0.03	0.01	---	---	---	19.01	0.51	0.13	1.11	
14	11/4/10	2.4	---	37.4	478.80	13.72	3.54	2.42	0.07	0.02	---	---	---	37.90	1.09	0.28	0.80	
15	11/4/10	4.8	---	74.9	477.44	16.45	4.25	4.82	0.17	0.04	---	---	---	75.59	2.60	0.67	0.51	
16	11/5/11	---	---	4.7	468.40	15.66	4.04	---	---	---	---	---	---	4.93	0.16	0.04	4.90	
17	11/5/11	---	---	9.4	469.30	15.51	4.00	---	---	---	---	---	---	9.88	0.33	0.08	5.11	
18	11/5/11	---	---	18.7	474.24	10.67	2.75	---	---	---	---	---	---	19.97	0.45	0.12	6.78	
19	11/5/11	---	---	37.4	469.28	15.34	3.96	---	---	---	---	---	---	39.52	1.29	0.33	5.66	
20	11/5/11	---	---	74.9	478.04	11.52	2.97	---	---	---	---	---	---	80.51	1.94	0.50	7.49	

Table A2. Treatment of Southern Pine with Oilborne Pentachlorophenol Wood Preservative Formulations for an AWPA E10--09 Soil Block Decay Test

Treatment		Target Retention (Kg/m ³)			Identifiers		Dimensions (mm)			Weight (g)		Calculated Retention (kg/m ³)				
Type	Date	Pentachlorophenol (PCP)	Biodiesel Co--Solvent (B20)	Conventional Co--solvent (Protreat)	Label #	Soil Block #	Length	Width	Thick	Initial	Final	Gross	PCP	B20	Protreat	
1	11/2/10	0.3	4.7	---	501	1--G1	19.20	18.91	19.03	4.11	7.34	467.5	0.3	4.6	---	
					502	1--G2	19.16	19.01	19.00	4.11	7.37	471.1	0.3	4.7	---	
					503	1--G3	18.91	19.24	19.36	4.12	7.55	487.0	0.3	4.8	---	
					504	---	19.07	18.81	19.21	3.86	7.26	493.4	0.3	4.9	---	
					505	1--G4	19.01	18.60	18.92	3.87	7.12	485.8	0.3	4.8	---	
					506	---	19.05	19.03	19.08	3.80	7.26	500.2	0.3	4.9	---	
					507	---	19.18	18.85	19.10	3.93	7.35	495.3	0.3	4.9	---	
					508	1--G5	19.32	18.95	19.12	4.15	7.50	478.6	0.3	4.7	---	
					509	1--N1	18.99	18.71	18.99	4.06	7.21	466.9	0.3	4.6	---	
					510	1--N2	19.22	19.00	18.96	4.16	7.39	466.5	0.3	4.6	---	
					511	1--N3	19.22	19.06	18.94	4.11	7.37	469.9	0.3	4.6	---	
					512	---	19.06	19.01	19.09	3.88	7.28	491.6	0.3	4.9	---	
					513	1--N4	19.13	18.89	19.09	4.11	7.37	472.6	0.3	4.7	---	
					514	1--N5	19.10	18.74	19.05	4.03	7.27	475.2	0.3	4.7	---	
					Average	---	19.12	18.91	19.05	4.03	7.33	478.93	0.30	4.74	---	
					Std Dev	---	0.11	0.16	0.13	0.12	0.11	12.23	0.01	0.12	---	
					Std Error	---	0.03	0.04	0.03	0.03	0.03	3.16	0.00	0.03	---	
2	11/2/10	0.6	9.4	---	516	2--G1	19.19	18.90	19.03	3.93	7.27	483.9	0.6	9.6	---	
					517	---	19.11	18.62	18.69	4.19	7.19	451.1	0.6	8.9	---	
					518	2--G2	19.14	18.84	19.12	3.99	7.35	487.3	0.6	9.6	---	
					519	2--G3	19.14	18.83	19.03	4.05	7.35	481.2	0.6	9.5	---	
					520	2--G4	19.24	19.26	18.87	4.21	7.50	470.5	0.6	9.3	---	
					521	---	19.18	19.10	18.53	3.95	7.27	489.1	0.6	9.7	---	
					522	2--G5	19.13	19.05	18.88	4.19	7.39	465.1	0.6	9.2	---	
					523	2--N1	19.15	19.08	18.80	3.92	7.20	477.5	0.6	9.4	---	
					524	2--N2	18.99	18.94	19.27	4.08	7.40	479.0	0.6	9.5	---	
					525	2--N3	18.99	18.68	19.03	4.08	7.18	459.2	0.6	9.1	---	
					526	---	19.08	19.17	19.08	3.91	7.37	495.8	0.6	9.8	---	
					527	---	19.04	19.10	19.04	3.88	7.30	493.9	0.6	9.8	---	
					528	---	19.14	19.03	18.74	3.98	7.31	487.9	0.6	9.7	---	
					529	2--N4	18.95	18.73	19.15	3.92	7.21	484.0	0.6	9.6	---	
					Average	---	19.10	18.95	18.96	4.02	7.31	478.77	0.60	9.47	---	
					Std Dev	---	0.08	0.19	0.20	0.11	0.09	12.69	0.02	0.25	---	
					Std Error	---	0.02	0.05	0.05	0.03	0.02	3.28	0.00	0.06	---	
3	11/2/10	1.2	18.7	---	531	---	19.00	19.00	19.08	4.01	7.39	490.7	1.2	19.3	---	
					532	3--G1	19.05	18.94	19.15	4.14	7.39	470.4	1.2	18.5	---	
					533	3--G2	19.27	18.96	19.05	4.05	7.37	477.0	1.2	18.8	---	
					534	3--G3	19.07	19.30	19.28	4.23	7.62	477.7	1.2	18.8	---	
					535	3--G4	19.15	19.07	19.10	3.98	7.33	480.3	1.2	18.9	---	
					536	3--G5	18.95	18.89	19.35	3.93	7.28	483.6	1.2	19.0	---	
					537	---	19.14	19.20	18.98	3.89	7.40	503.2	1.3	19.8	---	
					538	3--N1	19.14	19.00	18.97	4.00	7.34	484.2	1.2	19.1	---	
					539	3--N2	19.18	18.87	19.08	3.95	7.28	482.2	1.2	19.0	---	
					540	---	19.06	18.49	18.94	4.12	7.14	452.4	1.1	17.8	---	
					541	3--N3	19.12	19.23	19.45	4.20	7.70	489.4	1.2	19.3	---	
					542	3--N4	19.31	18.96	18.79	4.22	7.41	463.7	1.2	18.3	---	
					543	3--N5	19.17	19.05	19.13	3.95	7.37	489.5	1.2	19.3	---	
					544	---	19.26	18.89	18.91	3.99	7.36	489.8	1.2	19.3	---	
					Average	---	19.13	18.99	19.10	4.04	7.39	482.71	1.22	19.00	---	
					Std Dev	---	0.10	0.19	0.18	0.12	0.13	13.84	0.03	0.54	---	
					Std Error	---	0.03	0.05	0.05	0.03	0.03	3.57	0.01	0.14	---	
4	11/2/10	2.4	37.4	---	546	4--G1	19.22	19.37	19.05	4.14	7.55	480.8	2.4	37.9	---	
					547	---	19.17	18.72	18.75	3.93	7.02	459.2	2.3	36.2	---	
					548	4--G2	18.87	18.89	19.12	4.03	7.23	469.5	2.4	37.0	---	
					549	---	18.79	18.58	19.06	4.20	7.22	453.8	2.3	35.7	---	
					550	---	19.20	19.22	19.45	3.90	7.53	505.7	2.6	39.8	---	
					551	4--G3	19.07	19.02	18.93	3.98	7.22	471.9	2.4	37.2	---	
					552	4--G4	18.98	19.41	18.80	4.18	7.44	470.7	2.4	37.1	---	
					553	4--G5	19.20	18.88	18.92	3.96	7.27	482.6	2.4	38.0	---	
					554	4--N1	19.18	18.89	18.90	4.16	7.32	461.5	2.3	36.3	---	
					555	4--N2	19.16	19.06	18.84	3.95	7.25	479.6	2.4	37.8	---	
					556	4--N3	19.18	18.83	19.12	4.05	7.35	477.9	2.4	37.6	---	
					557	4--N4	19.01	19.01	18.92	4.16	7.31	460.7	2.3	36.3	---	
					558	---	19.05	19.11	19.15	4.23	7.42	457.6	2.3	36.0	---	
					559	---	19.04	18.89	19.17	4.21	7.35	455.4	2.3	35.9	---	
					Average	---	19.13	18.99	19.10	4.04	7.39	482.71	1.22	19.00	---	
					Std Dev	---	0.10	0.19	0.18	0.12	0.13	13.84	0.03	0.54	---	
					Std Error	---	0.03	0.05	0.05	0.03	0.03	3.57	0.01	0.14	---	
5	11/2/10	4.8	74.9	---	561	5--G1	19.16	19.11	19.02	4.18	7.49	475.3	4.8	74.9	---	
					562	5--G2	19.17	19.07	18.69	4.00	7.26	477.1	4.8	75.2	---	
					563	5--G3	18.96	19.00	19.06	4.00	7.32	483.5	4.9	76.2	---	
					564	---	19.07	18.91	19.37	3.87	7.37	501.1	5.1	79.0	---	
					565	---	19.05	19.02	18.89	3.83	7.24	498.2	5.0	78.6	---	
					566	5--G4	19.20	18.93	19.01	4.04	7.39	484.9	4.9	76.5	---	
					567	5--G5	19.24	18.99	19.07	4.08	7.41	477.9	4.8	75.4	---	
					568	5--N1	19.16	19.44	18.54	4.09	7.44	485.1	4.9	76.5	---	
					569	---	19.20	18.98	18.92	3.91	7.32	494.6	5.0	78.0	---	
					570	5--N2	18.99	18.72	19.07	4.06	7.29	476.5	4.8	75.1	---	
					571	5--N3	19.14	19.29	19.06	3.98	7.31	473.2	4.8	74.6	---	
					572	5--N4	19.18	18.96	19.08	3.98	7.31	479.9	4.8	75.7	---	
					573	---	19.08	18.82	19.00	3.97	7.29	486.6	4.9	76.7	---	
					574	5--N5	19.18	18.86	18.64	4.16	7.31	467.2	4.7	73.7	---	
					Average	---	19.13	19.01	18.98	4.01	7.33	481.29	4.86	75.89	---	
					Std Dev	---	0.08	0.18	0.22	0.10	0.08	11.33	0.11	1.79	---	
					Std Error	---	0.02	0.05	0.06	0.03	0.02	2.93	0.03	0.46	---	

7	11/3/10	—	9.4	—	591	—	19.19	19.05	18.87	3.85	7.32	503.0	—	10.0	—
					592	7—G1	19.18	19.09	19.02	4.12	7.41	472.4	—	9.3	—
					593	7—G2	19.17	19.24	18.85	4.16	7.47	476.1	—	9.4	—
					594	7—G3	19.14	18.79	19.18	4.03	7.35	481.3	—	9.5	—
					595	7—G4	19.24	19.39	19.42	4.15	7.68	487.2	—	9.6	—
					596	7—G5	19.11	19.02	19.01	4.04	7.26	466.0	—	9.2	—
					597	7—N1	19.04	18.95	18.71	3.89	7.11	477.0	—	9.4	—
					598	7—N2	19.06	19.04	19.02	3.89	7.20	479.5	—	9.5	—
					599	—	19.12	19.04	18.93	4.05	7.22	460.0	—	9.1	—
					600	—	19.23	18.99	19.14	4.10	7.32	460.7	—	9.1	—
					601	7—N3	18.78	19.40	18.48	3.91	7.05	466.4	—	9.2	—
					602	7—N4	19.12	18.96	18.95	3.87	7.18	481.8	—	9.5	—
					603	7—N5	19.27	19.22	19.00	4.18	7.51	473.2	—	9.4	—
					604	—	19.28	19.25	19.52	3.88	7.52	502.4	—	9.9	—
					605	—	19.00	19.03	19.30	3.88	7.21	466.6	—	9.8	—
					Average		19.13	19.08	19.02	4.00	7.32	478.81	—	9.48	—
					Std Dev		0.13	0.18	0.26	0.13	0.17	13.56	—	0.27	—
					Std Error		0.03	0.05	0.07	0.03	0.04	3.50	—	0.07	—
8	11/3/10	—	18.7	—	606	8—G1	19.05	19.06	18.75	3.89	7.11	473.0	—	18.6	—
					607	—	19.14	19.02	18.85	4.15	7.35	466.3	—	18.4	—
					608	8—G2	19.20	18.93	19.12	4.19	7.46	470.6	—	18.5	—
					609	—	19.08	19.13	19.02	4.17	7.38	462.4	—	18.2	—
					610	8—G3	19.14	18.87	18.58	4.05	7.19	467.9	—	18.4	—
					611	8—G4	19.16	19.00	19.11	4.01	7.28	470.0	—	18.5	—
					612	—	18.76	19.07	18.93	4.15	7.25	457.7	—	18.0	—
					613	8—G5	19.11	19.03	18.74	4.09	7.30	471.0	—	18.5	—
					614	8—N1	19.20	18.93	18.95	3.89	7.14	471.9	—	18.6	—
					615	8—N2	19.06	18.96	18.83	3.90	7.21	473.2	—	18.6	—
					616	—	19.16	19.06	18.87	3.88	7.33	500.6	—	19.7	—
					617	—	19.11	18.90	18.94	3.83	7.22	495.6	—	19.5	—
					618	8—N3	19.12	18.97	18.85	3.88	7.26	494.4	—	19.5	—
					619	8—N4	18.93	19.11	19.17	3.88	7.31	494.6	—	19.5	—
					620	8—N5	19.06	19.00	19.81	3.83	7.24	473.8	—	19.8	—
					Average		19.09	19.00	18.91	4.00	7.27	476.46	—	18.76	—
					Std Dev		0.11	0.08	0.16	0.12	0.09	13.30	—	0.52	—
					Std Error		0.03	0.02	0.04	0.03	0.02	3.43	—	0.14	—
9	11/3/10	—	37.4	—	621	—	19.03	18.85	18.94	3.98	7.34	494.5	—	38.9	—
					622	9—G1	18.98	19.07	19.14	4.12	7.38	470.6	—	37.1	—
					623	9—G2	19.14	19.16	19.06	4.18	7.53	479.3	—	37.7	—
					624	9—G3	19.05	19.10	18.81	4.11	7.37	476.3	—	37.5	—
					625	—	19.23	19.01	19.11	3.88	7.35	496.7	—	39.1	—
					626	9—G4	19.18	18.77	19.03	4.04	7.35	483.1	—	38.0	—
					627	9—G5	19.25	19.31	18.84	4.15	7.47	474.1	—	37.3	—
					628	—	19.01	18.95	17.95	4.08	6.97	446.9	—	35.2	—
					629	9—N1	18.99	19.01	19.16	3.83	7.19	485.8	—	38.2	—
					630	9—N2	19.11	19.06	19.01	4.14	7.39	469.4	—	37.0	—
					631	9—N3	19.00	18.93	19.06	4.09	7.33	472.6	—	37.2	—
					632	—	19.19	18.87	18.92	3.78	7.13	489.0	—	38.5	—
					633	—	19.32	18.89	19.16	3.87	7.45	512.0	—	40.3	—
					634	9—N4	19.05	19.05	18.87	4.12	7.44	484.8	—	38.2	—
					635	9—N5	19.12	18.88	19.05	3.88	7.27	473.0	—	37.6	—
					Average		19.11	18.99	18.94	4.02	7.33	480.81	—	37.86	—
					Std Dev		0.11	0.14	0.30	0.13	0.14	14.78	—	1.16	—
					Std Error		0.03	0.04	0.08	0.03	0.04	3.82	—	0.30	—
10	11/3/10	—	74.9	—	636	10—G1	19.07	18.76	19.13	3.97	7.32	485.5	—	77.2	—
					637	10—G2	19.11	19.27	18.81	3.94	7.24	476.1	—	75.1	—
					638	10—G3	18.96	18.85	19.00	3.86	7.17	487.4	—	76.9	—
					639	—	19.05	18.68	18.92	3.74	7.14	505.0	—	79.6	—
					640	10—G4	19.09	18.85	19.17	4.05	7.34	476.9	—	75.2	—
					641	—	19.05	18.87	19.04	3.91	7.31	496.8	—	78.3	—
					642	—	19.16	19.08	18.80	3.89	7.33	500.5	—	78.9	—
					643	10—G5	19.06	18.80	19.05	3.78	7.12	489.3	—	77.2	—
					644	10—N1	19.02	19.04	18.93	4.19	7.45	475.5	—	75.0	—
					645	10—N2	19.03	19.30	19.02	4.01	7.41	486.7	—	76.7	—
					646	—	19.16	19.02	19.22	3.90	7.38	496.8	—	78.3	—
					647	10—N3	19.07	18.94	18.87	3.93	7.26	488.6	—	77.0	—
					648	10—N4	19.00	19.06	19.05	4.15	7.45	478.3	—	75.4	—
					649	10—N5	19.07	18.91	19.07	3.84	7.21	490.0	—	77.3	—
					650	—	19.06	18.83	19.03	3.78	7.21	491.3	—	77.6	—
					Average		19.06	18.95	19.01	3.93	7.29	489.28	—	77.15	—
					Std Dev		0.05	0.18	0.12	0.13	0.11	9.52	—	1.50	—
					Std Error		0.01	0.05	0.03	0.03	0.03	2.46	—	0.39	—

Table A2. Treatment of Southern Pine with Oilborne Pentachlorophenol Wood Preservative Formulations for an AWP A E10--09 Soil Block Decay Test (con...)

Treatment		Target Retention (Kg/m ³)			Identifiers		Dimensions (mm)			Weight (g)		Calculated Retention (kg/m ³)			
Type	Date	Pentachlorophenol (PCP)	Biodiesel Co—Solvent (B20)	Conventional Co—solvent (Protreat)	Label #	Soil Block #	Length	Width	Thick	Initial	Final	Gross	PCP	B20	Protreat
11	11/4/10	0.3	—	4.7	651	11—G1	19.01	18.97	18.98	4.00	7.20	467.5	0.3	—	4.6
					652	11—G2	19.19	18.83	18.90	4.13	7.33	468.6	0.3	—	4.6
					653	11—G3	19.08	18.72	19.05	4.07	7.22	462.9	0.3	—	4.6
					654	11—G4	19.20	19.05	19.00	3.85	7.28	493.6	0.3	—	4.9
					655	11—G5	19.41	19.20	19.13	3.97	7.41	482.5	0.3	—	4.8
					656	11—N1	19.08	18.71	18.87	4.02	7.16	466.1	0.3	—	4.6
					657	—	18.96	18.74	18.75	4.10	7.08	447.3	0.3	—	4.4
					658	11—N2	19.18	18.93	19.24	4.09	7.33	463.8	0.3	—	4.6
					659	—	19.07	18.11	18.70	4.07	6.87	433.6	0.3	—	4.3
					660	11—N3	19.12	18.97	18.86	3.91	7.12	469.3	0.3	—	4.6
					661	—	19.10	19.08	18.89	3.91	7.03	453.2	0.3	—	4.5
					662	11—N4	19.11	18.91	18.91	3.91	7.18	478.5	0.3	—	4.7
					663	—	18.89	19.10	18.89	4.15	7.29	460.7	0.3	—	4.6
664	11—N5	19.18	18.97	18.96	3.94	7.22	475.5	0.3	—	4.7					
					Average	19.12	18.87	18.91	4.01	7.19	465.56	0.29	—	4.61	
					Std Dev	0.12	0.26	0.17	0.09	0.14	14.48	0.01	—	0.14	
					Std Error	0.03	0.07	0.04	0.02	0.03	3.74	0.00	—	0.04	
12	11/4/10	0.6	—	9.4	666	12—G1	18.96	18.91	19.00	4.08	7.28	469.7	0.6	—	9.3
					667	12—G2	18.99	18.74	18.90	3.91	7.07	469.8	0.6	—	9.3
					668	—	19.11	18.94	18.92	3.90	7.27	492.1	0.6	—	9.7
					669	12—G3	19.22	18.77	18.94	3.90	7.22	485.9	0.6	—	9.6
					670	12—G4	19.18	18.67	19.10	3.97	7.29	485.4	0.6	—	9.6
					671	12—G5	19.20	19.05	18.80	4.12	7.33	466.8	0.6	—	9.2
					672	—	18.96	19.01	18.95	3.89	7.03	459.7	0.6	—	9.1
					673	12—N1	19.09	18.86	19.06	4.01	7.22	467.8	0.6	—	9.3
					674	12—N2	19.26	18.84	18.95	3.92	7.17	472.6	0.6	—	9.4
					675	12—N3	19.15	18.89	19.16	4.00	7.24	467.5	0.6	—	9.3
					676	—	19.04	18.93	18.91	4.17	7.20	444.6	0.6	—	8.8
					677	—	18.99	19.21	19.00	3.83	7.23	490.5	0.6	—	9.7
					678	—	19.00	18.94	19.06	4.13	7.24	453.4	0.6	—	9.0
679	12—N4	19.25	19.20	19.11	3.92	7.37	488.5	0.6	—	9.7					
					Average	19.10	18.93	18.99	3.97	7.22	473.08	0.60	—	9.36	
					Std Dev	0.11	0.15	0.10	0.11	0.09	14.13	0.02	—	0.28	
					Std Error	0.03	0.04	0.02	0.03	0.02	3.65	0.00	—	0.07	

13	11/4/10	1.2	—	18.7	681	—	19.04	18.77	18.87	3.79	7.16	499.7	1.3	—	19.8
					682	13—G1	18.97	18.69	18.95	3.96	7.20	482.2	1.2	—	19.1
					683	13—G2	19.21	18.76	18.83	3.87	7.20	490.7	1.2	—	19.4
					684	—	19.12	19.02	19.06	3.87	7.29	493.4	1.2	—	19.5
					685	13—G3	19.17	19.38	19.20	4.18	7.58	476.7	1.2	—	18.9
					686	—	19.22	19.04	18.93	3.95	7.38	495.1	1.3	—	19.6
					687	13—G4	19.03	18.95	18.90	4.04	7.29	476.8	1.2	—	18.9
					688	—	19.36	18.84	19.12	4.13	7.35	461.7	1.2	—	18.3
					689	13—G5	19.21	19.15	18.92	3.88	7.29	489.9	1.2	—	19.4
					690	13—N1	19.03	18.87	19.05	3.88	7.07	466.3	1.2	—	18.5
					691	—	19.02	18.78	19.22	3.76	7.16	495.2	1.3	—	19.6
					692	13—N2	19.06	18.77	19.09	4.03	7.19	464.2	1.2	—	18.4
					693	13—N3	19.08	18.96	18.84	3.97	7.18	471.0	1.2	—	18.6
					694	13—N4	19.18	19.02	18.71	4.08	7.31	473.2	1.2	—	18.7
					Average	—	19.12	18.95	18.98	3.97	7.27	480.25	1.21	—	19.01
					Std Dev	—	0.11	0.20	0.14	0.13	0.13	12.89	0.03	—	0.51
					Std Error	—	0.03	0.05	0.04	0.03	0.03	3.33	0.01	—	0.13
14	11/4/10	2.4	—	37.4	696	14—G1	18.91	19.05	18.85	4.14	7.35	472.7	2.4	—	37.4
					697	14—G2	18.92	18.95	18.97	4.03	7.29	479.3	2.4	—	37.9
					698	—	19.13	17.83	18.97	3.92	6.91	462.1	2.3	—	36.6
					699	14—G3	19.18	18.97	18.86	3.88	7.17	479.4	2.4	—	38.0
					700	—	19.04	18.90	18.76	3.74	7.10	497.7	2.5	—	39.4
					701	14—G4	19.13	18.94	19.15	3.85	7.20	482.8	2.4	—	38.2
					702	14—G5	19.03	19.12	19.02	3.88	7.25	487.0	2.5	—	38.5
					703	14—N1	19.01	18.86	18.96	3.94	7.21	481.0	2.4	—	38.1
					704	14—N2	19.06	18.99	19.18	3.82	7.22	488.8	2.5	—	38.2
					705	—	19.28	18.94	18.97	3.80	7.24	496.6	2.5	—	39.3
					706	14—N3	19.06	18.84	18.87	3.93	7.13	472.3	2.4	—	37.4
					707	14—N4	19.11	18.87	19.06	4.04	7.31	475.8	2.4	—	37.7
					708	—	19.02	18.81	18.99	4.09	7.13	447.5	2.3	—	35.4
					709	—	19.18	18.84	18.91	3.87	7.24	493.2	2.5	—	39.0
					Average	—	19.07	18.85	18.97	3.94	7.20	478.80	2.42	—	37.90
					Std Dev	—	0.10	0.30	0.11	0.12	0.11	13.72	0.07	—	1.09
					Std Error	—	0.03	0.08	0.03	0.03	0.03	3.54	0.02	—	0.28
15	11/4/10	4.8	—	74.9	711	15—G1	19.35	18.95	18.81	4.07	7.33	472.6	4.8	—	74.8
					712	—	19.07	18.50	19.03	3.82	7.20	503.4	5.1	—	79.7
					713	15—G2	19.20	18.86	18.71	4.04	7.26	475.3	4.8	—	75.2
					714	15—G3	19.07	18.74	18.26	3.95	7.00	467.4	4.7	—	74.0
					715	—	19.12	18.95	18.99	4.09	7.23	456.4	4.6	—	72.2
					716	15—G4	19.07	18.84	18.90	3.81	7.15	491.9	5.0	—	77.9
					717	15—G5	19.14	18.71	18.97	3.77	7.11	491.7	5.0	—	77.8
					718	15—N1	18.72	19.32	18.94	4.15	7.32	462.8	4.7	—	73.3
					719	15—N2	19.22	18.56	18.84	3.86	7.09	480.6	4.9	—	76.1
					720	—	19.04	18.89	18.43	3.69	6.98	496.3	5.0	—	78.6
					721	—	18.98	19.08	19.06	3.87	7.27	492.6	5.0	—	78.0
					722	15—N3	18.84	19.33	18.40	3.88	7.14	486.5	4.9	—	77.0
					723	—	19.03	18.72	18.72	4.09	7.06	445.4	4.5	—	70.5
					724	15—N4	19.10	18.72	18.96	4.07	7.21	463.2	4.7	—	73.3
					Average	—	19.07	18.88	18.80	3.95	7.18	477.44	4.82	—	75.59
					Std Dev	—	0.15	0.24	0.25	0.14	0.11	16.45	0.17	—	2.60
					Std Error	—	0.04	0.06	0.06	0.04	0.03	4.25	0.04	—	0.67

Table A2. Treatment of Southern Pine with Oilborne Pentachlorophenol Wood Preservative Formulations for an AWP A E10--09 Soil Block Decay Test (con...)

Treatment		Target Retention (kg/m ³)			Identifiers		Dimensions (mm)			Weight (g)		Calculated Retention (kg/m ³)			
Type	Date	Pentachlorophenol (PCP)	Biodiesel Co-Solvent (B20)	Conventional Co-solvent (Protreat)	Label #	Soil Block #	Length	Width	Thick	Initial	Final	Gross	PCP	B20	Protreat
16	11/5/11	—	—	4.7	726	16-G1	19.08	18.98	19.02	4.05	7.30	471.8	—	—	5.0
					727	—	19.19	18.87	18.96	4.07	7.19	454.4	—	—	4.8
					728	16-G2	18.99	19.11	19.39	4.13	7.51	480.3	—	—	5.1
					729	16-G3	19.02	18.93	19.01	4.08	7.25	463.1	—	—	4.9
					730	16-G4	19.02	19.35	19.50	4.12	7.50	471.0	—	—	5.0
					731	—	19.20	18.42	18.94	4.14	7.07	437.4	—	—	4.6
					732	—	19.17	18.97	19.02	4.03	7.19	456.9	—	—	4.8
					733	16-G5	19.36	18.97	19.16	3.99	7.36	478.9	—	—	5.0
					734	—	19.13	17.76	19.00	3.89	6.76	444.6	—	—	4.7
					735	16-N1	19.30	18.93	18.72	3.88	7.11	472.3	—	—	5.0
					736	—	19.36	19.11	19.29	3.90	7.47	500.2	—	—	5.3
					737	16-N2	19.12	19.09	18.81	4.16	7.40	471.9	—	—	5.0
					738	16-N3	19.01	18.91	18.96	3.99	7.20	471.0	—	—	5.0
					739	16-N4	19.22	19.08	18.83	3.86	7.20	483.7	—	—	5.1
					Average	—	19.16	18.91	19.04	4.03	7.26	468.40	—	—	4.93
					Std Dev	—	0.12	0.38	0.22	0.11	0.20	15.66	—	—	0.16
					Std Error	—	0.03	0.10	0.06	0.03	0.05	4.04	—	—	0.04
17	11/5/11	—	—	9.4	741	17-G1	19.16	18.89	18.81	4.13	7.38	477.4	—	—	10.1
					742	17-G2	19.14	18.90	18.81	3.90	7.08	467.3	—	—	9.8
					743	—	19.16	19.20	19.03	3.95	7.39	491.4	—	—	10.3
					744	17-G3	19.05	18.66	19.06	3.92	7.12	472.3	—	—	9.9
					745	17-G4	19.33	19.05	19.02	3.98	7.33	478.3	—	—	10.1
					746	—	19.20	18.66	18.69	4.17	7.09	436.1	—	—	9.2
					747	—	18.75	18.95	18.59	4.14	7.06	442.1	—	—	9.3
					748	17-G5	19.15	19.21	18.93	3.94	7.27	478.2	—	—	10.1
					749	—	19.03	18.87	18.85	3.81	6.96	465.4	—	—	9.8
					750	—	19.14	18.98	19.14	4.11	7.25	451.6	—	—	9.5
					751	17-N1	19.10	18.73	18.98	3.90	7.14	477.2	—	—	10.0
					752	17-N2	19.04	19.02	18.95	3.87	7.07	466.3	—	—	9.8
					753	17-N3	19.13	19.04	18.66	4.07	7.26	469.4	—	—	9.9
					754	17-N4	19.10	18.98	19.03	3.85	7.18	482.7	—	—	10.2
					Average	—	19.12	18.94	18.92	3.97	7.19	469.30	—	—	9.88
					Std Dev	—	0.13	0.17	0.19	0.12	0.13	15.51	—	—	0.33
					Std Error	—	0.03	0.04	0.05	0.03	0.03	4.00	—	—	0.08
18	11/5/11	—	—	18.7	756	—	19.22	18.94	18.99	3.79	7.22	496.2	—	—	20.9
					757	—	19.14	18.46	19.17	3.94	7.09	465.1	—	—	19.6
					758	18-G1	19.06	18.95	18.98	3.98	7.21	471.2	—	—	19.8
					759	18-G2	19.16	18.91	18.89	3.94	7.21	477.8	—	—	20.1
					760	18-G3	19.10	18.83	19.06	3.97	7.23	475.6	—	—	20.0
					761	18-G4	19.08	18.91	18.91	3.86	7.16	483.7	—	—	20.4
					762	18-G5	19.13	19.19	18.98	4.01	7.34	477.9	—	—	20.1
					763	18-N1	19.15	19.40	18.92	4.13	7.42	468.1	—	—	19.7
					764	—	19.17	18.78	19.23	4.00	7.14	453.6	—	—	19.1
					765	18-N2	18.99	18.86	19.24	3.80	7.18	490.5	—	—	20.7
					766	—	18.99	18.80	18.87	4.00	7.15	467.6	—	—	19.7
					767	18-N3	19.10	18.99	18.74	4.11	7.30	469.3	—	—	19.8
					768	—	19.06	19.36	18.83	4.08	7.33	467.7	—	—	19.7
					769	18-N4	19.16	19.11	18.94	3.96	7.29	480.2	—	—	20.2
					Average	—	19.11	18.98	18.97	3.98	7.24	474.24	—	—	19.97
					Std Dev	—	0.07	0.24	0.16	0.10	0.09	10.67	—	—	0.45
					Std Error	—	0.02	0.06	0.04	0.03	0.02	2.75	—	—	0.12

19	11/5/11	—	—	37.4	771	19—G1	19.14	18.88	19.13	3.99	7.30	478.8	—	—	40.3
					772	19—G2	19.09	19.09	19.03	3.87	7.24	485.9	—	—	40.9
					773	19—G3	19.05	18.76	19.05	3.90	7.19	483.3	—	—	40.7
					774	19—G4	19.18	19.06	18.91	3.91	7.18	473.0	—	—	39.8
					775	19—G5	19.21	18.96	18.55	3.83	7.11	485.5	—	—	40.9
					776	19—N1	19.19	18.98	18.79	4.11	7.31	467.6	—	—	39.4
					777	—	18.80	19.08	18.40	4.06	7.07	456.0	—	—	38.4
					778	—	19.18	18.98	18.95	3.99	7.11	452.4	—	—	38.1
					779	—	19.10	18.77	18.46	4.04	7.02	449.7	—	—	37.9
					780	19—N2	19.20	18.90	18.98	3.92	7.23	480.6	—	—	40.5
					781	—	19.13	18.98	17.84	4.01	6.88	443.1	—	—	37.3
					782	19—N3	19.20	19.00	18.81	3.91	7.13	469.3	—	—	39.5
					783	—	19.01	19.05	19.06	3.96	7.06	449.1	—	—	37.8
					784	19—N4	19.11	19.14	18.92	3.94	7.31	487.0	—	—	41.0
					785	—	19.12	18.99	18.92	4.01	7.25	480.0	—	—	40.0
					Average		19.12	18.99	18.77	3.97	7.16	469.28	—	—	39.52
					Std Dev		0.11	0.12	0.34	0.08	0.13	15.34	—	—	1.29
					Std Error		0.03	0.03	0.09	0.02	0.03	3.96	—	—	0.33
20	11/5/11	—	—	74.9	786	20—G1	19.34	18.86	18.77	4.03	7.28	474.7	—	—	80.0
					787	20—G2	19.03	18.53	18.98	3.78	7.06	490.1	—	—	82.5
					788	—	19.01	18.94	19.15	3.82	7.20	490.2	—	—	82.6
					789	20—G3	19.15	19.25	18.90	4.01	7.38	483.7	—	—	81.5
					790	20—G4	19.08	18.86	18.87	3.86	7.16	486.0	—	—	81.9
					791	20—G5	19.21	19.10	19.01	3.86	7.24	484.6	—	—	81.6
					792	—	19.04	19.16	18.95	3.86	7.06	462.9	—	—	78.0
					793	—	19.14	18.92	18.93	3.82	6.95	456.6	—	—	76.9
					794	20—N1	18.90	19.05	19.10	4.04	7.26	468.2	—	—	78.9
					795	—	19.24	19.00	18.91	4.04	7.23	461.5	—	—	77.7
					796	20—N2	19.03	19.08	18.89	3.96	7.28	484.0	—	—	81.5
					797	20—N3	19.03	18.48	18.72	4.02	7.19	481.5	—	—	81.1
					798	20—N4	19.06	18.82	18.97	3.92	7.22	485.0	—	—	81.7
					799	—	19.02	18.92	19.21	3.85	7.25	491.8	—	—	82.8
					800	20—N5	19.15	19.37	18.98	4.00	7.38	460.7	—	—	76.1
					Average		19.10	18.95	18.96	3.93	7.21	478.04	—	—	80.51
					Std Dev		0.11	0.23	0.13	0.10	0.12	11.52	—	—	1.94
					Std Error		0.03	0.06	0.03	0.03	0.03	2.97	—	—	0.50

Appendix B: Soil Block Decay Test Data

Table B1. Summary Table of Average Wight Losses for Southern Pine Exposed to an AWP A E10---09 Ssoil Block Decay Test (Metric Units)

Specimen		Preservative System						Soil Block Decay Test					
		Pentachlorophenol Retention (kg/m ³)		Biodiesel/Oil Retention (kg/m ³)		Conventional Cosolvent/Oil Retention (kg/m ³)		<i>Gleophyllum trabeum</i>			<i>Neolentinus lepideus</i>		
Treatment	Description	Target	Calculated	Target	Calculated	Target	Calculated	Weight Loss (%)	STDEV	Std Error	Weight Loss (%)	STDEV	Std Error
1	Biodiesel---Based Formulation	0.30	0.30	4.7	4.7	-----	-----	4.59	2.55	1.14	2.01	0.85	0.38
2		0.60	0.60	9.4	9.5	-----	-----	1.65	1.48	0.66	1.55	0.56	0.25
3		1.20	1.22	18.7	19.0	-----	-----	1.30	1.03	0.46	1.19	0.31	0.14
4		2.40	2.38	37.4	37.0	-----	-----	1.26	0.21	0.10	1.59	0.95	0.42
5		4.80	4.86	74.9	75.9	-----	-----	2.31	0.12	0.05	2.16	0.43	0.19
6	Biodiesel Formulation Blank	-----	-----	4.7	4.7	-----	-----	16.3	6.22	2.78	24.4	7.70	3.44
7		-----	-----	9.4	9.5	-----	-----	13.2	2.61	1.17	15.0	12.08	5.40
8		-----	-----	18.7	18.8	-----	-----	16.9	2.89	1.29	30.0	8.14	3.64
9		-----	-----	37.4	37.9	-----	-----	11.3	2.17	0.97	27.1	1.90	0.85
10		-----	-----	74.9	77.2	-----	-----	10.3	8.83	3.95	26.2	1.39	0.62
11	Conventional Formulation	0.30	0.29	-----	-----	4.7	4.6	9.30	5.11	2.29	9.91	6.89	3.08
12		0.60	0.60	-----	-----	9.4	9.4	1.24	0.72	0.32	1.69	0.53	0.24
13		1.20	1.21	-----	-----	18.7	19.0	1.26	0.21	0.09	1.00	0.10	0.04
14		2.40	2.42	-----	-----	37.4	37.9	1.84	0.46	0.20	1.36	0.22	0.10
15		4.80	4.82	-----	-----	74.9	75.6	2.89	0.28	0.13	2.62	0.59	0.26
16	Conventional Formulation Blank	-----	-----	-----	-----	4.7	4.9	8.80	7.08	3.17	26.6	2.62	1.17
17		-----	-----	-----	-----	9.4	9.9	15.5	6.56	2.94	29.0	3.60	1.61
18		-----	-----	-----	-----	18.7	20.0	13.0	1.91	0.85	28.1	3.65	1.63
19		-----	-----	-----	-----	37.4	39.5	13.5	3.51	1.57	27.2	1.88	0.84
20		-----	-----	-----	-----	74.9	80.5	13.7	2.46	1.10	25.9	5.50	2.46
21	Untreated Southern Pine Control	-----	-----	-----	-----	-----	-----	42.9	7.09	3.17	29.5	3.55	1.59

Table B2. Summary Table of Average Wight Losses for Southern Pine Exposed to an AWP A E10---09 Ssoil Block Decay Test (English Units)

Specimen		Preservative System						Soil Block Decay Test					
		Pentachlorophenol Retention (pcf)		Biodiesel/Oil Retention (pcf)		Conventional Cosolvent/Oil Retention (pcf)		<i>Gleophyllum trabeum</i>			<i>Neolentinus lepideus</i>		
Treatment	Description	Target	Calculated	Target	Calculated	Target	Calculated	Weight Loss (%)	STDEV	Std Error	Weight Loss (%)	STDEV	Std Error
1	Biodiesel---Based Formulation	0.02	0.02	0.29	0.3	-----	-----	4.59	2.55	1.14	2.01	0.85	0.38
2		0.04	0.04	0.59	0.6	-----	-----	1.65	1.48	0.66	1.55	0.56	0.25
3		0.08	0.08	1.17	1.2	-----	-----	1.30	1.03	0.46	1.19	0.31	0.14
4		0.15	0.15	2.34	2.3	-----	-----	1.26	0.21	0.10	1.59	0.95	0.42
5		0.30	0.30	4.68	4.7	-----	-----	2.31	0.12	0.05	2.16	0.43	0.19
6	Biodiesel Formulation Blank	-----	-----	0.29	0.3	-----	-----	16.3	6.22	2.78	24.4	7.70	3.44
7		-----	-----	0.59	0.6	-----	-----	13.2	2.61	1.17	15.0	12.08	5.40
8		-----	-----	1.17	1.2	-----	-----	16.9	2.89	1.29	30.0	8.14	3.64
9		-----	-----	2.34	2.4	-----	-----	11.3	2.17	0.97	27.1	1.90	0.85
10		-----	-----	4.68	4.8	-----	-----	10.3	8.83	3.95	26.2	1.39	0.62
11	Conventional Formulation	0.02	0.02	-----	-----	0.29	0.3	9.30	5.11	2.29	9.91	6.89	3.08
12		0.04	0.04	-----	-----	0.59	0.6	1.24	0.72	0.32	1.69	0.53	0.24
13		0.08	0.08	-----	-----	1.17	1.2	1.26	0.21	0.09	1.00	0.10	0.04
14		0.15	0.15	-----	-----	2.34	2.4	1.84	0.46	0.20	1.36	0.22	0.10
15		0.30	0.30	-----	-----	4.68	4.7	2.89	0.28	0.13	2.62	0.59	0.26
16	Conventional Formulation Blank	-----	-----	-----	-----	0.29	0.3	8.80	7.08	3.17	26.6	2.62	1.17
17		-----	-----	-----	-----	0.59	0.6	15.5	6.56	2.94	29.0	3.60	1.61
18		-----	-----	-----	-----	1.17	1.2	13.0	1.91	0.85	28.1	3.65	1.63
19		-----	-----	-----	-----	2.34	2.5	13.5	3.51	1.57	27.2	1.88	0.84
20		-----	-----	-----	-----	4.68	5.0	13.7	2.46	1.10	25.9	5.50	2.46
21	Untreated Southern Pine Control	-----	-----	-----	-----	-----	-----	42.9	7.09	3.17	29.5	3.55	1.59

Table B3. Weight Loss of Southern Pine Exposed to *Gloeophyllum trabeum* (ATCC 11539) in an AWPA E10---09 Soil Block Decay Test

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-Solvent		Initial	Final	(g)	(%)
1	Biodiesel Formulation	0.3	4.7	---	G1	3.922	3.637	0.285	7.27
					G2	3.938	3.875	0.063	1.60
					G3	3.954	3.667	0.287	7.26
					G4	3.703	3.581	0.122	3.29
					G5	3.980	3.840	0.140	3.52
Average						3.899	3.720	0.179	4.59
STDEV						0.112	0.130	0.101	2.55
STDERR						0.050	0.058	0.045	1.14
2		0.6	9.4	---	G1	3.760	3.655	0.105	2.79
					G2	3.834	3.797	0.037	0.97
					G3	3.885	3.745	0.140	3.60
					G4	4.051	4.018	0.033	0.81
					G5	4.019	4.016	0.003	0.07
Average						3.910	3.846	0.064	1.65
STDEV						0.123	0.164	0.057	1.48
STDERR						0.055	0.073	0.025	0.66
3		1.2	18.7	---	G1	4.013	3.968	0.045	1.12
					G2	3.927	3.888	0.039	0.99
					G3	4.120	4.086	0.034	0.83
					G4	3.883	3.763	0.120	3.09
					G5	3.800	3.782	0.018	0.47
Average						3.949	3.897	0.051	1.30
STDEV						0.123	0.134	0.040	1.03
STDERR						0.055	0.060	0.018	0.46
4		2.4	37.4	---	G1	4.081	4.026	0.055	1.35
					G2	3.967	3.917	0.050	1.26
					G3	3.954	3.893	0.061	1.54
					G4	4.141	4.101	0.040	0.97
					G5	3.917	3.871	0.046	1.17
Average						4.012	3.962	0.050	1.26
STDEV						0.095	0.098	0.008	0.21
STDERR						0.042	0.044	0.004	0.10
5		4.8	74.9	---	G1	4.347	4.245	0.102	2.35
					G2	4.196	4.095	0.101	2.41
					G3	4.176	4.082	0.094	2.25
					G4	4.213	4.123	0.090	2.14
					G5	4.276	4.173	0.103	2.41
Average						4.242	4.144	0.098	2.31
STDEV						0.070	0.067	0.006	0.12
STDERR						0.031	0.030	0.003	0.05
6	Biodiesel Formulation Blank	---	4.7	---	G1	3.794	3.393	0.401	10.57
					G2	3.721	3.401	0.320	8.60
					G3	3.749	2.981	0.768	20.49
					G4	3.826	2.980	0.846	22.11
					G5	3.722	2.990	0.732	19.67
Average						3.762	3.149	0.613	16.29
STDEV						0.046	0.226	0.236	6.22
STDERR						0.021	0.101	0.106	2.78
7		---	9.4	---	G1	4.001	3.566	0.435	10.87
					G2	4.053	3.614	0.439	10.83
					G3	3.922	3.301	0.621	15.83
					G4	4.033	3.530	0.503	12.47
					G5	3.920	3.286	0.634	16.17
Average						3.986	3.459	0.526	13.24
STDEV						0.062	0.154	0.096	2.61
STDERR						0.028	0.069	0.043	1.17
8		---	18.7	---	G1	3.809	3.091	0.718	18.85
					G2	4.114	3.422	0.692	16.82
					G3	3.954	3.324	0.630	15.93
					G4	3.928	3.429	0.499	12.70
					G5	3.994	3.186	0.808	20.23
Average						3.960	3.290	0.669	16.91
STDEV						0.110	0.149	0.115	2.89
STDERR						0.049	0.066	0.051	1.29
9		---	37.4	---	G1	4.102	3.583	0.519	12.65
					G2	4.167	3.648	0.519	12.46
					G3	4.089	3.563	0.526	12.86
					G4	4.002	3.695	0.307	7.67
					G5	4.134	3.678	0.456	11.03
Average						4.099	3.633	0.465	11.33
STDEV						0.062	0.058	0.093	2.17
STDERR						0.028	0.026	0.042	0.97

10		—	74.9	----	G1	4.090	3.664	0.426	10.42
					G2	4.103	3.459	0.644	15.70
					G3	4.040	3.155	0.885	21.91
					G4	4.224	4.154	0.070	1.66
					G5	3.951	3.883	0.068	1.72
Average						4.082	3.663	0.419	10.28
STDEV						0.099	0.384	0.358	8.83
STDERR						0.044	0.172	0.160	3.95

Table B3. Weight Loss of Southern Pine Exposed to *Gloeophyllum trabeum* (ATCC 11539) in an AWP A E10--09 Soil Block Decay Test (con...)

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-Solvent		Initial	Final	(g)	(%)
11	Conventional Formulation	0.3	—	4.7	G1	3.875	3.449	0.426	10.99
					G2	3.994	3.981	0.013	0.33
					G3	3.942	3.539	0.403	10.22
					G4	3.732	3.261	0.471	12.62
					G5	3.838	3.364	0.474	12.35
Average						3.876	3.519	0.357	9.30
STDEV						0.101	0.278	0.195	5.11
STDERR						0.045	0.124	0.087	2.29
12		0.6	—	9.4	G1	3.954	3.854	0.100	2.53
					G2	3.792	3.758	0.034	0.90
					G3	3.788	3.752	0.036	0.95
					G4	3.862	3.825	0.037	0.96
					G5	3.991	3.956	0.035	0.88
Average						3.877	3.829	0.048	1.24
STDEV						0.093	0.083	0.029	0.72
STDERR						0.041	0.037	0.013	0.32
13		1.2	—	18.7	G1	3.885	3.848	0.037	0.95
					G2	3.790	3.746	0.044	1.16
					G3	4.104	4.048	0.056	1.36
					G4	3.964	3.905	0.059	1.49
					G5	3.818	3.768	0.050	1.31
Average						3.912	3.863	0.049	1.26
STDEV						0.127	0.121	0.009	0.21
STDERR						0.057	0.054	0.004	0.09
14		2.4	—	37.4	G1	4.133	4.074	0.059	1.43
					G2	4.041	3.980	0.061	1.51
					G3	3.907	3.815	0.092	2.35
					G4	3.884	3.794	0.090	2.32
					G5	3.891	3.829	0.062	1.59
Average						3.971	3.898	0.073	1.84
STDEV						0.111	0.123	0.017	0.46
STDERR						0.050	0.055	0.007	0.20
15		4.8	—	74.9	G1	4.243	4.115	0.128	3.02
					G2	4.155	4.053	0.102	2.45
					G3	4.104	3.973	0.131	3.19
					G4	4.009	3.889	0.120	2.99
					G5	3.943	3.832	0.111	2.82
Average						4.091	3.972	0.118	2.89
STDEV						0.118	0.116	0.012	0.28
STDERR						0.053	0.052	0.005	0.13
16	Conventional Formulation Blank	—	—	4.7	G1	3.923	3.896	0.027	0.69
					G2	4.005	3.515	0.490	12.23
					G3	3.963	3.894	0.069	1.74
					G4	3.995	3.470	0.525	13.14
					G5	3.865	3.240	0.625	16.17
Average						3.950	3.603	0.347	8.80
STDEV						0.057	0.286	0.278	7.08
STDERR						0.026	0.128	0.124	3.17
17		—	—	9.4	G1	4.015	3.509	0.506	12.60
					G2	3.789	3.509	0.280	7.39
					G3	3.797	3.162	0.635	16.72
					G4	3.857	2.880	0.977	25.33
					G5	3.834	3.249	0.585	15.26
Average						3.858	3.262	0.597	15.46
STDEV						0.092	0.264	0.252	6.56
STDERR						0.041	0.118	0.113	2.94
18		—	—	18.7	G1	3.898	3.283	0.615	15.78
					G2	3.853	3.388	0.465	12.07
					G3	3.894	3.381	0.513	13.17
					G4	3.785	3.275	0.510	13.47
					G5	3.929	3.512	0.417	10.61
Average						3.872	3.368	0.504	13.02
STDEV						0.056	0.096	0.073	1.91
STDERR						0.025	0.043	0.033	0.85
19		—	—	37.4	G1	3.952	3.283	0.669	16.93
					G2	3.883	3.388	0.495	12.75
					G3	3.911	3.381	0.530	13.55
					G4	3.912	3.275	0.637	16.28
					G5	3.821	3.512	0.309	8.09
Average						3.896	3.368	0.528	13.52
STDEV						0.049	0.096	0.142	3.51
STDERR						0.022	0.043	0.064	1.57
20		—	—	74.9	G1	4.182	3.653	0.529	12.65
					G2	3.929	3.475	0.454	11.56
					G3	4.184	3.538	0.646	15.44
					G4	3.987	3.515	0.472	11.84
					G5	4.044	3.350	0.694	17.16
Average						4.065	3.506	0.559	13.73
STDEV						0.115	0.110	0.106	2.46
STDERR						0.051	0.049	0.048	1.10

Table B3. Weight Loss of Southern Pine Exposed to *Gloeophyllum trabeum* (ATCC 11539) in an AWP A E10--09 Soil Block Decay Test (con...)

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-solvent		Initial	Final	(g)	(%)
21	Untreated Southern Pine	—	—	—	G1	3.789	1.803	1.986	52.41
					G2	4.039	2.699	1.340	33.18
					G3	3.914	2.118	1.796	45.89
					G4	3.678	2.105	1.573	42.77
					G5	3.935	2.352	1.583	40.23
Average						3.871	2.215	1.656	42.89
STDEV						0.140	0.333	0.245	7.09
STDERR						0.063	0.149	0.110	3.17

Table B4. Weight Loss of Southern Pine Exposed to *Neolentinus lepideus* (ATCC 12653) in an AWP A E10---09 Soil Block Decay Test

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-Solvent		Initial	Final	(g)	(%)
1	Biodiesel Formulation	0.3	4.7	—	N1	3.889	3.822	0.067	1.72
					N2	3.987	3.871	0.116	2.91
					N3	3.946	3.836	0.110	2.79
					N4	3.940	3.870	0.070	1.78
					N5	3.844	3.811	0.033	0.86
Average						3.921	3.842	0.079	2.01
STDEV						0.055	0.027	0.034	0.85
STDERR						0.025	0.012	0.015	0.38
2		0.6	9.4	—	N1	3.763	3.674	0.089	2.37
					N2	3.917	3.878	0.039	1.00
					N3	3.922	3.872	0.050	1.27
					N4	3.769	3.722	0.047	1.25
					N5	3.878	3.806	0.072	1.86
Average						3.850	3.790	0.059	1.55
STDEV						0.078	0.091	0.021	0.56
STDERR						0.035	0.040	0.009	0.25
3		1.2	18.7	—	N1	3.875	3.835	0.040	1.03
					N2	3.834	3.768	0.066	1.72
					N3	4.100	4.052	0.048	1.17
					N4	4.087	4.045	0.042	1.03
					N5	3.837	3.799	0.038	0.99
Average						3.947	3.900	0.047	1.19
STDEV						0.135	0.138	0.011	0.31
STDERR						0.060	0.062	0.005	0.14
4		2.4	37.4	—	N1	4.077	4.047	0.030	0.74
					N2	3.958	3.832	0.126	3.18
					N3	4.013	3.954	0.059	1.47
					N4	4.121	4.058	0.063	1.53
					N5	4.117	4.074	0.043	1.04
Average						4.057	3.993	0.064	1.59
STDEV						0.070	0.101	0.037	0.95
STDERR						0.031	0.045	0.017	0.42
5		4.8	74.9	—	N1	4.307	4.213	0.094	2.18
					N2	4.234	4.147	0.087	2.05
					N3	4.208	4.096	0.112	2.66
					N4	4.221	4.121	0.100	2.37
					N5	4.302	4.237	0.065	1.51
Average						4.254	4.163	0.092	2.16
STDEV						0.047	0.060	0.017	0.43
STDERR						0.021	0.027	0.008	0.19
6	Biodiesel Formulation Blank	—	4.7	—	N1	3.755	2.629	1.126	29.99
					N2	3.952	2.904	1.048	26.52
					N3	3.848	2.817	1.031	26.79
					N4	3.933	3.505	0.428	10.88
					N5	3.787	2.728	1.059	27.96
Average						3.855	2.917	0.938	24.43
STDEV						0.087	0.344	0.288	7.70
STDERR						0.039	0.154	0.129	3.44
7		—	9.4	—	N1	3.766	2.724	1.042	27.67
					N2	3.770	2.757	1.013	26.87
					N3	3.804	3.301	0.503	13.22
					N4	3.760	3.510	0.250	6.65
					N5	4.055	4.033	0.022	0.54
Average						3.831	3.265	0.566	14.99
STDEV						0.126	0.548	0.454	12.08
STDERR						0.057	0.245	0.203	5.40
8		—	18.7	—	N1	3.802	2.196	1.606	42.24
					N2	3.872	2.717	1.155	29.83
					N3	3.798	2.773	1.025	26.99
					N4	3.790	2.610	1.180	31.13
					N5	3.877	3.111	0.766	19.76
Average						3.828	2.681	1.146	29.99
STDEV						0.043	0.330	0.305	8.14
STDERR						0.019	0.147	0.136	3.64
9		—	37.4	—	N1	3.828	2.822	1.006	26.28
					N2	4.103	2.936	1.167	28.44
					N3	4.080	2.883	1.197	29.34
					N4	4.121	3.004	1.117	27.11
					N5	3.980	3.006	0.974	24.47
Average						4.022	2.930	1.092	27.13
STDEV						0.122	0.079	0.098	1.90
STDERR						0.054	0.035	0.044	0.85
10		—	74.9	—	N1	4.372	3.186	1.186	27.13
					N2	4.185	3.005	1.180	28.20
					N3	4.125	3.091	1.034	25.07
					N4	4.305	3.220	1.085	25.20
					N5	4.005	2.987	1.018	25.42
Average						4.198	3.098	1.101	26.20
STDEV						0.145	0.104	0.079	1.39
STDERR						0.065	0.047	0.035	0.62

Table B4. Weight Loss of Southern Pine Exposed to *Neolentinus lepideus* (ATCC 12653) in an AWP A E10--09 Soil Block Decay Test (con...)

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-solvent		Initial	Final	(g)	(%)
11	Conventional Formulation	0.3	—	4.7	N1	3.893	3.102	0.791	20.32
					N2	3.969	3.816	0.153	3.85
					N3	3.798	3.357	0.441	11.61
					N4	3.791	3.661	0.130	3.43
					N5	3.809	3.416	0.393	10.32
Average						3.852	3.470	0.382	9.91
STDEV						0.077	0.277	0.268	6.89
STDERR						0.035	0.124	0.120	3.08
12		0.6	—	9.4	N1	3.897	3.796	0.101	2.59
					N2	3.811	3.746	0.065	1.71
					N3	3.885	3.828	0.057	1.47
					N4	3.812	3.760	0.052	1.36
					N5	3.714	3.665	0.049	1.32
Average						3.824	3.759	0.065	1.69
STDEV						0.073	0.062	0.021	0.53
STDERR						0.033	0.028	0.009	0.24
13		1.2	—	18.7	N1	3.805	3.765	0.040	1.05
					N2	3.932	3.896	0.036	0.92
					N3	3.882	3.845	0.037	0.95
					N4	4.002	3.956	0.046	1.15
					N5	4.058	4.020	0.038	0.94
Average						3.936	3.896	0.039	1.00
STDEV						0.099	0.098	0.004	0.10
STDERR						0.044	0.044	0.002	0.04
14		2.4	—	37.4	N1	3.935	3.881	0.054	1.37
					N2	3.833	3.771	0.062	1.62
					N3	3.931	3.874	0.057	1.45
					N4	4.042	3.988	0.054	1.34
					N5	4.081	4.040	0.041	1.00
Average						3.964	3.911	0.054	1.36
STDEV						0.099	0.105	0.008	0.22
STDERR						0.044	0.047	0.003	0.10
15		4.8	—	74.9	N1	4.327	4.221	0.106	2.45
					N2	4.056	3.958	0.098	2.42
					N3	4.117	3.966	0.151	3.67
					N4	4.252	4.153	0.099	2.33
					N5	4.204	4.110	0.094	2.24
Average						4.191	4.082	0.110	2.62
STDEV						0.107	0.116	0.024	0.59
STDERR						0.048	0.052	0.011	0.26
16	Conventional Formulation Blank	—	—	4.7	N1	3.766	2.776	0.990	26.29
					N2	4.030	3.086	0.944	23.42
					N3	3.863	2.732	1.131	29.28
					N4	3.735	2.647	1.088	29.13
					N5	4.035	3.040	0.995	24.66
Average						3.886	2.856	1.030	26.56
STDEV						0.142	0.195	0.077	2.62
STDERR						0.064	0.087	0.034	1.17
17		—	—	9.4	N1	3.783	2.889	0.894	23.63
					N2	3.755	2.534	1.221	32.52
					N3	3.951	2.682	1.269	32.12
					N4	3.732	2.660	1.072	28.72
					N5	3.741	2.693	1.048	28.01
Average						3.792	2.692	1.101	29.00
STDEV						0.091	0.127	0.149	3.60
STDERR						0.041	0.057	0.067	1.61
18		—	—	18.7	N1	4.048	2.978	1.070	26.43
					N2	3.727	2.447	1.280	34.34
					N3	4.008	2.904	1.104	27.54
					N4	3.873	2.914	0.959	24.76
					N5	4.002	2.895	1.107	27.66
Average						3.932	2.828	1.104	28.15
STDEV						0.132	0.215	0.115	3.65
STDERR						0.059	0.096	0.052	1.63
19		—	—	37.4	N1	4.051	2.929	1.122	27.70
					N2	3.917	2.946	0.971	24.79
					N3	3.908	2.738	1.170	29.94
					N4	3.960	2.887	1.073	27.10
					N5	4.035	2.968	1.067	26.44
Average						3.974	2.894	1.081	27.19
STDEV						0.066	0.092	0.074	1.88
STDERR						0.030	0.041	0.033	0.84
20		—	—	74.9	N1	4.208	3.015	1.193	28.35
					N2	4.139	2.808	1.331	32.16
					N3	4.151	3.424	0.727	17.51
					N4	4.128	3.002	1.126	27.28
					N5	4.263	3.240	1.023	24.00
Average						4.178	3.098	1.080	25.86
STDEV						0.057	0.238	0.227	5.50
STDERR						0.025	0.106	0.101	2.46

Table B4. Weight Loss of Southern Pine Exposed to *Neolentinus lepideus* (ATCC 12653) in an AWPB E10--09 Soil Block Decay Test (con...)

Specimen		Target Retention (kg/m ³)			Block #	Weight (g)		Weight Loss	
Type	Description	Pentachlorophenol	Biodiesel Co-Solvent	Petroleum Co-Solvent		Initial	Final	(g)	(%)
21	Untreated Southern Pine	---	---	---	N1	3.920	2.920	1.000	25.51
					N2	3.886	2.694	1.192	30.67
					N3	4.000	2.662	1.338	33.45
					N4	3.860	2.635	1.225	31.74
					N5	3.951	2.926	1.025	25.94
Average						3.923	2.767	1.156	29.46
STDEV						0.055	0.144	0.142	3.55
STDERR						0.025	0.064	0.064	1.59