Assessment of Exposure To Metals In CCA-Preserved Wood: Full Study

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TABLE OF CONTENTS

APPENDICES ..... **IV**

LIST OF FIGURES ..... **IV**

LIST OF TABLES ..... **V**

EXECUTIVE SUMMARY **ES-1**

1.0 INTRODUCTION **1**
1.1 Background1
1.1.1 CCA Lumber and the Environment 1
1.1.2 Data Needs 1
1.1.3 Recent Studies 1
1.1.4 Institutional Review Board Application; Volunteer Information and Consent Form 2
1.2 Goals and Significant Findings of this Study 2
1.3 Highlights of this Report 5
1.3.1 Study Design (Section 3.0) 5
1.3.2 Quality Assurance (Section 4.0) 5
1.3.3 Database Development (Section 5.0) 6
1.3.4 Sample Collection and Coupon Preparation (Section 6.0) 6
1.3.5 Analysis of Samples (Section 7.0) 6
1.3.6 Field Test Results (Section 8.0) 6
1.3.7 Study Results (Section 9) 7
1.3.8 Conclusions (Section 10.0) 7

2.0 PILOT AND MINI STUDY **8**
2.1 Comparison of Pilot/Mini Study and Full Study Reports 8
2.2 Study Planning and Volunteer Recruitment 9
2.3 Wood Sample Collection and Preparation 10
2.4 Block and Hand Sampling Procedures 11
2.5 Analysis 12
2.5.1 Sample Preparation 13
2.5.2 Sample Analysis 13
2.6 Field Test Results 14
2.7 Mini Study Procedures 15
2.8 Mini Study Results 16

3.0 STUDY DESIGN **18**
3.1 Sample Size Calculation 18
3.2 Selection of Contract Testing Facility 19
3.3 Materials and Methods 19
3.3.1 Volunteer Recruitment 19
3.3.2 Wood Types 19
3.4 Documentation and Sample Custody 21
3.4.1 Field Procedures 21
3.4.2 Laboratory Procedures 22

3.4.3 Record Retention ... 23
3.5 Hand Sampling ... 23
3.5.1 Procedure ... 23
3.5.2 Handling of Hand Rinsate and Hand Wipe Samples ... 24
3.5.3 Quality Control for Laboratory Hand Sampling ... 25
3.5.4 Laboratory Quality Control ... 25
3.6 Block Wipe Sampling ... 25
3.6.1 Procedure ... 25
3.6.2 Handling of Block Wipe Samples ... 26
3.6.3 Quality Control for Laboratory Wipe Sampling ... 26
3.6.4 Laboratory Quality Control ... 26
3.7 Laboratory Analysis of Hand and Wipe Samples ... 26
3.7.1 Total Chromium, Copper, and Arsenic Analysis of Hand Rinsate Samples ... 26
3.7.2 Cr (VI) Analysis of Hand Rinsate Samples ... 27
3.7.3 Total Chromium, Copper, and Arsenic Analysis of Block and Hand Wipe Samples ... 27
3.8 Data Analysis and Presentation ... 27
3.9 Key Personnel and Responsibilities ... 28

4.0 QUALITY ASSURANCE AND QUALITY CONTROL ... 29
4.1 Summary of Field Audit ... 29
4.2 Sample Preparation and Laboratory QA ... 29
4.3 Analysis QC ... 30
4.3.1 Preparation Blanks ... 33
4.3.2 Wood Flour Spikes ... 33
4.3.3 Matrix Spikes ... 34
4.3.4 Rinsate Sample Spikes ... 36
4.3.5 Laboratory Duplicate Analyses ... 36
4.3.6 Instrument Check Samples ... 37
4.3.7 QC Analysis Summary ... 37

5.0 DATABASE DEVELOPMENT ... 38
5.1 Purpose 38
5.2 Format and File Location ... 38
5.3 Database Structure ... 38
5.4 Sample Tracking with Barcodes ... 41
5.4.1 Label Types ... 41
5.4.2 Check Digit Algorithm ... 42
5.5 Forms and Reports ... 43
5.5.1 Site Data ... 43
5.5.2 Board Moisture Content ... 44
5.5.3 Coupon Cutting ... 44
5.5.4 Volunteers ... 45
5.5.5 Samples ... 46
5.5.6 Analyses (Lab Imports) ... 48
5.6 Sample Archives ... 48

6.0 SAMPLE COLLECTION AND COUPON PREPARATION ... 49
6.1 Site Identification ... 49
6.1.1 Pittsburgh, Pennsylvania Area ... 49
6.1.2 Gainesville, Florida Area ... 50
6.2 Deck Board Selection, Collection, and Analysis Process ... 50

6.2.1 On-site Selection Criteria 50
6.2.2 Board Collection Process 51
6.2.3 On-Site Testing 51
6.2.4 Loading and Transportation of Boards and Samples 52
6.3 Post-Trip Assessment and Coupon Preparation 52
6.3.1 Post-Trip Testing and Cross-contamination Checks 52
6.3.2 Coupon Preparation 53
6.3.3 Cutting 53
6.3.4 Labeling 53
6.3.5 Contamination Testing 53
6.3.6 Storage 53

7.0 ANALYSIS OF SAMPLES 55
7.1 Sample Preparation 55
7.1.1 Block and Hand Wipes 55
7.1.2 Hand Rinse Samples 55
7.2 Total Chromium, Copper, and Arsenic Analysis 56
7.3 Hexavalent Chromium (Cr(VI)) Analysis 59
7.4 Summary 60

8.0 FIELD TESTS 61
8.1 Site Description and Ambient Conditions 61
8.2 Percent Moisture in Deck Board Wood 62
8.2.1 Percent Moisture in Deck Board Wood, Pittsburgh, Pennsylvania Area 63
8.2.2 Percent Moisture in Deck Board Wood, Gainesville, Florida Area 65
8.2.3 Observations Regarding Percent Moisture Content of CCA-Treated Boards 68
8.3 CCA Retention Analysis 69
8.4 Chromotropic Acid Spot Tests for Chromium (VI) 70
8.5 Field *Versus* Laboratory Block Wipe Samples 71
8.5.1 Cross Contamination of Untreated SYP Boards From Treatment Facilities 71
8.5.2 Comparison of On-Site and Post-trip Board Wipe Samples for Recently Treated 0.4 CCA pcf SYP From Treatment Facilities 75
8.5.3 Comparison of On-Site and Post-Trip Deck Board Block Wipe Samples Results 79
8.6 Field Blank and Field Spike Wipes 81

9.0 STUDY RESULTS 83
9.1 Purpose 83
9.2 Coupon Selection 83
9.3 Volunteers 84
9.4 Testing Process 85
9.4.1 Coupons 85
9.4.2 Block Wipe Sampling 86
9.4.3 Hand Rub Sampling 86
9.5 Statistical Analysis 87
9.5.1 Summary Statistics 92
9.5.2 Distributions of Block Wipe, Hand Sample, and Transfer Reduction Factor Values 95
9.5.3 Correlation Analyses 96
9.5.4 Mixed Effects Modeling 97
9.6 Cr(VI) Analysis Results 100

10.0 SUMMARY AND CONCLUSIONS 111
10.1 Study Protocols, Quality Assurance Project Plan and IRB Approval 111
10.2 Pilot Study 111
10.3 Findings From the Mini Study 111
10.4 Findings From The Full Study 113
10.4.1 Data Treatment – Statistical Tests 113
10.4.2 Findings from the Full Study 114
10.5 Cr(VI) Analysis 118
10.6 Conclusions 118

11.0 REFERENCES 119

APPENDICES

Appendix A - Summary Statistics
Appendix B - Distribution of Transfer Reduction Factors
Appendix C - Correlations
Appendix D - Mixed Effect Modeling
Appendix E - Detailed Quality Assurance and Quality Control Results
Appendix F - Site Descriptions

LIST OF FIGURES

Figure Page

Figure 5-1. Database Diagram 39
Figure 5-2. Main Menu 43
Figure 5-3. Site Data Entry Form 44
Figure 5-4. Board-Coupon Association Form 45
Figure 5-5. Volunteer Data Entry Form 45
Figure 5-6. Field Wipe Sample Data Entry Form 46
Figure 5-7. Lab Hand Sample Data Entry Form 46
Figure 5-8. Sample Batch Form 47
Figure 5-9. Example Chain of Custody Form 47
Figure 5-10. Example Sample Analysis Request Form 47
Figure 9-1. Block Wipe Loading as a Function of Deck Age for Arsenic 106
Figure 9-2. Hand Loading as a Function of Deck Age for Arsenic 106
Figure 9-3. Transfer Reduction Factor, R, as a Function of Deck Age for Arsenic 107
Figure 9-4. Geometric Mean of Block Wipe Arsenic Results as a Function of Age Category for Decks from North Region 107
Figure 9-5. Geometric Mean of Block Wipe Arsenic Results as a Function of Age Category for Decks from South Region 108
Figure 9-6. Geometric Mean of Hand Sample Arsenic Results as a Function of Age Category for Decks from North Region 108
Figure 9-7. Geometric Mean of Hand Sample Arsenic Results as a Function of Age Category for Decks from South Region 109

Figure 9-8. Geometric Mean of Transfer Reduction Factor for Arsenic as a Function of Age Category for Decks in North Region 109
Figure 9-9. Geometric Mean of Transfer Reduction Factor as a Function of Age Category for Decks in South Region..... 110

LIST OF TABLES

Table Page
Table 2-1. Performance Parameters for Total CCA and Cr(VI) Measurement 14
Table 3-1. Sample Sizes Needed to Detect a Significant Difference in the Amount of Dislodgeable Arsenic Complex Between Recently Treated and Aged CCA-Preserved Wood..... 18
Table 3-2. Summary of Wood Types and Approximate Number of Coupons and Hand & Wipe Samples22
Table 4-1. Analytical QC Requirements..... 32
Table 4-2. Summary Results of Preparation Blank Analysis for ICP-MS (µg/L) 33
Table 4-3. Summary of % Recoveries of Wood Flour Spikes for ICP-MS 34
Table 4-4. Summary of % Recoveries of Wood Flour Spikes for ICP-AES 34
Table 4-5. Summary Results of High Spikes for ICP-AES 34
Table 4-6. Summary Results of Medium Spikes for ICP-AES..... 35
Table 4-7. Summary Results of Low Spikes for ICP-AES..... 35
Table 4-8. Summary Results of High Spikes for ICP-MS 35
Table 4-9. Summary Results of Medium Spikes for ICP-MS 35
Table 4-10. Summary Results of Low Spikes for ICP-MS..... 35
Table 4-11. Summary of % Recoveries of Spiked Samples for ICP-MS 36
Table 4-12. Summary of % Recoveries of Spiked Samples for Hexavalent Chromium 36
Table 4-13. Summary of Relative Percent Difference Results of Duplicate Analysis for ICP-MS..... 37
Table 4-14. Summary Results of Check Samples for Hexavalent Chromium..... 37
Table 5-2. Types and Specifications for Barcode Labels 41
Table 7-1. Performance Parameters for the Perkin-Elmer Optima 4300DV for Measurement of Total Chromium, Copper, Arsenic in Block Wipe Digests..... 57
Table 7-2. Performance Parameters for the ThermoElemental X-7 ICP/MS for Measurement of Total Chromium, Copper, and Arsenic in Hand Wipe Digests..... 58
Table 7-3. Performance Parameters for the ThermoElemental X-7 ICP/MS for Measurement of Total Chromium, Copper, and Arsenic in Hand Rinse Digests 59
Table 7-4. Performance Parameters for the Metrohm IC for the Measurement of Cr(VI) in Hand Rinse Solution..... 60
Table 8-1. Characteristics of Decks Used in the Full Study 62
Table 8-2. On-site, Post-trip, and Storage Average % MC for SYP Deck Boards From Pittsburgh, PA Area..... 64
Table 8-3. On-site, Post-trip, and Storage % MC for Recently-Treated 0.4 pcf CCA Boards From Pittsburgh, PA Area 64
Table 8-4. On-site, Post-trip, and Storage Average % MC for SYP Deck Boards From the Gainesville, FL Area 66
Table 8-5. On-site, Post-trip, and Storage % MC for Recently-Treated 0.4 pcf CCA Boards From the Gainesville, FL Area..... 67
Table 8-7. Deck Board CCA Retention, CCA Type, Species Type, and % Moisture Content Results. Analyses by Timber Products Inspection of the 20 Decks Used For the Full-Study..... 70
Table 8-8. Chromotropic Acid Spot Test Results for Recently Treated 0.4 CCA Deck Wood..... 71
Table 8-9. On-Site Sample Results for Untreated Boards from Treatment Facilities, µg/wipe 73
Table 8-10. Post-Trip Sample Results for Untreated Boards from Treatment Facilities, µg/wipe..... 74

Table 8-11. On-Site Sample Results for Recently Treated 0.4 CCA pcf Boards From Treatment Facilities, µg/wipe 76
Table 8-12. Post-Trip Sample Results for Recently Treated 0.4 CCA pcf Boards from Treatment Facilities, µg/wipe 78
Table 8-13. Summary of On-site and Post-trip Block Wipe Sample Results for Deck Boards from Pittsburgh, PA and Gainesville, FL Areas, µg/wipe 79
Table 8-14. Field Wipe Blanks for Testing from Pittsburgh and Gainesville, µg/wipe 81
Table 8-15. Field Wipe Spikes from Pittsburgh, PA and Gainesville, FL with Concentration (µg/wipe) and % Recoveries 82
Table 9-1. Coupons for the Mini and Full Studies 84
Table 9-2. Hand Areas for Full Study Hand Rubbing Participants 85
Table 9-3. Summary of Mean and Geometric Mean Block and Hand Wipe Values for Both Equilibrium Approaches 94
Table 9-4. Summary of Mean and Geometric Mean Block and Hand Wipe Values by Region for Both Approaches to Equilibrium 94
Table 9-5. Distribution of Block Wipe Loadings for the Combined Mini and Full Study Datasets for Both Approaches to Equilibrium 95
Table 9-6. Distribution of Hand Loadings for the Combined Mini and Full Study Dataset for Both Approaches to Equilibrium 95
Table 9-7. Distribution of R Values for the Combined Full and Mini-study Data Sets for Both Approaches to Equilibrium 96
Table 9-8. Summary of Spearman Correlation Coefficients for the Combined Full and Mini Study Data Sets 97
Table 9-9. Fixed Effects for Log(R), Log(hand) and Log(block) for As, Cr, and Cu for Full Study for Approach to Equilibrium using Wipe Block as µg/cm^2 Block Wipe 98
Table 9-10. Values for Y and X for South and North from Predictive Equations 99
Table 9-11. Summary Statistics by Deck for Arsenic - X Term Calculated as µg/cm^2 Block Wipe 100
Table 9-12. Summary Statistics by Deck for Chromium - X Term Calculated as µg/cm^2 Block Wipe 101
Table 9-13. Summary Statistics by Deck for Copper - X Term Calculated as µg/cm^2 Block Wipe 102
Table 9-14. Summary Statistics by Deck for Arsenic - X Term Calculated as µg/cm^2 Coupon 103
Table 9-15. Summary Statistics by Deck for Chromium - X Term Calculated as µg/cm^2 Coupon 104
Table 9-16. Summary Statistics by Deck for Copper - X Term Calculated as µg/cm^2 Coupon 105
Table 10-1. Summary of Mean and Geometric Mean Block and Hand Wipe Values for Both Approaches to Data From the Combined Full and Mini-study Data Sets 115
Table 10-2. Distribution of R Values for the Combined Full and Mini-study Data Sets for Both Approaches to Equilibrium 116
Table 10-3. Summary of Spearman Correlation Coefficients for the Combined Full and Mini-study Data Sets 116
Table 10- 4. Fixed Effects for Log(R), Log(hand) and Log(block) for As, Cr, and Cu for Full Study for Approach to Equilibrium using Wipe Block as µg/cm^2 Block Wipe 117

EXECUTIVE SUMMARY

Assessment of Exposure to Metals in CCA-Preserved Wood: Full Study

Study Rationale

Lumber treated with preservatives is commonly used as a building material, especially in areas where insects and fungus are known to cause damage to wooden structures. While a number of commercially-applied treatments are available, the most commonly used wood preservative in the U.S. is chromated copper arsenate or CCA, which is registered with the U.S. Environmental Protection Agency (USEPA) for wood preservative use (USEPA, 2000). The rationale for this study was to provide a comprehensive data set to facilitate the study of or make decisions regarding three key risk assessment issues:

1. **Potential For Exposure.** The potential for exposure (*i.e.*, incidental ingestion and dermal contact) to dislodgeable metal complex exists because most of the outdoor wooden decks and play structures in the U.S. are constructed with CCA-preserved wood. Furthermore, the results of risk assessments for CCA-preserved wood (e.g., Gradient, 2001; HS&WMR, 2001) indicate that hand-to-mouth exposure is the most significant pathway in the assessment of exposure and potential health risks. Thus, this study seeks to provide reliable estimates of the amounts of metal complex removed via hand contact with treated deck wood surfaces.
2. **Change in Amount of Dislodgeable Metal Complex Over Time.** Limited data show a potential decline in the amount of dislodgeable metal complex on the surface of CCA-preserved wood from the aging effects of sunlight and rainfall. Demonstrating that the amount of dislodgeable metal complex declines with age has important implications in exposure and risk assessments. Therefore, a study is needed to evaluate and quantify such changes using samples from in-service structures.
3. **Transfer Reduction Factor.** A study is also needed to develop data that compare the amount of metal complex dislodged from CCA-treated wood surfaces by cloth wipe procedures to that removed by the human hand. Such data can be used to derive a reliable transfer reduction factor (TRF) to more accurately relate the amount of metal complex dislodged using commonly employed wipe procedures to the amount removed by the adult hand. The Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel, in its report to the EPA Office of Pesticide Programs, suggested such data be gathered from existing CCA-preserved structures at different geographic locations in the U.S. (USEPA, 2001).

Study Objectives

The principal study objectives were to:

1. Conduct a pilot study to develop and optimize methods for sampling of CCA-treated deck boards using (a) the bare hand, and (b) a cloth wipe attached to a 1,100-gram, 64 cm^2 steel block.

2. Develop reliable estimates of the amount of dislodgeable metal complex removed *via* hand and wipe sampling of CCA-preserved wood to enable more accurate estimates of potential exposure and risk associated with existing CCA-preserved structures.

3. Collect a sufficient number of hand samples to detect if a statistically significant reduction in the amount of dislodgeable metal complex between recently treated and aged CCA-preserved wood exists.

4. Estimate a reliable TRF to relate the amount of metal complex removed using a defined wipe sampling technique to the amount of metal complex removed using a defined hand sampling technique. The TRF is defined as the ratio of hand value to block wipe value.

5. Quantify the amount of chromium, in oxidation state 6^+, that may be transferred from the surfaces of treated wood boards to the bare hand.

Overview of the Total Study Process

1. Pilot Studies

Tests and experiments were performed to: (a) develop methods for non-contaminating collection and transport of deck boards from the field to the laboratory, (b) determine the extent of change in surface wipe metal concentration and board percent moisture content between the field and laboratory locations, (c) cut the boards into test coupons, (d) optimize and standardize block wipe and hand rub sampling techniques, and (e) develop sample digestion and chemical analysis methods for total CCA using ICP/AES and ICP/MS and for Cr(VI) using IC/colorimetry.

2. Mini Study

A Mini Study was conducted using the techniques developed in the pilot studies to establish a small data set that may be useful to: (a) assess differences in the amount of metal complex removed from the surface of various ages of CCA-preserved wood obtained in the northeast and southeast sections of the United States; (b) statistically assess the difference between the amounts of dislodgeable material removed using wipe sampling *versus* hand sampling; (c) compare the amount of dislodgeable materials *versus* deck board age; and (d) provide preliminary data for the USEPA's probabilistic risk assessment.

3. Full Study

The full study followed the same design as the Mini Study. However, approximately seven times more samples were collected and the geographical distribution of decks tested included 10 decks from the Gainesville, Florida, area and 10 decks from the Pittsburgh Pennsylvania, area.

Summary of Key Results

1. Pilot Studies

- **Deck Selection and On-site Testing.** Methods for deck selection and non-contaminating means for deck board removal, field sampling, board transport, and sample coupon preparation were developed and documented.

- **Wipe Sampling Method Development and Refinement.** A wipe sampling device (consisting of an 8 cm by 8 cm square steel block weighing 1,100 g and having attached hooks, rubber pad, Parafilm, and Alpha Wipe) was fabricated. Studies with the block sampler of the effects of variations in pressure, speed of movement over a 40 cm sampling path, and the number of one-way passes over the same distance, showed the optimum sampling conditions for pickup of

material from a board to be: 3 seconds for each pass; 1,100-gram pressure per block, and 20 passes.

- **Hand Rub Sampling Method Development and Optimization.** A hand rub sampling method was developed that provided for: (a) hygienic considerations, (b) reproducible positioning of both the coupon to be sampled and the participant, (c) consistent sampling pressure across the back of the hand via an attached plastic bag containing 1,100 g of steel shot, and (d) careful observation of and assistance to the sampling participant. Pilot studies of the effects of variations in pressure applied to the back of the hand, speed of movement of the hand along a 40 cm sampling path, and the number of one-way passes over the same distance, showed the optimum sampling conditions for pickup of material from a board to be: 3 seconds for each pass, 1,100 g weight on the hand, and 20 passes. A means of efficient transfer of the material picked up by the hand to containers was developed. It consisted of four sequential sets of multiple immersions and rubbing of a hand in deionized water, followed by forceful wiping of the participant's palm, fingers, and the spaces between the fingers with an Alpha Wipe cloth. Results from the hand rinse and hand wipe were combined to give the total hand loading

- **Sample Preparation and Analytical Methods Application.**

  - The final method for preparation of both the block wipes and the hand wipes was digestion in 10% nitric acid in a 50-mL centrifuge tube in a shaking hot water bath at 60ºC for 12 hours, followed by dilution to 50 mL with deionized water.

  - The final method for preparation of the hand rinse samples was digestion in nitric acid and 30% hydrogen peroxide (25 mL sample + 2.5 mL concentrated nitric acid + 2.0 mL 30% hydrogen peroxide) heated to 95°C in a hot block for 30 minutes.

  - The analytical methods were validated per EPA methodology. Reproducible recoveries (within 20 % of expectations) were found for metals from solution or wood flour (containing known masses of As, Cr, and Cu) spikes of polyester Alpha Wipes used with either the block wipe or hand sampling method.

  - Analysis of the block wipe samples was performed using inductively coupled plasma atomic emission spectrometry (ICP/AES); Method Detection Limits (MDLs), as µg/wipe, were: 0.96 for Cu and Cr and 4.8 for As. Analyses for the hand wipe samples and the hand rinse samples were performed using inductively coupled plasma mass spectrometry (ICP/MS); the MDL, as µg/hand rinse or µg/wipe was 0.048 for each metal. Cr(VI) analysis was performed using ion chromatography with post-column reaction and colorimetric detection; the MDL was 0.25 µg/L (0.035 µg per hand rinse).

2. Mini Study

In the Mini Study, about 120 coupons from untreated wood, recently treated wood and five decks were subjected to block wipe and hand rub sampling. Eight volunteers performed the hand rubbing. The deck wood age ranged from 1 to 23 years. The block wipes were collected by one staff member following the procedure described in RTI SOP No. CCA-020 (RTI, 2003c). The hand rub sampling was performed following the procedures described in RTI SOP No. CCA-040 (RTI, 2003e). The block wipe, hand rinse, and hand wipe samples were analyzed following the procedures described in RTI SOP's EG-280, EG-281, EG-282, and EG-803 (RTI, 2003f, 2003g, 2003h, 2003i). Note that the hand rinsates were digested using the nitric acid/hydrogen peroxide mixture and heating in a water bath.

The analytical data were subjected to statistical analysis. The outcome included:

- Summary statistics for each element for each type of wood and deck

- Regression analyses that relate block wipe values, the sum of hand rinse plus hand wipe values, and age of the wood/deck.

- One-way ANOVA analyses to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metal complex.

For As, the mean wipe block values ranged from 88.6 to 195.8 µg and the mean sum of hand rinse plus hand wipe values ranged from 2.97 to 6.14 µg. For Cr, the mean wipe block values ranged from 119 to 242 µg and the mean sum of hand rinse plus hand wipe values ranged from 3.54 to 6.78 µg. For Cu, the mean wipe block values ranged from 50.5 to 90.6 µg and the mean sum of hand rinse plus hand wipe values ranged from 2.85 to 5.62 µg. The ratios of mean sum of hand rinse plus hand wipe values to mean block wipe values, *i.e.*, the TRFs, are: As, 0.0266; Cr, 0.0263; Cu, and 0.0483.

Regression analyses were performed using both non-log and log functions. The dependent variables in these analyses were the hand rinse value and the sum of the hand rinse plus the hand wipe value; that is, these values were modeled as a function of block wipe value and age, and also secondary effects of these two parameters. The best fit for As, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value and age

- Using log terms, function parameters are – intercept, log of block wipe value, age, and log of block wipe value squared.

The best fit for Cr, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value, age, block wipe value times age, and block wipe value squared

- Using log terms, function parameters are – intercept, log of block wipe value, age, and log of block wipe value squared.

The best fit for Cu, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value, age, and block wipe value squared

- Using log terms, function parameters are – intercept, log of block wipe value, and age.

ANOVA analyses performed on the log-transformed data to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metals did not show consistent relationships between aging and block wipes and hand rinse/wipe results. Key findings from the ANOVA analyses were as follows:

- Although not always statistically significant, mean levels of dislodgeable metal complex are nearly always greatest for the recently treated (age=0) wood type, when either block wipe or hand rinse/wipe data are evaluated.

- Multiple comparisons of population means do not show a consistent trend between metal levels and age.

3. Full Study

For the Full Study, 20 additional sets of deck wood (10 from the Pittsburgh, Pennsylvania area and 10 from the Gainesville, Florida area) were collected. Data from 19 of these decks were subjected to statistical, correlation, and modeling studies; Data from the five decks in the Mini Study were combined with the Full Study data for the correlation analyses.

There are several possible choices regarding how the hand and block wipe results are presented for statistical analysis and used to derive a TRF. Two approaches are described below. The first approach is to assume that the sampling procedures used reach a state of equilibrium between the amount of dislodgeable material on a coupon and on a sampling device, *i.e.*, a volunteer's hand or the block wipe. Results from both the RTI Pilot Study and the recent CPSC study (CPSC, 2003) indicate that the amount of dislodgeable arsenic collected on a block wipe or a hand does not increase after about 10 to 15 passes on a test board, and that increasing the weight of the block or the weight on the hand does not significantly increase the amount collected. Also, based on experiments in the CPSC (2003) study, once equilibrium is achieved, even sampling a larger surface area of treated wood does not significantly increase levels of dislodgeable arsenic on a sampling device. If equilibrium is achieved, then it is appropriate to divide the mass of dislodged metal by the surface area of the sampling device. Thus, when a hand is used, the mass of dislodged metal is divided by the measured size of a volunteer's palm, and when a block wipe is used the mass of dislodged metal is divided by the size of the block-sampling device. When normalized this way, the hand load results are reported as $\mu g/cm^2$ of hand surface, and the block wipe results are reported as $\mu g/cm^2$ of block area. These values are then subjected to statistical analysis. Using this approach, statistical analyses were performed using the load or amount collected on a hand divided by the area of a hand, which averaged about 140 cm^2, and the load collected on a block wipe divided by 64 cm^2, the surface of the block that contacts the wood coupon during sampling.

An alternative approach is to treat the hand samples as having achieved equilibrium, but to assume that the block wipe samples have not achieved equilibrium. That is, the block wipe loading is assumed to increase with an increase in the amount of wood surface rubbed. Although there are reasons why it may be easier for a hand to achieve equilibrium than a wipe (*e.g.*, a wipe has greater absorption capacity than a hand, more friction with a wipe, *etc.*), the results of the CPSC (2003) and RTI pilot studies indicate that the hand and block wipe sampling procedures used in these studies achieved equilibrium for both types of sampling devices. In this alternative approach, the hand sample results are still represented as $\mu g/cm^2$ of hand surface, but the block wipe results are represented as $\mu g/cm^2$ of board area sampled. In the RTI study, the board (coupon) area sampled was 500 cm^2. Statistical analyses were also performed using this alternative approach.

The goals and significant findings of the full study are:

Goal. Develop reliable estimates of the amount of dislodgeable metal complex removed by hand and block wipe sampling.

Hand and block wipe sampling were performed on a large set of coupons taken from decks from both the north and the south. The results of these tests for the mini-study and full study combined are as follows:

Block Wipe Values, X, for the Combination of the Mini Study and the Full Study (Assuming Equilibrium for Both Block Wipe and Hand Sampling)

Element	Mean X (μg/cm^2 of block area)	Median X (μg/cm^2 of block area)	95% Quantile	5% Quantile
As	2.15	1.77	4.63	0.75
Cr	2.74	2.28	5.73	0.88
Cu	1.59	1.31	3.47	0.56

Block Wipe Values, X, for the Combination of the Mini Study and the Full Study (Assuming Equilibrium for Hand Sampling but not Block Wipe Sampling)

Element	Mean X (μg/cm^2 of coupon area sampled)	Median X (μg/cm^2 of coupon area sampled)	95% Quantile	5% Quantile
As	0.276	0.227	0.593	0.096
Cr	0.351	0.292	0.734	0.113
Cu	0.204	0.167	0.444	0.072

Hand Sample Values, Y, for the Combination of the Mini Study and the Full Study

Element	Mean Y (μg/cm^2 of hand area)	Median Y (μg/cm^2 of hand area)	95% Quantile	5% Quantile
As	0.061	0.035	0.186	0.011
Cr	0.058	0.032	0.189	0.010
Cu	0.053	0.034	0.152	0.012

The distribution of the values are near log-normal (*i.e.*, right-skewed) and thus the medians provide a better representation of the data set than the mean.

Goal. Determine, with statistical significance, if the amount of dislodgeable metal complex relates to the age of the structure.

To answer this question, both correlation analyses and mixed effects modeling were performed. The correlation analyses showed a statistically significant, negative relationship between hand sample value and age. This result was supported by the results of the mixed effects modeling.

Goal. Determine, with statistical significance, if the amount of dislodgeable metal complex relates to the region from which the deck boards originated.

Summaries of mean and geometric mean block wipe or hand concentrations show an apparent regional difference, with the values in the north being higher than those of the south.

Goal. Estimate a reliable Transfer Reduction Factor (TRF).

The TRF value, R, was calculated for each volunteer for each coupon tested (rubbed). The results of these tests for the combined Mini Study and Full Study data sets are calculated according to the two assumptions described above: first, by dividing the hand loading expressed as μg/cm^2 of hand area by the

block wipe loading expressed as μg/cm^2 of block wipe area (block wipe area being 64 cm^2), and second, by dividing the hand loading expressed as μg/cm^2 of hand area by the block wipe loading expressed as μg/cm^2 of coupon area sampled by the block (coupon area sampled being 500 cm^2). Summarized results of TRFs determined using these two approaches are tabulated below.

TRF Values for the Combination of the Mini Study and the Full Study (First Assumption)

Element	Mean R	Median R	95% Quantile	5% Quantile
As	0.0321	0.0196	0.0943	0.00550
Cr	0.0237	0.0146	0.0692	0.00379
Cu	0.0375	0.0257	0.1057	0.00889

TRF Values for the Combination of the Mini Study and the Full Study (Second Assumption)

Element	Mean R	Median R	95% Quantile	5% Quantile
As	0.251	0.153	0.736	0.043
Cr	0.185	0.114	0.541	0.030
Cu	0.293	0.201	0.826	0.070

Again, the distribution of the R values is right-skewed and thus the medians provide a better representation of the data set than the mean.

Goal. Determine if chromium, in oxidation state +6, is present in the rinsate from the hand rubbing experiments.

For 145 hand rinsate samples, Cr(VI) was analyzed using ion chromatography. Of these samples, only three had concentrations above the method detection limit of 0.25 μg/L or 0.035 μg/hand. Two of these samples came from recently treated deck wood (0.644 and 0.28 μg/L) and one sample was from a 1-year old deck from the Pittsburgh area (0.279 μg/L). These values correspond to 0.09, 0.04, and 0.04 μg Cr(VI) per hand rinse.

Overall conclusions are as follows:

- The relationship between the level of dislodgeables on a board sample and the level on a sampling device after 20 passes across the board may or may not represent a state of equilibrium. Experimental evidence collected by RTI and CPSC suggest that a state of equilibrium exists between these levels for both the block wipe and hand sampling.
- All data indicate that the distributions of the block wipe and hand sample data are near-log normal, or right skewed.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for As is about 2 μg/cm^2 block wipe and about 0.04 μg/cm^2 hand.
- Assuming that a state of sampling equilibrium exists for the hand samples but not the block wipe samples, the median value for As on the block wipe is about 0.2 μg/cm^2 board (coupon) and about 0.04 μg/cm^2 hand.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for the transfer reduction factor for As is about 0.02.
- The levels of CCA recovered from the deck surfaces are higher in the north than the south.

- It is unclear whether the levels of CCA collected on block wipes increase or decrease with deck age.
- The levels of CCA collected on hand surfaces decrease with the age of the decks.
- Cr(VI) is virtually non-existent in hand rinse samples.

1.0 INTRODUCTION

1.1 Background

1.1.1 CCA Lumber and the Environment

Lumber treated with preservatives is commonly used as a building material, especially in areas where insects and fungus are known to cause damage to wooden structures. A number of commercially-applied treatments are available. The most commonly used wood preservative in the U.S. is chromated copper arsenate or CCA, which is registered with the U.S. Environmental Protection Agency (USEPA) for wood preservative use (USEPA, 2000). Wood treated with CCA is used primarily in outdoor structures, such as decks, walkways, fences, docks, play structures, sign and utility posts, and retaining walls.

Arsenic is a component of the CCA preservative used to treat the wood. There is potential for exposure to dislodgeable metal complex on the surface of CCA-preserved wood that can be removed from the wood surface by dermal contact with the hands and other skin surfaces (*e.g.*, arms and legs).

1.1.2 Data Needs

Some uncertainty remains regarding the amount of dislodgeable metal complex that is available for exposure over time. Several lines of evidence indicate a decline in the amount of dislodgeable metal complex from CCA-treated wood due to the aging effects of sunlight and rainfall (SCS, 1998 and 2001; Solomon and Warner, 1989; Stillwell, 1998); however, additional data are needed to better quantify this observation and to improve the assessment of exposure to existing CCA-treated structures. Further information is also needed to characterize if the amount of dislodgeable metals varies with geography, *i.e.*, between the northeastern U.S. and locations in a warmer climate, such as Florida. Additional data are also needed to better characterize, under closely controlled conditions, the relationship between the amount of dislodgeable materials removed by a human hand (as the hand moves back and forth along a CCA-treated board) and the amount of material removed by a saline-moistened cloth wipe attached to a metal block (as the block is pulled back and forth along a CCA-treated board).

1.1.3 Recent Studies

Results of several studies have recently been reported that provide additional data. In early 2003, the Consumer Product Safety Commission, CPSC, released a report that described in-situ sampling methods for deck lumber, methods for chemical analysis, and a set of hand rubbing and block wipe data from sampling of several wooden decks in the Washington, DC, area (CPSC, 2003). Also very recently, the CCA Work Group of the American Chemistry Council released a draft report containing the results of pilot research and data from a Mini Study that compared hand sampling and block wipe sampling results (American Chemistry Council, 2003). The protocol for this study, entitled *Protocol for Hand and Wipe Sampling of CCA-Preserved Wood, October 11, 2002*, was prepared by the Gradient Corporation (Gradient, 2002) and the U.S. EPA and was carried out by Research Triangle Institute (RTI International). The pilot study determined optimized procedures for sampling CCA-treated southern yellow pine (SYP) coupons by a steel block, with polyester wipe attached, and by the human hand. The Mini Study component of the project involved 8 volunteer participants who hand-sampled wooden coupons. These procedures developed in the pilot tests and utilized in the Mini Study were utilized in the full study that is the subject of this report. The full study was conducted following, where appropriate, good laboratory practices and EPA quality assurance guidelines, and was approved by the RTI Institutional Review Board (IRB).

1.1.4 Institutional Review Board Application; Volunteer Information and Consent Form

The full study, described in this report, involved the participation of human volunteers. The Protocol and the Volunteer Information and Consent Form prepared by Gradient Corporation were first reviewed by RTI technical staff members and by the CCA Working Group. After some modifications, the RTI IRB approved both the Protocol and the Volunteer Information and Consent Form. The RTI laboratory supervisor, project manager, and all personnel assigned to work with human volunteers completed RTI's required on-line Human Subjects Training Tutorial to increase their awareness of human subjects' protections offered by their research design, ethical issues and concerns, and the regulations and assurances by which RTI's human subjects research is governed.

1.2 Goals and Significant Findings of this Study

This research project, *Assessment of Exposure to Metals in CCA-Preserved Wood, Full Study*, was developed by the CCA Work Group of the American Chemistry Council, Arlington, Virginia. The protocol for its implementation was developed in conjunction with the Gradient Corporation of Cambridge, Massachusetts. Advice and comments on the draft protocol(s) were sought and obtained from State and Federal agencies. Research Triangle Institute (RTI International) of Research Triangle Park, North Carolina, implemented the protocol. Twenty-one volunteers, drawn from the general population workforce, hand-sampled one end of approximately 750 wooden coupons representing various ages of deck wood from 10 locations in the northeastern U.S. (Pittsburgh, Pennsylvania and vicinity) and 10 locations in the extreme southeastern U.S. (Gainesville, Florida and vicinity). The other ends of these same coupons were also sampled using a block wipe technique so that hand and wipe sampling results could be compared. All samples of dislodgeable metal complex were analyzed for total chromium, copper, and arsenic; 20 percent of the samples were also analyzed for chromium (VI). For several statistical studies, the full study data set was combined with the data set from a smaller mini study in which a total of about 120 coupons from three decks from the south (Atlanta, Georgia and vicinity) and two decks from the north (Pittsburgh) were sampled by hand and by block wipe.

There are several possible choices regarding how the hand and block wipe results are presented for statistical analysis and used to derive a TRF. Two approaches are described below. The first approach is to assume that the sampling procedures used reach a state of equilibrium between the amount of dislodgeable material on a coupon and on a sampling device, *i.e.*, a volunteer's hand or the block wipe. Results from both the RTI Pilot Study and the recent CPSC study (CPSC, 2003) indicate that the amount of dislodgeable arsenic collected on a block wipe or a hand does not increase after about 10 to 15 passes on a test board, and that increasing the weight of the block or the weight on the hand does not significantly increase the amount collected. Also, based on experiments in the CPSC (2003) study, once equilibrium is achieved, even sampling a larger surface area of treated wood does not significantly increase levels of dislodgeable arsenic on a sampling device. If equilibrium is achieved, then it is appropriate to divide the mass of dislodged metal by the surface area of the sampling device. Thus, when a hand is used, the mass of dislodged metal is divided by the measured size of a volunteer's palm, and when a block wipe is used the mass of dislodged metal is divided by the size of the block-sampling device. When normalized this way, the hand load results are reported as $\mu g/cm^2$ of hand surface, and the block wipe results are reported as $\mu g/cm^2$ of block area. These values are then subjected to statistical analysis. Using this approach, statistical analyses were performed using the load or amount collected on a hand divided by the area of a hand, which averaged about 140 cm^2, and the load collected on a block wipe divided by 64 cm^2, the surface of the block that contacts the wood coupon during sampling.

An alternative approach is to treat the hand samples as having achieved equilibrium, but to assume that the block wipe samples have not achieved equilibrium. That is, the block wipe loading is

assumed to increase with an increase in the amount of wood surface rubbed. Although there are reasons why it may be easier for a hand to achieve equilibrium than a wipe (*e.g.*, a wipe has greater absorption capacity than a hand, more friction with a wipe, *etc.*), the results of the CPSC (2003) and RTI pilot studies indicate that the hand and block wipe sampling procedures used in these studies achieved equilibrium for both types of sampling devices. In this alternative approach, the hand sample results are still represented as $\mu g/cm^2$ of hand surface, but the block wipe results are represented as $\mu g/cm^2$ of board area sampled. In the RTI study, the board (coupon) area sampled was 500 cm^2. Statistical analyses were also performed using this alternative approach.

The goals and significant findings of the full study are:

Goal. Develop reliable estimates of the amount of dislodgeble metal complex removed by hand and block wipe sampling.

Hand and block wipe sampling were performed on a large set of coupons taken from decks from both the north and the south. The results of these tests based on combined data points of the 5-deck Mini Study and the 19-deck Full Study are listed below. Note that the block wipe loading value is presented in two ways: First Assumption - as $\mu g/cm^2$ of the block's surface area (64 cm^2) and Second Assumption - as $\mu g/cm^2$ of the coupon area (500 cm^2) sampled by the block.

Block Wipe Values, X, for the Combination of the Mini Study and the Full Study (Assuming Equilibrium for Both Block Wipe and Hand Sampling)

Element	Mean X ($\mu g/cm^2$ of block area)	Median X ($\mu g/cm^2$ of block area)	95% Quantile	5% Quantile
As	2.15	1.77	4.63	0.75
Cr	2.74	2.28	5.73	0.88
Cu	1.59	1.31	3.47	0.56

Block Wipe Values, X, for the Combination of the Mini Study and the Full Study (Assuming Equilibrium for Hand Sampling but not Block Wipe Sampling)

Element	Mean X ($\mu g/cm^2$ of coupon area sampled)	Median X ($\mu g/cm^2$ of coupon area sampled)	95% Quantile	5% Quantile
As	0.276	0.227	0.593	0.096
Cr	0.351	0.292	0.734	0.113
Cu	0.204	0.167	0.444	0.072

Hand Sample Values, Y, for the Combination of the Mini Study and the Full Study

Element	Mean Y ($\mu g/cm^2$ of hand area)	Median Y ($\mu g/cm^2$ of hand area)	95% Quantile	5% Quantile
As	0.061	0.035	0.186	0.011
Cr	0.058	0.032	0.189	0.010
Cu	0.053	0.034	0.152	0.012

The distribution of the values was determined to be more log normal than normal and thus the median provides a better representation of the data set than does the arithmetic mean.

Goal. Determine, with statistical significance, if the amount of dislodgeable metal complex relates to the age of the structure.

To answer this question, both correlation analyses and mixed effects modeling were performed. The correlation analyses showed a statistically significant, negative relationship between hand sample value and age. These analysis results were supported by the results of the mixed effects modeling.

Goal. Determine, with statistical significance, if the amount of dislodgeable metal complex relates to the geographic location (i.e, northern or southern region of the eastern United States).

Summaries of mean and geometric mean block wipe or hand concentrations show an apparent regional difference, with the values in the north being higher than those of the south.

Goal. Estimate a reliable Transfer Reduction Factor (TRF).

The TRF value, R, was calculated for each volunteer for each coupon tested (rubbed). The results of these tests for the combined Mini Study and Full Study data sets are calculated based on the two assumptions stated earlier: first, by dividing the hand loading expressed as $\mu g/cm^2$ of hand area by the block wipe loading expressed as $\mu g/cm^2$ of block wipe area (block wipe area being 64 cm^2), and second, by dividing the hand loading expressed as $\mu g/cm^2$ of hand area by the block wipe loading expressed as $\mu g/cm^2$ of coupon area sampled by the block (coupon area sampled being 500 cm^2). Summarized results of TRFs determined using these two approaches are tabulated below.

TRF Values for the Combination of the Mini Study and the Full Study (First Assumption)

Element	Mean R	Median R	95% Quantile	5% Quantile
As	0.0321	0.0196	0.0943	0.00550
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Cu	0.293	0.201	0.826	0.070

Again, the distribution of the R values is more log normal than normal and thus the medians provide a better representation of the data set than the mean.

Goal. Determine if chromium, in oxidation state +6, is present in the rinsate from the hand rubbing experiments.

For 145 hand rinse samples, Cr(VI) was analyzed using ion chromatography. Of these samples, only three had concentrations above the method detection limit of 0.25 µg/L or 0.035 µg/hand. Two of these samples came from recently treated wood (0.644 and 0.28 µg/L) and one sample was from a one-year old deck from the Pittsburgh area (0.279 µg/L). These values correspond to 0.09, 0.04, and 0.04 µg Cr(VI) per hand rinse.

1.3 Highlights of this Report

1.3.1 Study Design (Section 3.0)

- Twenty-one volunteers participated in the full study hand sampling experiments. Thirty stacks of coupons (a coupon is a 3-foot section cut from the deck board, labeled and marked off for sampling, one half by hand rubbing and the other half by block wiping) were prepared in advance. Each stack contained 25 coupons, consisting of usually one coupon from each from the twenty decks, four recently treated wood coupons, and one untreated coupon. Sampling all stacks yielded a total of 750 hand rub samples and 750 block wipe samples.

1.3.2 Quality Assurance (Section 4.0)

- A total of 20 field blank samples were collected and analyzed. No field blank contamination occurred for As, Cr, or Cu, indicating that field and laboratory procedures were in control.
- A total of 21 field spikes were analyzed for As, Cr, and Cu. Most of the field spikes met the recovery criteria of 70 to 120 %, indicating that, in general, accuracy criteria were met and that no significant bias was introduced.
- An on-site audit of field sampling and the deck board removal process found all procedures were properly followed. Laboratory activities were observed and found to follow the SOPs.
- No metals of interest were detected in preparation blanks for hexavalent chromium or the samples analyzed by ICP-AES. Low levels of Cr were detected in two of the preparation blanks analyzed by ICP-MS. Low levels of Cu were detected in several of the preparation blanks analyzed by ICP-MS. The levels were sufficiently low that the contaminant had no impact on study results.
- Blank matrix was spiked with CCA-treated wood flour that had been independently characterized for metal content. Generally, the wood flour spikes met defined acceptance criteria of 70 to 120 % recovery. The few exceedances are not expected to affect the reported sample results.
- Matrix spikes were prepared at three concentration levels (high, medium, and low). There were few exceedances of the 70 to 120 % recovery acceptance criteria, and no analytical bias that would affect the associated sample results was detected.
- Hand rinse sample spikes were prepared and analyzed to verify the hand rinse sample preparation and the As, Cr, Cu, and Cr(VI) analysis processes. Again, the acceptance criteria of 70 to 120 % recovery were generally met, and no analytical bias was detected.
- Duplicate samples were analyzed for the hand rinse and hexavalent chromium samples. The acceptance criterion was ± 20 RPD (relative percent difference). The averages of the RPD for hand rinses were 4.5 % for As, 3.1 % for Cr, and 0.8 % for Cu. None of the duplicate samples for Cr(VI) had detections.
- Instrument check samples were included in the Cr(VI) analytical runs. The recoveries for these samples ranged from 95.5 % to 108 %, with a mean of 101 %.

1.3.3 Database Development (Section 5.0)

- The CCA wood relational database was designed using Microsoft Access 2000 and Visual Basic for Applications (VBA) programming language. It allows management and tracking of all sample-related information.
- Barcode labels were used extensively to minimize typographical errors during sample transfer.
- The database includes information on: collection of deck boards; field measurements; conversion of boards to coupons; sampling of the coupons (hand rinse and two types of wipe samples); laboratory analytical results for As, Cr, Cu, and Cr(VI); and archiving of the sample materials.
- The database also includes information about each site's deck and meteorological conditions at the time of deck removal. Information about each of the volunteers who hand sampled the coupons is also included.

1.3.4 Sample Collection and Coupon Preparation (Section 6.0)

- Ten sets of deck boards from the Pittsburgh, PA area were collected and tested. Five of the decks ranged in age from 7 months to one year old; five ranged in age from 5 to 21 years old.
- Ten sets of deck boards from the Gainesville, FL area were collected and tested. Five of the decks ranged in age from one year to 16 months old; five ranged in age from 5 to 15 years old.
- Recently treated and untreated deck lumber was acquired from two treatment plants near Pittsburgh and two treatment plants near Gainesville.
- Procedures were established and equipment provided to transport the boards from the site to the laboratory and cut them into 3-foot length coupons. The procedures were designed to provide positive identification of each board and coupon by barcodes, and to avoid contamination of one board by another as well as by any other sources.

1.3.5 Analysis of Samples (Section 7.0)

- Methods for sample preparation are described for block wipes, hand rinses, and hand wipes.
- Total chromium, copper, and arsenic analyses of the block wipe samples were performed using a Perkin-Elmer ICP/AES instrument. Method detection limits (MDLs) are 0.96 μg/wipe for Cr and Cu, and 4.8 μg/wipe for As.
- Total chromium, copper, and arsenic analyses of the hand rinse and hand wipe samples were performed using a ThermoElemental X-7 ICP/MS instrument. MDLs are 0.048 μg per hand rinse or hand wipe for each element. Chromium (VI) was analyzed by ion chromatography with colorimetric detection. The MDL is 0.035 μg/hand.

1.3.6 Field Test Results (Section 8.0)

- Essentially no cross-contamination of treated and untreated deck boards occurred during handling and truck transport of deck boards from the sites to the laboratory.
- Percent moisture content of deck boards declined with time and storage under dry conditions. The moisture content approached values predicted in the literature.
- Independently-determined CCA retention analysis results were generally near the specified 0.4 pcf value. CCA retention test results on boards from deck AB varied significantly from the desired 0.4 pcf value; its retention value of 0.62 pcf was 55 % higher than the desired 0.4 pcf.

- All deck boards used in the study were independently confirmed to be southern yellow pine (SYP).

1.3.7 Study Results (Section 9)

- In the course of a two-week period, 21 volunteers from the general work force hand sampled 750 wood coupons taken from 10 decks near Pittsburgh, Pennsylvania and 10 decks near Gainesville, Florida. 750 block wipe samples were also obtained from the other end of each of these coupons.
- Summary statistics were compiled to describe the central tendency and variability of the hand sampling results, the block wipe results, and the transfer reduction factors (TRFs).
- Pearson and Spearman correlation analyses were conducted to quantify the relationship between hand sample and block wipe data, and between hand and block results and deck age, without controlling for other parameters.
- Mixed model analyses were employed to describe the effects of deck parameters such as age and geographic region on TRFs, hand results, and block results, while controlling for other parameters.

1.3.8 Conclusions (Section 10.0)

- The relationship between the level of dislodgeables on a board sample and the level on a sampling device after 20 passes across the board may or may not represent a state of equilibrium. Experimental evidence collected by RTI and CPSC suggest that a state of equilibrium exists between these levels for both the block wipe and hand sampling.
- All data indicate that the distributions of the block wipe and hand sample data are near-log normal, or right skewed.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for As is about 2 $\mu g/cm^2$ block wipe and about 0.04 $\mu g/cm^2$ hand.
- Assuming that a state of sampling equilibrium exists for the hand samples but not the block wipe samples, the median value for As on the block wipe is about 0.2 $\mu g/cm^2$ board (coupon) and about 0.04 $\mu g/cm^2$ hand.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for the transfer reduction factor for As is about 0.02.
- The levels of CCA recovered from the deck surfaces are higher in the north than the south.
- It is unclear whether the levels of CCA collected on block wipes increase or decrease with deck age.
- The levels of CCA collected on hand surfaces decrease with the age of the decks.
- Cr(VI) is virtually non-existent in hand rinse samples.

2.0 PILOT AND MINI STUDY

2.1 Comparison of Pilot/Mini Study and Full Study Reports

The Pilot and Mini Studies are described in detail in the report entitled "Assessment of Exposure to Metals in CCA-Preserved Wood" (American Chemistry Council, 2003). This section summarizes the essential elements of each study and several important differences in the data used and in the statistical analyses conducted.

The Mini Study involved eight human volunteers who sampled about 120 coupons from five different decks. In contrast, the Full Study involved 21 human volunteers who sampled approximately 750 coupons from 20 different decks. In each case, a block wipe (polyester cloth wipe) was taken from an area on the opposite end of the coupons.

The reader should be aware that data from the Mini Study were often combined with Full Study data for further examination. Whenever this occurred, the Mini Study data were presented and analyzed in the same manner as the Full Study.

When comparing the Mini Study report to the Full Study report, the reader should be aware of the following differences between how the data were prepared and analyzed.

- Data expression. In the Mini Study report, the focus was on arithmetic means, assuming the data were normally distributed. In the Full Study report, medians and geometric means from the datasets are utilized because it was determined that the full study data are log-normally distributed

- Computation of transfer reduction factor (TRF). In the Mini Study report, the TRF is expressed as a metal's mean block wipe loading (μg/block wipe) divided by the metal's mean hand loading (μg/hand). This results in TRFs that are much greater than one (*i.e.*, >>1.0). In the Full Study, the TRF differs in three ways. First, the TRFs were calculated for individual coupons and a distribution of TRFs was calculated from which mean and percentile TRF values (e.g., 50th and 95th) were determined. Secondly, the loading of a dislodged metal on a block wipe was normalized (*i.e.*, divided by) to both the area of the block and to the area of the wood coupon sampled, resulting in the units of $\mu g/cm^2$. Loading of a metal on a hand was normalized to the area of the hand, resulting in the same units (*i.e.*, $\mu g/cm^2$). Thirdly, the TRF was calculated as the ratio of the hand loading, $\mu g/cm^2$, divided by the block wipe loading, $\mu g/cm^2$, to give TRF values less than one. Thus, TRF values in the Full Study report are the inverse of those in the Mini Study report (*i.e.*, a TRF of 20 in the Mini Study would be 0.05 in the Full Study).

- Use of data from recently treated deck boards. Several of the Mini Study statistical analyses that sought relationships between dislodgeable metal complex and deck age included results from boards that had been recently treated with CCA and considered such samples to come from "decks" of age zero years. Results from recently treated deck wood were not included in the statistical analyses conducted in the Full Study because most exposures to CCA-treated will be to aged structures.

- Pearson correlation analysis. In the Mini Study report, the Pearson correlation technique was applied to a relatively small data set, and it was assumed that its data points were normally distributed. Data generated in the full study were determined to be better fit by a log

transformation of the data. In retrospect, use of the Pearson correlation in the Mini Study report was inappropriate because these data were also log-normally distributed and the Pearson correlation requires the data to follow a standard normal distribution. In the Full Study, the Pearson correlation was applied to the log-transformed data. Furthermore, an additional correlation analysis, the Spearman correlation, was performed using the Full Study data with no transformation.

2.2 Study Planning and Volunteer Recruitment

The pilot study was performed to refine and optimize the sampling and analytical methods to be used in the both the Mini Study and the larger, full study. The first step was preparation of a study protocol, which was first drafted by Gradient Corporation. The draft was reviewed and then modified by RTI, and finally approved by all parties.

Next to be addressed was the method of recruiting study volunteers. Both the pilot study and the Mini Study involved the participation of human volunteers. A Volunteer Information and Consent Form was prepared by Gradient Corporation and reviewed by RTI and its Institutional Review Board (IRB) committee chairperson; after several modifications, the Form was submitted to the RTI IRB for approval. The IRB approved the Form and the Protocol. The RTI laboratory supervisor, project manager, and all personnel assigned to work with human volunteers completed RTI's required on-line Human Subjects Training Tutorial to increase their awareness of human subjects' protections offered by their research design, ethical issues and concerns, and the regulations and assurances by which RTI's human subjects research is governed.

The pilot study consisted of a number of tasks including:

- Preparing draft Standard Operating Procedures for locating and selecting decks, documenting decks, labeling the boards, conducting field tests, shipping the boards from the field to the laboratory, cutting the boards into coupons, and storing the boards and coupons for future tests.

- Obtaining deck boards from homeowners and from treatment facilities in the Pittsburgh, PA and Atlanta, GA areas.

- Conducting field tests of the deck boards, acquiring data and photographs concerning each site, packing and returning the boards to the RTI warehouse storage facility and laboratory in a manner that avoided cross-contamination.

- Upon return to the laboratory facilities, conditioning the boards for several days in the warehouse, conducting post-field tests, cutting the boards into coupons, labeling the coupons, and submitting the coupons to the sampling laboratory for various cloth wipe and hand rub pilot study experiments.

- Developing and validating methods for block wipe and hand sampling, based on the methodology performed by the Consumer Product Safety Commission (CPSC, 2003).

- Developing and validating analytical methods to digest/extract and analyze material from cloth wipe and hand rinse/wipe samples for chromium, copper, and arsenic content

- Based on the pilot study data, choosing optimized analytical methods and optimized wipe and hand sampling techniques.

While the pilot studies were underway, an MS-Access database was constructed. This database was designed to maintain all data on the wood collection, preparation of the wood test coupons, as well as all results from the block wipe and hand sample analyses.

The Mini Study was performed after completion of the pilot study. There were several reasons for conducting a Mini Study, including testing the sample collection and analysis methodologies developed during the pilot study, and developing a preliminary data set that could be used in risk assessment. The objectives of the Mini Study are the same as in the Full Study and include:

1. Develop reliable estimates of the amount of dislodgeable metal complex removed by hand and wipe sampling of CCA-preserved wood.
2. Determine, with statistical significance, if the amount of dislodgeable metal complex relates to the age of the structure.
3. Estimate a reliable Transfer Reduction Factor (TRF). In the Mini Study, the TRF was expressed as the ratio of the mass of a metal adhering to the 64 cm^2 area of the block wipe to the mass of a metal adhering to a participant's hand, following wipe and hand sampling of a test coupon.

2.3 Wood Sample Collection and Preparation

For the pilot study experiments and the Mini Study, sites for wood collection were chosen from the northern and southern areas of the eastern United States. Decks were identified in Atlanta, Georgia, and Pittsburgh, Pennsylvania. Deck owners were located and contacted in several ways – through personal contacts in these areas, via realtors who also rented home properties, and through deck builders who advertised in the Yellow Pages. Homeowners were remunerated for their inconvenience and the deck boards were replaced with new boards soon after removal. Certain specifications were required to be met before decks were considered acceptable for study inclusion. To be acceptable for use, decks had to meet the following specifications. All deck wood had to be southern yellow pine (SYP), CCA-treated to 0.4 pcf, and have never been stained or coated in any manner. Two ages of decks were required: decks approximately one year old (ranging in age from 6 months to 16 months), and decks that were five or more years old. In addition, recently treated CCA deck boards and untreated boards were obtained, by prior arrangement, from treating plants in the vicinity of Pittsburgh and Atlanta. Recently treated lumber from a local Home Depot was also purchased for use in the pilot study tests. The wood collection was performed according to the RTI SOP CCA-010, "Standard Operating Procedures for CCA-treated Deck Sample Collection and Shipping" (RTI, 2003b).

Information was collected and testing was performed at the collection sites prior to shipment back to RTI. The tests are described in RTI SOP CCA-020, "Standard Operating Procedures for CCA-Treated Wood Field Tests" (RTI, 2003c). Information collected and testing performed included:

- Digital photographs of the deck in the four cardinal directions
- Information from the homeowner concerning deck age and use, and estimated sunshine exposure
- A hand-drawn sketch of the deck showing dimensions and locations of the house, nearby trees, and so on.
- Ambient air relative humidity (percent) and temperature (degrees F and C).
- Percent moisture content of representative deck boards.
- Core samples, scrapings, and segments of aged and recently CCA-treated deck boards for subsequent, off-site confirmatory testing by Timber Products Inspections (TPI) for CCA

retention value and percent moisture content. Some samples were also submitted to a nearby treatment plant for Cr, Cu, and As retentions using X-ray techniques.

- Wipe tests of two 12.5 by 40 cm sections (500 cm^2 each) from two or more boards from each deck.
- Wipe tests of two 12.5 by 40 cm sections (500 cm^2 each) from two or more recently treated boards and two or more untreated boards.

Each board was uniquely identifiable *via* a plastic barcode label that was attached to the board's extreme end with glue and staples. Each section of a board that was subjected to the wipe test was further identified with an additional bar code label that identified a wipe area. After the field wipe tests were completed, the boards from each deck were carefully placed, on their sides, at an angle, on notched shelves in a rack that was custom-built to fit into the enclosed cargo space of a rental truck. The deck boards were then transported to RTI.

Upon return from the field sites, all decking boards were removed from the rack in the truck. Care was taken not to touch the weather-exposed side of the boards. Boards were placed in secure storage in a separate wooden rack in the RTI warehouse. Recently treated lumber was kept segregated from aged deck boards. After the boards were stored at least two days at the RTI warehouse, room temperature and relative humidity measurements were made, and the percent moisture content of the boards was re-determined. Wipe sampling was then repeated on a fresh test area of the same boards that had been sampled in the field. Percent moisture content of the wood was also determined.

Three-foot sections of the boards, called coupons, were cut from boards that had been stored in the warehouse for an extended time. RTI SOP CCA-030, "Standard Operating Procedures for Cutting CCA-Treated Deck Boards into Test Coupons" (RTI, 2003d), was followed for this operation. The cutting was performed using a miter saw. In order to avoid cross-contamination, the saw blade was cleaned after sectioning each board. All appropriate safety precautions were taken. Each coupon was labeled with a barcode sticker.

2.4 Block and Hand Sampling Procedures

A large number of experiments were performed to develop the best procedures for preparation of the block sampling system and process, the hand sampling process, and sample analysis. Variables tested included:

- Mass of the block
- Ruggedness of the polyester cloth wipe on the block
- Number of passes to be made with the block
- Speed of movement of the block
- Mass placed on the back of the hand
- Number of passes to be made with the hand
- Speed of movement of the hand
- Method of removing dislodgeables from the hand
- Sample preparation procedures
- Analysis procedures

The optimum mass for the 8 cm by 8 cm square steel block was found to be 1,100g, the same weight as used by the CPSC. The optimum number of passes was found to be 20; optimum loading of the hand appeared to occur between 10 and 20 passes. The most reasonable speed was found to be 3 seconds per pass. The final block wipe procedure is detailed below:

- Equilibrate a clean ~11 cm by ~11 cm Alpha Wipe with 1.9 g of 0.9% saline and attach it to the block using a Teflon collar and tape.
- Pull the attached cord to move the block back and forth over the 40 cm path for 10 passes while simultaneously moving the block slowly side to side across the 12.5 cm test area width.
- Rotate the block 90º and pull it back and forth for another 10 passes.
- Carefully remove the wipe from the block, fold it lightly in a funnel shape, and place it in a 50-mL plastic centrifuge tube.
- Label the tube with a barcode label and enter the coupon identifier and tube/sample identifier into the database via the barcode reader at the computer terminal in the laboratory.

The optimum weight on the back of the hand was determined to be 1,100 g. It was determined that 20 passes yielded optimum loading of the hand and a 3-second speed per pass was most reasonable. The final hand sampling procedure is detailed below:

- Moisten the hand by squeezing a sponge wet with 0.9% saline solution.
- Secure an 1,100 gram mass (plastic bag containing steel shot) to the back of the hand
- Rub the wood surface, 20 passes at 3 seconds per pass
- Pour 30 mL of deionized water into a 2 quart, rectangular baking dish.
- Place the hand in the water and push down gently five (5) times
- Lift the hand and rub the fingers together and rub the fingers on the palm to dislodge particles
- Repeat the last two steps two more times each
- Lift the hand and let any drops fall into the dish
- Shake the hand in a downward motion over the dish to further remove excess water
- Carefully pour the water from the dish into a 200 mL plastic bottle using a 3 in. funnel
- Allow the dish to drain into the funnel
- Pour another 30 mL of deionized water into the dish and repeat the entire sequence as described above
- Repeat the last step two more times for a total of 120 mL of rinse water
- Rinse the dish with 20 mL of deionized water and pour this into the bottle
- Label the bottle with a barcode label and enter the coupon identifier and tube/sample identifier into the database with the terminal in the laboratory.

As a result of the pilot work, it was determined that a wipe of the hand was needed to remove CCA-containing dislodgables that did not come off in the rinse water. Therefore, after the final rinse, the handler took the same wipe normally used with the block wipe and firmly wiped the palm of the hand including the fingertips, the heel of the palm, and between the fingers. This wipe was carefully placed in a 50 mL centrifuge tube that was labeled with a barcode label and then the coupon identifier and tube/sample identifier were entered into the database using the terminal in the laboratory.

2.5 Analysis

Four different types of samples were collected and analyzed during the pilot study. These were: (1) the wipe from the block wipe; (2) the rinsate generated during the hand rub, (3) the wipe of the hand following the rinse step; and (4) an aliquot of the hand-rub rinsate taken for Cr (VI) analysis. The first three samples were analyzed for chromium, copper, and arsenic, and the fourth sample was analyzed only for Cr(VI).

2.5.1 Sample Preparation

The block wipes and hand wipes were extracted for total copper, chromium, and arsenic in the same manner. First, the sample tubes were gently tapped to bring the wipes to the bottom of the tubes. Then, twenty-five (25) mL of 10% GFS redistilled trace element grade nitric acid was added to each tube, caps were tightly attached, and the tubes were placed in a shaking hot water bath at 60°C for 12 hours. The tubes were removed from the bath and tipped over several times to gently mix the contents. Then, 25 mL of deionized water were added to each tube and the contents were gently mixed by tipping the tubes several times. The samples were then ready for analysis.

The hand rinses totaled 140 mL of deionized water from the four sequential 30-mL hand rinses, plus a 20-mL rinse of the collection pan and funnel; these samples were collected in 200 mL high-density polyethylene bottles. A 10-mL aliquot for Cr(VI) analysis was taken from about every tenth sample bottle. The aliquot for Cr(VI) analysis was poured into a 15 mL plastic centrifuge tube and was adjusted to a pH of 9.0 to 9.5 using a 0.01 N NaOH solution. The pH of each hand rinse sample intended for analysis of Cr, Cu, and As was adjusted to about 1 by the addition of 1% or 1.4 mL of trace element grade nitric acid and the samples were manually shaken. In the trace metals preparation laboratory, the samples were shaken manually one more time and 25 mL of sample was taken from each bottle of sample using a motorized pipette with a disposable tip. The 25 mL aliquots were placed in 50-mL plastic centrifuge tubes. Following EPA Method 6020, 2.5 mL of trace element grade nitric acid and 2.0 mL of trace element grade, 30% hydrogen peroxide (EM "Suprapur," VWR No. EM-7298-2) were added to each tube. The samples were digested either by heating in a shaking hot water bath at 60ºC for 12 hours or by heating at 95ºC in a carbon hot block for 30 minutes. In the Mini Study, the hand rinse samples were digested in a shaking hot water bath at 60ºC for 12 hours. For the Full Study, hydrogen peroxide was added to the samples and hand rinse digestion occurred in a carbon hot block at 95ºC for 30 minutes. After either procedure, the digested samples were then shaken by hand. The digestion process was changed in the interest of speed and efficiency of sample preparation. Experiments using both digestion processes with reference material wood flour in water (approximating a hand rinse) showed acceptable recoveries of all metals from digested wood flour at two concentration levels. Expected microgram masses of metals in the lower level test samples were: Cr, 83.5; Cu, 49.0; As, 81.25. Recoveries for the hot water bath method were: Cr, 84%; Cu, 98%; As, 101%. Average recoveries for three separate tests with the hot block method were: Cr, 91.2 ± 7%; Cu, 85.8 ± 6%; As, 95.5 ± 7%. Expected microgram masses of metals in the higher level test samples were: Cr, 167; Cu, 98.0; As, 162.5. Recoveries for the hot water bath method were: Cr, 76%; Cu, 87%; As, 94%. Average recoveries for three separate tests with the hot block method were: Cr, 89.5 ± 8%; Cu, 98.9 ± 10%; As, 93.9 ± 4%.

2.5.2 Sample Analysis

Total chromium, copper, and arsenic analysis of the <u>block wipe samples</u> was performed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP/AES). The instrument used was a Perkin - Elmer Optima 4300DV ICP/AES. Total chromium, copper, and arsenic analysis for the <u>hand rinse</u> and <u>hand wipe samples</u> was performed using Inductively Coupled Plasma Mass Spectrometry (ICP/MS operating conditions as described in Standard Operating Procedures included with the Quality Assurance Project Plan (RTI, 2003a) were optimized for these analyses. Performance parameters achieved are shown in Table 2-1.

The Cr(VI) analysis procedure was set up using Metrohm Ion Chromatography (IC) with post-column reaction and colorimetric detection. Of the 15 samples analyzed, all were below the instrument's detection limit of 0.025 µg/L (0.035 µg/hand rinse). The Cr(VI) analysis performance parameters achieved with this instrument are as follows:

Parameter	Level Achieved
Precision (N=7)	3.6% RSD @ 0.28 µg/hand
Accuracy	101% - Spiking of Solution with an alternate Cr^{6+} source
Method Detection Limit	0.25 ppb; 0.035 µg/hand

The results of the block wipe samples were expressed as µg metal/wipe. The area of the block wipe is 64cm^2. The results of the hand rinse were expressed as µg metal/hand. The outlined area of the hands of course varied. The results of the hand wipe samples were expressed as µg/hand wipe. The total µg of a given metal removed from a board is the sum of the hand rinse and the hand wipe results. The results of analysis of chromium (VI) from the hand rinse were expressed as µg/hand rinse.

Table 2-1. Performance Parameters for Total CCA and Cr(VI) Measurement

Parameter	Level Achieved		
	Copper	**Chromium**	**Arsenic**
	ICP/AES for CCA on Block Wipes		
Precision (N=7)	7% RSD @ 12 µg/wipe	8% RSD @ 12 µg/wipe	7% RSD @ 12 µg/wipe
Accuracy	99%	99%	95%
Method Detection Limit	0.96 µg/wipe	0.96 µg/wipe	4.8 µg/wipe
	ICP/MS for CCA in Hand Rinsate		
Precision (N=7)	6% RSD @ 0.24 µg/wipe	3% RSD @ 0.24 µg/wipe	13% RSD @ 0.24 µg/wipe
Accuracy	81%	102%	86%
Method Detection Limit	0.048 µg/wipe	0.048 µg/wipe	0.048 µg/wipe
	ICP/MS for CCA on Hand Wipes		
Precision (N=6)	3%, 50 mg wood flour spike	3%, 50 mg wood flour spike	4%, 50 mg wood flour spike
Accuracy	97%	88%	99%
Method Detection Limit	0.28 µg/hand	0.28 µg/hand	0.28 µg/hand

2.6 Field Test Results

Mini Study field tests, including measurement of percent moisture and block wipes were performed. The deck boards from Atlanta and the Pittsburgh both showed a drop in moisture when returned to RTI. In the field, percent moisture content (%MC) was typically in the low 20's. The deck boards from Atlanta showed a decrease of 4 to 8 %MC after being returned to RTI and a decrease of 11 to 16 %MC (from their original field values) after storage in the RTI warehouse for about 80 days. The

deck boards from Pittsburgh showed a decrease of 1 to 5 %MC after being returned to RTI and a decrease of 3 to 10 %MC (from their original field values) after storage in the RTI warehouse for about 20 days.

Untreated boards were included with each deck during the shipment of the boards from the field site to RTI. These boards were tested with block wipes before and after the return trip to estimate cross contamination as a result of the shipment process. Contamination was minimal, on the order of 2 to 3 μg arsenic per 64-cm^2 wipe over a 500 cm^2 sampling area. This value is to be compared to arsenic concentrations ranging from 67 to 185 μg per wipe for samples taken from deck boards.

2.7 Mini Study Procedures

The Mini Study included the use of coupons from five (5) decks that were of the same age distribution as expected with the 20 decks in the full study. The deck boards collected from the field sites were cut into 3-foot coupons at RTI's Regent Place facility. The coupons used in this study were cut from deck boards collected from three decks located in the Atlanta, Georgia area, and two decks located in the Pittsburgh, Pennsylvania area. A barcode label was attached to each coupon. Approximately 15 coupons were prepared from each deck. Untreated lumber and recently treated deck wood were also used. About 120 coupons were sampled using the block wipe and hand sampling methods optimized in the pilot study.

An announcement was made to all staff in the Environmental and Industrial Sciences Division at RTI calling for volunteers to participate in a deck wood exposure study. The volunteers met as a group, at which time the project was explained to them. Each volunteer was provided a copy of the consent form and those willing and able to participate signed the consent form. The final volunteer count for the Mini Study was eight. Each volunteer was taken to the laboratory where they became familiar with the setup and practiced the hand rubbing and rinsing/wipe process.

The coupons from the untreated wood, recently treated wood, and five decks were randomly distributed into eight (8) groups for the eight volunteers. This assured that each volunteer would sample untreated wood, recently treated wood, and wood from each of the five decks. Each of the coupons was subjected to block wipe sampling. One experienced staff member conducted all block-wipe sampling.

Two hand-rubbing stations were set up in the laboratory. Each was equipped with a clamping system to hold the coupons in place, dishes for rinsing the hands, a supply of 200-mL high density polyethylene bottles for the rinse samples, plastic funnels, saline-treated wipes in 50-mL plastic centrifuge tubes for wiping the hands after rinsing, and a video camera to capture the rubbing and rinsing procedures for each volunteer. An "operator" directed each sampling session. Staff serving as operators had experience with the hand rubbing process through their support of the research component of this work and all had completed the required Human Subjects Training Course. The duties of the operator were to:

- Select and mount a coupon and enter the coupon identifier into the database
- Enter the volunteer identifier into the database
- Observe the volunteer wash his/her hands with soap and water and dry the hands with clean paper towels
- Observe that the volunteer wets his/her hand with 0.9% saline
- Attach the 1,100 g bag to the back of the volunteer's hand
- Watch that the volunteer rubs at 3 seconds per pass and performs 20 passes
- Put on rubber gloves that are rinsed in deionized water
- Pour 30 mL of deionized water into the clean, hand rinse dish and observe that the volunteer follows protocol for rinsing/washing the hand in the water

- Watch that the volunteer allows hanging drops to fall back into the dish
- Pour the rinse water through a funnel into a 200-mL plastic bottle
- Repeat the 30-mL rinse/wash process with the volunteer three more times
- Rinse the dish with 20 mL of deionized water and adds the rinse to the bottle for a total of 140 mL of sample
- Take a wipe treated with saline and rub the hand firmly, getting between the fingers, across the fingers and thumb, and especially across the high point of the palm. Note that the hand wiping took place in a vigorous scrubbing manner with some pressure being exerted to further remove dislodgeable materials that may be trapped in the cracks and crevices of the skin's surface.
- Place the wipe lightly folded back into the 50-mL centrifuge tube that it came in
- Attach barcode labels to the bottle and centrifuge tube and enter the identifiers into the database
- For any Cr(VI) aliquots, adjust the pH to 9 with sodium hydroxide solution
- Prepare laboratory request/chain of custody forms for the samples and submit samples to the laboratory. (Rinse solutions are treated with nitric acid to bring pH to about 1.)

Over the course of several days, the handlers worked with eight volunteers to collect 120 hand-rubbing samples.

Testing of each coupon resulted in nine analytical results – values for As, Cr, and Cu from the block wipe, the hand rinse, and the hand wipe. These values were provided in spreadsheets from the trace metals laboratory and were manually entered into a larger Excel spreadsheet that included barcode identifiers for the coupon, the block wipe, the volunteer, the hand rinse sample, and the hand rinse sample.

The spreadsheet was submitted for statistical analysis using SAS software, Version 8.2. The output of these statistical analyses included:

- Summary statistics for each metal from each wood type.
- Correlation analyses including means for each metal over all coupons and Pearson correlation coefficients relating block wipe values, hand rinse values, and the sum of hand rinse plus hand wipe values.
- Regression analyses that relate block wipe values, the sum of hand rinse plus hand wipe values, and age of the wood/deck.
- One-way ANOVA, performed to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metal complex.

2.8 Mini Study Results

For As, the mean block wipe values for the recently treated wood and the five decks ranged from 88.6 to 195.8 µg (1.4 to 3.1 µg/cm^2, based on a block area of 64 cm^2) and the mean sum of hand rinse plus hand wipe values ranged from 2.97 to 6.14 µg (0.021 to 0.044 µg/cm^2, based on an average measured hand size for each volunteer of 140 cm^2). For Cr, the mean block wipe values ranged from 119 to 242 µg (1.9 to 3.8 µg/cm^2) and the mean sum of hand rinse plus hand wipe values ranged from 3.54 to 6.78 µg (0.025 to 0.049 µg/cm^2). For Cu, the mean block wipe values ranged from 50.5 to 90.6 µg (0.8 to 1.4 µg/cm^2) and the mean sum of hand rinse plus hand wipe values ranged from 2.85 to 5.62 µg (0.020 to 0.040 µg/cm^2).

For all block wipe samples (excluding untreated wood), the As values for the block wipe samples ranged from 31.4 to 471 µg (0.49 to 7.36 µg/cm^2) and the As values for the sum of hand rinse plus hand

wipe samples ranged from 0.56 to 18.8 μg (0.004 to 0.134 μg/cm^2). The Cr values for the block wipe samples ranged from 44.2 to 493 μg (0.69 to 7.70 μg/cm^2) and the Cr values for the sum of hand rinse plus hand wipe samples ranged from 0.56 to 37.2 μg (0.004 to 0.266 μg/cm^2). The Cu values for the block wipe samples ranged from 24.3 to 301 μg (0.38 to 4.70 μg/cm^2) and the sum of hand rinse samples plus hand wipe samples ranged from 0.28 to 11.8μg (0.002 to 0.084 μg/cm^2).

The TRFs, based on the ratio of the average mass of dislodgeable metal removed with a block wipe, to the average mass of metal removed with a hand were 37.6, 38.0, and 20.7 for As, Cr, and Cu, respectively. Expressed as the inverse ratio (hand divided by block), the TRFs were 0.0266, 0.0263, and 0.0483 for As, Cr, and Cu, respectively. The standard deviation of the data points composing these averages are relatively high and thus the values for these ratios are relatively uncertain.

Regression analyses were performed with the sum of hand rinse plus hand wipe as the dependent variable. Five models having different parameters in the function were tested, and both standard normal and log-transformed distributions of the data were analyzed. The best fit for As, as indicated by an R-square value of 0.444, used the function terms log intercept, log block wipe, age, log block wipe times age, and log block wipe times log block wipe. The best fit for Cr, as indicated by an R-square value of 0.433, used the function terms intercept, block wipe, age, block wipe times age, and block wipe times block wipe. The best fit for Cu, as indicated by an R-square value of 0.119, included the same parameters listed above for Cr.

One-way ANOVA was performed to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metal complex. Included in the analysis were:

- Six levels of age (age = 0, 1, 1.5, 4, 15, and 23 years)
- Log-transformed data, which better satisfy assumptions of normality and similar degree of variance (homoscedasticity)
- Multiple comparisons performed using Scheffe's method due to unequal sample sizes within age classes.

ANOVA results do not show a consistent relationship between aging and block wipes and hand rinse/wipe results.

- Although not always statistically significant, mean levels of dislodgeable metal complex are nearly always greatest for the recently treated (age=0) wood type, when either block wipe or hand rinse/wipe data are evaluated.
- Multiple comparisons of population means do not show a consistent trend between metal levels and age.

3.0 STUDY DESIGN

The first stage in this study was the pilot study, where sampling and analytical methods were developed and optimized. The second stage was the Mini Study, which was a scaled-down version of the full study; nevertheless, preliminary data and estimates were developed in the Mini Study that reflect the three study objectives described in Chapter 1. The third stage was the full study, where significantly more data were generated to enable more reliable estimates of the three study objectives.

The study design is described in detail in the Protocol for the full study (Gradient, 2003). Included in this chapter are the essential components of that design.

3.1 Sample Size Calculation

A sample size calculation was performed by Gradient Corporation to estimate the number of hand load samples needed to detect (with statistical significance) a 50% reduction in the amount of dislodgeable arsenic complex from aged CCA-preserved wood, compared to recently purchased preserved wood. This calculation is based on hand load results for dislodgeable arsenic complex from a study conducted by Scientific Certification Systems (SCS, 2001).

Changes in the amount of dislodgeable arsenic complex due to aging were evaluated using a two-sample t-test. The two-sample t-test compares the means of two data sets to determine if one mean is statistically different from the other.

The sample sizes required to detect a statistically significant difference in the amount of dislodgeable arsenic complex between recently treated and aged CCA-preserved wood are presented in Table 3-1. These sample sizes are based on a one-sided alpha level of 0.05 and 80% power.

Table 3-1. Sample Sizes Needed to Detect a Significant Difference in the Amount of Dislodgeable Arsenic Complex Between Recently Treated and Aged CCA-Preserved Wood

		% Reduction in Arsenic Complex Due to Aging							
Power (1-β)	**SD_{aged}**	20%	30%	40%	50%	60%	70%	80%	90%
80%	0.029	118	53	31	20	14	11	9	7
80%	0.039	166	75	43	28	20	15	12	9
80%	0.049	227	102	58	38	27	20	16	13

Because the magnitude of the standard deviation in dislodgeable arsenic complex levels from the aged wood types to be evaluated in the study is uncertain, it was recommended that at least 30 hand load samples be collected from each wood type. It is estimated that a sample size of 30 should allow at least a 2-fold (i.e., 50%) reduction in the amount of dislodgeable arsenic complex between recently treated and aged CCA-preserved wood to be detected with statistical significance. Thus, for each wood type evaluated, at least 15 adult volunteers, each using both hands, were used for the hand-sampling portion of the study; 30 wipe samples were also collected (the number of wipe samples collected is based on the number of hand samples, and not on any kind of statistical analysis because the underlying wipe data necessary for such a calculation was not available). The decision to use a sample size of 30 for the hand-sampling portion of the study is based on a balance between statistical power and practicality. The

underlying data and description of the equations used to calculate the sample size are given the Appendix B of the Full Study Protocol (Gradient, 2003).

3.2 Selection of Contract Testing Facility

For consistency, all hand and wipe sampling, and preparation of samples for laboratory analysis for all three stages of the study were performed at a single geographic location. Other considerations for the testing facility site included:

- Availability of the required number of study volunteers.
- Availability of a study director and necessary staff to ensure compliance with the protocol.
- Adequate facilities, including climate control, sufficient table and/or bench space, and storage.
- Availability of sampling equipment (e.g., wipes, sample blocks, hand rinsate bottles, etc.) and containers for laboratory shipment of samples.
- Ability to comply with GLP standards, where applicable in the study.

Based on these criteria, and a review of their extensive exposure and analytical testing capabilities, and GLP experience, the CCA Work group identified RTI International (RTI), based in Research Triangle Park, North Carolina, as the contract testing facility. Except for the retention analysis of aged and recently treated wood collected in the field, RTI was contracted to: conduct all field sampling, collect all of the wood types evaluated in the study and ship them to their testing facility, perform all laboratory sampling of the wood types, conduct chemical analysis of the hand and wipe samples, and carry out statistical analyses of the study database

3.3 Materials and Methods

This section describes volunteer recruitment, wood types, collection/shipment of boards in the field, documentation procedures, hand and wipe sampling protocols, and analytical methods for the study.

3.3.1 Volunteer Recruitment

RTI recruited volunteers for the hand-sampling portion of the study. Only male and female adults (ages 18 to 65 years) that provided informed consent using the Consent Form developed for this study, and that were able to follow basic instructions, were allowed to participate. A copy of the Consent Form for use in the study is available in Appendix A of the Full Study Protocol (Gradient, 2003).

3.3.2 Wood Types

3.3.2.1 General

CCA-type C preserved SYP was used exclusively in the study because this is the most commonly used type of CCA and species of wood for CCA treatment in the U.S. (AWPA, 1998 and 2002). Only wood treated to a retention of 0.4 PCF in accordance with American Wood-Preservers' Association (AWPA) standards was used in the study. A retention of 0.4 PCF was thought to provide a conservative estimate of the amount of dislodgeable total metals because this retention is recommended by the AWPA for both above and below ground use.

Only boards were included in the study because this is the predominant type of dimensional lumber used in the construction of CCA-preserved structures, and because boards provide a sufficient surface area for hand and wipe sampling.

3.3.2.2 Recently Treated Lumber

Lumber recently treated (*i.e.*, treated within 4-6 weeks of use in the study) to a retention of 0.4 PCF in accordance with AWPA standards was used in the study. CCA-preserved lumber obtained from two different suppliers (*i.e.*, treatment facilities) in the North and in the South (for a total of 4 different suppliers) was included to reflect the potential variability in treatment conditions of the wood in existing structures in the U.S.

3.3.2.3 Aged Wood

In addition to the general requirements in Section 3.3.2 above, the aged wood types included in the study had undergone natural, outdoor aging for different time periods (e.g., 1 and 5+ years). Furthermore, aged wood from different regions of the U.S. (*i.e.*, north and south) were included to reflect variability in weather conditions.

Residential decks provide a good potential source for aged wood because decks are commonly used and one structure can provide a significant amount of aged wood, especially boards. For aged wood identified for the study, the following information and samples were collected:

1. Owner information
2. Structure data
3. Site data
4. Field test data, including analysis of wood moisture content of the boards in the field, and twice more at the RTI testing facility.
5. Duplicate wipes samples on at least two boards from a structure both at the site and back at RTI. In addition, duplicate wipe samples in the field from an untreated board, which is then packed with the aged wood and shipped back to RTI. The same untreated board was resampled at RTI to assess whether any cross contamination occurred during shipment.
6. Field blank and field spike (*i.e.*, sodium arsenate added to an unused wipe) samples were collected and analyzed.
7. Samples of each aged deck were sent to Timber Products Inspector (TPI) for determination of CCA retention values.

3.3.2.4 Control Samples

Untreated lumber (*i.e.*, not preserved with CCA) was used in the study as a negative control. Most of this wood type was purchased from one commercial supplier in Concord, North Carolina. This wood had not been sent to a CCA treatment plant.

3.3.2.5 Wood Coupons

Study personnel from RTI were responsible for acquiring and shipping untreated and recently treated lumber, and aged boards to the RTI testing facility. All lumber/boards were sectioned into approximately three-foot long coupons at the testing facility. All reasonable precautions were taken to

avoid any cross-contamination during the cutting process. Also, safety precautions were taken. Based on the calculated number of hand rinsate samples needed (discussed above in Section 3.1), at least 30, three-foot long coupons were prepared for each wood type and the same coupon were sampled (in different places) in accordance with the hand and wipe sampling procedures. Table 3-2 (below) contains a summary of the different wood types and the approximate number of coupons, and the number of hand and wipe samples collected in the full study.

3.4 Documentation and Sample Custody

The study design called for careful documentation of all field and laboratory activities. In addition, all appropriate quality control/quality assurance activities were performed. Details of these activities may be found in the Protocol (Gradient, 2003) and the Quality Assurance Project Plan (RTI, 2003a).

3.4.1 Field Procedures

A log form was used to record all sampling events, field observations or other information pertinent to the field effort. All samples (including wood coupons and wipes) were adequately marked for identification from the time of procurement, collection, and packaging through shipping and storage (as necessary). All samples collected by the sampling team were properly identified with a barcode label. Sample identification and information is traceable to the database or associated forms through this label. Details are presented Section 4.3 of the Protocol (Gradient, 2003), and in Section 5.0 of this report.

Specially-designed preformatted Chain of Custody (COC) forms were used as the primary documentation mechanism to ensure that information pertaining to each sample was recorded. Initially, COC began at the point of origin of the wood (*i.e.*, locations where untreated and recently treated lumber, and aged wood were procured). Documentation of the sample COC is provided through the use of COC forms that recorded the sampling location, the type and amount of samples collected, requested analyses, the date and time of sample collection, the name(s) of the person(s) responsible for sample collection, the date and time of all custody transfers, the signature of the person relinquishing and accepting sample custody, and other pertinent information. One COC form accompanied each sample shipment. The COC form was filled out by field personnel at the time of sampling. The original was shipped with the samples to RTI. The second part of the form was retained by the field personnel for the project files.

Table 3-2. Summary of Wood Types and Approximate Number of Coupons and Hand & Wipe Samples

Wood Type	~ Number of Coupons for Hand and Wipe Sampling	~ Number of Hand and Wipe Samples
Untreated SYP from two suppliers	30	60
Recently treated SYP from two different suppliers in the North and South	120	240
Aged CCA-preserved SYP*		
One year old wood from two regions	300	600
5+ year old wood from two regions	300	600
**Total:	750	1,500

Notes:
*Five structures per age group per region (*i.e.*, five, one year old structures in the North and South and five, five plus year old structures in the North and South.
**Does not include the additional hand and wipe samples collected for QA/QC purposes.

The sampling team was be responsible for the maintenance and custody of any samples collected until those samples were delivered to the laboratory. After sample collection, block wipe samples were must maintained at 4°C and hand-carried to the laboratory. A laboratory sample request form was used to ask for sample analysis and was prepared to indicate the required analysis for the samples. When the laboratory receives the box or cooler containing the samples, the laboratory inspected the container, ensured the specified number and type of samples are present, sign and date the COC form, and documented the condition of the container and the samples on the COC form.

3.4.2 Laboratory Procedures

Upon receipt in the laboratory, the sample custodian or representative unpacked or repacked containers, compared the container contents with the COC record, and signed and dated the record. Upon sample receipt, the sample custodian or designee:

- Examined all samples and determined if proper temperature had been maintained during shipment.
- Checked for damage or possible contamination of the samples.
- Compared samples received against those listed on the COC/request for analysis form.
- Signed and dated the COC form.
- Placed the samples in a refrigerated, locked laboratory storage room.
- Logged the samples into a computerized information management system at the time of sample preparation.

The project director inspected all paperwork and, if all was in order, directed the laboratory sections to retrieve the samples from refrigerated storage and to begin analysis. Sample COC was maintained throughout the laboratory processing/analysis steps.

3.4.3 Record Retention

All records, study documentation, and raw data pertaining to this study will be retained at RTI for a minimum of 15 years following the date on which the results of the study were submitted to the USEPA. Laboratory samples (e.g., wipe digests and hand rinsates) and wood types will be retained at RTI for at least 2 years unless a longer period is required by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

3.5 Hand Sampling

All appropriate materials for the hand sampling were acquired and were made available in the laboratory. A detailed list of materials is provided in Section 4.4 of the Study Protocol (Gradient, 2003).

The following sub-sections give the procedures that were used during training and performance of volunteers in the main study hand sampling. Refer to RTI SOP No. CCA-040, "Standard Operating Procedures for Acquiring CCA-Treated Deck Board Hand Rinse and Wipe Samples" (RTI, 2003e).

3.5.1 Procedure

Please note that there will be no eating, drinking or smoking by study volunteers or staff during the sampling procedure and all study volunteers and staff will thoroughly wash their hands with pure soap and warm water before beginning training, after each sequence of coupon hand sampling, and after completing the sampling procedure. A blank hand rinse sample and a blank hand wipe sample will be collected from each volunteer after he/she has washed the hands, and prior to sampling any coupons.

1. Both hands of each adult volunteer are traced on sheets of plain white paper to determine the approximate surface area (cm^2) of the palmar-side of each hand (the hand surface area potentially available for contact with the wood surface). Each volunteer is assigned a code and the hand measurements for each volunteer are recorded by this code.
2. The sample area for each coupon (test and control) is measured to approximately 500 cm^2 and demarcated with tape. The sample area will not include the edges or underside of the coupon (for aged coupons this is the side not exposed to weathering).
3. Each coupon to be sampled will be securely clamped to a lab bench or table to prevent movement during the sampling event. Hand and block-wipe sampling of the same coupon will be performed separately.
4. With an approximate 1.1 kg weight attached to the back of her/his hand, the volunteer, will practice rubbing an untreated sample coupon to develop a feel for how to rub a coupon while maintaining consistent pressure. After practicing the sampling technique with each hand (separately), the volunteer will wash both hands with soap and warm water and dry her/his hands using a clean paper towel. The volunteer will gently squeeze a large sponge that has been wetted with a 0.9% saline solution. If the hand is too wet, the volunteer will remove the excess moisture by lightly blotting her/his hand on a laboratory paper towel. The volunteer will rub the coupon with her/his hand, palm side down, fingers together, with a consistent pressure, straight forward and back 10 times

within the marked sample area (for a total of 20 passes), and then lift the hand off the board.

5. Study personnel wearing new, powder-free gloves will remove any visible particles of wood from a volunteer's hand with clean tweezers.[1] The volunteer's hand is rinsed with 4 individual 30 mL aliquots of deionized water (for a total of approximately 120 mL). Each 30 mL aliquot is placed in a 2-quart, glass, baking dish. The volunteer gently pushes her/his hand up and down in the water and then rubs her/his fingers against one another and the palm to facilitate removal of residue from the hand. After repeating these steps several times, using the same 30 mL of deionized water, the rinsate is then transferred to a pre-labeled, 250 mL polyethylene sample bottle using a clean 100 mL polyethylene funnel. An additional 20 mL of the deionized water is used for a final rinse of the baking dish. This 20 mL is added to the sample bottle for a total of 140 mL.

6. Following the last rinse, the handler will use a saline-wetted Alpha Wipe to firmly wipe the palmer side of the hand, including wiping between the fingers. The wipe will be placed in a 50 mL screw-capped tube for analysis.

7. After washing her/his hands again, the volunteer uses her/his other hand to sample a new coupon as described in Step 4 and a second, unique hand rinsate and wipe sample is collected. A new coupon is used for each sampling event. The coupon is then taken to another area of the laboratory for collection of a block wipe sample from the opposite end of the coupon.

8. 10 mL aliquots are randomly collected from 20% of the hand rinsate samples collected from each of the four recently-treated wood supplies, and from each of the 20 decks in the study. Each 10 mL aliquot is placed into a 15 mL screw cap centrifuge tube for Cr (VI) analysis. Study personnel will label each 15 mL centrifuge tube with the appropriate barcode. These samples must be stabilized to pH 9.0 – 9.5 on the day of hand rinse collection, kept refrigerated, and analyzed within 24 hours; therefore, selection of samples collected in the early morning or late afternoon is recommended so that the laboratory will have enough time to prepare and analyze the Cr (VI) samples within the stipulated holding time. The remainder of the hand rinsate sample is then preserved by adding nitric acid and is used for total copper, chromium, and arsenic analyses.

3.5.2 Handling of Hand Rinsate and Hand Wipe Samples

Following removal of the 10 mL Cr (VI) aliquot sample, the remainder of each hand rinsate sample will be preserved with nitric acid to a pH < 2.0. This sample will be placed in a walk-in cooler dedicated to sample storage and kept at 4ºC ± 2ºC until laboratory analysis for total metals. The hand wipe samples will be placed in a cooler dedicated to sample storage and kept at 4 ºC ± 2 ºC until laboratory analysis.

Immediately after the unpreserved 10 mL Cr (VI) analysis aliquot sample is removed from the hand rinsate sample bottle, this aliquot will be adjusted to a pH of 9-9.5 using a solution of 0.01 N sodium hydroxide. These samples will be placed in a refrigerator and kept at 4ºC ± 2 ºC until laboratory analysis. These samples will then undergo Cr (VI) analysis within 24 hours after the hand rinse samples were collected.

[1] This does not include splinters, which will be removed using disposable tweezers and the puncture site thoroughly cleaned with antiseptic by on-site medical personnel to prevent infection.

3.5.3 Quality Control for Laboratory Hand Sampling

Two types of hand rinsate and wipe blanks will be collected at a frequency of 5%. The materials blank for total copper, chromium, and arsenic analysis will consist of 100 mL of deionized water in a 100 mL sample bottle stabilized with nitric acid. A blank wipe will also be used. The second type of blank samples, a process blank in which the hand is rinsed and wiped but does not rub a coupon beforehand, will be taken at three points in each volunteer's daily hand sampling. First, after the volunteer has washed his hands thoroughly but before any boards are touched; second, half-way through the coupon sampling; and third, at the end when all coupons have been hand-sampled. The blank for Cr (VI) analysis will consist of 10 mL of deionized water in a 15 mL plastic centrifuge tube, adjusted to pH 9.0-9.5 with 0.01 N sodium hydroxide solution. Where applicable, rinsate solutions spiked with standard solution or standard wood flour will also be prepared at a frequency of 5%. All hand rinsate and wipe blanks and spikes will be placed in a refrigerator and kept cold until laboratory analysis.

3.5.4 Laboratory Quality Control

Laboratory quality control samples will include matrix spikes, matrix duplicates, laboratory control samples, interference check samples, initial and continuing calibration samples/blanks, and method blanks for ICP-MS; and matrix spikes, matrix duplicates, laboratory control samples, initial and continuing calibration samples/blanks, and method blanks for Cr (VI) analysis.

3.6 Block Wipe Sampling

All appropriate materials for the block wipe sampling were acquired and were available for field or laboratory use. A detailed list is provided in Section 4.7 of the Full Study Protocol (Gradient, 2003). Wipe samples will be collected both in the field (*i.e.*, at the point of origin of the different wood types) and at RTI's testing facility. The following sub-sections give the procedures that were used for the field and laboratory block wipe sampling.

3.6.1 Procedure

Please note that there will be no eating, drinking or smoking by study personnel during the sampling procedure and all study personnel will thoroughly wash their hands with soap and water after completing the sampling procedure.

1. All wipe sampling will be conducted by trained study personnel only. Clean, powder-free gloves will be worn during the sampling procedure. New gloves are used for each series of wipe samples.
2. Once one end of a coupon is sampled in the hand sampling portion of the study; the coupon's other end is then sampled using the steel block and attached wipe. Study personnel must be careful that only the non-sampled portion of the coupon is used for wipe sampling. A new coupon is used for each wipe sample. A 1.5 by 40 cm (500 cm^2) sampling area is measured and demarcated with tape on each coupon.
3. Each coupon to be sampled is securely clamped to a table to prevent movement during the sampling event.
4. An 11.4 x 11.4 cm piece of polyester wipe is cut and weighed (this step can be done prior to the sampling day). Each cut cloth weighs about 1.9 grams. Each cloth is moistened to double its original weight with a 0.9% saline solution (total weight of moistened cloth is about 3.8 grams); wipes will be damp but not dripping.

5. The sampling block and rubberized attachment are covered entirely with Parafilm. Then the rubberized sampling area of the sample block is covered again with a clean piece of Parafilm® to prevent contamination of the block. The wet wipe is stretched smoothly over the Parafilm® and secured to the block with a square collar of stiff plastic such as Teflon.
6. The wipe-covered block is placed at one end of the marked sample area and pulled by a string back and forth 5 times (for a total of 10 passes) before being rotated 90 degrees for another set of back and forth wipes across the sample area for a total of 20 passes over each coupon. The polyester wipe is removed from the block. Any visible pieces of wood are removed from the wipe using disposable tweezers. The used wipe is placed in a labeled screw cap test tube or 50 mL plastic centrifuge tube and the tube is capped and labeled with a barcode by study personnel.
7. Each sample tube is packed in ice or refrigerated until laboratory analysis. A fresh sheet of Parafilm® is installed whenever the sampling wipe is removal and another wipe is installed.

3.6.2 Handling of Block Wipe Samples

In accordance with the CPSC (2001) protocol, nitric acid preservative will not be added to the wipe samples immediately after collection. Each wipe sample will be contained in a 50 mL polyethylene bottle or polypropylene centrifuge tube and will be packed in ice or otherwise kept cold until laboratory analysis. All wipe samples will be submitted for total copper, chromium, and arsenic analysis.

3.6.3 Quality Control for Laboratory Wipe Sampling

Laboratory wipe sample blanks will be collected at a frequency of 5%. Wipe sample blanks will consist of an unused wipe in a 50 mL plastic centrifuge tube. Laboratory sampling spikes will also be prepared at a frequency of 5%. All laboratory wipe sampling blanks and spikes will be kept cold (4ºC ± 2ºC) until laboratory analysis.

3.6.4 Laboratory Quality Control

Laboratory quality control samples will include matrix spikes, matrix duplicates, laboratory control samples, interference check samples, initial and continuing calibration samples/blanks, and method blanks for ICP-AES and will be analyzed as stipulated by the respective analytical methods.

3.7 Laboratory Analysis of Hand and Wipe Samples

All hand rinsate and wipe samples will be analyzed for total chromium, copper and arsenic. Also, approximately 20% of the hand rinsate samples collected from the recently-treated and aged wood types will be analyzed for Cr (VI).

The following sub-sections give the procedures that were used for the laboratory analyses of the metals.

3.7.1 Total Chromium, Copper, and Arsenic Analysis of Hand Rinsate Samples

Hand rinsate samples will be preserved at RTI with nitric acid (HNO_3) to a pH of ≤ 2 prior to laboratory analysis. The samples will be prepared for total copper, chromium, and arsenic analysis following RTI SOP EG-281, "Extraction of Arsenic, Chromium, and Copper from Hand Rinse Samples

and Subsequent Measurement by ICP-MS," which is based on USEPA SW846 Method 3010, *Acid Digestion of Aqueous Samples and Extracts for Total Metals by FLAA or ICP Spectroscopy.* Twenty-five mL of the well-mixed hand rinse sample are pipetted into a 50 mL polypropylene centrifuge tube. Two and one-half (2.5) mL of HNO_3, and two (2) mL of 30% H_2O_2 are added to the sample. The centrifuge tube with sample aliquot, acid, and hydrogen peroxide is then placed in a digestion block and heated at 95°C for 30 minutes. The digests are then allowed to cool and diluted to volume with deionized water. Following sample preparation, the samples will be analyzed for total arsenic, chromium, and copper using USEPA SW846 Method 6020, *Inductively Coupled Plasma-Mass Spectrometry* (ICP-MS) to achieve the lowest possible detection limits. Refer to RTI SOP EG-281 (RTI, 2003g).

A method detection limit (MDL) of at least 1 µg/ (or 0.28 µg/hand) must be achieved for these metals. Method 6020 (ICP–MS) is the method of choice to achieve these low detection limits.

3.7.2 Cr (VI) Analysis of Hand Rinsate Samples

The hand rinsate samples designated for Cr (VI) analysis will be preserved with sodium hydroxide solution and stored at approximately 4°C until laboratory analysis. It should be noted that the analysis holding time is 24 hours from sampling time. Therefore, late afternoon or early morning sampling is recommended so that the laboratory will have sufficient time to prepare and analyze the samples within the stipulated holding time. The samples will be analyzed for Cr(VI) following RTI SOP EG-803, "Hexavalent Chromium (CrVI) Analysis using the Metrohm-Peak Ion Chromatographic System" (RTI, 2003i), which is based on SW846 Method 7199, *Determination of Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography*. A minimum detection limit of 2 µg/L is required for this analysis**.** Based on the results of the pilot studies, the MDL for the Cr (VI) analysis is 0.25 µg/L, equivalent to 0.036 µg/hand rinse.

3.7.3 Total Chromium, Copper, and Arsenic Analysis of Block and Hand Wipe Samples

Wipe samples will be stored at 4°C and will be prepared in accordance with CPSC (2001) methodology using acid extraction. Each wipe will be placed in a 50 mL plastic centrifuge tube and 25 mL of 10% nitric acid will be added. The combination will be heated in a shaker water bath at 60 ºC for 12 hours minimum. Refer to RTI SOP EG-280, "Extraction of Arsenic, Chromium and Copper from Hand Wipe Samples for Subsequent Measurement by ICP/MS" and RTI SOP-282, "Extraction of Arsenic, Chromium and Copper from Block Wipe Samples for Subsequent Measurement by ICP/AES" (RTI, 2003f and 2003h). The wipe sample extracts will then be analyzed for total arsenic, chromium, and copper using USEPA SW846 Method 6010 (for blank wipes) and Method 6020 (for hand wipes) to achieve the lowest possible detection limits. The laboratory's MDLs, IDLs, and method and analysis SOPs will be thoroughly reviewed to ensure that all data quality objectives will be met for wipe sample analysis. In pilot studies, RTI determined MDLs for block wipe samples to be 20 µg/L for chromium and copper and 100 µg/L for arsenic. The results will be reported as metal in µg per wipe with a detection limit of 0.96 µg/wipe for chromium and copper and 4.8 µg/wipe for arsenic in the block wipe digests. Hand wipe detection limits will be reported as metal in µg per wipe with detection limits of 0.048 µg/wipe for each metal. Additional details regarding the preparation and analysis of the wipe samples are presented in RTI's SOP EG-280 (RTI, 2003f) and SOP EG-281 (RTI, 2003g).

3.8 Data Analysis and Presentation

Complete laboratory data packages of hand and block wipe sample results for total chromium, copper, and arsenic and Cr (VI) (hand rinse only) will be submitted to the Study Coordinator. These data

will be in the form of Excel spreadsheets and will be linked to information regarding deck identification, volunteer identification, sampling date, hand area, etc.

RTI will perform statistical analysis of the laboratory results for each of the hand and block wipe datasets. A data set is defined as the data from testing of samples collected for each of the wood types (*e.g.*, recently treated, 1-year, and 5+ -year aged CCA-preserved SYP) evaluated in the study. Hand and block wipe loadings for total copper, chromium, and arsenic, expressed as $\mu g/cm^2$, will be calculated for each dataset based on the mass (μg) of each reported metal and the surface area (cm^2) of either the block wipe, the area sampled, or the measured volunteer hand size, depending on the sampling method and approach used.

The statistical analysis will include: a calculation of summary statistics for each deck in the mini- and full studies, including mean wipe block and hand values, standard deviations for these values, and minimum and maximum values; calculation of overall means for block wipe and hand samples for the mini- and full study; the distribution of block wipe values, hand sample values, and transfer reduction factors for the combination of the mini-study and the full study data, both in the non-log and log form; and Pearson and Spearman correlation analyses for the combination of the mini-study and the full study. The difference between dislodgeable metal loadings between hands and block wipe for each coupon will be used to calculate a TRF for each wood type. A TRF value will be calculated for each volunteer for each coupon; the area used to determine $\mu g/cm^2$ will be the actual outlined area of the volunteer's hand as measured at the time of testing.

The mean wood surface loading of total metals, based on both the hand and block wipe sample results, will be compared across several wood age categories using a mixed effects model. This comparison will be used to calculate the change (*e.g.*, reduction) in the amount of total dislodgeable metals due to aging, and whether this change is statistically significant given the power of the comparison.

The results of these analyses will be presented in tables and graphs. The raw data and data separated by type of test will be available in spreadsheet format.

3.9 Key Personnel and Responsibilities

Project Director *– Dr. William F. Gutknecht, RTI International*

Project Manager *– Dr. W. Cary Eaton, RTI International*
Review and comment on study protocol, implement and execute study, perform sample analysis, perform QA/QC, and summarize results.

Study Coordinator - *Dr. Has Shah, American Chemistry Council.*
Monitor implementation of the pilot and full study protocols.

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

RTI's internal Quality Assurance (QA) effort encompassed all aspects of the study, including

- preparation of documentation,
- field activities,
- sampling of coupons by participants,
- preparation of samples for analysis,
- sample analysis, and
- data generation and interpretation.

Details on these activities are provided in the QAPP ("Quality Assurance Project Plan: Assessment of Exposure to Metals In CCA Preserved Wood" RTI, 2003a). A QA officer who was independent of data generation was assigned to the project. The QA officer participated in weekly project meetings to maintain an awareness of progress and problems encountered. The QA officer also routinely observed project activities, both to assess compliance with procedures and the relevant good laboratory practices (GLPs) and to maintain technical staff's awareness of QA. The QA officer helped assemble and reviewed all project documentation, including the protocol, Standard Operating Procedures (SOPs), and QAPP, and also reviewed all analytical data sets.

As described below, the QA officer audited field activities, including field measurements in Gainesville, FL, on March 17, 2003, when Deck S was removed. She observed participant activities starting on April 14, 2003, sample preparation on April 15, 2003, and sample analysis on April 22, 2003. All activities performed were found to be in compliance with study SOPs.

4.1 Summary of Field Audit

During the audit of field activities on March 17, 2003, the QA officer observed that careful notes, including sketches of the site, were entered into a dedicated laboratory notebook and on paper forms. Prompts for information, similar to a data collection form, were written in the notebook prior to arrival at the site to ensure that all necessary information was collected in an efficient manner. Bar code labels were stapled to the boards to ensure that they adhered to the wood, even when damp. Field supplies were arranged in the rented truck to allow easy access to them during sampling. Field sampling (percent moisture content, ambient temperature, and relative humidity) and block wipe sampling were carried out as stated in the SOPs. Loading boards onto the rack in the truck was observed and corresponded to the SOP for transport (RTI 2003b). As a measure of field QA, field spikes and blanks were prepared for evaluation. The results of field spikes and blanks are provided in Chapter 8.

4.2 Sample Preparation and Laboratory QA

The RTI project leader observed preparation of coupons from the deck boards and storage of the wood in RTI's warehouse. QC procedures for this part of the project included steps to control contamination and ensure careful tracking of the samples. These included:

- gloves worn during all steps
- temperature and humidity control of the warehouse
- boards separated in a rack with plastic sheeting placed between each shelf and also covering the entire stack
- vacuuming during sawing to prepare coupons
- cleaning of the sawing area and the saw blade between cutting of each deck's boards

- prompt attachment of barcode labels to coupons
- coupons stacked and transported with spacers between them

During hand sampling of coupons by participants, several quality control (QC) measures were incorporated into the activities to ensure that critical study information, such as which coupon and participant were associated with a sample, were entered into the database correctly. For example, a 24-step "summary of operator activities," summarizing the SOP, was posted by the data entry computers as a reminder to the operators of the key steps in the procedure such as scanning the barcodes for the coupons and checking the video camera. Stacks of coupons, separated by small wooden spacers, were prepared ahead of time for each participant to ensure that each participant sampled a board from each of the possible sources to be tested (all decks, recently treated lumber, and untreated lumber). Forms and sample bottles were also arranged ahead of time to allow for greater efficiency and organization during sample collection. Checks performed at the end of each sampling day ensured that all samples were accounted for.

Experienced operators, who had worked with participants during the pilot studies and mini study, trained the additional operators needed for the full study. The operators explained the procedures to the participants, observed the new operators practice procedures before they assisted volunteers in sampling deck coupons, and worked with the new operators during the entire sampling period. Bar code labels were used for tracking coupons and samples. Their use made the system both more efficient than typing or writing sample numbers and reduced problems with typographical errors. The barcodes for coupons, boards, and samples were entered directly into the database with a barcode reader to facilitate tracking. All transfers of the samples were tracked in the database as well as on chain-of-custody paperwork. Samples were stored in a locked cold room inside a locked building.

Each participant's hand size was determined using PhotoShop software to count pixels from electronically scanned hand outlines. This analysis was performed to determine participant hand size for use in normalization of results. The scanning results were checked by cutting out the paper hand outlines and weighing them against paper of known area. Agreement was generally within 5%, indicating excellent accuracy and precision of the area determination method.

As requested by the client, a nurse was on-site during coupon sampling by participants in the full study. The nurse maintained notes on all splinters removed. The notes include a sketch of the hand, a description of the injury, and the participant identification number.

QC for sample preparation began with checks of the balance calibration before weighing of the wood flour used for spiking. An antistatic device was used with the wood flour. A summary of the main sample preparation steps of the SOP was posted in the laboratory, and all analytical laboratory SOPs were also available in the laboratory. Some of the laboratory QC provided information on sample preparation; for instance, blanks would detect contamination problems from sample preparation procedures.

4.3 Analysis QC

QC results for the laboratory analyses are described in the following paragraphs. Table 4-1 presents the analytical QC acceptance criteria. Numerous QC samples were analyzed during this study. For example, internal standards were analyzed in conjunction with all ICP-MS sample analyses in order to ascertain potential matrix effects. Based on RTI's review of the data , little to no interferences were noted that would affect quantitation of the sample results reported. Calibration curves were established each day, at the beginning of the run. An independently prepared initial calibration verification (ICV) standard was analyzed after the calibration curve was established. Triplicate readings were taken of all samples, calibration standards, and QC samples.

Following sample analysis, a systematic data review was performed that included comparison of all QC results with the acceptance criteria presented in Table 4-1 and set forth in the QAPP. The QA officer was one of several data reviewers involved in this data evaluation process. The QA officer also followed up with analysis staff if QC exceedances occurred, unusually high numbers were reported, or other analytical issues requiring additional review arose. Occasionally, study samples were reanalyzed to follow up on obvious problems, when feasible. For example, several wipe sample extracts were reanalyzed to confirm the initial results, but this type of sample could not be taken through the sample preparation step again because the cloth wipe had already been extracted.

Based on RTI's review of all study QC data (*i.e.*, wipe samples, hand rinsates, block wipes), all sample results were considered usable for study objectives. No sample results were excluded due to QC exceedances or other issues.

Table 4-1. Analytical QC Requirements

QC sample	QC Parameter	Acceptance Criteria	Frequency per Samples	Comments
Overall Method Quality Control				
Wipe Sampling				
Matrix Spike High Medium Low	Accuracy	70% - 120% Recovery	2 at each level per 100 samples	
Reference Material	Accuracy	70% - 120% Recovery	Every 20	Wood Flour Spike
Blank Wipe	Reagent Contamination	<Method Detection Limit (MDL)	Every 20	
Hand Rinsate Sampling				
Matrix Spike High Medium Low	Accuracy	70% - 120% Recovery	2 at each level per 100 samples	
Rinsate Duplicate	Precision – Entire Analytical Process	+/- 20% RPD	Every 20	
Rinsate Spike	Accuracy - Entire Analytical Process	70% - 120% Recovery	Every 20	.
Blank rinsate	Process Contamination	<MDL	Every 20	
Measurement Quality Control Samples				
ICB, CCB (ICP- AES, MS, Cr +6)	Calibration Blank Check Blank & Continuing Intercept check	<MDL	ICB follows initial calibration; CCB every 10	ICP/MS Measurement Contamination Check
CCV (ICP- AES)	Initial & Continuing Calibration slope check	90% - 110% of expected value	CCV every 10	
CCV (ICP-MS, Cr+6)	Initial & Continuing Calibration slope check	85% - 115% of expected value	CCV every 10	
ICV (ICP-MS, AES, Cr+6)	Slope Check	90% - 110% of expected value	ICV follows calibration	Different source than for Calibration Standard
ICSA (ICP- AES, MS)	Check Spectral Interference Correction	<MDL	Each run	
ICSAB (ICP- AES, MS)	Accuracy of Interference Correction	80% - 120% of expected value for As, Cr, Cu	Each run	

4.3.1 Preparation Blanks

Several types of laboratory blanks (method/preparation blanks, continuing calibration blanks) were analyzed in order to evaluate contamination derived from sample preparation and/or laboratory analysis. The summary results of preparation blank analyses by the ICP-MS are presented in Table 4-2; detailed results are presented in Appendix E. No metals of interest were detected in the blanks for hexavalent chromium or the samples analyzed by ICP-AES. Copper was detected in some of the blanks analyzed by ICP-MS, as shown in the table. A number of potential sources of copper have been considered, including metal fittings and pipes in some of the laboratories, copper on hands from jewelry or coins, and copper on skin from lotions and other skin care products. Unfortunately, the source of the copper has not yet been determined. From a risk assessment perspective, copper is, of course, of less concern than arsenic or chromium, but the laboratory will continue to consider potential sources. Chromium was detected in two of the blank samples analyzed by ICP-MS; the source of the chromium has not been determined. The levels of chromium and copper detected in the blank samples were sufficiently low to have no impact on study results.

Table 4-2. Summary Results of Preparation Blank Analysis for ICP-MS (μg/L)

	As	Cr	Cu
Min	Below detection limit (bdl)	0.08	0.05
Max	Bdl	0.10	0.15

4.3.2 Wood Flour Spikes

Wood flour spike samples (blank spikes) were prepared by adding known weights of wood flour derived from CCA-treated wood to blank matrix. The CCA Task Force provided RTI with the wood flour, which was derived from 0.40 pcf treated lumber prepared and chemically characterized by Arch Wood Protection, Inc. Comparison of the recoveries of the wood flour spikes to the known concentrations allowed evaluation of the overall accuracy of the preparation and analytical methods. The summary results of these analyses are presented in Tables 4-3 and 4-4; detailed results are presented in Appendix E. The acceptance criteria range for wood flour spike recovery was 70% to 120%. For ICP-MS, the results for the wood flour spikes varied from 71.8% to 112.9%, with a mean of 91.0% recovery for arsenic; 69.2% to 110.7%, with a mean of 91.3% recovery for chromium; and 77.4% to 120.1% with a mean of 100.7% recovery for copper. For ICP-AES, the wood flour spike recoveries varied from 60.2% to 109.9%, with a mean of 90.4% recovery for arsenic; 56.0% to 114.4%, with a mean of 94.9% recovery for chromium; and 71.5% to 132.1% with a mean of 109.5% recovery for copper. Wood flour spikes were not prepared for hexavalent chromium analyses. Generally, wood flour spike results met defined recovery criteria. Exceedances of recovery criteria were few and were likely due to difficulties in attaining a homogenous spike due to the consistency of the wood flour provided, rather than to analytical problems; the exceedances are not expected to affect the reported sample results.

Table 4-3. Summary of % Recoveries of Wood Flour Spikes for ICP-MS

	As	Cr	Cu
Min	71.8%	69.2%	77.4%
Max	112.9%	110.7%	120.1%
Mean	91.0%	91.3%	100.7%
Std dev	0.06	0.07	0.09
RSD	6.6%	7.7%	9.0%

Table 4-4. Summary of % Recoveries of Wood Flour Spikes for ICP-AES

	As	Cr	Cu
Min	60.2%	56.0%	71.5%
Max	109.9%	114.4%	132.1%
Mean	90.4%	94.9%	109.5%
Std dev	0.095	0.119	0.126
RSD	10.6%	12.6%	11.5%

4.3.3 Matrix Spikes

Matrix spikes were prepared and analyzed at three levels (high, medium, and low) by spiking the appropriate matrix (blank wipe for block and hand wipe samples, aliquot of DI water for hand rinse samples) with known concentrations of a liquid spiking solution containing the analytes of interest. The matrix spikes were analyzed as indicators of accuracy and allowed RTI to evaluate the potential effect of matrix interferences on sample quantitation. The acceptance criteria range for matrix spike recovery was 70% to 120%. The summary results of the matrix spikes are presented in Tables 4-5 through 4-10. Detailed results are presented in Appendix E. Matrix spikes were not analyzed for hexavalent chromium. For the ICP-AES samples, the averages of the recoveries for the high spikes were 104.0% for arsenic, 102.2% for chromium, and 105.1% for copper; for the medium spikes, the averages were 100.3% for arsenic, 101.5% for chromium, and 105.1% for copper; and, for the low spikes, the averages were 90.2% for arsenic, 92.4% for chromium, and 98.4% for copper. For the ICP-MS samples, the averages of the recoveries for the high spikes were 96.5% for arsenic, 93.5% for chromium, and 94.5% for copper; for the medium spikes, the averages were 97.3% for arsenic, 94.8% for chromium, and 91.5% for copper; and, for the low spikes, the averages were 102.1% for arsenic, 98.2% for chromium, and 101.6% for copper. Because more than 9.3% of ICP-AES and more than 99%j of ICP-MS matrix spike samples met recovery criteria, there is little evidence of analytical bias that would affect the associated samples.

Table 4-5. Summary Results of High Spikes for ICP-AES

	As	Cr	Cu
Min	62.8%	79.4%	51.4%
Max	186.1%	143.4%	164.2%
Mean	104.0%	102.2%	105.1%
Std dev	0.250	0.155	0.211
RSD	24.1%	15.2%	20.1%

Table 4-6. Summary Results of Medium Spikes for ICP-AES

	As	Cr	Cu
Min	80.7%	81.3%	89.8%
Max	129.4%	127.3%	128.9%
Mean	100.3%	101.5%	105.1%
Std dev	0.117	0.110	0.110
RSD	11.7%	10.9%	10.5%

Table 4-7. Summary Results of Low Spikes for ICP-AES

	As	Cr	Cu
Min	57.0%	68.1%	71.8%
Max	121.9%	120.1%	127.0%
Mean	90.2%	92.4%	98.4%
Std dev	0.192	0.158	0.165
RSD	21.3%	17.1%	16.8%

Table 4-8. Summary Results of High Spikes for ICP-MS

	As	Cr	Cu
Min	68.7%	73.0%	71.9%
Max	107.6%	110.9%	109.2%
Mean	96.5%	93.5%	94.5%
Std dev	0.07	0.07	0.07
RSD	7.2%	7.5%	7.8%

Table 4-9. Summary Results of Medium Spikes for ICP-MS

	As	Cr	Cu
Min	78.3%	83.9%	81.1%
Max	111.6%	107.7%	113.1%
Mean	97.3%	94.8%	95.1%
Std dev	0.06	0.06	0.08
RSD	6.5%	6.1%	8.2%

Table 4-10. Summary Results of Low Spikes for ICP-MS

	As	Cr	Cu
Min	88.3%	85.1%	81.6%
Max	117.6%	112.4%	128.3%
Mean	102.1%	98.2%	101.6%
Std dev	0.08	0.08	0.11
RSD	8.0%	8.1%	11.2%

4.3.4 Rinsate Sample Spikes

Rinsate sample spikes were prepared and analyzed in association with the hand rinse samples and the hexavalent chromium samples. The acceptance criteria range for the rinsate sample spikes was 70% to 120%. Summary results for the rinsate sample spikes are presented in Tables 4-11 and 4-12. Detailed results are presented in Appendix E. For the hexavalent chromium samples, rinsate sample spike recoveries ranged from 66.0% to 118.0%, with an average of 102.8% recovery. For the hand rinse samples, the average control spike recoveries were 95.1% for arsenic, 93.3% for chromium, and 95.4% for copper.

Table 4-11. Summary of % Recoveries of Spiked Samples for ICP-MS

	As	Cr	Cu
Min	45.3%	54.0%	81.7%
Max	103.5%	103.5%	115.0%
Mean	95.1%	93.3%	95.4%
Std dev	0.075	0.070	0.066
RSD	7.9%	7.5%	6.9%

Table 4-12. Summary of % Recoveries of Spiked Samples for Hexavalent Chromium

Min	66.0%
Max	118.0%
Mean	102.8%
Std dev	0.114
RSD	11.1%

4.3.5 Laboratory Duplicate Analyses

Duplicate samples were also analyzed for the hand rinse samples and the hexavalent chromium samples as an indicator of precision. The acceptance criterion for duplicates was ± 20% RPD. The results of the duplicate analyses are presented in Table 4-13. Detailed results are presented in Appendix E. Duplicates were analyzed for hexavalent chromium samples, but none of the samples analyzed in duplicate had detections of hexavalent chromium; therefore, precision could not be evaluated for these samples.

The averages of the relative percent differences between duplicate samples for the hand rinses were 4.5% for arsenic, 3.1% for chromium, and 0.8% for copper. As would be expected, some of the higher relative percent differences were from some of the lower concentration samples. For two of the results which had RPDs greater than 20%, including the 60.0% RPD, the concentrations of the samples were less than two times the detection limit. In general, precision criteria were met for these samples.

Table 4-13. Summary of Relative Percent Difference Results of Duplicate Analysis for ICP-MS

	As	Cr	Cu
Min	0.2%	0.0%	0.3%
Max	28.3%	60.0%	37.1%
Mean	6.7%	10.9%	7.3%
Std dev	0.06	0.11	0.09

4.3.6 Instrument Check Samples

Instrument check verification solutions, initial calibration verification (ICVs) and continuing calibration verification solutions (CCVs), were prepared and processed during the hexavalent chromium analyses. These samples were analyzed to ascertain whether the hexavalent chromium system was in control. The results of these samples are presented in Table 4-14. The recoveries for these samples ranged from 95.5% to 108%, with a mean of 101.2% recovery. Accuracy criteria were met and there was no evidence of bias expected to affect these results.

Table 4-14. Summary Results of Check Samples for Hexavalent Chromium

Min	95.5%
Max	108.0%
Mean	101.2%
Std dev	0.0309
RSD	3.1%

4.3.7 QC Analysis Summary

Some QC samples exceeded the acceptance criteria presented in Table 4-1 and the QAPP, however, the exceedances were very infrequent (see Appendix E) and, based on RTI's data review, were not expected to have any significant effect on the associated sample results. Any QC samples exceeding criteria were evaluated in conjunction with other QC results from the associated analytical run, such as the continuing intercept checks and continuing calibration checks, to determine if there were problems inherent to the analysis; no such problems were noted. Some QC and study samples were also reanalyzed in some instances to determine the source of the problem and procedural problems with preparation of the QC samples were identified as the reason for the exceedances. Based on the review of the QC results, all study samples were considered usable for data analysis.

5.0 DATABASE DEVELOPMENT

5.1 Purpose

Development of the CCA wood database incorporated several functional components including collection of deck boards and field measurements, cutting these boards into coupons, sampling of the coupons (hand rinse and wipe samples), laboratory analysis, and archiving of the sample materials. To manage and track the sample-related information for the CCA project, a relational database was designed.

5.2 Format and File Location

The CCA database was designed using Microsoft Access 2000 and Visual Basic for Applications (VBA) programming language. It resides on a file server inside RTI's firewall and is backed up nightly onto tape backup.

5.3 Database Structure

Figure 5-1 provides an overview of the CCA database structure and table relationships. Primary keys are displayed at the top of each table. Foreign keys and indices are indicated beside the field names in parentheses. Table 5-1 provides descriptions for each of these tables.

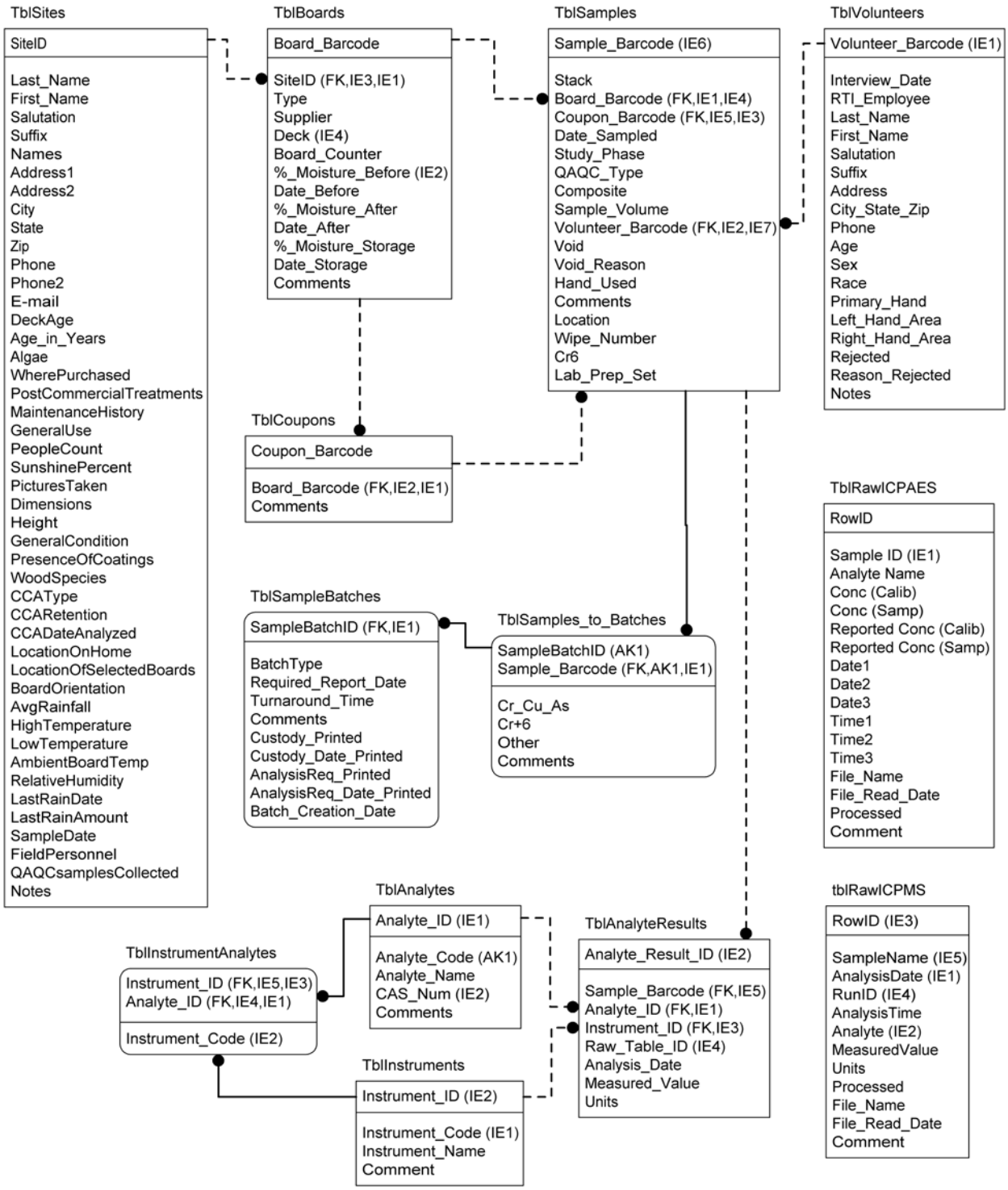


Figure 5-1. Database Diagram

Table 5-1. CCA Table Descriptions

Table Name	Description
TblSites	Site identification information (e.g., homeowner, address, deck age, wood species, treatments, maintenance history, general condition, dimensions, weather conditions)
TblBoards	Average board moisture content readings taken onsite, post-trip (3-4 days after placed in warehouse storage), and 1 month after sitting in storage.
TblCoupons	Relates coupons to the boards from which they were cut.
TblSamples	Contains data on wipe and hand rinse samples (e.g., sample date, sample type, sample volume, volunteer ID, hand used, void flag, void reason).
TblVolunteers	Information about volunteers used for hand samples (e.g., name, address, phone, primary hand, hand area, rejected flag, rejected reason).
TblSamples_to_Batches	Groups the samples into batches for submitting to the analytical laboratory. Indicates which analysis is requested for each sample in the batch. Hand rinse and wipe samples are batched separately.
TblSampleBatches	Contains information on sample batches, such as turn-around time for analysis, required report date, and flags for whether or not the custody forms and sample analysis request forms have been printed.
TblAnalytes	Contains the analyte name and abbreviation to be used in CCA reports.
TblInstruments	Contains information on laboratory instruments used to analyze CCA samples.
TblInstrumentAnalytes	Contains list of analyte codes used by ICP-MS and ICP-AES instruments. Relates the codes to CCA analyte names.
TblAnalyteResults	Contains the processed (adjusted for sample volume) analytical results for the CCA samples.
TblRawICPMS	Contains raw data as imported from ICP-MS electronic files.
TblRawICPAES	Contains raw data as imported from ICP-AES electronic files.

5.4 Sample Tracking with Barcodes

A system for labeling samples was developed to track and associate the various CCA sample types (explained further in Section 5.4.1). The labeling system:

- Creates unique identifiers for samples (used as key fields in database tables).
- Enables users to visually identify the sample type by the sample number prefix.
- Facilitates data entry via barcode readers wherever possible.
- Enables validation of appropriate sample types at the time of data entry using the sample number prefix.
- Enables validation of sample numbers (checks for transcription errors) at the time of data entry using check digits.

5.4.1 Label Types

There are seven types of barcode labels created for use in the CCA-treated wood project. They are printed with a laser printer on polyester labels, which are water resistant, tear resistant, durable and secure (e.g., Avery® Laser 5520). Table 5-2 summarizes each of these types and includes specifications for their use.

Table 5-2. Types and Specifications for Barcode Labels

Label Type	Prefix	Number of Digits	Example [1]	Label Use			
				1	2	3	4
Board	"B"	4	*B1284D*	Board	Site Custody Form	Coupon Custody Form	N/A
Field Wipe Sample	"F"	6	*F100404J*	Bottle	Board	Custody Form	Analysis Form [2]
Coupon	"C"	5	*C10251M*	Coupon	Custody Form	(Extra)	N/A
Volunteer	"V"	4	*V1001G*	Participant Check List	N/A	N/A	N/A
Hand Rinse Sample	"H"	6	*H100019S*	Hand Test Area	Sample Bottle	(Extra)	N/A
Hand Wipe Sample	"X"	6	*X100494J*	Sample Bottle	N/A	N/A	N/A
Lab Wipe Sample	"W"	6	*W100006K*	Wipe Test Area	Sample Bottle	(Extra)	N/A

[1] Asterisks mark either end of the sample number to identify the start and finish of the label for the barcode reader.
[2] Most labels are printed three-across per page. A fourth label was required for the field wipe samples and is printed separately. The field scientist must take care to match them correctly.

The first character, or prefix, of the sample number is used to identify the type of sample. For example, labels for hand rinse samples begin with "H" and labels for the testing lab wipe samples begin with "W".

The number of digits in the sample number was determined by the approximate number of samples anticipated for collection during the life of the project. For example, the board sample numbers contain four digits. This allows for sample numbers from 1001 to 9999 (or 8,999 samples). If the estimate was too low and more numbers are needed, another digit can be added to the sample number without problem. The last digit in each sample number is the check digit. A mathematical algorithm is used to generate the check digit and is also used to make sure that the sample numbers are entered correctly in the database. This algorithm is explained further below.

5.4.2 Check Digit Algorithm

The algorithm used to create and inversely check the CCA sample numbers is described below. This algorithm assumes that an input string has only characters 0-9 and A-Z (uppercase only). It also assumes that only an ASCII (or similar) character set is used.

a) Algorithm:

Each character is given a numeric value as follows (these are the <u>only</u> legal characters):

0 = 0	A = 10	K = 20	U = 30
1 = 1	B = 11	L = 21	V = 31
2 = 2	C = 12	M = 22	W = 32
3 = 3	D = 13	N = 23	X = 33
4 = 4	E = 14	O = 24	Y = 34
5 = 5	F = 15	P = 25	Z = 35
6 = 6	G = 16	Q = 26	
7 = 7	H = 17	R = 27	
8 = 8	I = 18	S = 28	
9 = 9	J = 19	T = 29	

b) Multiply each character's value by its position.

```
e.g.,   "A  1  2  3  X"     string
        10  1  2  3  33     value
         5  4  3  2   1     position
        ------------------
        50  4  6  6  33     product
```

c) Add the products.
e.g., 50 + 4 + 6 + 6 + 33 = 99

d) Take the 36 modulus.
e.g., 99 mod 36 = 27

e) The character with this value (e.g., 27 = "R") is referred to as the check digit, or checksum character.

f) The complete barcode label is composed of the original string plus the check digit (e.g., "A123X" + "R" = "A123XR").

5.5 Forms and Reports

The CCA database has several forms and reports designed around functional components of the database. Their purpose is to assist the users in data entry, generating custody and sample analysis request forms, importing laboratory data, and generating reports. All forms and reports are accessible through the Main Menu (see figure 5-2). Several of the forms are discussed and illustrated below.

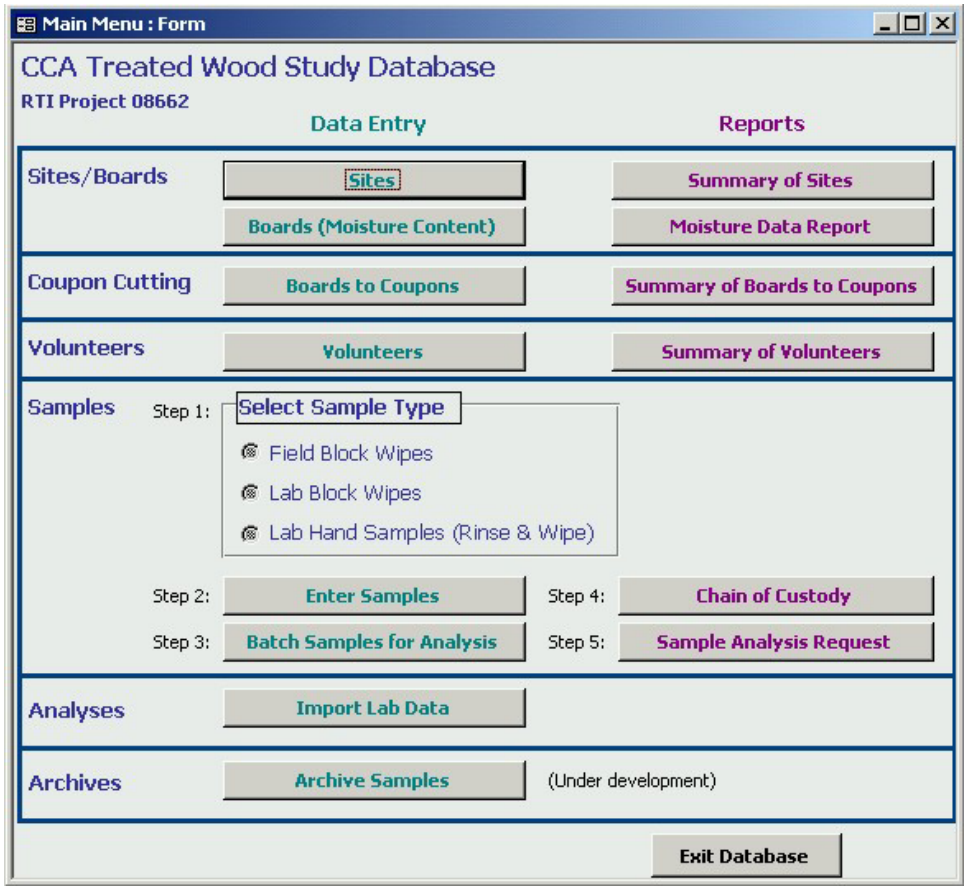


Figure 5-2. Main Menu

5.5.1 Site Data

Information about the deck board collection sites is stored in the table called TblSites. This includes, for example, contact information for the homeowner, street address, deck age, wood species, post commercial treatments, maintenance history, deck dimensions, deck orientation, average rainfall, and environmental conditions. Sites have been assigned alphabetic letters (e.g., “A”, “B”, “C”) to enable anonymity in reporting. Figure 5-3 provides an example of the form used for entering site data.

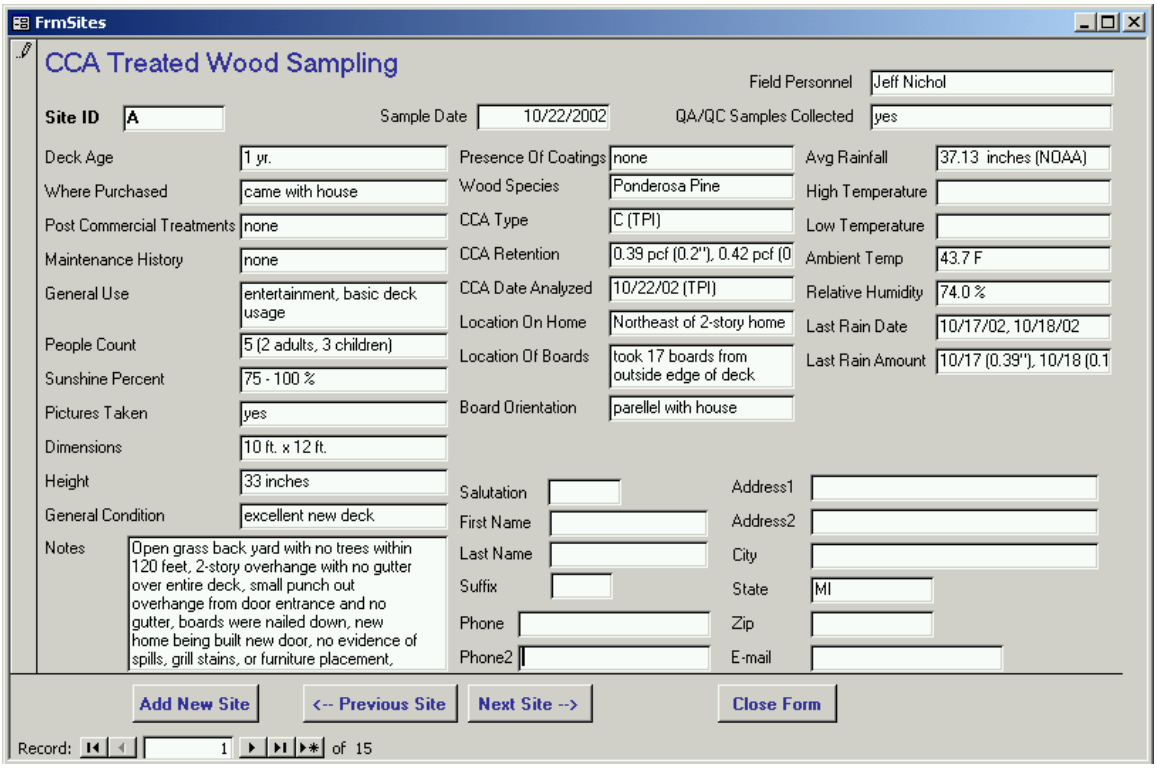


Figure 5-3. Site Data Entry Form

5.5.2 Board Moisture Content

Average moisture content readings are taken from the boards at the time of sample collection and are recorded in the "Pre/On Site" column of the moisture content data entry form (not shown), along with the board sample barcode number and any related comments. Average readings taken 3 to 4 days after the boards have been placed in warehouse storage (at RTI) are recorded in the "Post" column. Average readings taken one month after sitting in storage are recorded in the "Storage" column. These moisture content readings are discussed further in Chapter 6.0.

5.5.3 Coupon Cutting

At the RTI warehouse, the boards are cut into 3-foot lengths called "coupons". The form in Figure 5-4 is used to associate these coupons with their originating board for tracking purposes.

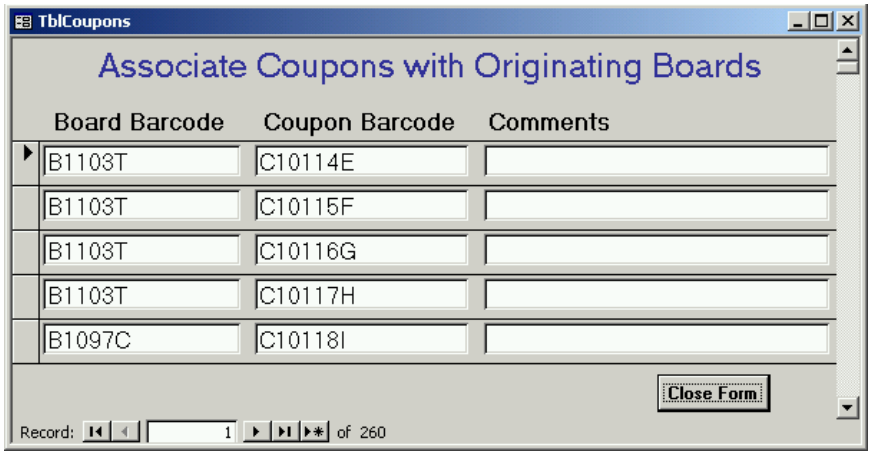


Figure 5-4. Board-Coupon Association Form

5.5.4 Volunteers

For the pilot study, volunteers are used for obtaining hand samples. Figure 5-5 illustrates the form used to record the information collected from the preliminary interviews. If a volunteer is rejected (e.g., due to cut or abrasion on hand, known allergies to metals, inability to expose forearm or move hand properly), that information should be recorded here as well.

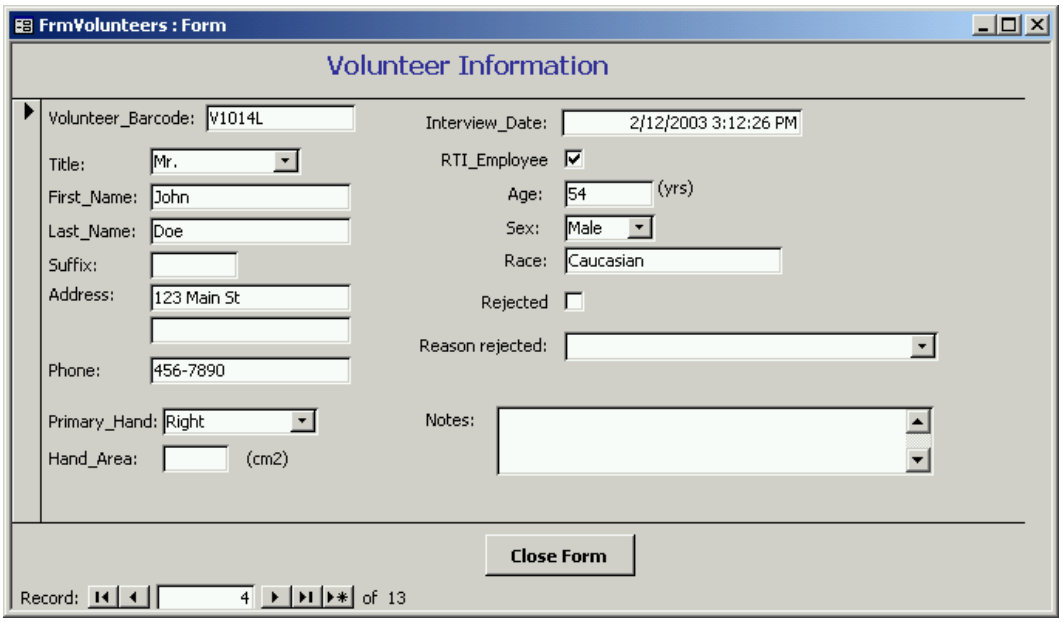


Figure 5-5. Volunteer Data Entry Form

5.5.5 Samples

The forms for sample data entry vary according to sample type. For example, volunteer IDs and sample volume apply only to the hand rinse samples. Differences in sample types also make it necessary to submit samples to the analysis laboratory in separate batches. For these reasons, the sample types are processed separately. Figure 5-6 illustrates the form used for entering field wipe data. Figure 5-7 illustrates the form used for entering hand samples (rinse and wipes).

FrmSamplesField : Form

Field - Wipe Samples

Study Phase	Board Barcode	Sample Barcode	Sample Date/Time	Sample Location	QA/QC Type	Comments	Void	Reason Voided
Pilot	B1001O	F1000014	10/20/2002 10:30:00 PM		Routine			
Pilot	B1021S	F1000025	10/20/2002 9:50:00 PM		Routine			
Pilot	B1021S	F1000036	10/20/2002 9:30:00 PM		Routine			
Pilot	B1002P	F1000047	10/20/2002 11:40:00 PM		Routine			
Pilot	B1001O	F1000058	10/20/2002 10:10:00 PM		Routine			
Pilot	B1041W	F1000069	10/20/2002 10:40:00 PM		Routine			

Note: To zoom, select a field and press <Shift> + <F2>. Show ALL Records Show Today's Records Close Form

Record: 1 of 374 (Filtered)

Figure 5-6. Field Wipe Sample Data Entry Form

FrmSamplesTestingLab : Form

Lab Hand Samples

Study Phase	Coupon Barcode	Sample Barcode	Sample Date/Time	QA/QC Type	Volunteer Barcode*	Hand Used *	Sample Volume (mL) *	Comments	Void?	Reason Voided
Pilot	C10185T	H100001I	1/8/2003 1:55:54 PM	Routine	V1001G	Right	85	Preliminary Testing		
Pilot	C10185T	H100002J	1/8/2003 1:58:44 PM	Routine	V1001G	Left	110	10 passes.		
Pilot	C10195V	H100003K	1/15/2003 2:07:23 PM	Routine	V1001G	Right	110	Preliminary Testing		
Pilot	C10195V	H100004L	1/15/2003 2:11:44 PM	Routine	V1001G	Left	110	10 passes.		
Pilot	C10188W	H100005M	1/15/2003 2:16:58 PM	Routine	V1001G	Right	110	Preliminary Testing		
Pilot	C10188W	H100006N	1/15/2003 2:17:52 PM	Routine	V1001G	Left	110	10 passes.		
Pilot	C10187V	H100007O	1/17/2003 2:31:47 PM	Routine	V1001G	Right	140	Preliminary Testing		

* Applies to Hand Rinse samples only.

Note: To zoom, select a field and press <Shift> + <F2>. Show Today's Records Show ALL Records Close Form

Record: 1 of 465 (Filtered)

Figure 5-7. Lab Hand Sample Data Entry Form

Once the sample data is entered in the database, the samples are "batched" for submittal to the analysis laboratory. At this time, the user specifies the requested analyses, the turnaround time (typically one week), and the required report date. Wipe and rinse samples are batched separately. Figure 5-8 illustrates the form used for sample batching. Figures 5-9 and 5-10 illustrate the custody form and sample analysis request form, respectively, which are generated according to these sample batches.

FrmSampleAnalysisRequest : Form

Batch Samples for Analysis - Hand Samples

SampleBatch ID: 25

Turnaround Time: 1 week (e.g., 1 week)

Required Report Date: 2/26/2003 (mm/dd/yy)

Custody Form Printed? ☑

Sample Analysis Request Printed? ☑

Sample Barcode	Date Sampled	Sample Volume (mL)	Cr, Cu, As	Cr+6	Other	Comments
H100141T	2/19/2003 9:29:38 AM	140	☑	☐		
H100142U	2/19/2003 10:03:47 AM	140	☑	☐		
H100143V	2/19/2003 10:27:50 AM	136.54	☑	☐		
H100144W	2/19/2003 10:52:30 AM	140	☑	☐		
H1001560	2/19/2003 12:19:10 PM	140	☑	☐		
H1001571	2/19/2003 11:54:03 AM	139	☑	☐		

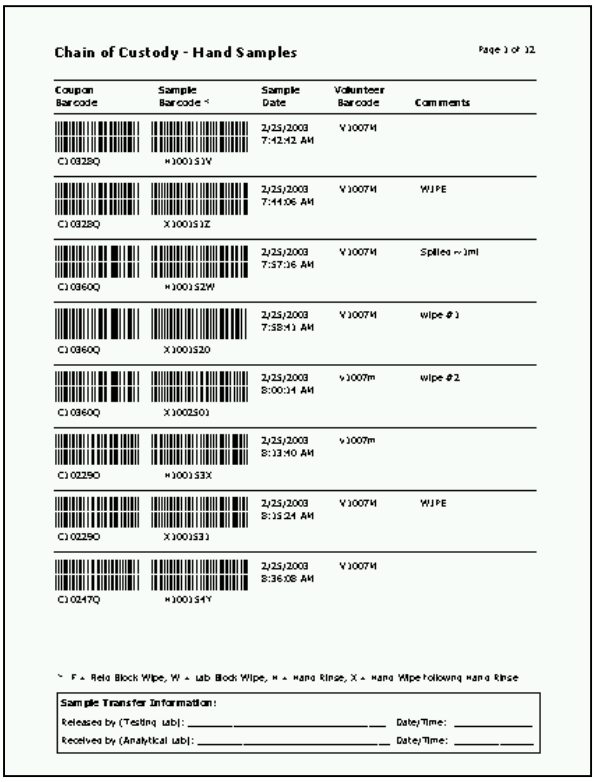
Record: 1 of 40 (Filtered)

Comments:

Show UNPRINTED Batches Only | Show ALL Batches | Close Form

Record: 4 of 8 (Filtered)

Figure 5-8. Sample Batch Form



Chain of Custody - Hand Samples

Page 1 of 12

Coupon Barcode	Sample Barcode *	Sample Date	Volunteer Barcode	Comments
C10328Q	H100153V	2/25/2003 7:42:42 AM	V1007M	
C10328Q	X100153Z	2/25/2003 7:44:06 AM	V1007M	WIPE
C10360Q	H100152W	2/25/2003 7:57:36 AM	V1007M	Spilled ~1ml
C10360Q	X100152O	2/25/2003 7:58:41 AM	V1007M	wipe #1
C10360Q	X100250J	2/25/2003 8:00:14 AM	v1007m	wipe #2
C10229Q	H100153X	2/25/2003 8:13:40 AM	v1007m	
C10229Q	X100153J	2/25/2003 8:15:24 AM	V1007M	WIPE
C10247Q	H100154Y	2/25/2003 8:36:08 AM	V1007M	

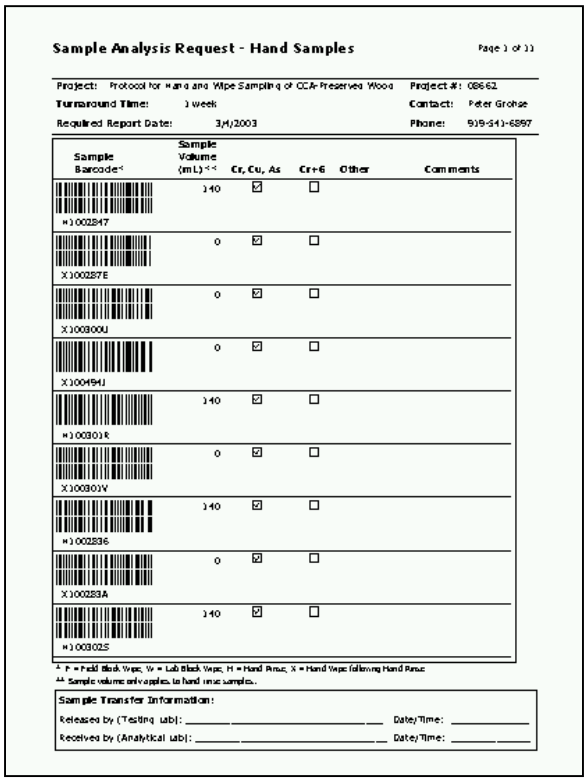
* F = Field Block Wipe, W = Lab Block Wipe, H = Hand Rinse, X = Hand Wipe following Hand Rinse

Sample Transfer Information:

Released by (Testing Lab): _____ Date/Time: _____

Received by (Analytical Lab): _____ Date/Time: _____

Figure 5-9. Example Chain of Custody Form



Sample Analysis Request - Hand Samples

Page 1 of 11

Project: Protocol for Hand and Wipe Sampling of CCA-Preserved Wood — Project #: 08662

Turnaround Time: 1 week — Contact: Peter Grohse

Required Report Date: 3/4/2003 — Phone: 919-541-6897

Sample Barcode*	Sample Volume (mL)**	Cr, Cu, As	Cr+6	Other	Comments
H1002847	140	☑	☐		
X100287E	0	☑	☐		
X100300U	0	☑	☐		
X100494J	0	☑	☐		
H100301R	140	☑	☐		
X100301V	0	☑	☐		
H1002836	140	☑	☐		
X100283A	0	☑	☐		
H100302S	140	☑	☐		

* F = Field Block Wipe, W = Lab Block Wipe, H = Hand Rinse, X = Hand Wipe following Hand Rinse

** Sample volume only applies to hand rinse samples.

Sample Transfer Information:

Released by (Testing Lab): _____ Date/Time: _____

Received by (Analytical Lab): _____ Date/Time: _____

Figure 5-10. Example Sample Analysis Request Form

5.5.6 Analyses (Lab Imports)

As described in Section 7, analyses for arsenic, copper, and chromium are performed by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) or by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), depending on the sample matrix and expected analyte concentrations. Both instruments are capable of exporting data into comma-separated value (CSV) file format. To improve efficiencies in the data entry process and eliminate transcription errors, software routines were developed to import the lab files directly into the CCA database.

Because the structure, or layout, of the export files differs by instrument, separate import routines were required for each instrument. Each import routine follows two basic steps. First, the data from instrument files are parsed and reformatted into "raw data tables". Separate tables were created to store the raw data for each instrument. Second, the imported raw data is processed, using the sample volume to convert concentration to mass, in order to fill the analytical results table (TblAnalyteResults). Both instruments export sample, calibration, and blank results. Sample and blank results are maintained in the raw tables for quality control review, but are not included in the analytical results table.

For the pilot study and Mini Study, the analytical data were imported from instrument records to an Excel spreadsheet. Values were reviewed for reasonableness and outliers were confirmed or corrected. Spot checks of unit conversion calculations were made.

For the full study, import routines were developed for each instrument and subjected to QC checks before incorporating them into the main database. All data for the full study were imported using these routines.

In addition to checks to see that the data were imported correctly, QC checks were run to detect duplicate results (due to data being either in more than one instrument file or in both an imported instrument file and a hand-entered Excel spreadsheet). All duplicate results were hand reviewed and a single entry was shown.

5.6 Sample Archives

A system for sample archiving has not yet been developed in the CCA database. The intended purpose is to store information for archived samples including: sample number, date/time archived, destruction date, and archive location.

6.0 SAMPLE COLLECTION AND COUPON PREPARATION

6.1 Site Identification

For the Full Study, sites were chosen from the northern and southern areas of the eastern United States. Decks were identified in areas near Pittsburgh, Pennsylvania and Gainesville, Florida. Deck owners were located and contacted in several ways – through personal contacts in these areas, via realtors who also rented home properties, and through deck builders who advertised in the Yellow Pages. Oftentimes a single contact provided several decks for evaluation. General information about the research project was forwarded to the contacts so they could discuss the reasons for deck board removal with the homeowners. Homeowners were remunerated for their inconvenience and the deck boards were replaced with new ones soon after removal. The decks had to meet certain specifications before they were accepted. Of greatest importance were the deck's age, CCA retention, and wood species. Two ages of decks were required: approximately one-year old decks (ranging in age from 6 months to 16 months) and decks that were five or more years old. The deck boards were required to be southern yellow pine with a CCA retention of 0.4 pound per cubic foot. In addition, recently treated CCA deck boards and untreated boards were obtained, through prior arrangements, from two treatment plants in the vicinity of Pittsburgh and two treatment facilities near Gainesville.

The untreated boards obtained from the treatment facilities were placed in the rack of the transport truck in a location adjacent to the recently-treated boards and the boards from decks. The purpose of these untreated boards was to detect significant upward changes in the concentrations of metals on block wipes taken from boards after the return trip as compared to those of wipes taken on-site. Such changes may indicate the occurrence of cross-contamination among boards during transit. In addition to the untreated boards obtained at treatment facilities, a set of untreated deck boards was obtained directly from a lumberyard to provide control coupons for use in the laboratory hand rubbing versus block wipe experiments. These coupons had never been in the vicinity of a CCA treatment plant and thus would be expected to be most representative of untreated wood.

6.1.1 Pittsburgh, Pennsylvania Area

Ten decks were used in the Full Study from the Pittsburgh area. These 10 decks were collected during three trips to Pittsburgh. Five decks were collected during the first trip that occurred from January 6 through 9, 2003. These decks are identified as Site H, I, L, M, and N. Four decks labeled Site K, P, Q, and R were removed during the second trip to Pittsburgh from March 3 through 7, 2003. The final deck (Site X) was collected during the third trip on March 31, 2003. A brief description of each deck's age and condition at the time the boards were removed is given below. More details on each deck or given in Appendix F.

Deck Label	Location Retrieved	Age	Weather and Deck Condition
Deck H	Charleroi, PA	8 years old	Snowing at time of deck board removal. Wet.
Deck I	Charleroi, PA	6 years old	Snowing at time of deck board removal. Wet.
Deck L	California, PA	5 years old	Boards covered with 3 inches of snow and ice at time of removal. Snowing at time of removal.
Deck M	California, PA	1 year old	Snowing at time of board removal.
Deck N	California, PA	15 years old	Deck boards covered with snow, ice. Poor condition.

Deck K	California, PA	21 years old	No precipitation during removal. Poor condition.
Deck P	California, PA	7 months old	No precipitation during removal. Excellent condition.
Deck Q	Mt. Pleasant, PA	8 months old	Boards covered with snow and ice at time of removal. Wet.
Deck R	Greensburg, PA	11 months old	Boards covered with snow at time of removal. Wet.
Deck X	Greensburg, PA	1 year old	No precipitation during removal. Excellent condition.

6.1.2 Gainesville, Florida Area

Ten decks were used in the Full Study from the Gainesville area. These 10 decks were collected during two separate trips to Gainesville. Five decks were collected during the first trip that occurred from March 17 through 21, 2003. These decks are identified as Site S, T, U, V, and W. Five additional decks were collected from April 7 through 11, 2003, and these decks were labeled Site Y, Z, AA, AB, and AC. A brief description of each deck's age and condition at the time the boards were removed is given below. More details on each deck or given in Appendix F.

Deck Label	Location Retrieved	Age	Weather and Deck Condition
Deck S	Gainesville, FL	15 years old	No precipitation at time of deck board removal. Poor condition.
Deck T	Gainesville, FL	1 year old	No precipitation at time of deck board removal. Deck covered with leaves.
Deck U	Gainesville, FL	15 years old	No precipitation at time of deck board removal. Deck covered with leaves.
Deck V	Crystal River, FL	5 years old	No precipitation at time of deck board removal. Fair condition.
Deck W	Homosassa, FL	6 years old	No precipitation at time of deck board removal. Poor condition.
Deck Y	Gainesville, FL	1 year old	No precipitation during removal. Excellent condition.
Deck Z	Gainesville, FL	1 year old	No precipitation during removal. Excellent condition.
Deck AA	Gainesville, FL	13 months old	No precipitation at time of deck board removal. Excellent condition.
Deck AB	Trenton, FL	16 months old	No precipitation at time of deck board removal. Fair condition.
Deck AC	Palatka, FL	15 years old	No precipitation at time of deck board removal. Poor condition.

6.2 Deck Board Selection, Collection, and Analysis Process

6.2.1 On-site Selection Criteria

The *Standard Operating Procedure for CCA-Treated Deck Sample Collection and Shipment* (RTI, 2003b) developed for this project was followed for collection of deck boards. This SOP is included in the project's Quality Assurance Project Plan. The specifications and procedures were as follows:

- Decks approximately 1 year (6 months to 16 months) and 5 years or more in age

- Decks from both northern and southern locations in the eastern United States
- Deck wood must be southern yellow pine (SYP) with 0.4 pounds per cubic foot (pcf) retention of chromated copper arsenate (CCA), type C
- Deck must have been continuously exposed to the weather and must not be located in extreme shade or under a roof
- Preferably, the deck board dimensions will be 5/4 inch by 5.5 inches (5/4 by 6 inches nominal) and 10, 12, or 14 feet in length
- The deck should not have been treated with water repellants, stains, or paint of any kind. The deck should not have been power washed and it should not be extremely dirty, oily, or have significant algae growth.

6.2.2 Board Collection Process

Deck boards were selected by first identifying the deck flooring to be removed as samples. A number was marked at the extreme end of boards with permanent black marker. The board numbers and board locations were then recorded on a data sheet. More boards than needed were selected in case some were destroyed during the removal process. Boards were selected in a randomized fashion using the sampler's best judgment. Boards that were badly warped; exhibited significant splits or large knotholes; were painted, stained, or waterproofed; were located in the drip line of the house roof; were coated with dirt, mud, algae, and/or grease (from grill use); or were of a length not sufficient to produce two or three 3-foot coupons; were not selected for use in this study. Areas of the deck boards that were beneath furniture that had not been moved for some time were noted.

The following steps were followed to instruct the deck crew. The deck crew was provided with more detailed procedures for dismantling the deck. Signatures were obtained showing that the crew members understood and agreed with the procedures for dismantling the deck and carefully handling the boards. The following points were emphasized with the deck crew:

- Avoid getting mud or dirt on boards (shoe, hand transfer)
- Avoid splintering or cracking boards during removal
- Do not stack boards one against the other
- Do not allow boards to contact ground or grass once removed from deck
- Use care to remove all nails and screws from boards without splitting or popping the wood. One method is to pull nails through the wood, rather than driving them back out. Police area and collect nails and screws.
- If sawdust is created, avoid getting it on the surfaces of any test boards.

6.2.3 On-Site Testing

The following tests and documentation were performed on-site to characterize the locale of the deck and to make initial tests of the deck boards. These tests are described in another SOP, *Standard Operating Procedure for CCA-Treated Wood Field Test* (RTI, 2003c). This SOP includes a description of how the block wipe sampler is constructed and also presents data sheets for recording information. The SOP is part of the study Quality Assurance Project Plan. The information and tests obtained or performed at each field site included:

- Digital photographs of the deck in the four cardinal directions.
- Information from the homeowner concerning deck age and use, and estimated sunshine exposure.
- A hand-drawn sketch of the deck showing dimensions and locations of the house, nearby trees, *etc.* Ambient air relative humidity (percent) and temperature (degrees F and C).

- Percent moisture content of representative deck boards.
- Core samples, scrapings, and segments of aged and recently CCA-treated deck boards for subsequent, off-site confirmatory testing by Timber Products Inspections (TPI) for CCA retention value and percent moisture content. Some samples were also submitted to a nearby treatment plant for determination Cr, Cu, and As retention using X-ray techniques.
- Wipe tests in duplicate of 12.5 by 40 cm sections from two or more boards from each deck were performed. The wipe tests were normally done immediately after removal of the boards from the deck and before they were loaded into the truck. However, in cases where the boards were extremely wet due to snow or rain, they were allowed to dry out, while stored in the truck, for several hours or overnight, and then were tested before shipment to the RTI facility in North Carolina. Note: The wipe test is conducted using a 10.2 cm by 10.2 cm (4 inch by 4 inch) polyester Alpha Wipe stretched across two layers of Parafilm, which is in turn applied across a rigid foam rubber pad, which is in turn glued to an 1,100 gram steel square block, 8 cm by 8 cm in dimension and having a 64 cm^2 contact area and delivering a contact pressure of ~ 17.2 g/cm^2 as it is pulled across a defined segment of the board (or coupon) by way of a string attached to an eye-hook mounted on the narrow sides of the block.
- Wipe tests in duplicate from two or more recently treated boards and two or more untreated boards. These boards were obtained from treatment plants in the vicinity of Pittsburgh and Gainesville at the time of the trips to retrieve deck boards.

6.2.4 Loading and Transportation of Boards and Samples

Each board was uniquely identified with a plastic bar code label that was attached to the board's extreme end with glue and staples. Each marked-off section of a board that was subjected to the wipe test was further identified with a bar code label that identified a specific wipe area. After the field wipe tests were completed, the boards from each deck were carefully placed, on their sides and at an angle, on notched shelves in a rack that was custom-built to fit into the enclosed cargo space of a rental truck. Freshly treated and untreated boards were also loaded onto each shelf. The rack was constructed of untreated pine and could accommodate up to fifteen 15-foot length boards from as many as eight separate decks. Heavy plastic sheeting was stapled to the bottom of each shelf in order to catch any material that may fall from a board during transit and thus limit the possibility of cross-contamination. The rack's positioning in the truck is illustrated in the SOP *Standard Operating Procedure for CCA-Treated Deck Sample Collection and Shipment* (RTI, 2003b).

6.3 Post-Trip Assessment and Coupon Preparation

6.3.1 Post-Trip Testing and Cross-contamination Checks

Upon return from the field sites, all decking boards were removed from the rack in the truck. Care was taken not to touch the weather-exposed side of the boards. Boards were placed in secure storage in a separate wooden rack in the RTI warehouse. Recently treated lumber was segregated from aged deck boards. The entire rack assembly was covered with plastic sheets to protect the boards from dust.

The insulated cooler used to package the field samples was checked with a thermistor thermometer to be sure it was still cool and the temperature was noted on the field sample collection change of custody form. Bottles containing wipe samples, accompanied by the analytical laboratory field sample collection chain of custody and sample analysis request forms, were then taken to the metals analysis laboratory.

After the boards had been stored and conditioned at least two days at the RTI warehouse, room temperature and relative humidity measurements were made, and the percent moisture content of the

boards was remeasured. Then wipe sampling was repeated on another test area of the boards that were tested in the field. A percent moisture content determination was also rerun. The wipe samples and their supporting documentation were delivered to the analytical laboratory. Results will be compared to assess (1) how well data from wipe samples taken on-site and post-trip agree (perhaps a measure of the representativeness of the stored boards to the original on-site deck boards and the recently-treated boards), (2) how well percent moisture values agree, and (3) whether or not the untreated boards were contaminated with CCA after the return trip as compared to the values taken in the field (a possible measure of cross-contamination).

6.3.2 Coupon Preparation

Coupons were prepared from boards that had been stored in the warehouse for an extended time. An SOP, *Standard Operating Procedures for Cutting CCA-Treated Deck Boards into Test Coupons* (RTI, 2003d), was prepared and followed for this operation.

6.3.3 Cutting

All cutting was done outdoors. Safety glasses and dust mask were required. New white cotton gloves were used to handle each deck's boards. The stored and labeled deck board was carried from the warehouse storage rack to the sawing area. The sawing took place on a saw table positioned approximately three feet above the ground. The miter saw was connected to a take-off vacuum that pulled dust away from the rotating blade to a shop vacuum canister that was located about six feet from the table. The cutting platform was vacuumed cleaned before use and after the cutting of each board. Prior to cutting each board, the saw blade was wiped clean with an Alpha wipe that had been moistened with isopropyl alcohol (see *Standard Operating Procedures for Cutting CCA-Treated Deck Boards into Test Coupon,*RTI, 2003d).

6.3.4 Labeling

The deck boards were labeled in the field at the time of deck board removal. Immediately after cutting the boards into coupons, a stick-on bar code label was attached to one extreme end of the cut wood to identify it as a coupon. When entered to the database, this coupon number was automatically related to the board number which is, of course, related to the deck identification (a letter of the alphabet) and the data bases describing the deck features. All labels were stapled to the wood if they did not adhere well.

6.3.5 Contamination Testing

Contamination of one board by another was minimized by packing the boards in the racks described earlier. However, the potential for contamination was checked by comparing the concentrations of metals on the on-site wipe sample of several untreated boards taken before the journey back to Research Triangle Park, NC to the analytical results from wipe samples taken several days later from a fresh section of the same untreated board. These comparisons and their significance are discussed in Section 8.0.

6.3.6 Storage

All coupons were stored in a safe, undisturbed location either in the RTI warehouse or in a room adjacent to the sample test laboratory in RTI's Building No. 3. The coupons were stacked about eight boards high; each coupon was separated from the one beneath it or from the table on which it rests by a small 4-inch strip of untreated wood placed at the extreme ends of the coupons. This served to separate

the coupons and allowed circulation of air around them. This storage arrangement is illustrated in the *Standard Operating Procedures for Cutting CCA-Treated Deck Boards into Test Coupons* (RTI, 2003d). All untreated coupons were segregated from treated coupons by covering the stack with a sheet of thin polyethylene plastic.

7.0 ANALYSIS OF SAMPLES

Four different types of samples were collected and analyzed during the full study. These included (1) the wipe from the block wipe; (2) the rinsate generated during the hand rub, (3) the wipe of the hand following the rinse step; and (4) an aliquot of the hand-rub rinsate taken for chromium(VI) analysis. The first three samples were analyzed for chromium, copper, and arsenic, and the fourth sample was analyzed only for chromium(VI).

7.1 Sample Preparation

7.1.1 Block and Hand Wipes

The polyester cloth Alpha Wipe samples removed from the 1,100 gram steel block sampling device were folded into a funnel shape to minimize the folds in the cloth and then were placed in 50-mL polypropylene plastic centrifuge tubes immediately following sampling. Each tube had been pre-labeled with a prepared adhesive bar code label. These tubes were capped. The barcode number on the tube was then entered (blipped) into the database to correspond to the barcode label either on the deck board in the field or on the coupon in the laboratory.

The wipes taken following the hand rinses were also placed in 50-mL polypropylene plastic centrifuge tubes. The wipes were folded in a funnel shape to minimize the folds in the cloth. The pre-labeled tubes were capped. The barcode values were entered in a laboratory research notebook and also into the database using a computer connected to the RTI internal web. Using the database screen, the barcode values on these tubes were related to the rinse sample barcode values and the coupon barcode values.

Both the block wipes and the hand wipes were extracted in the same manner. First, the sample tubes were gently tapped to bring the wipes to the bottom of the tubes. Then, twenty-five (25) mL of 10% GFS redistilled trace element grade nitric acid was added to each tube, caps were tightly attached, and the tubes were placed in a shaking hot water bath at 60°C for 12 hours. The tubes were removed from the bath and tipped over several times to mix the contents. Then, an amount of deionized water was added to each tube to bring the total volume to 50 mL, and the contents were mixed by tipping the tubes several times. The samples were then ready for analysis.

7.1.2 Hand Rinse Samples

The hand rinses totaled 140 mL of deionized water (Section 6.3) from the four sequential 30-mL hand rinses, plus a 20-mL rinse of the collection pan and funnel; these rinses were combined in a 200 mL high density polyethylene bottle. A 10-mL aliquot for Cr(VI) analysis was taken from about every fifth sample bottle. The aliquot for Cr(VI) analysis was poured into a 15 mL plastic centrifuge tube. The aliquots taken for Cr (VI) analysis were adjusted to a pH of 9.0 to 9.5 using a 0.01 N NaOH solution. The pH of each hand rinse sample intended for analysis of Cr, Cu, and As was adjusted to about 1 by the addition of 1% or 1.4 mL of trace element grade nitric acid and the samples were manually shaken. In the trace metals preparation laboratory, the samples were shaken manually one more time and an aliquot of sample was poured from each bottle of sample into a 50 mL plastic centrifuge tube. This 25 mL aliquot was then transferred to a 50 mL glass or quartz test tube. Following EPA Method 6020, 2.5 mL of trace element grade nitric acid and 2.0 mL of trace element grade, 30% hydrogen peroxide (EM "Suprapur," VWR No. EM-7298-2) were added to each tube. The samples were digested in a carbon hot block for 30 minutes. The digested samples were then shaken by hand.

Note that hand wipe samples, as described above in 7.1.1, were also taken. This was done in order to maximize the removal of material from the hand.

7.2 Total Chromium, Copper, and Arsenic Analysis

Total chromium, copper, and arsenic analysis of the block wipe samples was performed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP/AES). The analytical method was based on EPA SW846 Method 6020 and is summarized in RTI SOP EG-282 (RTI, 2003h). The instrument used was a Perkin-Elmer Optima 4300DV ICP/AES with the following accessories/ capabilities:

- Segmented Array Charged Coupled Device detector for "simultaneous" measurement
- Dual view (axial, radial) torch
- Cyclonic spray chamber (or ultrasonic nebulizer if necessary)
- Purged optics
- Echelle high resolution monochromator
- 157 position autosampler
- Windows NT based data and instrument management

A validation of the instrument for the analysis of the block wipe extracts was performed and a validation report is included in the Quality Assurance Project Plan (RTI, 2003a). A Standard Operating Procedure (SOP) describing the measurement is also included in the QAPP. The procedure consists of the following steps:

- **Setting the operating parameters**: 1500W forward power, 0.81 L/min nebulizer gas flow, 0.2 L/min auxiliary gas flow, 12.8 L/min cool gas flow.

- **Calibration**: Calibration consists of a blank and 5 standards ranging from 0.500 µg/mL to 25.0 µg/mL for As, Cr, Cu, Ca, Fe, Mg, and Na.

- **Calibration Checks**:

Check	Analysis Sequence	Pass / Fail
ICV	Analyzed immediately after curve	+/- 10 %
ICB	Analyzed immediately after ICV	+/- MDL
ICSA	Analyzed after ICB	+/- 20%
ICSAB	Analyzed after ICSA	+/- 20%
CCV	Analyzed after ICSAB and every ten samples	+/- 10%
CCB	Analyzed after CCV and every ten samples	+/- MDL

- **Sample analysis**: Samples are analyzed after the curve and initial QC checks are verified. A CCV/CCB set is analyzed every ten samples to monitor instrument performance. The performance parameters achieved with this instrument for this measurement are shown in Table 7-1. The accuracy and precision were calculated from the analysis of spiked alpha wipes (n=7) that were prepared and extracted following the same procedures as samples. Accuracy was based on the average recovery of the spiked samples. Precision was calculated from the standard deviation and mean of the spiked alpha wipes at the indicated concentration level.

- **Quality Control**: For every batch of 100 samples digested, two blanks and two spikes at low, medium, and high levels are digested and analyzed with the samples.

Table 7-1. Performance Parameters for the Perkin-Elmer Optima 4300DV for Measurement of Total Chromium, Copper, Arsenic in Block Wipe Digests

Parameter	Level Achieved		
	Copper	**Chromium**	**Arsenic**
Precision	7% RSD @ 12 µg/wipe	8% RSD @ 12 µg/wipe	7% RSD @ 12 µg/wipe
Accuracy	99%	99%	95%
Method Detection Limit	0.96 µg/wipe	0.96 µg/wipe	4.8 µg/wipe

Total chromium, copper, and arsenic analysis for the hand wipe samples was performed using Inductively Coupled Plasma Mass Spectrometry (ICP/MS). The instrument used was a ThermoElemental X-7 ICP/MS with the following accessories/capabilities:

- CETAC 500 Autosampler with 240 sample positions.
- Pentium 4 - 1.80 GHZ processor/ 256 Mbyte of RAM, 1.44 inch Floppy Drive/NEC Read-Write CD Drive/ Samsung CD-DVD drive/ PlasmaLab Windows 2000 Instrument Software/ 15 inch monitor.
- Second Generation Collision Cell Technology for measurement of analytes prone to Ar+ based interferents.
- PlasmaScreen Plus Technology with Cool and Hot Plasma modes allowing selective reduction of molecular interferences (e.g. Ar, ArO), determination of easily ionizable elements such as Li, Na, Mg, K, Ca, and Fe to sub-ng/L in clean matrices, and higher sensitivities (Hot Plasma Mode) compared to normal plasmas.
- Xi Interface reduces polyatomics in complex environmental matrices enabling detection of Fe at single figure µg/L and trace elements such as Cd and Pb at ng/L levels. Also allows measurement of over 200 mg/L Na in the same mass scan as ng/L levels of ultra trace analytes.
- Infinity Lens Ion Optics design yielding lower backgrounds (*i.e.*, 0.5 cps at m/z 5 and 220).
- High Performance Quadrapole Mass Filter yielding highest signal to noise ratio of any quadrapole based ICP-MS.
- Peltier Cooled Mini Spray Chamber.

A validation of instrument for the analysis of the hand wipe digests was performed and a validation report is included in the QAPP. An SOP (RTI, 2003g)describing the measurement is also included in the QAPP. The procedure consists of the following steps:

- **Setting the operating parameters**: 1080W Forward power, cool gas 12.8 L/min, Auxiliary gas 0.84 L/min, nebulizer gas 1.01 L/min, and collision cell gas around 7 L/min. Gas flows and forward power are adjusted daily to optimize signal and minimize the formation of polyatomic interferences.

- **Calibration**: Calibration consists of a blank and eight standards ranging in concentration from 0.002 µg/mL to 1.0 µg/mL.

- **Calibration Checks**:

Check	Analysis Sequence	Pass / Fail
ICV	Analyzed immediately after curve	+/- 10 %
ICB	Analyzed immediately after ICV	+/- MDL
ICSA	Analyzed after ICB	+/- 20%
ICSAB	Analyzed after ICSA	+/- 20%
CCV	Analyzed after ICSAB and every ten samples	+/- 15%
CCB	Analyzed after CCV and every ten samples	+/- MDL

- **Samples analysis**: Samples are analyzed after the curve and initial QC checks are verified. A CCV/CCB set is analyzed every ten samples to monitor instrument performance.

- **Quality Control**: For every batch of samples digested, two blanks and low, medium, and high spikes are digested and analyzed with the samples

The performance parameters achieved with this instrument for this measurement are shown in Table 7-2. The accuracy and precision were calculated from the analysis of spiked alpha wipes (n=7) that were prepared and extracted following the same procedures as samples. Accuracy was based on the average recovery of the spiked samples. Precision was calculated from the standard deviation and mean of the spiked alpha wipes at the indicated concentration level.

Table 7-2. Performance Parameters for the ThermoElemental X-7 ICP/MS for Measurement of Total Chromium, Copper, and Arsenic in Hand Wipe Digests

Parameter	Level Achieved		
	Copper	Chromium	Arsenic
Precision (N=7)	6% RSD @ 0.24 µg/wipe	3% RSD @ 0.24 µg/wipe	13% RSD @ 0.24 µg/wipe
Accuracy	81%	102%	86%
Method Detection Limit	0.048 µg/wipe	0.048 µg/wipe	0.048 µg/wipe

Total chromium, copper, and arsenic analysis of hand rinse samples was also performed using the ThermoElemental X-7 inductively coupled plasma mass spectrometer (ICP/MS). A validation of the instrument for the analysis of the hand rinse digests was performed and a validation report is included in the QAPP. RTI SOP EG-281 (RTI, 2003g), describing the measurement, is also included in the QAPP. The procedural parameters are identical to those used for the ICP/MS analysis of the hand wipes as listed above. The performance parameters achieved with this instrument for the measurement of the hand rinses have not been finalized because of last minute instrument problems. The parameters for this analysis are shown in Table 7-3. For hand rinses two blanks, two spikes, and two duplicates are analyzed per set of rinses.

Table 7-3. Performance Parameters for the ThermoElemental X-7 ICP/MS for Measurement of Total Chromium, Copper, and Arsenic in Hand Rinse Digests

Parameter	Level Achieved		
	Copper	**Chromium**	**Arsenic**
Precision (N=6)	3%, 50 mg wood flour spike	3%, 50 mg wood flour spike	4%, 50 mg wood flour spike
Accuracy	97%	88%	99%
Method Detection Limit	0.28 µg/hand	0.28 µg/hand	0.28 µg/hand

7.3 Hexavalent Chromium (Cr(VI)) Analysis

Cr(VI) analysis was performed using Ion Chromatography (IC) with post-column reaction and colorimetric detection. The analytical method is based on EPA Method 7198 (USEPA, Method 7198) and is summarized in RTI SOP EG-803 (RTI, 2003i). The ion chromatograph separates the chromate species from other species in the sample. The solution exiting from the separation column is reacted in a mixing column with a solution of 1,5-diphenylcarbohydrazide. The chromate reacts with this chemical to form a colored complex that is detected with a sensitive colorimetric detector. The instrument used was a Metrohm ion chromatographic system with the following accessories/capabilities:

- 709 IC column eluent pump
- 752 colorimetric reagent pump
- 766 IC sample processor
- 127 position autosampler
- Lambda 1010 flow-through colorimetric detector
- Autodatabase 1.0 for archiving and administration of chromatograms
- IC Net 2.1 software

Validation of the instrument for the analysis of the hand wipe rinsates for Cr(VI) was performed and a validation report is included in the Quality Assurance Project Plan. A Standard Operating Procedure describing the measurement is also included in the QAPP. The procedure consists of the following steps:

- **Setting the operating parameters**: 0.72 mL/min eluent flow; 0.5 mL/min post-column reagent flow; 540 nm detector wavelength

- **Calibration:** Calibration consists of a blank and six (6) standards ranging from 0.5 µg/L to 10.0 µg/L for Cr(VI)

- **Calibration Checks**:

Check	Analysis Sequence	Pass / Fail
ICV	Analyzed immediately after curve	+/- 10 %
ICB	Analyzed immediately after ICV	+/- MDL
CCV	Analyzed after ICSAB and every ten samples	+/- 10%
CCB	Analyzed after CCV and every ten samples	+/- MDL

- **Sample Analysis**: Samples are analyzed after the curve and initial QC checks are verified. A CCV/CCB set is analyzed every ten samples to monitor instrument performance.

- **Quality Control**: A blank, spike, and duplicate are run for each set of hand rinse samples analyzed.

The performance parameters achieved with this instrument for this measurement are shown in Table 7-4. The accuracy and precision were calculated from the analysis of spiked blanks (n=7) that were analyzed following the same procedure as samples. Accuracy was based on the average recovery of the spiked samples. Precision was calculated from the standard deviation and mean of the spiked blanks at the indicated concentration level.

Table 7-4. Performance Parameters for the Metrohm IC for the Measurement of Cr(VI) in Hand Rinse Solution

Parameter	Level Achieved
Precision (N=7)	3.6% RSD @ 0.28 µg/hand
Accuracy	101% - Spiking of Solution with an alternate Cr^{6+} source
Method Detection Limit	0.25 ppb; 0.035 µg/hand

7.4 Summary

The ICP/AES and ICP/MS methods were validated for total chromium, copper, and arsenic analysis while the IC method was validated for the Cr(VI). SOP's have been prepared for each of the four analyses – total chromium, cooper, and arsenic in block wipes, total chromium, copper, and arsenic in hand wipes, total chromium, copper, and arsenic in hand rinsate, and Cr(VI) in hand rinsate.

8.0 FIELD TESTS

This section describes the results of physical and chemical tests of deck boards performed both on-site and following shipment of the boards to RTI's warehouse in Research Triangle Park, North Carolina.

On-site tests included identification of the wood type (southern yellow pine (SYP) was specified), measurements of ambient temperature, relative humidity, and wood percent moisture content, as well as steel block Alpha Wipe sampling of portions of several of the boards. Small samples of deck wood were also collected for use in determination of chromium, copper, and arsenic retention by Timber Products Inspection and, on occasion, for analysis by X-ray using an instrument at a nearby wood treatment plant.

In addition to the numerous field tests performed, the protocol for the CCA treated wood full study called for substantial documentation of the placement and condition of the decks identified for use. Information such as home addresses, weather conditions and field notes are included as part of the Access database for this project. In addition, field information documented for the decks used in the full study included such items as the field manager's observations, photographs, and sketches describing the deck itself and the recent and long-term weather patterns.

8.1 Site Description and Ambient Conditions

Boards from ten decks were collected in the greater Pittsburgh, Pennsylvania area during the period January 6 through March 31, 2003. Ten decks also were collected from homes near Gainesville, Florida and Crystal River, Florida during the period March 17 through April 11, 2003. Table 8-1 lists these 20 decks, describes their features, and gives ambient conditions at the time of deck board removal. More details on each deck are given in Appendix F.

Table 8-1. Characteristics of Decks Used in the Full Study

Deck Identification and City Area	Deck Description	Weather Conditions at Time of Deck Removal
Site H, Pittsburgh	8 years old. 11 foot by 12 foot. 8 inches above ground. North of home.	Snowing. Two inches of snow on deck.
Site I, Pittsburgh	6 years old. 12 foot by 10 foot. 52.5 inches above ground. Northeast of home.	Snowing. Three inches of snow on deck.
Site K, Pittsburgh	21 years old. 5.5 foot by 14.3 foot. 180 inches above ground. North of home.	Rained day before collection.
Site L, Pittsburgh	5 years old. 15 foot by 14 foot. 12 inches above ground. NNW of home.	Snowed day before removal. Three inches of snow and ice on deck.
Site M, Pittsburgh	1 year old. 8.5 foot by 12 foot. From 12 to 36 inches above ground. Northeast of home.	Snowing. Two inches of snow on deck.
Site N, Pittsburgh	15 years old. 8 foot by 21 foot. 116 inches above ground. East of home.	Ice on deck surface at time of removal.
Site P, Pittsburgh	7 months old. 5.5 foot by 14 foot. 40 inches above ground. Northwest of home.	Snowed day before removal. Snow removed, but board's surface wet.
Site Q, Pittsburgh	8 months old. 12 foot by 22 foot. 8 inches above ground. Northeast of home.	Snowed day before removal. Two inches of snow on deck.
Site R, Pittsburgh	11 months old. 7 foot by 36 foot. 8 inches to 3.5 feet above ground. East of home.	Snowed day before removal. Three inches of snow.
Site X, Pittsburgh	1 year old. 10 foot by 40 foot. 8.5 feet above ground. South of home.	Raining the day before removal and during removal.
Site S, Gainesville	15 years old. 18 foot by 45 foot. 29 inches above ground. East of home and caged pool area.	Rained day before collection.
Site T, Gainesville	1 year old. 10 foot by 15 foot. 12 inches above ground. South of home.	Rained day before collection.
Site U, Gainesville	15 years old. 10 foot by 30 foot. 18 inches above ground. South of home.	Rained day before collection.
Site V, Crystal River, FL	5 years old. 6.5 foot by 12.5 foot. 34 inches above ground. North of home.	Rained day before collection.
Site W, Homosassa, FL	6 years old. 13 foot by 16 foot. 8 inches above ground. North of home.	Rained day before collection.
Site Y, Gainesville	1 year old. 11.5 foot by 15 foot. 12 inches above ground. South of home.	Rained day before collection, but deck was dry.
Site Z, Gainesville	1 year old. 15 foot by 34 foot. 24 inches above ground. South of home.	Rained day before collection, but deck was dry.
Site AA, Gainesville	13 months old. 10 foot by 12 foot. 8 inches above ground. South of home.	Rained day before collection, but deck was dry.
Site AB, Trenton, FL	16 months old. 16 foot by 24 foot. 31 inches above ground. West of trailer.	Rained day before collection, but deck was dry.
Site AC, Palatka, FL	15 years old. 16 foot by 10 foot. 8 inches above ground. South of pool and home.	Rained day before collection and during removal.

8.2 Percent Moisture in Deck Board Wood

There was interest in knowing if and to what degree the percent moisture content of the deck wood changed in the time interval between the initial measurement at the deck site and the time it was stored at the laboratory warehouse facility. The percent moisture of the wood may have some effect on the amount of dislodgeable materials removed from the board using the steel block wipe technique. Percent moisture was determined using the Delmhorst Instrument Company Model RC-1E/SP moisture

meter equipped with a No. 26-ES electrode probe. Percent moisture content information for boards retrieved from the Pittsburgh and Gainesville areas are presented in this subsection.

8.2.1 Percent Moisture in Deck Board Wood, Pittsburgh, Pennsylvania Area

From January 6 through 10, 2003, RTI collected seven southern yellow pine (SYP) decks from the greater Pittsburgh area. Five of the seven decks were used for the full study. The remaining two decks were used during the hand rinse and wipe sampling performed during the pilot study and Mini Study. The five decks used during the Full Study were assigned as sites H, I, L, M, and N. From March 3 through 7, 2003, RTI collected boards from four more SYP decks and assigned these as sites K, P, Q, and R. Boards from the tenth and final deck were collected on March 31, 2003 and assigned as site X.

At each Pittsburgh site location, RTI's field manager performed percent moisture content (% MC) on three boards selected from each deck. The procedure used for the % MC analysis is presented in *Standard Operating Procedures for CCA-Treated Wood Pilot Study Field Tests* (RTI, 2003c). A total of eight % MC readings were taken on each board. These values were averaged and corrected for temperature and wood species according to the instructions given in the Delmhorst Instrument manual. The corrected average % MC readings for the on-site measurements are presented in Table 8-2. Also listed for each board are each site's ambient temperature and relative humidity for the day the deck was removed. Upon the return from Pittsburgh, the boards were placed on storage racks in a warehouse at RTI. The storage racks were designed so that the boards were not in contact with each other.

The boards were allowed to equilibrate to the warehouse temperature and relative humidity before post-trip % MC readings were recorded. After 4 to 12 days, RTI conducted the % MC analysis on the same boards tested at the field sites. The average % MC values for the post-trip analysis are given in Table 8-2. The boards were then returned to the storage racks. A long-term storage % MC reading was taken for the boards on January 31, 2003, for Sites H, I, L, M, and N. Long-term storage % MC readings were taken on April 30, 2003, for Sites K, P, Q, R, and X. The averages for these readings are listed under the category "storage" in Table 8.2.

Whenever RTI visited a particular region, untreated SYP and recently treated 0.4 pcf CCA SYP boards were obtained and sampled along with each site's deck boards. The untreated and recently treated boards were collected from Quality One/Universal Forest Products in Fombell, PA and Schroth Industries in Indiana, PA. The number of untreated and recently treated 0.4 pcf CCA boards needed was determined by the number of sites to be visited. During the visit to the Pittsburgh area, 10 decks were obtained. Thus, a total of ten untreated boards (see Table 8-6) and ten boards recently treated to a retention value of 0.4 pcf CCA (see Table 8-3) were obtained and one of each type board was assigned to and loaded on the same transport rack with boards from Sites H, I, K, L, M, N, P, Q, R, and X.

The % MC readings for untreated and recently treated boards were taken at the same time using the same procedure as used for the site deck boards. The on-site, post-trip, and storage % MC averages for the recently treated 0.4 pcf CCA boards are listed in Table 8-3. The post-trip readings were taken on January 20, 2003, and the storage readings were taken on January 31, 2003, for Sites H, I, L, M, and N. The post-trip readings were taken on March 16, 2003, and the storage readings were taken on April 30, 2003, for Sites K, P, Q, R, and X.

Note that the long-term storage readings for % MC for several Pittsburgh sites (P, Q, R, and X) were taken after coupons had been cut from the boards and used in the Full Study hand rubbing and block wiping comparison experiments.

Table 8-2. On-site, Post-trip, and Storage Average % MC for SYP Deck Boards From Pittsburgh, PA Area

Deck Identity	On-site			Post-trip			Storage		
	Test Date	Temp and %RH	Average % MC and SD	Test Date	Temp and %RH	Average % MC and SD	Test Date	Temp and %RH	Average % MC and SD
Site H	1/8/03	30.4 °F : 72.0 %	23±0.6	1/20/03	67.9 °F : 35.0 %	19±1.0	1/31/03	64.5 °F: 45.1 %	13±1.0
Site I	1/8/03	33.2 °F : 75.7 %	23±0.6	1/20/03	67.9 °F : 35.0 %	18±0.6	1/31/03	64.6 °F : 41.1%	15±0.0
Site L	1/9/03	18.4 °F : 70.0 %	22±0.6	1/20/03	67.9 °F : 35.0 %	19±1.2	1/31/03	64.6 °F : 41.1%	14±0.6
Site M	1/9/03	35.1 °F : 74.4 %	20±0.6	1/20/03	67.9 °F : 35.0 %	18±1.0	1/31/03	64.6 °F : 41.1%	13±1.7
Site N	1/10/03	39.3 °F : 67.4 %	22±0.0	1/20/03	67.9 °F : 35.0 %	19±0.6	1/31/03	64.6 °F : 41.1%	16±1.2
Site K	3/3/03	16.3 °F : 57.7 %	33±2.1	3/16/03	50.4 °F : 63.5 %	27±0.6	4/30/03	70.4 °F : 63.5%	14±0.6
Site P	3/4/03	33.6 °F : 65.4 %	23±0.6	3/16/03	50.4 °F : 63.5 %	23±0.6	4/30/03	70.4 °F : 63.5%	11±0.6
Site Q	3/6/03	48.3 °F : 75.6 %	27±0.6	3/16/03	50.4 F : 63.5 %	24±0.6	4/30/03	70.4 °F : 63.5%	10±0.6
Site R	3/6/03	42.3 F : 68.4 %	25±1.2	3/16/03	50.4 °F : 63.5 %	24±0.6	4/30/03	70.4 °F : 63.5%	10±1.0
Site X	3/31/03	33.6 °F : 72.1 %	21±0	4/4/03	59.3 °F : 68.0 %	17±0.0	4/30/03	70.4 °F : 63.5%	13±0.6

Table 8-3. On-site, Post-trip, and Storage % MC for Recently-Treated 0.4 pcf CCA Boards From Pittsburgh, PA Area

Deck Identity Board Number	On-site			Post-trip			Storage		
	Test Date	Temp. and %RH	% MC	Test Date	Temp. and %RH	% MC	Test Date	Temp. and %RH	% MC
Site H B14225	1/8/03	30.4 °F : 72.0 %	35	1/20/03	67.9 °F : 35.0 %	33	1/30/03	64.6 °F : 41.1%	16
Site I B14247	1/8/03	33.2 °F : 75.7 %	35	1/20/03	67.9 °F : 35.0 %	33	1/31/03	64.6 °F : 41.1%	18
Site K B12081	1/8/03	33.7 °F : 70.6 %	35	1/20/03	67.9 °F : 35.0 %	30	1/31/03	64.6 °F : 41.1%	17
Site L B12398	1/9/03	18.4 °F : 70.0 %	36	1/20/03	67.9 °F : 35.0 %	31	1/31/03	64.6 °F : 41.1%	18
Site M B1297I	1/9/03	35.1 °F : 74.4 %	33	1/20/03	67.9 °F : 35.0 %	27	1/31/03	64.6 °F : 41.1%	18
Site N	1/10/0	39.3 °F :	35	1/20/03	67.9 °F :	28	1/31/03	64.6 °F :	18

Deck Identity Board Number	On-site			Post-trip			Storage		
	Test Date	Temp. and %RH	% MC	Test Date	Temp. and %RH	% MC	Test Date	Temp. and %RH	% MC
B13200	3	67.4 %			35.0 %			41.1%	
Site P B13426	3/4/03	38.4 °F : 66.4 %	37	3/16/03	50.4 °F : 63.5 %	38	4/30/03	70.4 °F : 63.5%	20
Site Q B1362A	3/6/03	33.7 °F : 70.6 %	39	3/16/03	50.4 °F : 63.5 %	37	4/30/03	70.4 °F : 63.5%	18
Site R B1382E	3/6/03	18.4 °F : 70.0 %	38	3/16/03	50.4 °F : 63.5 %	36	4/30/03	70.4 °F : 63.5%	20
Site X B1297I	3/28/03	35.1 °F : 74.4 %	44	4/4/03	59.3 °F : 68.0 %	35	4/30/03	70.4 °F : 63.5%	20

8.2.2 Percent Moisture in Deck Board Wood, Gainesville, Florida Area

Ten decks were used in the full study from the Gainesville, FL area. Boards from these 10 decks were collected during two trips to Gainesville. Five decks were collected during the first trip that occurred from March 17 through 21, 2003. These decks are identified as Site S, T, U, V, and W. The five remaining decks were collected from April 7 through 11, 2003, and these decks were labeled Site Y, Z, AA, AB, and AC.

At each Gainesville site location, RTI performed percent % MC on three boards selected from each deck. Eight % MC readings were taken on each board. These values were averaged and corrected for temperature and wood species. The % MC values for the average on-site measurements from three boards are presented in Table 8-4. Also listed are the ambient temperature and relative humidity recorded at the time the deck was removed. Upon the return from Gainesville, the boards were placed on storage racks in a warehouse at RTI. The storage racks were designed so that the boards were not in contact with each other.

The boards were allowed to equilibrate to the warehouse temperature and relative humidity before post-trip % MC readings were recorded. After 7 to 11 days, RTI conducted the % MC analysis on the same boards tested at the field sites. The averages for the post-trip analysis are given in Table 8-4. The boards were then returned to the storage racks. A long-term storage % MC reading was taken for the boards on March 28, 2003, for Sites S, T, U, V, and W. Long-term storage % MC readings were taken on May 9, 2003, for Sites Y, Z, AA, AB, and AC. The averages for these readings are listed under the category “storage” in Table 8.4.

Note that the long-term storage readings for % MC for all boards from the Florida sites were taken after coupons were prepared and testing in the Full Study hand rubbing and block wiping experiments.

Table 8-4. On-site, Post-trip, and Storage Average % MC for SYP Deck Boards From the Gainesville, FL Area

Deck Identity	On-site			Post-trip			Storage		
	Test Date	Temp. and %RH	Avg. % MC and SD	Test Date	Temp. and %RH	Avg. % MC and SD	Test Date	Temp. and %RH	Avg. % MC and SD
Site S	3/17/03	66.5 °F : 94.7 %	25±2.1	3/28/03	69.4 °F : 68.8 %	19±0.6	4/30/03	70.4 °F : 63.5%	12±0.6
Site T	3/19/03	67.2 °F : 94.6 %	22±0.0	3/28/03	69.4 °F : 68.8 %	18±0.6	4/30/03	70.4 °F : 63.5%	13±0.6
Site U	3/19/03	72.8 °F : 94.3 %	26±1.0	3/28/03	69.4 °F : 68.8 %	19±0.0	4/30/03	70.4 °F : 63.5%	12±1.2
Site V	3/20/03	77.4 °F : 96.2 %	24±0.6	3/28/03	69.4 °F : 68.8 %	18±0.0	4/30/03	70.4 °F : 63.5%	12±0.6
Site W	3/21/03	83.9 °F : 82.5 %	21±1.2	3/28/03	69.4 °F : 68.8 %	18±0.6	4/30/03	70.4 °F : 63.5%	13±0.0
Site Y	4/9/03	72.6 °F : 80.2 %	25±0.6	4/18/03	71.1 °F : 70.5 %	19±0.0	5/9/03	74.6 °F : 71.5%	13±0.6
Site Z	4/9/03	80.6 °F : 76.5 %	24±0.6	4/18/03	71.1 °F : 70.5 %	20±0.6	5/9/03	74.6 °F : 71.5%	12±0.6
Site AA	4/9/03	74.8 °F : 82.1 %	24±0.0	4/18/03	71.1 °F : 70.5 %	20±0.6	5/9/03	74.6 °F : 71.5%	14±0.0
Site AB	4/9/03	73.2 F : 81.0 %	25±0.6	4/18/03	71.1 °F : 70.5 %	20±0.6	5/9/03	74.6 °F : 71.5%	12±0.6
Site AC	4/9/03	55.4 °F : 68.4 %	25±0.0	4/18/03	71.1 °F : 70.5 %	20±0.6	5/9/03	74.6 °F : 71.5%	13±0.0

Untreated SYP and recently treated 0.4 pcf CCA SYP boards were collected to be analyzed along with each site's deck boards. The untreated and recently treated boards were obtained from Great Southern in Bushnell, FL and Robbins Manufacturing in Lockhart, FL. The number of untreated and recently treated 0.4 pcf CCA boards needed was determined by the number of sites to be visited. During the visit to the Gainesville area, boards from ten decks were removed. Thus, ten untreated boards (see Table 8-6) and ten recently treated boards (see Table 8-5) were obtained and one of each type board was assigned to Sites S, T, U, V, W, Y, Z, AA, AB, and AC.

The % MC readings were taken at the same time and using the same procedure as used on-site for each site's deck boards. The on-site, post-trip, and storage % MC averages for the recently treated 0.4 pcf CCA boards from Florida are listed in Table 8-5. For Sites S, T, U, V, and W, the post-trip readings were taken on March 28, 2003, and the storage readings were taken on April 30, 2003. For Sites Y, Z, AA, AB, and AC, the post-trip readings were taken on April 18, 2003, and the storage readings were taken on May 9, 2003.

Table 8-5. On-site, Post-trip, and Storage % MC for Recently-Treated 0.4 pcf CCA Boards From the Gainesville, FL Area

Deck Identity Board Number	On-site			Post-trip			Storage		
	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC
Site S B1266B	3/17/03	66.5 °F : 94.7 %	45	3/28/03	69.4 °F : 68.8 %	38	4/30/03	70.4 °F : 63.5%	20
Site T B1460B	3/19/03	67.2 °F : 94.6 %	46	3/28/03	69.4 °F : 68.8 %	32	4/30/03	70.4 °F : 63.5%	21
Site U B1480F	3/19/03	72.8 °F : 94.3 %	43	3/28/03	69.4 °F : 68.8 %	33	4/30/03	70.4 °F : 63.5%	20
Site V B1482H	3/20/03	77.4 °F : 96.2 %	45	3/28/03	69.4 °F : 68.8 %	34	4/30/03	70.4 °F : 63.5%	19
Site W B15024	3/21/03	83.9 °F : 82.5 %	44	3/28/03	69.4 °F : 68.8 %	34	4/30/03	70.4 °F : 63.5%	21
Site Y B1542C	4/9/03	72.6 °F : 80.2 %	42	4/18/03	71.1 °F : 70.5 %	38	5/9/03	74.6 °F : 71.5%	19
Site Z B1562G	4/9/03	80.6 °F : 76.5 %	42	4/18/03	71.1 °F : 70.5 %	36	5/9/03	74.6 °F : 71.5%	19
Site AA B1582K	4/9/03	74.8 °F : 82.1 %	42	4/18/03	71.1 °F : 70.5 %	35	5/9/03	74.6 °F : 71.5%	18
Site AB B16027	4/9/03	73.2 F : 81.0 %	42	4/18/03	71.1 °F : 70.5 %	34	5/9/03	74.6 °F : 71.5%	18
Site AC B1622B	4/9/03	55.4 °F : 68.4 %	42	4/18/03	71.1 °F : 70.5 %	35	5/9/03	74.6 °F : 71.5%	18

Table 8-6. On-site, Post-trip, and Storage % MC for Untreated SYP Deck Boards From Pittsburgh, PA and Gainesville, FL Areas

Deck Identity Board Number	On-site			Post-trip			Storage		
	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC
Site H B14214	1/8/03	30.4 °F : 72.0 %	18	1/20/03	67.9 °F : 35.0 %	15	1/31/03	64.6 °F : 41.1%	9
Site I B14236	1/8/03	33.2 °F : 75.7 %	17	1/20/03	67.9 °F : 35.0 %	16	1/31/03	64.6 °F : 41.1%	9
Site K B12070	1/8/03	33.7 °F : 70.6 %	18	1/20/03	67.9 °F : 35.0 %	16	1/31/03	64.6 °F : 41.1%	9
Site L B12387	1/9/03	18.4 °F : 70.0 %	17	1/20/03	67.9 °F : 35.0 %	18	1/31/03	64.6 °F : 41.1%	9
Site M B1296H	1/9/03	35.1 °F : 74.4 %	17	1/20/03	67.9 °F : 35.0 %	18	1/31/03	64.6 F : 41.1%	9
Site N B13197	1/10/03	39.3 °F : 67.4 %	17	1/20/03	67.9 F : 35.0 %	16	1/31/03	64.6 °F : 41.1%	9
Site P	3/4/03	38.4 °F :	17	3/16/03	50.4 °F :	13	4/30/03	70.4 °F :	8

Deck Identity Board Number	On-site			Post-trip			Storage		
	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC	Test Date	Temp and %RH	% MC
B13415		66.4 %			63.5 %			63.5%	
Site Q B13619	3/6/03	33.7 °F : 70.6 %	19	3/16/03	50.4 °F : 63.5 %	18	4/30/03	70.4 °F : 63.5%	8
Site R B1381D	3/6/03	18.4 °F : 70.0 %	16	3/16/03	50.4 °F : 63.5 %	16	4/30/03	70.4 °F : 63.5%	8
Site S B1265A	3/17/03	66.5 °F : 94.7 %	16	3/28/03	69.4 °F : 68.8 %	16	4/30/03	70.4 °F : 63.5%	8
Site T B1459I	3/19/03	67.2 °F : 94.6 %	17	3/28/03	69.4 °F : 68.8 %	17	4/30/03	70.4 °F : 63.5%	8
Site U B1479M	3/19/03	72.8 °F : 94.3 %	16	3/28/03	69.4 °F : 68.8 %	16	4/30/03	70.4 °F : 63.5%	9
Site V B1481G	3/20/03	77.4 °F : 96.2 %	17	3/28/03	69.4 °F : 68.8 %	16	4/30/03	70.4 °F : 63.5%	9
Site W B15013	3/21/03	83.9 °F : 82.5 %	17	3/28/03	69.4 °F : 68.8 %	15	4/30/03	70.4 °F : 63.5%	9
Site X B15217	3/31/03	35.1 °F : 74.4 %	17	4/4/03	59.3 °F : 68.0 %	16	4/30/03	70.4 °F : 63.5%	8
Site Y B1541B	4/9/03	72.6 °F : 80.2 %	20	4/18/03	71.1 °F : 70.5 %	16	5/9/03	74.6 °F : 71.5%	8
Site Z B1561F	4/9/03	80.6 °F : 76.5 %	20	4/18/03	71.1 °F : 70.5 %	15	5/9/03	74.6 °F : 71.5%	8
Site AA B1581J	4/9/03	74.8 °F : 82.1 %	20	4/18/03	71.1 °F : 70.5 %	16	5/9/03	74.6 °F : 71.5%	8
Site AB B16016	4/9/03	73.2 F : 81.0 %	20	4/18/03	71.1 °F : 70.5 %	16	5/9/03	74.6 °F : 71.5%	8
Site AC B1621A	4/9/03	55.4 °F : 68.4 %	20	4/18/03	71.1 °F : 70.5 %	16	5/9/03	74.6 °F : 71.5%	8

8.2.3 Observations Regarding Percent Moisture Content of CCA-Treated Boards

Deck boards were collected from 10 sites in the Pittsburgh area and 10 sites in the Gainesville and Crystal River area from January 6 through April 11, 2003. Recently treated 0.4 pcf boards and untreated deck boards were also purchased from two treatment facilities near Pittsburgh and two treatment facilities near Gainesville. Due to the need to remove these decks during the fall and winter months, RTI often had to work under weather conditions (snow, rain) that affected the % moisture content (% MC) measurements, especially those made in the field at the time of the initial percent moisture content determinations and block wipe sample collections.

Prior to and during RTI's visits to the Pittsburgh area, severe weather moved into the area. The daytime temperatures dropped into the 20's (degrees F) and the overnight temperatures dropped into the single digits. The total snow accumulation was more than 10 inches in those four days, equivalent to approximately 0.7 inch of rain, as reported by WTAE-TV in Pittsburgh. There was standing snow on deck boards for Sites H, I, L, M, N, Q, and R. Ice was found beneath the snow covering boards from Sites L, M, and N. The snow was brushed off but no attempt was made to remove the ice. When

temperatures eventually increased, the ice melted. Prior to deck board removal, the general contractor gently brushed away any snow.

When RTI was in the Gainesville and Crystal River areas, scattered rain showers occurred almost daily. At times, the amount of rain was rather significant. The increased surface moisture on the deck boards caused a delay in determining % MC. The deck boards were placed in the transportation rack and % MC measurements were made later in the day. Since none of the deck boards obtained in this study were believed to have been treated with water repellant, the increase in surface moisture penetrating into the boards may have caused a slight elevation in the measured internal %MC reading.

The effect of environmental conditions such as temperature and percent relative humidity creates an ever-changing response in % MC of wood. Based on the moisture content table in the USDA publication, *A Wood Handbook: Wood as an Engineering Material* (USDA, 1999), the % MC can be estimated for wood that is kept at a certain temperature and percent relative humidity. This is the % MC that would be present when the wood reaches equilibrium; it is usually identified as the equilibrium moisture content. When wood is outside at ambient conditions, there are other factors that affect attainment of equilibrium. Wind, precipitation, temperature extremes, and the amount of sunshine are only a few of the factors that would affect the wood's ability to maintain equilibrium moisture content under ambient conditions. Thus, the USDA moisture content table can give only a "ballpark" value for wood exposed to the weather. However, in spite of this, the % MC values recorded for Pittsburgh, Gainesville, and Crystal River deck boards during the time of post-trip sampling are all reasonable as compared to the predicted values based on the sites' readings of temperature and relative humidity.

Environmental factors such as wind, water precipitation, and amount of sunshine of course do not affect wood when stored and maintained indoors. This can best be observed by reviewing the results of the storage % MC recorded for boards from all 20 sites used in the full study. The temperature and percent relative humidity are maintained in the RTI's warehouse at approximately 65 °F and 40%RH. According to the USDA moisture content table, under these conditions the wood will equilibrate to approximately 7.7 % MC. The drop of % MC for the deck boards coincides with the wood trying to reach equilibrium. The storage % MC readings for the 20 sites ranged from 9-17% MC. The longer the deck boards are stores in a controlled environment, the closer the % MC readings are to the predicted equilibrated value. Boards placed in the warehouse for 22 to 23 days showed % MC ranging from 11 to 17%. Boards left in the warehouse for 30 days had % MC values ranging from 12 to 14%. As the storage time increases to 59 days, the % MC was in the range of 9 to 11%. The %MC is constantly moving towards the equilibrium % MC when the temperature and relative humidity are controlled.

8.3 CCA Retention Analysis

The retention of CCA in the treated wood is expressed in terms of the amount of chromated copper arsenate, in pounds, present per cubic foot of wood (pcf). The study protocol specifies that southern yellow pine boards, originally treated to 0.4 pcf by CCA type C, were to be used.

Table 8-7 presents the results of pcf analyses of samples of the deck boards used in the full study. Analyses were conducted by Timber Products Inspection, (TPI), Conyers, GA. TPI found the CCA retention somewhat exceeded 0.4 pcf for samples taken from 10 of the 20 deck sites. One site was tested at exactly 0.4 pcf and nine sites tested below the 0.4 pcf level. Of the nine sites that tested below the 0.4 pcf level, only one site, Site AC, tested below the next standard treatment level of 0.25 pcf. The average CCA retention value for the ten one-year age sites was 0.45 pcf; the average retention for the ten 5^{+}-year age sites was 0.36 pcf. The average retention value for the northern and southern decks were very similar: 0.4 ± 0.08 pcf for Pittsburgh decks and 0.42 ± 0.09 pcf for Florida decks.

Table 8-7. Deck Board CCA Retention, CCA Type, Species Type, and % Moisture Content Results. Analyses by Timber Products Inspection of the 20 Decks Used For the Full-Study

Deck Name	Deck Age (yrs.)	CCA Retention (pcf)	CCA Type	Species Type	% Moisture Content	Date Analyzed by TPI
H	8	0.37	C	Southern Yellow Pine	11.9	2/3/03
I	6	0.49	C	Southern Yellow Pine	11.3	2/3/03
L	5	0.29	C	Southern Yellow Pine	11.8	2/3/03
M	1	0.41	C	Southern Yellow Pine	8.6	2/3/03
N	15	0.32	C	Southern Yellow Pine	11.5	2/3/03
K	21	0.32	C	Southern Yellow Pine	13	4/23/03
P	0.6	0.48	C	Southern Yellow Pine	15	4/23/03
Q	0.7	0.35	C	Southern Yellow Pine	14	4/23/03
R	0.9	0.46	C	Southern Yellow Pine	13	4/23/03
X	1	0.49	C	Southern Yellow Pine	8.9	4/25/03
S	15	0.32	C	Southern Yellow Pine	17	4/23/03
T	1	0.49	C	Southern Yellow Pine	20	4/23/03
U	15	0.54	C	Southern Yellow Pine	22	4/23/03
V	5	0.35	C	Southern Yellow Pine	13	4/23/03
W	6	0.40	C	Southern Yellow Pine	15	4/23/03
Y	1	0.48	C	Southern Yellow Pine	9.8	4/25/03
Z	1	0.30	C	Southern Yellow Pine	8.9	4/25/03
AA	1.1	0.46	C	Southern Yellow Pine	9.5	4/25/03
AB	1.3	0.62; 067	C	Southern Yellow Pine	9.9	4/25/03 and 6/2/03
AC	15	0.22	C	Southern Yellow Pine	10.0	4/25/03

8.4 Chromotropic Acid Spot Tests for Chromium (VI)

The chromotropic acid spot test for chromium (VI) was conducted in the field on freshly treated CCA deck boards obtained directly from wood treatment facilities. A positive test for Cr(VI) is the appearance of a pink to purple color when the test reagent is added to a freshly-cut wood boring. The test procedures are given in Section 11 of the American Wood-Preservers Association Standard A3-00 and in

RTI SOP No. CCA-020, "Standard Operating Procedures for CCA-Treated Wood Field Tests" (RTI, 2003c).

Sixteen recently treated boards (8 each from Pennsylvania and Florida treatment plants) were tested on-site. Thirteen of the 16 tested positively for the presence of Cr(VI). Five untreated boards and one reagent blank were tested as controls; all gave negative results. Results are summarized in Table 8-8.

Table 8-8. Chromotropic Acid Spot Test Results for Recently Treated 0.4 CCA Deck Wood

Treatment Plant and Location	Number and Type of Boards Tested	Treatment Date	Test Date	Results
Universal Quality 1 (PA)	4 treated	3/5/2003	3/6/2003	3 of 4 positive
Schroth (PA)	4 treated	2/26/2003	3/6/2003	4 positive
Great Southern (FL)	4 treated	~ 3/18/2003	3/19/2003	4 positive
Great Southern (FL)	3 untreated	--	3/19/2003	3 negative
(FL)	Reagent blank	--	3/19/2003	negative
Great Southern (FL)	2 treated	4/7/2003	4/9/2003	2 positive
Robbins (FL)	2 untreated	--	4/9/2003	2 negative
Robbins (FL)	2 treated	~ 3/31/2003	4/9/2003	2 negative

8.5 Field *Versus* Laboratory Block Wipe Samples

In order to assess whether laboratory block wipe sample data adequately represent a block wipe sample collected in the field from a board on a CCA-treated structure, the study protocol called for collection of duplicate wipe samples from at least two boards on site and following return to the testing facility. SYP boards were selected from these categories: (a) untreated boards obtained from commercial wood-treating facilities in the northeastern and southeastern United States, (b) recently treated boards from the same facilities, (c) aged deck boards the northeastern (Pittsburgh) and southeastern (Gainesville) United States. During the full study, RTI sampled all board types described above. All wipe samples were collected using the 1,100-gram steel block/Alpha Wipe device according to the sampling method presented in the standard operating procedures of the quality assurance project plan. Each sample was taken from a different location on the boards.

The purposes of the field *versus* laboratory sampling experiments were first, to assess if cross-contamination of boards was occurring during handling and transportation, and second, to determine the differences between sampling boards on-site as compared to sampling later under indoor conditions.

8.5.1 Cross Contamination of Untreated SYP Boards From Treatment Facilities

Untreated boards were acquired from two treatment facilities near Pittsburgh and two facilities near Gainesville in order to evaluate the potential of cross-contamination during sample shipment. One untreated board was assigned to each of the deck sites scheduled for that trip. On-site wipe tests were performed soon after the boards were picked up from the treatment plant. Within two weeks after return to the RTI laboratories or warehouse, post-trip wipe samples were acquired from each untreated board. The on-site and post-trip wipe test results were compared to detect significant differences. Such

differences could be indicative of the possibility of cross-contamination of untreated boards by treated boards during handling and shipment.

The results for on-site and post-trip testing of untreated boards are presented in Tables 8-9 and 8-10, respectively. Analytical results for many of the untreated boards from Pittsburgh were below the Method Detection Limit (MDL). The average arsenic concentration of block wipes for on-site Pittsburgh untreated boards was 18.3 µg/wipe (0.286 µg/cm^2 of block wipe surface area) with a standard deviation of 11.6 µg/wipe (0.18 µg/cm^2). The post-trip average arsenic concentration for the Pittsburgh untreated boards was 15.3 µg/wipe (0.239 µg/cm^2) and the standard deviation was 10.0 µg/wipe (0.156 µg/cm^2). This indicates a decrease of 3.0 µg/wipe (0.047 µg/cm^2) from field to laboratory, although the standard deviations are so large one cannot really say that the two data sets are different. This finding may indicate that no cross contamination occurred during handling and shipment; however, this decrease corresponds to less than one percent of the average block wipe result from recently treated wood obtained from the Fombell, Pennsylvania treatment facility and may not be statistically significant.

The average arsenic concentration and standard deviation for the on-site readings of the Gainesville untreated boards were 38.7 µg/wipe (0.605 µg/cm^2) and 56.9 µg/wipe (0.889 µg/cm^2), respectively. The post-trip average concentration and standard deviation for the Gainesville untreated boards were 37.4 µg/wipe (0.583 µg/cm^2) and 39.9 µg/wipe (0.623 µg/cm^2), respectively. This indicates a decrease of 1.3 µg/wipe (0.020 µg/cm^2) from field to laboratory. When compared to the Pittsburgh findings, the concentrations of arsenic in dislodgeable metal complex material from Florida untreated deck wood were much higher. An explanation of this finding follows.

When the untreated and recently treated 0.4 pcf CCA boards were received from the two treatment facilities in the Pittsburgh area, the two types of boards were separated from one another. There was a stack of untreated boards in one location and a stack of the 0.4 pcf CCA treated boards in another location. However, at the Great Southern facility in Bushnell, FL, the untreated and 0.4 pcf CCA boards were bound together and were sitting in the lumberyard, exposed to atmospheric conditions. The recently treated 0.4 pcf CCA boards were stacked on top of the untreated boards. Furthermore, it had rained the day before and on the day the boards were received by the RTI Field Manager. This may explain why elevated on-site and post-trip arsenic concentrations were found for untreated boards B1459I, B1479M, B1541B, and B1561F. The contact between the untreated boards and the treated boards and the rain-assisted transfer of preservative from the treated boards onto the untreated boards could explain the high arsenic concentration found in the on-site and post-trip readings, as cross contamination of the stacked boards was highly likely.

When the results of the four presumably contaminated untreated boards from the Great Southern plant are omitted, the average on-site arsenic concentration decreases to 11.8 µg/wipe (0.184 µg/cm^2) and the standard deviation improves to 4.7 µg/wipe (0.073 µg/cm^2). The post-trip average arsenic concentration for the Gainesville untreated boards is then 14.2 µg/wipe (0.222 µg/cm^2) with a standard deviation of 6.8 µg/wipe (0.106 µg/cm^2). This refined data set shows an increase in arsenic of 2.4 µg/wipe (0.038 µg/cm^2) for samples collected at RTI over the values from samples taken on-site. This value is comparable to the average difference derived from the Pittsburgh data and indicates that little, if any, cross contamination of boards occurred during transit.

To further examine the potential for cross-contamination during the study, three of the untreated boards (corresponding to three duplicate samples) from Pittsburgh were wrapped in polyethylene, just after the on-site samples were collected, in order to protect them from cross-contamination. These boards are designated with a (W) in Table 8.9. For the wrapped boards, the on-site arsenic concentrations were all below the MDL (4.8 µg/wipe) and the average post-trip concentration was 4.9 µg/wipe (0.077 µg/cm^2), only 0.1 µg/wipe above the MDL. For the boards that were not wrapped, the average on-site arsenic concentration for Pittsburgh untreated boards was 18.3 ± 11.6 µg/wipe. The post-trip value was

18.2 ± 9.4 µg/wipe (from Table 8-10). These values are essentially the same and indicate that no cross contamination occurred during board handling and transit.

Table 8-9. On-Site Sample Results for Untreated Boards from Treatment Facilities, µg/wipe

Untreated boards from treatment facilities that were tested on-site at Pittsburgh (P) and Gainesville (G). (W) Indicates board test segment was wrapped during transit.

Sample ID		As	Cr	Cu
F100223G	Site H, On-site, untreated, Board B14214 (P) (W)	<MDL	2.6	1.2
F100224H	Site H, On-site, untreated, Board B14214 (P) (W)	<MDL	<MDL	2.0
F100227K	Site I, On-site, untreated, Board B14236 (P)	<MDL	1.0	<MDL
F100228L	Site I, On-site, untreated, Board B14236 (P)	<MDL	1.3	2.6
F100253M	Site K, On-site, untreated, Board B12070 (P) (W)	<MDL	1.9	1.1
F100254N	Site K, On-site, untreated, Board B12070 (P) (W)	<MDL	<MDL	<MDL
F100257Q	Site L, On-site, untreated, Board B12387 (P) (W)	<MDL	1.6	1.0
F100258R	Site L, On-site, untreated, Board B12387 (P) (W)	<MDL	<MDL	<MDL
F100261M	Site M, On-site, untreated, Board B1296H (P)	<MDL	1.2	<MDL
F100262N	Site M, On-site, untreated, Board B1296H (P)	<MDL	<MDL	<MDL
F100265Q	Site N, On-site, untreated, Board B13197 (P)	<MDL	1.0	<MDL
F100266R	Site N, On-site, untreated, Board B13197 (P)	<MDL	<MDL	<MDL
F100387Z	Site P, On-site, untreated, Board B13415 (P)	13.0	8.5	5.1
F1003880	Site P, On-site, untreated, Board B13415 (P)	9.6	7.8	49.5
F100397I	Site Q, On-site, untreated, Board B13619 (P)	15.4	11.4	5.7
F1003982	Site Q, On-site, untreated, Board B13619 (P)	12.2	10.5	5.7
F100407M	Site R, On-site, untreated, Board B1381D (P)	18.2	12.7	5.6
F100408N	Site R, On-site, untreated, Board B1381D (P)	41.3	27.8	12.0
	Average of 18 tests (# >MDL)	18.3 (6)	7.2 (13)	8.3 (11)
	Standard deviation of tests	11.6	7.9	14.0
	%RSD	63.7	110.2	169.1
F100461S	Site S, On-site, untreated, Board B1265A (G)	15.9	11.7	6.0
F100462T	Site S, On-site, untreated, Board B1265A (G)	8.0	5.4	3.2
F100473W	Site T, On-site, untreated, Board B1459I (G)	110.9	77.4	39.3
F100474X	Site T, On-site, untreated, Board B1459I (G)	110.9	76.6	43.4
F1004850	Site U, On-site, untreated, Board B1479M (G)	83.1	55.9	33.0
F1004861	Site U, On-site, untreated, Board B1479M (G)	250.0	180.2	110.1
F1004974	Site V, On-site, untreated, Board B1481G (G)	10.3	8.9	3.7
F1004985	Site V, On-site, untreated, Board B1481G (G)	13.1	8.1	5.3
F100509R	Site W, On-site, untreated, Board B15013 (G)	9.1	7.5	3.5
F100510K	Site W, On-site, untreated, Board B15013 (G)	11.1	7.1	4.6
F100515P	Site X, On-site, untreated, Board B15217 (G)	12.0	8.5	4.4
F100516Q	Site X, On-site, untreated, Board B15217 (G)	7.3	4.5	2.4
F1005933	Site Y, On-site, untreated, Board B1541B (G)	38.0	38.1	12.8
F1005944	Site Y, On-site, untreated, Board B1541B (G)	47.8	39.6	11.3
F100605Q	Site Z, On-site, untreated, Board B1561F (G)	25.7	24.6	9.4
F100606R	Site Z, On-site, untreated, Board B1561F (G)	20.3	19.2	6.2

Untreated boards from treatment facilities that were tested on-site at Pittsburgh (P) and Gainesville (G). (W) Indicates board test segment was wrapped during transit.				
Sample ID		**As**	**Cr**	**Cu**
F100617U	Site AA, On-site, untreated, Board B1581J (G)	5.6	7.1	3.1
F100618V	Site AA, On-site, untreated, Board B1581J (G)	5.8	6.0	2.2
F100629Y	Site AB, On-site, untreated, Board B16016 (G)	11.8	11.6	4.8
F100630R	Site AB, On-site, untreated, Board B16016 (G)	18.5	15.2	6.4
F100641U	Site AC, On-site, untreated, Board B1621A (G)	14.6	13.8	5.8
F100642V	Site AC, On-site, untreated, Board B1621A (G)	21.7	18.0	8.5
	Average of 22 tests	38.7	29.3	15.0
	Standard deviation of 22 tests	56.9	40.2	24.3
	%RSD	147.1	137.3	162.6

Table 8-10. Post-Trip Sample Results for Untreated Boards from Treatment Facilities, µg/wipe

Untreated boards from treatment facilities in Pittsburgh (P) and Gainesville (G) that were tested post-trip. (W) Indicates board test segment was wrapped during transit.				
Sample ID		**As**	**Cr**	**Cu**
F100285U	Site H, Post-trip, untreated, Board B14214 (P) (W)	<MDL	3.2	2.0
F100302E	Site H, Post-trip, untreated, Board B14214 (P) (W)	<MDL	2.0	1.8
F100311F	Site I, Post-trip, untreated, Board B14236 (P)	<MDL	3.0	1.8
F100312G	Site I, Post-trip, untreated, Board B14236 (P)	<MDL	3.5	2.0
F100331J	Site K, Post-trip, untreated, Board B12070 (P) (W)	<MDL	2.0	1.1
F100332K	Site K, Post-trip, untreated, Board B12070 (P) (W)	4.8	2.5	1.7
F100335N	Site L, Post-trip, untreated, Board B12387 (P) (W)	5.0	4.3	3.0
F100336O	Site L, Post-trip, untreated, Board B12387 (P) (W)	<MDL	2.3	1.4
F100345P	Site M, Post-trip, untreated, Board B1296H (P)	<MDL	3.6	2.3
F100346Q	Site M, Post-trip, untreated, Board B1296H (P)	<MDL	2.2	1.4
F100355R	Site N, Post-trip, untreated, Board B13197 (P)	14.8	12.6	8.6
F100356S	Site N, Post-trip, untreated, Board B13197 (P)	<MDL	2.5	2.0
F100425O	Site P, Post-trip, untreated, Board B13415 (P)	15.8	13.7	6.2
F100426P	Site P, Post-trip, untreated, Board B13415 (P)	28.0	25.0	10.2
F100437S	Site Q, Post-trip, untreated, Board B13619 (P)	14.8	12.1	6.6
F100438T	Site Q, Post-trip, untreated, Board B13619 (P)	7.6	7.7	3.9
F100449W	Site R, Post-trip, untreated, Board B1381D (P)	12.4	9.4	4.1
F100450P	Site R, Post-trip, untreated, Board B1381D (P)	34.3	24.6	9.5
	Average of tests (# >MDL)	15.3 (9)	7.6 (22)	3.9 (22)
	Standard deviation of 22 tests	10	7.4	3.0
	%RSD	65.6	98.0	77.6
F100525R	Site S, Post-trip, untreated, Board B1265A (G)	19.7	19.2	9.2
F100526S	Site S, Post-trip, untreated, Board B1265A (G)	10.8	11.8	4.3
F100535T	Site T, Post-trip, untreated, Board B1459I (G)	85.8	68.0	33.7
F100536U	Site T, Post-trip, untreated, Board B1459I (G)	89.3	69.4	34.5

Untreated boards from treatment facilities in Pittsburgh (P) and Gainesville (G) that were tested post-trip. (W) Indicates board test segment was wrapped during transit.				
Sample ID		**As**	**Cr**	**Cu**
F100545V	Site U, Post-trip, untreated, Board B1479M (G)	146.7	110.3	57.7
F100546W	Site U, Post-trip, untreated, Board B1479M (G)	84.0	66.4	36.7
F100555X	Site V, Post-trip, untreated, Board B1481G (G)	10.1	9.4	5.0
F100556Y	Site V, Post-trip, untreated, Board B1481G (G)	12.3	11.0	5.3
F100565Z	Site W, Post-trip, untreated, Board B15013 (G)	10.9	9.8	4.2
F1005660	Site W, Post-trip, untreated, Board B15013 (G)	6.3	8.1	4.1
F1005693	Site X, Post-trip, untreated, Board B15217 (G)	8.6	6.4	3.4
F100570W	Site X, Post-trip, untreated, Board B15217 (G)	9.5	8.6	4.1
F100652X	Site Y, Post-trip, untreated, Board B1541B (G)	53.7	53.7	18.2
F100653Y	Site Y, Post-trip, untreated, Board B1541B (G)	112.5	137.6	114.1
F100661Y	Site Z, Post-trip, untreated, Board B1561F (G)	21.8	18.5	8.3
F100662Z	Site Z, Post-trip, untreated, Board B1561F (G)	30.2	27.9	10.8
F1006710	Site AA, Post-trip, untreated, Board B1581J (G)	15.5	14.3	6.4
F1006721	Site AA, Post-trip, untreated, Board B1581J (G)	9.6	10.2	5.6
F1006812	Site AB, Post-trip, untreated, Board B16016 (G)	32.1	25.6	10.5
F1006823	Site AB, Post-trip, untreated, Board B16016 (G)	15.8	16.0	8.5
F1006914	Site AC, Post-trip, untreated, Board B1621A (G)	16.3	15.8	7.8
F1006925	Site AC, Post-trip, untreated, Board B1621A (G)	22.0	22.3	13.6
	Average of 22 tests	37.4	33.7	18.5
	Standard deviation of 22 tests	39.9	35.9	25.6
	%RSD	106.6	106.5	138.7

8.5.2 Comparison of On-Site and Post-trip Board Wipe Samples for Recently Treated 0.4 CCA pcf SYP From Treatment Facilities

Recently treated 0.4 CCA pcf boards were acquired from two treatment facilities in the northeast and two facilities in the south. Near Pittsburgh, PA, the two facilities were Quality One/Universal Forest Products in Fombell, PA and Schroth Industries in Indiana, PA. The Schroth Industries boards were only used for the hand rubbing and block wipe sampling comparisons in the Full Study; they were not used for the field tests. The two facilities near Gainesville, FL were Great Southern in Bushnell, FL and Robbins Manufacturing in Lockhart, FL. One recently treated board was assigned to each of the deck sites scheduled for that trip. An on-site wipe test was performed on each board soon after its receipt from the treatment plant. Within a week or two after arrival at the testing facility, post-trip wipe test were performed on a different section of each recently treated board.

The results for on-site and post-trip testing of recently treated 0.4 pcf CCA boards are given in Tables 8-11 and 8-12, respectively. The average arsenic concentration for on-site Pittsburgh recently treated boards was 564.2 µg/wipe (8.816 µg/cm^2) with a standard deviation of 464.8 µg/wipe (7.263 µg/cm^2). The post-trip average arsenic concentration for the Pittsburgh recently treated boards was 678.5 µg/wipe (10.602 µg/cm^2) and the standard deviation was 576.3 µg/wipe (9.005 µg/cm^2). This represents an increase of 114.3 µg/wipe (1.786 µg/cm^2).

The average arsenic concentrations and standard deviations for the on-site readings of the Gainesville recently treated boards were 492.8 µg/wipe (7.7 µg/cm^2) and 756.0 µg/wipe (11.8 µg/cm^2), respectively. The post-trip average concentration and standard deviation for the Gainesville recently

treated boards were 630.1 µg/wipe (9.8 µg/cm^2) and 946.5 µg/wipe (14.8 µg/cm^2), respectively. This represents an increase of 137.3 µg/wipe (2.1 µg/cm^2). Considering the large standard deviations, the average arsenic concentrations for recently treated boards acquired from both Pittsburgh and Gainesville locations appear to be in agreement. Attention is called to the fact that no recently treated boards from Schroth Industries of Indiana, Pennsylvania, were subjected to field tests. Schroth recently treated boards were used only for the hand rubbing and block wipe testing in the Full Study.

The recently treated 0.4 pcf CCA boards showed a wide range of variation in arsenic concentrations in the on-site and post-trip readings. The maximum value was 3816.5 µg/wipe (59.6 µg/cm^2) and the minimum value was 67.5 µg/wipe (1.1 µg/cm^2). This variation could be due to the nature of the wood. For example, the absorption of the preservative into pine heartwood is considered to be moderately difficult (USDA, 1999, Chapter 14, pg. 14-12). However, some locations on the boards seemed to be very susceptible to concentrating the preservative, thus creating areas that exhibited high arsenic concentrations during the wipe tests. In 16 of the 40 field samples, the on-site arsenic values were considerably higher than the post-trip values. On some boards, one on-site value was larger than the post-trip value, but the second on-site value was less than that of the post-trip. When results for each individual board are considered, it is possible that the differences may not be statistically significant.

Table 8-11. On-Site Sample Results for Recently Treated 0.4 CCA pcf Boards From Treatment Facilities, µg/wipe

Recently treated 0.4 CCA pcf boards from treatment facilities that were tested on-site at Pittsburgh (P) and Gainesville (G).				
Sample ID		**As**	**Cr**	**Cu**
F100225I	Site H, On-site, recently treated 0.4 CCA, Board B14225 (P)	189.5	198.2	134.3
F100226J	Site H, On-site, recently treated 0.4 CCA, Board B14225 (P)	163.8	166.3	110.5
F100229M	Site I, On-site, recently treated 0.4 CCA, Board B14247 (P)	1380.0	1401.1	766.1
F100230F	Site I, On-site, recently treated 0.4 CCA, Board B14247 (P)	1557.8	1501.5	922.6
F100255O	Site K, On-site, recently treated 0.4 CCA, Board B12081 (P)	586.3	394.8	241.8
F100256P	Site K, On-site, recently treated 0.4 CCA, Board B12081 (P)	783.9	530.5	346.6
F100259S	Site L, On-site, recently treated 0.4 CCA, Board B12398 (P)	1033.3	836.2	396.3
F100260L	Site L, On-site, recently treated 0.4 CCA, Board B12398 (P)	1299.5	1010.5	506.4
F100263O	Site M, On-site, recently treated 0.4 CCA, Board B1297I (P)	107.7	92.1	54.8
F100264P	Site M, On-site, recently treated 0.4 CCA, Board B1297I (P)	89.2	65.6	46.2
F100267S	Site N, On-site, recently treated 0.4 CCA, Board B13200 (P)	117.8	76.2	67.0
F100268T	Site N, On-site, recently treated 0.4 CCA, Board B13200 (P)	183.6	108.0	98.6
F100389I	Site P, On-site, recently treated 0.4 CCA, Board B13426 (P)	397.6	301.7	167.7
F100390U	Site P, On-site, recently treated 0.4 CCA, Board B13426 (P)	363.6	300.0	175.7
F1003993	Site Q, On-site, recently treated 0.4 CCA, Board B1362A (P)	479.2	415.5	220.1
F100400F	Site Q, On-site, recently treated 0.4 CCA, Board B1362A (P)	620.2	465.2	276.6
F100409O	Site R, On-site, recently treated 0.4 CCA, Board B1382E (P)	392.7	437.9	195.7
F100410H	Site R, On-site, recently treated 0.4 CCA, Board B1382E (P)	409.2	389.1	199.3
	Average of 18 tests	564.2	482.8	273.7
	Standard deviation of 18 tests	464.8	433.2	241.7
	%RSD	82.4	89.7	88.3

Recently treated 0.4 CCA pcf boards from treatment facilities that were tested on-site at Pittsburgh (P) and Gainesville (G).				
Sample ID		**As**	**Cr**	**Cu**
F100463U	Site S, On-site, recently treated 0.4 CCA, Board B14021 (G)	166.0	171.4	88.8
F100464V	Site S, On-site, recently treated 0.4 CCA, Board B14021 (G)	189.9	194.5	125.3
F100475Y	Site T, On-site, recently treated 0.4 CCA, Board B1460B (G)	162.8	157.5	71.7
F100476Z	Site T, On-site, recently treated 0.4 CCA, Board B1460B (G)	269.3	290.0	150.4
F1004872	Site U, On-site, recently treated 0.4 CCA, Board B1480F (G)	844.8	989.0	209.6
F1004883	Site U, On-site, recently treated 0.4 CCA, Board B1480F (G)	699.5	707.2	184.8
F1004996	Site V, On-site, recently treated 0.4 CCA, Board B1482H (G)	499.7	464.2	227.7
F100500I	Site V, On-site, recently treated 0.4 CCA, Board B1482H (G)	1215.0	1079.5	460.4
F100511L	Site W, On-site, recently treated 0.4 CCA, Board B15024 (G)	300.3	326.9	164.4
F100512M	Site W, On-site, recently treated 0.4 CCA, Board B15024 (G)	178.6	187.6	79.6
F100517R	Site X, On-site, recently treated 0.4 CCA, Board B15228 (G)	2591.3	2368.7	648.4
F100518S	Site X, On-site, recently treated 0.4 CCA, Board B15228 (G)	2703.9	2300.1	669.5
F1005955	Site Y, On-site, recently treated 0.4 CCA, Board B1542C (G)	93.9	115.0	91.2
F1005966	Site Y, On-site, recently treated 0.4 CCA, Board B1542C (G)	90.1	112.9	97.2
F100607S	Site Z, On-site, recently treated 0.4 CCA, Board B1561F (G)	111.2	127.6	113.2
F100608T	Site Z, On-site, recently treated 0.4 CCA, Board B1561F (G)	97.2	124.1	82.1
F100619W	Site AA, On-site, recently treated 0.4 CCA, Board B1581J (G)	67.5	78.0	47.6
F100620P	Site AA, On-site, recently treated 0.4 CCA, Board B1581J (G)	131.0	144.0	101.4
F100631S	Site AB, On-site, recently treated 0.4 CCA, Board B16027 (G)	116.1	123.1	70.6
F100632T	Site AB, On-site, recently treated 0.4 CCA, Board B16027 (G)	91.6	109.0	73.6
F100643W	Site AC, On-site, recently treated 0.4 CCA, Board B1622B (G)	119.8	132.3	77.7
F100644X	Site AC, On-site, recently treated 0.4 CCA, Board B1622B (G)	103.3	133.0	112.1
	Average of 22 tests	492.8	474.3	179.4
	Standard deviation of 22 tests	756.0	664.6	178.1
	%RSD	153.4	140.1	99.3

Table 8-12. Post-Trip Sample Results for Recently Treated 0.4 CCA pcf Boards from Treatment Facilities, µg/wipe

Recently treated 0.4 CCA pcf boards from treatment facilities at Pittsburgh (P) and Gainesville (G) that were tested post-trip				
Sample ID		**As**	**Cr**	**Cu**
F100303F	Site H, Post-trip, recently treated 0.4 CCA, Board B14225 (P)	129.1	126.0	93.5
F100304G	Site H, Post-trip, recently treated 0.4 CCA, Board B14225 (P)	106.1	100.8	76.5
F100313H	Site I, Post-trip, recently treated 0.4 CCA, Board B14247 (P)	984.2	961.7	498.6
F100314I	Site I, Post-trip, recently treated 0.4 CCA, Board B14247 (P)	1604.2	1294.2	866.4
F100333L	Site K, Post-trip, recently treated 0.4 CCA, Board B12081 (P)	1159.2	699.4	493.0
F100334M	Site K, Post-trip, recently treated 0.4 CCA, Board B12081 (P)	1482.2	817.9	685.4
F100337P	Site L, Post-trip, recently treated 0.4 CCA, Board B12398 (P)	1478.9	967.4	540.8
F100338Q	Site L, Post-trip, recently treated 0.4 CCA, Board B12398 (P)	1702.1	1446.5	633.8
F100347R	Site M, Post-trip, recently treated 0.4 CCA, Board B1297I (P)	131.2	111.4	78.4
F100348S	Site M, Post-trip, recently treated 0.4 CCA, Board B1297I (P)	189.3	181.8	98.2
F100357T	Site N, Post-trip, recently treated 0.4 CCA, Board B13200 (P)	191.2	134.3	107.9
F100358U	Site N, Post-trip, recently treated 0.4 CCA, Board B13200 (P)	128.3	81.8	64.2
F100427Q	Site P, Post-trip, recently treated 0.4 CCA, Board B13426 (P)	462.0	505.9	233.1
F100428R	Site P, Post-trip, recently treated 0.4 CCA, Board B13426 (P)	807.4	798.7	347.0
F100439U	Site Q, Post-trip, recently treated 0.4 CCA, Board B1362A (P)	406.8	491.0	198.7
F100440N	Site Q, Post-trip, recently treated 0.4 CCA, Board B1362A (P)	647.0	673.4	336.4
F100451Q	Site R, Post-trip, recently treated 0.4 CCA, Board B1382E (P)	286.8	473.9	152.8
F100452R	Site R, Post-trip, recently treated 0.4 CCA, Board B1382E (P)	317.3	404.3	162.3
	Average of 18 tests	678.5	570.6	314.8
	Standard deviation of 18 tests	576.3	420.0	248.0
	%RSD	84.9	73.6	78.8
F100527T	Site S, Post-trip, recently treated 0.4 CCA, Board B14021 (G)	283.8	313.7	166.0
F100528U	Site S, Post-trip, recently treated 0.4 CCA, Board B14021 (G)	201.0	224.9	132.8
F100537V	Site T, Post-trip, recently treated 0.4 CCA, Board B1460B (G)	281.8	329.7	149.5
F100538W	Site T, Post-trip, recently treated 0.4 CCA, Board B1460B (G)	142.1	224.1	97.6
F100547X	Site U, Post-trip, recently treated 0.4 CCA, Board B1480F (G)	633.9	643.3	192.5
F100548Y	Site U, Post-trip, recently treated 0.4 CCA, Board B1480F (G)	512.9	484.8	198.7
F100557Z	Site V, Post-trip, recently treated 0.4 CCA, Board B1482H (G)	1422.2	1406.7	564.2
F1005580	Site V, Post-trip, recently treated 0.4 CCA, Board B1482H (G)	888.0	876.0	409.9
F1005671	Site W, Post-trip, recently treated 0.4 CCA, Board B15024 (G)	283.0	369.6	173.3
F1005682	Site W, Post-trip, recently treated 0.4 CCA, Board B15024 (G)	269.7	360.8	158.0
F100571X	Site X, Post-trip, recently treated 0.4 CCA, Board B15228 (G)	3816.5	4683.5	943.1
F100572Y	Site X, Post-trip, recently treated 0.4 CCA, Board B15228 (G)	2709.4	3155.9	625.1
F100653Y	Site Y, Post-trip, recently treated 0.4 CCA, Board B1542C (G)	112.5	137.6	114.1
F100654Z	Site Y, Post-trip, recently treated 0.4 CCA, Board B1542C (G)	103.5	122.1	88.9
F1006630	Site Z, Post-trip, recently treated 0.4 CCA, Board B1561F (G)	135.7	170.5	108.4
F1006641	Site Z, Post-trip, recently treated 0.4 CCA, Board B1561F (G)	140.6	167.1	107.2
F1006732	Site AA, Post-trip, recently treated 0.4 CCA, Board B1581J (G)	164.9	192.1	122.6
F1006743	Site AA, Post-trip, recently treated 0.4 CCA, Board B1581J (G)	1282.1	1475.0	387.1
F1006834	Site AB, Post-trip, recently treated 0.4 CCA, Board B16027 (G)	111.4	140.9	90.8

Recently treated 0.4 CCA pcf boards from treatment facilities at Pittsburgh (P) and Gainesville (G) that were tested post-trip				
Sample ID		**As**	**Cr**	**Cu**
F1006845	Site AB, Post-trip, recently treated 0.4 CCA, Board B16027 (G)	112.4	138.1	80.3
F1006936	Site AC, Post-trip, recently treated 0.4 CCA, Board B1622B (G)	149.0	168.2	157.6
F1006947	Site AC, Post-trip, recently treated 0.4 CCA, Board B1622B (G)	106.5	159.7	123.1
	Average of 22 tests	630.1	724.8	235.9
	Standard deviation of 22 tests	946.5	1127.7	219.7
	%RSD	150.2	155.6	93.1

8.5.3 Comparison of On-Site and Post-Trip Deck Board Block Wipe Samples Results

Tables 8-13 presents average analytical data from black wipe sampling of each site's deck boards. Results for ten decks from the Pittsburgh area and ten decks from the Gainesville area are summarized. The results for individual boards (not shown in Table 8-3) show considerable variability in concentrations in duplicate sample results and from board to board on the same deck, for both on-site and post-trip samples. Average concentrations of wipe samples acquired on-site and of wipe samples collected after return to the testing facility were also compared.

For the Pittsburgh trips, the average post-trip concentrations were higher for boards from three of the 10 decks. For the Gainesville trips, the post-trip concentrations were higher for seven of the 10 decks. In most cases, the deck samples were collected soon after or during precipitation events, and the field wipe samples were taken as soon as the boards were judged to be dry enough to sample, usually within 24 hours after the deck was dismantled. The boards had ample time to dry before the post-trip wipe sampling.

A total of 240 field samples were collected for the 20 decks during on-site and post-trip block wipe testing. Two on-site field samples for Site K were not analyzed because the centrifuge tubes for both samples were destroyed when placed in the centrifuge. Two post-trip samples from Site S were not analyzed because they were contaminated either during transit to the laboratory or during laboratory dilutions.

More discussion on the comparison of block wipe results from deck wood from various locations and of various ages can be found in Section 9.0 of this report.

Table 8-13. Summary of On-site and Post-trip Block Wipe Sample Results for Deck Boards from Pittsburgh, PA and Gainesville, FL Areas, µg/wipe

Deck Identity Age	On-site			Post-trip		
	As Average and SD	**Cr Average and SD**	**Cu Average and SD**	**As Average and SD**	**Cr Average and SD**	**Cu Average and SD**
Pittsburgh, PA (Decks H, I, K, L, M, N, P, Q, R, and X)						
Site H 8 years old	124.0±29.6	143.8±68.1	46.0±7.7	106.6±11.1	137.7±46.1	50.0±7.4
Site I 6 years old	184.8±123.8	244.5±126.2	59.8±34.6	142.6±109.9	192.7±131.3	55.5±24.3

Deck Identity Age	On-site			Post-trip		
	As Average and SD	Cr Average and SD	Cu Average and SD	As Average and SD	Cr Average and SD	Cu Average and SD
Site K 21 years old	365.0±211.7	436.5±223.9	115.5±43.4	172.0±66.2	211.8±80.9	127.3±23.1
Site L 5 years old	337.4±77.4	414.8±61.7	164.9±76.4	252.7±90.3	300.2±99.4	100.4±23.1
Site M 1 year old	398.9±337.4	432.2±350.7	95.4±38.1	261.2±193.9	284.0±230.6	75.0±26.2
Site N 15 years old	135.8±59.5	115.6±39.0	85.8±21.4	202.0±87.9	172.5±68.3	140.1±63.6
Site P 7 months old	141.9±62.4	112.6±47.3	212.3±110.0	155.9±34.0	121.2±25.1	244.1±87.9
Site Q 8 months old	178.8±43.8	219.6±98.5	321.5±149.5	131.6±20.1	152.0±42.1	183.8±97.2
Site R 11 months old	323.5±212.6	465.6±270.5	240.3±108.9	145.5±56.8	237.1±79.1	115.7±24.7
Site X 1 year old	100.2±30.7	165.0±53.3	54.7±12.1	106.6±22.9	157.9±31.8	66.5±20.0
Gainesville, FL (Decks S, T, U, V, W, Y, Z, AA, AB, and AC)						
Site S 15 years old	118.6±42.9	167.3±70.1	77.5±19.6	78.2±12.0	118.4±25.5	72.7±25.2
Site T 1 year old	78.1±10.6	78.4±11.0	247.6±67.4	80.7±16.9	90.6±18.4	192.0±47.5
Site U 15 years old	71.4±39.9	89.9±44.5	41.9±10.9	78.7±14.3	107.3±6.5	47.8±7.7
Site V 5 years old	259.9±106.1	230.6±96.0	70.3±13.6	228.4±116.0	235.5±133.3	72.4±42.2
Site W 6 years old	315.8±100.1	358.9±84.1	57.6±21.1	439.0±195.5	531.0±172.4	91.1±40.0
Site Y 1 year old	68.7±23.8	126.8±41.3	195.1±62.1	74.3±16.3	136.0±27.1	237.5±77.6
Site Z 1 year old	80.7±38.1	67.1±23.8	138.1±82.7	111.4±29.9	96.8±19.6	147.2±71.7
Site AA 13 months old	51.7±12.0	84.9±15.1	171.9±89.3	77.8±18.7	134.8±30.7	242.8±123.2
Site AB 16 months old	1097.0±297.9	1156.7±412.0	371.7±119.4	1206.6±360.9	1403.7±522.5	450.6±187.7
Site AC 15 years old	107.1±28.0	113.9±36.8	63.8±15.2	93.1±20.7	108.5±26.9	56.9±27.5

8.6 Field Blank and Field Spike Wipes

Field blank and field spike studies of wipe sampling material were conducted to assess the possibility of contamination or loss of material from the polyester Alpha Wipes during the course of the study. Just prior to departure from RTI to the sites for collection of deck boards, two types of Alpha Wipes were prepared – blank and spiked. The blank wipe consisted of a recently cut, 11.4 cm by 11.4 cm (4 inch by 4 inch) segment. It was placed in a pre-cleaned, 250 mL HDPE screw cap bottle or into a 50 mL polystyrene centrifuge tube. A spiked wipe was prepared by placing a new Alpha Wipe of the same dimensions into a HDPE bottle or centrifuge tube. Several mL of an aqueous solution containing known amounts of arsenic, chromium, and copper salts were added by pipet to the interior wall of the sample container. The container was sealed, shaken, and not opened again until its return to the laboratory for analysis. These blank and spike samples were transported to and from the field and handled in exactly the same manner as a study wipe sample. Analytical results for the field blanks and field spikes are presented in Tables 8-14 and 8-15, respectively. The blank wipe concentrations for arsenic chromium copper were very low, well below the MDLs of the instruments. The recoveries from the spiked wipes were almost all within 20 percent of the expected values. The expected value for each metal was 120 µg/wipe.

Table 8-14. Field Wipe Blanks for Testing from Pittsburgh and Gainesville, µg/wipe

Sample ID	Assigned Site	As	Cr	Cu
F100294V	Site H, Field Blank	<4.8[(a)]	<0.96[(a)]	<0.96[(a)]
F100295W	Site I, Field Blank	<4.8	<0.96	<0.96
F100297Y	Site K, Field Blank	<4.8	<0.96	<0.96
F100298Z	Site L, Field Blank	<4.8	<0.96	<0.96
F1002990	Site M, Field Blank	<4.8	<0.96	<0.96
F100300C	Site N, Field Blank	<4.8	<0.96	<0.96
F100417O	Site P, Field Blank	<4.8	<0.96	<0.96
F100429S	Site Q, Field Blank	<4.8	<0.96	<0.96
F100441O	Site R, Field Blank	<4.8	<0.96	<0.96
F100453S	Site S, Field Blank	<4.8	<0.96	<0.96
F100465W	Site T, Field Blank	<4.8	<0.96	<0.96
F1004770	Site U, Field Blank	<4.8	<0.96	<0.96
F1004894	Site V, Field Blank	<4.8	<0.96	<0.96
F100501J	Site W, Field Blank	<4.8	<0.96	<0.96
F100513N	Site X, Field Blank	<4.8	<0.96	<0.96
F1005853	Site Y, Field Blank	<4.8	<0.96	<0.96
F1005977	Site Z, Field Blank	<4.8	<0.96	<0.96
F100609U	Site AA, Field Blank	<4.8	<0.96	<0.96
F100621Q	Site AB, Field Blank	<4.8	<0.96	<0.96
F100633U	Site AC, Field Blank	<4.8	<0.96	<0.96

[(a)]Method Detection Limit.

Table 8-15. Field Wipe Spikes from Pittsburgh, PA and Gainesville, FL with Concentration (µg/wipe) and % Recoveries

Sample ID	Field Spike	As		Cr		Cu	
		Concentration (µg/wipe)	Spike % Recovery	Concentration (µg/wipe)	Spike % Recovery	Concentration (µg/wipe)	Spike % Recovery
F100286V	Site H	147	**123**	153	**128**	157	**131**
F100287W	Site I	132	110	128	107	135	113
F100288X	Site J	137	114	131	109	141	118
F100289Y	Site K	153	**128**	143	119	154	**128**
F100290R	Site L	154	**128**	149	**124**	160	**133**
F100291S	Site M	133	111	125	104	135	113
F100292T	Site N	133	111	126	105	136	113
F100418P	Site P	120	100	126	105	129	108
F100430L	Site Q	113	95	113	95	121	101
F100442P	Site R	111	93	113	95	124	103
F100454T	Site S	98.4	82	85.7	**71**	97.9	82
F100466X	Site T	96.5	80	84.0	**70**	98.2	82
F1004781	Site U	97.3	81	89.9	**75**	102	85
F100490X	Site V	97.6	82	89.6	**75**	104	87
F100502K	Site W	95.7	80	89.5	**75**	99.6	83
F100514O	Site X	115	96	105	88	125	104
F1005864	Site Y	122	102	121	101	127	105
F1005988	Site Z	130	108	131	109	135	113
F100610N	Site AA	122	102	120	101	127	105
F100622R	Site AB	125	104	121	101	128	107
F100634V	Site AC	122	102	120	101	126	105

[(a)]The values in bold exceed the evaluation criteria for recovery of ±20%. The acceptable range for percent recovery is from 80 to 120%.

9.0 STUDY RESULTS

9.1 Purpose

The purposes of the full study were to implement the sampling and chemical analysis procedures developed in the project's pilot study, to expand on the findings from the smaller mini-study, and to develop more reliable information and data to achieve the following study objectives:

- Provide reliable estimates of the amount of dislodgeable metal complex removed by hand and by wipe sampling of CCA-preserved wood
- Determine if a statistically significant reduction in the amount of dislodgeable metal complex occurs between recently treated and aged CCA-preserved wood and with region, *i.e.*, north vs south
- Provide information from which a reliable transfer reduction factor (TRF) may be derived to adjust the amount of metal complex removed using a wipe sampling technique to the amount of metal complex removed using a hand sampling technique.
- Test for the presence of Cr(VI) in the hand sample rinse solutions.

The full study included the use of coupons from twenty (20) residential decks, 10 from the Pittsburgh, Pennsylvania, area (north) and 10 from the Gainesville, Florida, area (south). Half of the decks from each city had been in service for approximately one year, and half had been in service for five or more years. The newer decks ranged in age from 0.6 to 1.3 years while the older decks ranged in age from five to 21 years. Recently treated 0.4 pcf CCA wood deck boards were purchased directly from two treatment facilities near these same cities. Untreated deck boards were obtained directly from a lumberyard in Concord, North Carolina, to serve as control blanks. About 750 coupons were sampled using the block wipe and hand sampling methods developed and optimized in the pilot study. Twenty-one volunteers performed the hand sampling; a single RTI employee performed all block wipe sampling.

9.2 Coupon Selection

The 3-ft. wood coupons used in this study were cut from deck boards collected from the Gainesville and Pittsburgh areas. A barcode label was attached to each coupon. Approximately 30 coupons were prepared from each deck. Recently treated deck lumber, purchased from two treatment facilities near the same cities, were also collected and cut into coupons. Untreated wood coupons purchased directly from a sawmill/lumber yard served as negative control and as a means of testing for cross contamination during shipment of the aged decks. The coupon sources and number of coupons are shown in Table 9.1. Thirty separate stacks of coupons, each containing one coupon from each of the 20 decks, one recently treated coupon from each of the four treatment facilities (treated within 7 weeks of testing), and one untreated coupon were assembled (for a total of 25 coupons per stack) such that each of the 21 volunteers would be able to sample (*i.e.*, rub) coupons of each type and from each deck. Note that nine of the volunteers rubbed samples from two complete stacks of coupons. Each volunteer alternated left and right (or right and left) hands as he/she worked through the coupons of a stack. The coupons in each stack were randomly arranged and were separated from each other by narrow strips of untreated wood. In a few cases, not enough coupons were available from a specific deck; in these cases a coupon from a deck of the same age and geographic location was substituted.

Table 9-1. Coupons for the Mini and Full Studies

Wood Type	Source	Age, yrs	No. of Coupons Used
Untreated	Klutz Lumber, Concord, NC	--	20
Untreated	Lowes, Raleigh, NC	--	10
Untreated[(a)]	Universal Forest Prod., Union City, GA	--	8
Recently Treated[(a)]	Universal Forest Prod., Union City, GA	0	8
Recently Treated	Great Southern, Bushnell, FL	0	23
Recently Treated	Robbins Manufacturing, Lockhart, FL	0	35
Recently Treated	Quality One/Universal Forest Products, Fombell, PA	0	28
Recently Treated	Schroth Industries, Indiana, PA	0	32
Deck D[(a)]	Sharpsburg, GA	4	20
Deck E[(a)]	Marietta, GA	1.5	22
Deck G[(a)]	Sharpsburg, GA	1	21
Deck H	Charleroi, PA	8	30
Deck I	Charleroi, PA	6	30
Deck J[(a)]	Belle Vernon, PA	23	20
Deck K	California, PA	21	30
Deck L	California, PA	5	30
Deck M	California, PA	1	32
Deck N	California, PA	15	30
Deck O[(a)]	California, PA	15	21
Deck P	California, PA	7 mo.	23
Deck Q	Mt. Pleasant, PA	8 mo.	30
Deck R	Greensburg, PA	11 mo.	34
Deck S	Gainesville, FL	15	31
Deck T	Gainesville, FL	1	30
Deck U	Gainesville, FL	15	30
Deck V	Crystal River, FL	5	27
Deck W	Homosassa, FL	6	31
Deck X	Greensburg, PA	1	31
Deck Y	Gainesville, FL	1	29
Deck Z	Gainesville, FL	1	30
Deck AA	Gainesville, FL	13 mo.	30
Deck AB	Trenton, FL	16 mo.	30
Deck AC	Palatka, FL	15	30

[(a)]Used In Mini Study. Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

9.3 Volunteers

Public announcements were posted at a local temporary employment agency and at a local university calling for volunteers, aged 18 to 65 years, to participate in a deck wood exposure study. Twenty one volunteers signed up for testing. Each volunteer was reimbursed for participating. Approximately 4 volunteers came to RTI each day to meet with project personnel. The purpose and intended procedures of the study were described to each volunteer. Each volunteer was then asked to read

and sign the IRB-approved Volunteer Information and Consent Form. Each volunteer was provided a signed copy of the consent form. Each volunteer was taken to the laboratory where they became familiar with the hand rubbing technique, the setup of the equipment, and had an outline of their hand traced in order to determine approximate hand area. Each volunteer then practiced the rubbing and hand rinsing/hand wiping process using untreated wood coupons.

Image scanning and computer program applications were implemented to outline and determine the areas of each volunteer's left and right hand. The data from these measurements are presented in Table 9.2.

Table 9-2. Hand Areas for Full Study Hand Rubbing Participants

Participant identification number	Gender, Male or Female	Outlined hand area, cm^2, left hand	Outlined hand area, cm^2, right hand
V1016	F	119.7	138.7
V1017	M	163.2	158.7
V1018	M	153.3	148.5
V1019	M	141.6	142.8
V1020	F	118.4	121.6
V1021	F	146.9	137.7
V1023	M	140.2	139.1
V1024	M	130.9	130.9
V1025	M	182.1	188.2
V1026	F	116.0	118.5
V1027	M	127.2	137.2
V1028	F	114.0	119.8
V1029	F	108.9	109.3
V1030	F	111.0	106.8
V1031	F	120.6	126.6
V1032	M	130.1	131.0
V1033	M	135.3	140.0
V1034	M	120.2	130.5
V1035	M	155.6	158.5
V1036	M	122.0	133.6
V1037	M	153.7	155.9

9.4 Testing Process

The testing process included collecting the block wipe samples, collecting the hand samples, and sample analysis.

9.4.1 Coupons

As noted above, the coupons from the untreated wood, recently treated wood, and twenty decks were randomly distributed into thirty (30) stacks for the 21 volunteers. This assured that each volunteer would sample untreated wood, recently treated wood, and aged wood from each of the decks. Several volunteers sampled up to two stacks of wood in a two-day period.

9.4.2 Block Wipe Sampling

Each of the coupons was subjected to block-wipe sampling. All block-wipe sampling was performed by one experienced RTI staff member according to the following procedure:

- A clean wipe that was equilibrated with 1.9 g of 0.9% saline was attached to the sampling block using a Teflon collar and tape.
- The 1100 gram, 8 cm by 8 cm block was pulled with cords back and forth along a 40 cm path for 10 passes (5 backward and forward movements) while moving slowly side to side. The block was moved at a rate of ~ 3 seconds per pass.
- The block was then rotated 90º and pulled back and forth for another 10 passes. The total sampling time was approximately 60 seconds.
- The wipe was carefully removed and lightly folded before being placed in a 50-mL plastic centrifuge tube.
- The tube was labeled with a barcode label and the coupon identifier and tube/sample identifier were entered into the database with the terminal in the laboratory.
- Analysis request forms (*i.e.*, chain of custody forms) were generated that listed the samples collected.
- The sample collection person and the laboratory person both signed the form when the samples were given to the laboratory. The sample collection person retained copies of the forms.

The wipe samples were analyzed *via* digestion in 25 mL of 10% nitric acid for 12 hours in a shaking water bath at 60ºC. Quality control included duplicate analysis of select extracts, analysis of extracts spiked with either a standard solution of metal salts or reference material wood flour, and analysis of blanks. The digests were analyzed using a Perkin Elmer 4300DV ICP/AES according to procedures defined in EPA Method 6010-mod. (USEPA, Method 6010B) and RTI SOP EG-282, "Extraction of Arsenic, Chromium, and Copper from Block Wipe Samples and Subsequent Measurement by ICP-AES" (RTI, 2003h).

9.4.3 Hand Rub Sampling

Four hand-rubbing stations were set up in the laboratory. Each station was equipped with a clamping system to hold the coupons in place, dishes for rinsing the hands, a supply of 200-mL high density polyethylene bottles to contain the rinse samples, plastic funnels, saline-treated Alpha Wipes in 50-mL plastic centrifuge tubes for wiping the hands after rinsing, and a video camera to capture the rubbing and rinsing procedures for each volunteer and each coupon sampled. Details of the procedure are given in RTI SOP No. CCA-040, "Standard Operating Procedure for Acquiring CCA-Treated Deck Board Hand Rinse and Wipe Samples" (RTI 2003e).

An "operator" directed each sampling session at each sampling station. Staff who served as operators were experienced in the hand rubbing process either through their support of the research component of the work or through a training session. All operators completed the IRB required Human Subjects Training Course. The duties of the operators were to:

- Select and mount a coupon and enter the coupon identifier into the database
- Enter the volunteer identifier into the database
- Observe the volunteer wash his/her hands with soap and water and dry the hands with clean paper towels
- Observe that the volunteer wets his/her hand with 0.9% saline by squeezing a saline-wetted sponge
- Attach the 1,100 g bag to the back of the volunteer's hand

- Watch that the volunteer rub at approximately 3 seconds per pass and performs 20 passes
- Put on rubber gloves that are rinsed in deionized water
- Pour 30 mL of deionized water into the clean, hand rinse dish and observe that the volunteer follows protocol for rinsing/washing the hand in the water
- Watch that the volunteer allows hanging drops to fall back into the dish
- Pour the rinse water through a funnel into a 200-mL plastic bottle
- Repeat the 30-mL rinse/wash process with the volunteer three more times
- Rinse the dish with 20 mL of deionized water and add the rinse to the bottle for a total of 140 mL hand rinse sample
- Take a wipe treated with saline and rub the hand firmly, getting between the fingers, across the fingers and thumb, and especially across the high point of the palm. Note that the hand wiping takes place in a vigorous scrubbing manner with some pressure being exerted to further remove dislodgeable materials that may be trapped in the cracks and crevices of the skin's surface. For every tenth sample, the hand was wiped with two separate Alpha Wipes and these wipes were submitted for individual analysis.
- Place the wipe cloth lightly folded back into the 50-mL centrifuge tube that it came in
- Attach barcode labels to the bottle and centrifuge tube and enter the identifiers into the database
- Take 10 mL aliquots from every fifth hand rinse samples for Cr(VI) analysis and adjust pH to about 9 with sodium hydroxide solution
- Prepare laboratory request/chain of custody forms for the samples and submit samples to the laboratory. (Rinse solutions are treated with nitric acid to bring the pH to about 1.)

Over the course of nine days, the operators worked with 21 volunteers to collect approximately 750 hand rubbing samples. No problems were encountered during this operation other than an occasional splinter which the on-duty nurse removed followed by treatment with an antiseptic.

The hand rinse and hand wipe samples were analyzed in the laboratory. The hand wipe samples were digested using the same procedure used for the block wipe samples. Details of the sample preparation and analysis procedures are given in the Quality Assurance Project Plan as RTI SOP EG-280, "Extraction of Arsenic, Chromium, and Copper from Hand Wipe Samples and Subsequent Measurement by ICP-MS" (RTI, 2003f) and RTI SOP EG-281, "Extraction of Arsenic, Chromium, and Copper from Hand Rinse Samples and Subsequent Measurement by ICP-MS" (RTI, 2003g). The Cr(VI) was measured according to RTI SOP EG-803, "Hexavalent Chromium (CrVI) Analysis Using the Metrohm-Peak Ion Chromatographic System" (RTI, 2003i).

9.5 Statistical Analysis

The principal goals of the statistical analysis were: (1) to derive reliable estimates of the amounts of CCA complex removed by hand and wipe sampling; (2) to calculate a transfer reduction factor; and (3) to evaluate the effect of wood age on levels of dislodgeable metals collected *via* hands and block wipe. The statistical models also included variables such as the effects of the deck, region (north, south), volunteer, and hand (left, right) on levels of dislodgeable metals.

There are several possible choices regarding how the hand and block wipe results are presented for statistical analysis and used to derive a TRF. Two approaches are described below. The first approach is to assume that the sampling procedures used reach a state of equilibrium between the amount of dislodgeable material on a coupon and on a sampling device, *i.e.*, a volunteer's hand or the block wipe. Results from both the RTI Pilot Study and the recent CPSC study (CPSC, 2003; Levenson, 2003a and 2003b) indicate that the amount of dislodgeable arsenic collected on a block wipe or a hand does not increase after about 10 to 15 passes on a test board, and that increasing the weight of the block or the weight on the hand does not significantly increase the amount collected. Also, based on experiments in

the CPSC (2003) study, once equilibrium is achieved, even sampling a larger surface area of treated wood does not significantly increase levels of dislodgeable arsenic on a sampling device. If equilibrium is achieved, then it is appropriate to divide the mass of dislodged metal by the surface area of the sampling device. Thus, when a hand is used, the mass of dislodged metal is divided by the measured size of a volunteer's palm, and when a block wipe is used the mass of dislodged metal is divided by the size of the block-sampling device. When normalized this way, the hand load results are reported as $\mu g/cm^2$ of hand surface, and the block wipe results are reported as $\mu g/cm^2$ of block area. These values are then subjected to statistical analysis. Using this approach, statistical analyses were performed using the load or amount collected on a hand divided by the area of a hand, which averaged about 140 cm^2, and the load collected on a block wipe divided by 64 cm^2, the surface of the block that contacts the wood coupon during sampling.

An alternative approach is to treat the hand samples as having achieved equilibrium, but to assume that the block wipe samples have not achieved equilibrium. That is, the block wipe loading is assumed to increase with an increase in the amount of wood surface rubbed. Although there are reasons why it may be easier for a hand to achieve equilibrium than a wipe (*e.g.*, a wipe has greater absorption capacity than a hand, more friction with a wipe, *etc.*), the results of the CPSC (2003) and RTI pilot studies indicate that the hand and block wipe sampling procedures used in these studies achieved equilibrium for both types of sampling devices. In this alternative approach, the hand sample results are still represented as $\mu g/cm^2$ of hand surface, but the block wipe results are represented as $\mu g/cm^2$ of board area sampled. In the RTI study, the board (coupon) area sampled was 500 cm^2. Statistical analyses were also performed using this alternative approach.

The statistical analyses to test for these effects and relationships were performed using routines in SAS Version 8.2, a statistical software package. Three basic types of analyses were done. These are:

- Summary statistics: to provide descriptive statistics summarizing the central tendency and variability of the hand results, block results, and transfer reduction factors (TRFs).

- Correlations: to quantify the relationship between hand and block data, and between hand and block results and deck age, without controlling for other parameters.

- Mixed model analyses: to describe the effects of deck parameters such as age and region on TRFs, hand results, and block results, while controlling for other parameters.

The analysis variables are as follows:
Y=hand sample result = sum of hand rinse and wipe
LY=log(Y)
X=block sample result
LX=log(X)
R=Y/X
LR=log(Y/X)

SUMMARY STATISTICS

Summary statistics are determined for the following datasets and parameters:

- BY DECKID - produces means and standard deviations and minima and maxima for Y, X, LY, LX, R, and LR
- BY STUDY and OVERALL, but excluding untreated boards - produces means and standard deviations and minima and maxima for Y, X, LY, LX, R, LR, and AGE

- BY REGION, but excluding untreated boards - produces means and standard deviations and minima and maxima for Y, X, LY, LX, R, and LR
- BY STUDY and OVERALL - detailed distributional information for X, LX, Y, LY, R, LR, including histograms

CORRELATIONS

Correlations were determined by study (excluding untreated and recently treated (AGE=0)boards). Spearmen correlations, which are independent of measurement scale, were determined for Y, X, R, and AGE, while Pearson correlations were determined for LY, LX, LR, and AGE, using Pearson option.

MIXED MODEL ANALYSES FOR ESTIMATING EFFECTS ON TRANSFER REDUCTION FACTORS AND FOR FURTHER EXAMINING THE EFFECTS OF AGE AND REGION ON HAND AND BLOCK RESULTS

Predictor variables (fixed effects) used in the mixed model analyses were the deck-related variables, REGION and age. Age is coded in two ways: AGECAT (several age categories) and AGE, which is continuous. REGION identifies north/south deck sampling location.

Mixed effects models were used to model the logarithms of the transfer reduction factors, hand sample values, and block wipe values observed in the full study. Log transformed data were used because of the assumption of multiplicative errors and the belief that the residuals are more "normal" on the log scale. A similar approach was taken by the CPSC (CPSC, 2003). The data were viewed as having a doubly repeated measures structure - that is, a structure in which the observations were considered to be correlated possibly in two dimensions. One dimension of the repeated measures is the decks (*i.e.*, coupons within the same deck are assumed to be correlated). The other dimension, called stacks," refers to the groups of coupons rubbed by the various volunteers (*i.e.*, coupons within the same stack are assumed to be correlated, primarily because they were rubbed by the same person). Thus the "stack" effect is largely the same as a subject (or volunteer) effect, except that in a few cases, the same volunteer rubbed two stacks of coupons (on different days). All volunteers alternated hands (left and right) as they worked through the coupons in a stack. Restricted maximum likelihood was used to estimate the model parameters.

The random effects considered in the model were:

- A component due to decks (after accounting for the associated fixed effects, described below),
- A component due to "stacks,"
- A component due to hand used (*i.e.*, left vs. right) within "stacks,"
- A residual component (includes analytical error).

Fixed effects, which were associated with decks, were as follows:

- Age
- Region (North, South)
- Age by region interactions.

The age effect was modeled in two ways, noting that again untreated and recently treated (AGE=0) boards are excluded:

1. Age was treated as a continuous effect, with linear and quadratic components.
2. Age was treated as a categorical variable with three levels:

Category	Age Range (years)
1	0.6 - 1.5
2	4 - 8
3	15 - 23

The model for case 1 where age is a continuous effect can be written explicitly as

$$LR_{ijh} = \beta_0 + \gamma_0 R_i + (\beta_1 + \gamma_1 R_i) A_i + (\beta_2 + \gamma_2 R_i) A_i^2 + \delta_i + \lambda_j + \eta_{hj} + \varepsilon_{ijh}$$

where 'i' denotes deck, 'j' denotes stack, 'h' denotes hand (left or right); where 'LR_{ijh}' denotes the observed log (base e) of the transfer reduction factor (*i.e.*, log[hand result/block result]) for the coupon from the ith deck, jth stack, as rubbed by the volunteer's hth hand; where 'R'_I is a region indicator (0 if south, 1 if north) for the ith deck; where 'A'_i denotes the age (in years) of the ith deck; where the 'βs' and 's' are fixed-effect parameters to be estimated; and where the last four terms are the random effects indicated above (in the order listed). The objective of the analysis is therefore to estimate variance components associated with the four random effects and to estimate the fixed-effect (β and γ) parameters.

A similar model with age effects defined in terms of a three-level categorical variable applies for case 2.

A generic analysis of variance table for cases 1 and 2 is shown below. In this table, d = number of decks, s = number of stacks, and n = total number of coupons with measured LR values.

Source of Variation	Degrees of Freedom (Case 1)	Degrees of Freedom (Case 2)
Decks	d-1	d-1
Age	2 (linear, quadratic)	3
Region	1	1
Interaction	2	3
Remainder (= Var[δ])	d-6	d-8
Stacks (= Var [λ])	s-1	s-1
Hands within Stacks (= Var[η])	S	S
Residual (= Var[ϵ])	n-d-2s-1	n-d-2s-1
Total	n-1	n-1

Similar models for the log of the hand results (LY) were also run. In this case the region and age effects reflect the influences of those factors on both the true analyte levels and the hand-method results.

Models for the log of the block wipes (LX) were also run, but they do not include stack- or hand-related effects. In this case, the region and age effects reflect the influences of those factors on both the true analyte levels and the block-method results.

RATIONALE FOR MODELS

The mixed models for the log of R assume a fundamental multiplicative relationship between Y and X of the form Y=CX. This will be reasonable if both methods each extract an essentially constant fraction of the given element from the board surfaces. These models further assume that measurement errors and potential biases due to volunteers are of a multiplicative nature. This can be written as

(Eq. 1) $Y_{ijkh} = X_{ij}(C + V_k + H_{kh} + e_{ijkh})$

or as

(Eq. 2) $Y_{ijkh} = X_{ij} \exp[C + V_k + H_{kh} + e_{ijkh}]$

where

$Y_{ijkh} =$ hand sample value for ith board of jth deck, based on kth volunteer's hand wipe using hth hand,

$X_{ij} =$ block sample value ith board of jth deck,

$V_k =$ random effect for kth volunteer,

$H_{kh} =$ random effect for hth hand of kth volunteer,

and $e_{ijkh} =$ random measurement error for ith board of jth deck, based on kth volunteer's hand wipe using hth hand.

Dividing equation 1 by X_{ij} yields an expression for the ratio:

(Eq. 3) $R_{ijkh} = C + V_k + H_{kh} + e_{ijkh}$

Dividing equation 2 by X_{ij} and then taking logs yields an expression for the log of the ratio:

(Eq. 4) $LR_{ijkh} = C + V_k + H_{kh} + e_{ijkh}$.

In both cases, the constant C is the only fixed effect in the model; it represents a transfer reduction factor. If we believe that this factor may vary systematically by region and/or age (or other properties of decks) or want to test whether it does so, then C can be allowed to vary accordingly. For example, if we believe (or want to test) that this constant may vary by region and by age, then we could write C, for example, as

$$C = \gamma + \delta L_j + \alpha A_j + \beta A_j^2$$

where the Greek letters are fixed effects to be estimated,

$L_j =$ 1 if deck j is in the southern region, =0 otherwise, and

$A_j =$ age of the of jth deck.

This approach leads to the models indicated above.

Note that region and/or age may affect underlying true levels of an element or they may affect a method's performance, or both. The mixed model analyses for LY cannot distinguish between these situations; however, if the region and/or age effects are significant for these variables and are not significant for the LR analyses, then this provides evidence that region and/or age affect primarily the true levels. If age and/or region effects for LR are significant, then those factors would be regarded as having differential impacts on the X and Y measures.

9.5.1 Summary Statistics

The results of the summary statistical analysis are presented in Appendix A. Appendix A1 presents data developed assuming that both the block wipe and the hand sampling results represent equilibrium with the levels of dislodgeable material on the coupons. Appendix A2 presents data developed assuming the hand sampling results represent equilibrium with the levels of dislodgeable material on the coupons, but that the block wipe samples do not represent equilibrium. Here and in all remaining tables,

- X = BLOCK SAMPLE $\mu g/cm^2$ block wipe (Appendix A1); B = BLOCK SAMPLE $\mu g/cm^2$ coupon area (Appendix A2);
- Y = HAND SAMPLE(TOTAL) $\mu g/cm^2$
- R = HAND/BLOCK, that is, R = Y/X (Appendix A1) or R = Y/B (Appendix A2)
- LX = LOG(X), LY = LOG(X), LR = LOG(R)

Pages A1-1 through A1-25 present data for all decks sampled during the mini-study and full study, again based on the assumption that both the block wipe and the hand sampling results represent equilibrium with the level of dislodgeable material on the coupons. Pages A2-1 through A2-25 present data for all decks sampled during the mini-study and full study, again based on the assumption that hand sampling results represent equilibrium with the level of dislodgeable material on the coupons, but that block wipe samples do not represent equilibrium. Mini-study data are presented in Appendix A because they are combined with the full study data for distribution and correlation analyses (note that the two sets of data are not presented for comparison with each other, since the mini-study included a much smaller sample size).

Data are presented in both non-log (*i.e.*, untransformed) and log form. The log values are presented because it has been determined (see below) that the X and Y data sets are near log-normal rather than normal; presenting both data forms gives the reader the option of selecting the mean value or calculating the geometric mean (which is more appropriate for a log-normal distribution) as EXP(Mean Log Value). As noted, the results are separated first by element (As, Cr, Cu) and then by deck. AGE= means untreated wood and AGE=0 means recently treated wood. The deck identifications (DECKID) are given as state (e.g., FL), in combination with a deck identifier (e.g., T). Therefore DECKID=FLT means deck T from Florida and DECKID=PAL means deck L from Pennsylvania. It should be noted that FLUn refers to the 20 untreated coupons purchased from a lumber company in Concord, NC, and the NCUn refers to the untreated lumber purchased from Lowes in Raleigh, NC.

Data from one set of recently treated boards and one deck were found to be apparent outliers. The first of these was PS (recently-treated CCA wood from the Schroth treatment plant near Pittsburgh, PA). This data set is not included in statistical analyses due to the unusually high concentrations of metals found by hand and block wipe sampling in which the ratio of arsenic to chromium exceeded the expected ratio by 100 to 150 %. Retention analysis of wood corings by CSI showed a higher than expected value of 0.588 pcf, but also showed that chromium, copper, and arsenic were present in the proper preservation ratio for type C treatment.

It should be noted that deck AB, a 16-month old Florida deck, generated unusual analytical results during the study. In addition, this deck exhibited an uncharacteristically high initial CCA retention sampling value of 0.62 pcf, which was over 50% higher than the study protocol specification of 0.4 pcf. This retention value, measured in the deck boards by Timber Products Inspection (TPI) soon after collection, is considered not comparable to the other decks RTI tested. The retention value was also surprising because the label attached to the end of one of the deck boards indicated the lumber had been treated to 0.4 pcf CCA retention. The retention value reported by TPI was confirmed in a later reanalysis,

which resulted in a value of 0.67 pcf. More recent confirmatory analyses performed by CSI and Osmose reported even higher retention values of 0.724 and 0.71 pcf, respectively. Further issues contributing to the uncertainty of the results reported for this deck include its collection site, which was a rural area with agricultural fields on three sides of the dwelling, and the fact that it appeared dark along the grain lines. Additionally, the field manager's notes indicate that there was a "blackish" residue covering most of the surface of this deck. Therefore, the data set for this deck was excluded from the other Full Study data sets, and was not included in statistical analyses.

The data were scanned for outliers. Values that were calculated as negative, *i.e.*, below the baseline, were eliminated. Also, missing data for any parameter - block wipe values, hand rinse values, and/or hand wipe values - resulted in elimination of all data for that coupon. One volunteer, V0123, showed an unusually high result for Deck M. He also had the highest results for a majority of the boards. That is, when the result for the coupon rubbed by V0123 was compared to results for other coupons from the same board, he often had the highest result. The average ranking for V0123 for all decks was 8th from the top amongst the 21 volunteers. There is no clear reason to eliminate data from volunteer V0123 from the study, but his results are suspect. One might ask, for example, whether he pushed down when he should have been letting the weight on the back of his hand provide the downward force.

Summaries of the results (assuming equilibrium was achieved for both block wipe and hand samples) for all untreated and recently treated boards and all decks are presented on pages A1-26 through A1-29 and in Tables 9-11 through 9-13 at the end of this section. The mean deck block wipe (X) values for arsenic in the full study are generally less than about 4 $\mu g/cm^2$ block wipe, with one exception (Deck FB). The mean hand (Y) values (rinse + wipe) for arsenic are generally less than 0.1 $\mu g/cm^2$ hand, except for Decks PAM and FLAB. The mean X values are above 4 $\mu g/cm^2$ block wipe for three of the recently treated wood sets and the mean Y values are above 0.1 $\mu g/cm^2$ hand for all four of the recently treated wood sample sets. The geometric means [calculated as e^x where $x = \log(X)$], are also provided. The mean block wipe values for chromium in the full study are generally less than 4 $\mu g/cm^2$, except again for Decks PAM and FLAB; the mean hand values are again generally less than 0.1 $\mu g/cm^2$. The copper values parallel the arsenic and chromium values, but are lower. The standard deviations are not presented because results presented below strongly suggest a log-normal distribution for the X and Y values. In such a case, the conventional standard deviation has little meaning. Another result of this finding is that the geometric means are more representative of the data sets than the means.

Summaries of the results (assuming equilibrium achieved for the hand samples, but not the block wipe samples) for all untreated and recently treated boards and all decks are presented on pages A2-26 through A2-29 and in Tables 9-14 through 9-16 at the end of this section. The mean deck block wipe (X) values for arsenic in the full study are generally less than about 0.5 $\mu g/cm^2$ coupon, with one exception (Deck FB). The mean hand (Y) values (rinse + wipe) for arsenic are the same for both approaches, that is, less than 0.1 $\mu g/cm^2$ hand, except for Decks PAM and FLAB. The mean X values are above 0.5$\mu g/cm^2$ coupon for three of the recently treated wood sets.

Overall study mean and geometric mean values for block and hand results (excluding results for Deck AB and all recently treated boards) are given on pages A1-30 through A1-32 and A2-30 through A2-32. A summary of the results is presented in Table 9-3 for the combination of the mini- and full studies, and both approaches regarding the assumption of equilibrium for the sampling devices.

Table 9-3. Summary of Mean and Geometric Mean Block and Hand Wipe Values for Both Equilibrium Approaches

	Mean Block Wipe, μg/cm^2 Block Wipe	Mean Block Wipe, μg/cm^2 Coupon	Geom. Mean Block Wipe, μg/cm^2 Block Wipe	Geom. Mean Block Wipe, μg/cm^2 Coupon	Mean Hand, μg/cm^2 Hand	Geom. Mean Hand, μg/cm^2 Hand	Mean Ratio, R (Based on μg/cm^2 Block Wipe)	Mean Ratio, R (Based on μg/cm^2 Coupon)
As	2.15	0.276	1.81	0.231	0.061	0.039	0.032	0.251
Cr	2.74	0.351	2.29	0.294	0.058	0.036	0.024	0.185
Cu	1.59	0.204	1.35	0.173	0.053	0.037	0.038	0.293

The difference in μg/cm^2 block wipe and μg/cm^2 coupon is simply the result of multiplication by the constant, (64 cm^2 block wipe area)/(500 cm^2 coupon area). One can see that the geometric mean values are about 20% less than the arithmetic means, further supporting the occurrence of right-skewed distributions in the data sets. The values for R given in this table cannot be compared as they are defined by different terms; one is defined as (μg/cm^2 hand)/(μg/cm^2 block wipe) whereas the other is defined as (μg/cm^2 hand)/(μg/cm^2 coupon). The values for the geometric means of the R values would be about 35% less than the arithmetic means presented in Table 9-3.

Pages A1-33 through A1-35 and A2-33 through A2-35 present summary statistics by region. These results show an apparent regional difference, with the north being higher than the south. Table 9-4 present a summary of the results by region.

Table 9-4. Summary of Mean and Geometric Mean Block and Hand Wipe Values by Region for Both Approaches to Equilibrium

	Mean Block Wipe, μg/cm^2 Block Wipe	Mean Block Wipe, μg/cm^2 Coupon	Geom. Mean Block Wipe, μg/cm^2 Block Wipe	Geom. Mean Block Wipe, μg/cm^2 Coupon	Mean Hand, μg/cm^2 Hand	Geom. Mean Hand, μg/cm^2 Hand	Mean Ratio, R (Based on μg/cm^2 Block Wipe)	Mean Ratio, R (Based on μg/cm^2 Coupon)
Full Study - North								
As	2.46	0.315	2.14	0.274	0.0884	0.059	0.040	0.313
Cr	3.24	0.415	2.75	0.352	0.0852	0.055	0.029	0.229
Cu	1.65	0.211	1.48	0.189	0.0658	0.047	0.044	0.340
Full Study - South								
As	1.80	0.230	1.50	0.191	0.0418	0.031	0.031	0.239
Cr	2.19	0.281	1.85	0.237	0.0371	0.027	0.022	0.170
Cu	1.73	0.222	1.39	0.178	0.0513	0.036	0.036	0.278
Mini-study - North								
As	2.70	0.346	2.23	0.285	0.0302	0.022	0.012	0.0902
Cr	3.69	0.412	3.11	0.398	0.0419	0.027	0.011	0.0846
Cu	1.10	0.141	0.997	0.128	0.0233	0.020	0.024	0.189

Mini-study - South								
As	1.89	0.242	1.66	0.212	0.0256	0.021	0.015	0.117
Cr	2.20	0.281	2.00	0.256	0.0294	0.024	0.015	0.116
Cu	1.09	0.140	0.985	0.126	0.0251	0.023	0.027	0.209

9.5.2 Distributions of Block Wipe, Hand Sample, and Transfer Reduction Factor Values

The distributions of block wipe, hand sample, and transfer reduction factor values for the combination of the mini-study and the full study are presented in Appendix B. Appendix B1 presents data developed assuming that both the block wipe and the hand sampling results represent equilibrium with the level of dislodgeable material on the coupons. Appendix B2 presents data developed assuming the hand sampling results represent equilibrium with the level of dislodgeable material on the coupons, but that the block wipe samples do not represent equilibrium with the coupons. Both non-log and log forms of the data are presented.

Table 9-5 presents a summary of the distribution of block wipe loading values and Table 9-6 presents a summary of the distribution of hand loading values. One can see that the median value is less than the mean, indicating a log-normal distribution. Graphical presentations of the block wipe value distributions are given on pages B1-37 through B1-42 and B2-37 through B2-42, while graphical presentations of the hand sample value distributions are given on pages B1-43 through B1-48 and B2-43 through B2-48. These graphs illustrate the skewed nature of the data and indicate that they are better represented by a log-normal distribution.

Table 9-5. Distribution of Block Wipe Loadings for the Combined Mini and Full Study Datasets for Both Approaches to Equilibrium

	Mean Block Wipe, μg/cm^2 Block Wipe	Median Block Wipe, μg/cm^2 Block Wipe	5% Quantile (Based on μg/cm^2 Block Wipe)	95% Quantile (Based on μg/cm^2 Block Wipe)	Mean Block Wipe, μg/cm^2 Coupon	Median Block Wipe, μg/cm^2 Coupon	5% Quantile (Based on μg/cm^2 Coupon)	95% Quantile (Based on μg/cm^2 Coupon)
As	2.15	1.77	0.75	4.63	0.276	0.227	0.096	0.593
Cr	2.74	2.28	0.88	5.73	0.351	0.292	0.113	0.734
Cu	1.59	1.31	0.56	3.47	0.204	0.167	0.072	0.444

Table 9-6. Distribution of Hand Loadings for the Combined Mini and Full Study Dataset for Both Approaches to Equilibrium

	Mean Y, μg/cm^2	Median Y, μg/cm^2	95% Quantile, μg/cm^2	5% Quantile, μg/cm^2
As	0.061	0.035	0.186	0.011
Cr	0.058	0.032	0.189	0.010
Cu	0.053	0.034	0.152	0.012

Table 9-7 presents a summary of the distribution of transfer reduction factors or R values calculated for each coupon. Here again, the median value is less than the mean, indicating a skewed

distribution. As before, this conclusion is supported by the fact that the mean in not close to halfway between the 5% and 95% quantiles, which suggests that the median is a better indicator of central tendency than the mean. Graphical presentations of the transfer reduction factor distributions are given on pages B-49 through B-54 and B2-49 through B2-54.

Table 9-7. Distribution of R Values for the Combined Full and Mini-study Data Sets for Both Approaches to Equilibrium

	Mean Ratio, R (Based on μg/cm² Block Wipe)	Median Ratio, R (Based on μg/cm² Block Wipe)	5% Quantile (Based on μg/cm² Block Wipe)	95% Quantile (Based on μg/cm² Block Wipe)	Mean Ratio, R (Based on μg/cm² Coupon)	Median Ratio, R (Based on μg/cm² Coupon)	5% Quantile (Based on μg/cm² Coupon)	95% Quantile (Based on μg/cm² Coupon)
As	0.0321	0.0196	0.00550	0.0943	0.251	0.153	0.043	0.736
Cr	0.0237	0.0146	0.00379	0.0692	0.185	0.114	0.030	0.541
Cu	0.0375	0.0257	0.00889	0.1057	0.293	0.201	0.070	0.826

In addition, the geometric, mean transfer reduction factors (R) for each deck, determined by dividing each individual hand value (in terms of μg/cm^2 hand) by each block wipe value (in terms of μg/cm^2 block wipe) for a coupon are presented for all decks in Tables 9-11 through 9-13. These values range from about 0.0088 to about 0.0477 (excluding untreated boards) for arsenic in the full study. The geometric mean R values for chromium in the full study range from 0.0061 to 0.0334, while the geometric mean R values for copper in the full study range from 0.0182 to 0.0469.

The geometric mean transfer reduction factors (R) for each deck, determined by dividing each individual hand value (in terms of μg/cm^2 hand) by each block wipe value (in terms of μg/cm^2 coupon) for a coupon are presented for all decks in Tables 9-14 through 9-16. These values range from about 0.0682 to about 0.377 (excluding untreated boards) for arsenic for the full study. The geometric mean R values for chromium in the full study range from 0.0466 to 0.263, while the geometric mean R values for copper in the full study range from 0.135 to 0.370.

9.5.3 Correlation Analyses

Results of Pearson and Spearman correlation analyses are given in Appendix C. Appendix C1 presents data developed assuming that both the block wipe and the hand sampling results represent equilibrium with the level of dislodgeable material on the coupons. Appendix C2 presents data developed assuming the hand sampling results represent equilibrium with the level of dislodgeable material on the coupons, but that the block wipe samples do not represent equilibrium with the level of dislodgeable material on the coupons. Because the difference in the two forms of the data is a constant (*i.e.*, multiplication of the block value in μg/cm^2 block area by 64/500 to arrive at block value in μg/cm^2 coupon area), there is no difference in the correlation results for both equilibrium approaches. The Pearson analyses were performed using log data (*i.e.*, transformed) while the Spearman analyses were performed using non-transformed data.

These correlation results should be treated with caution not only because they are based on the combined data sets (mini- and full studies), but also because they treat coupon-level observations as independent observations when, in fact, they are not independent. The degrees of freedom associated with the tests of significance of the correlations are thus too large and result in overstating their

significance. (The mixed-model approach attempts to appropriately account for the dependence among the observations.)

As shown in Table 9-8, Spearman correlation coefficients for the combined dataset show statistically significant inverse relationships between age and hand sample results for each of the dislodgeable metals. For the hand results, statistically significant (p-value<0.0001) Spearman correlation coefficients of -0.17, -0.19, and -0.38 were obtained for As, Cr, and Cu, respectively, with age. The relationship between age and block wipe results was positive for As and Cr, but negative for Cu. For the block results, smaller but statistically significant Spearman correlation coefficients of 0.15, 0.16, and -0.32 were obtained for As, Cr, and Cu, respectively, with age. Without controlling for other parameters, these results suggest that significant reductions in dislodgeable metals levels occur on the hands with increasing deck age. The reason for the increase with age with the block wipes is uncertain.

Table 9-8. Summary of Spearman Correlation Coefficients for the Combined Full and Mini Study Data Sets

	Arsenic	**Chromium**	**Copper**
Block Wipe vs Hand	0.313	0.343	0.434
Age vs Block Wipe	0.154	0.157	-0.321
Age vs Hand	-0.168	-0.193	-0.380
Age vs R	-0.266	-0.298	-0.178

Plots of arsenic values for block wipe, hand sample and transfer reduction factor (all based on $\mu g/cm^2$ block wipe area) versus age are presented in Figures 9-1, 9-2, and 9-3 for the full study data set. First, one notices that the decks are clustered in four age groups. Figure 9-2 (hand sample) does show a negative slope. Figure 9-1 (block wipe) shows a great deal of scatter. Visually, one can see that there is some uncertainty as to the slope even though the correlation analysis indicated a positive slope. In addition, statistically significant correlations were obtained between hand and block results for each metal (0.31, 0.34, and 0.43 for As, Cr, and Cu, respectively). These results indicate consistencies between the two methods in the measurement of dislodgeable metals levels.

It is noted in Appendix C that the value of R shows a statistically significant change with age of the decks. There is no simple explanation for this phenomenon as one would expect the block and hand to remove constant proportions of the total dislodgeable material available. Perhaps there are changes in the board surfaces with age that favor less pickup by the hand as compared to the block wipe. One possibility is that the block wipe is able to abrade more dislodgeable material than the hand from older, softer deck surfaces as compared to newer deck surfaces.

9.5.4 Mixed Effects Modeling

Mixed effects modeling was performed only with coupons from 19 decks from the full study. Output for these mixed effects model analyses is given in Appendix D. Appendix D1 presents data developed assuming that both the block wipe and the hand sampling results represent equilibrium with the levels of dislodgeable material on the coupons. Appendix D2 presents data developed assuming the hand sampling results represent equilibrium with the levels of dislodgeable material on the coupons, but that the block wipe samples do not represent equilibrium with the levels of dislodgeable material on the coupons. Age is treated in two ways; it is treated as a continuous effect in one set of models, and as a categorical variable in a second set of models. The age categories, as listed above, are 0.6 to 1.5, 4 to 8, and 15 to 23 years. The dependent variables in these models are log(R), log(Y) and log(X). The fixed effects are region and age. The only differences in Appendices D1 and D2 are the intercept values for the fixed effects. That is, the intercept values in Appendix D1 for the models for log(R) (*i.e.*,

log[hand/block]), are different than the intercept values in Appendix D2 for the models for log(R), (*i.e.*, log[hand/coupon]); this difference is equal to log(500/64). Likewise, the intercept values for the models for log(block) are different than the intercept values for the models for log(coupon); this difference is equal to log(64/500). All other fixed effects do not change from Appendix D1 to Appendix D2.

The random effects for which variance components were estimated are Stack, DeckID, Stack*HandID (left or right), and Residual. The fixed effect values for the log(R), log(hand) and log(block) are given in Table 9-9, along with indications of statistical significance, for the mixed effects models where age was treated as a continuous variable. One notes that age and region have a significant effect on log(R) for As and Cr but not for Cr. For log(hand), age and region have a significant effect for Cu but only region has an effect for As and Cr. For log(block), age and region have a significant effect for As and Cr, but only age seems to have a significant effect for Cu.

The results also clearly indicate that there is a region effect, and specifically that results for the north are somewhat higher than results for the south. This conclusion is supported by the low p values for the terms Age*Region and Age*Age*Region in the solutions for the fixed effects.

Table 9-9. Fixed Effects for Log(R), Log(hand) and Log(block) for As, Cr, and Cu for Full Study for Approach to Equilibrium using Wipe Block as μg/cm^2 Block Wipe

Mixed Model Analysis for Log(R)			
Effect	**As**	**Cr**	**Cu**
Intercept	-3.275*	-3.5875*	-3.5943*
Region, North	-0.2099	-0.1576	0.2133
Age	-0.2985*	-0.3201*	-0.00262
Age*Age	0.01684*	0.01797*	-0.00060
Age*Region, North	0.3138*	0.3098*	0.02632
Age*Age*Region, North	-0.01924*	-0.01923*	-0.00200
Mixed Model Analysis for Log(Hand)			
Effect	**As**	**Cr**	**Cu**
Intercept	-3.4553*	-3.4932*	-2.5727*
Region, North	0.7243*	0.7035*	-0.2001
Age	0.01102	-0.04366	-0.2957*
Age*Age	-0.00107	0.001938	0.01488*
Age*Region, North	-0.01998	0.03880	0.2176**
Age*Age*Region, North	0.000460	-0.000314	-0.01260**
Mixed Model Analysis for Log(Block)			
Effect	**As**	**Cr**	**Cu**
Intercept	-0.1795	0.09099	1.0218*
Region, North	0.9240*	0.8528**	-0.4092
Age	0.3052*	0.2742**	-0.2945*
Age*Age	-0.01767*	-0.01587**	0.01552**
Age*Region, North	-0.3238*	-0.2637	0.1948
Age*Age*Region, North	0.01914*	0.01566	-0.01081

* Indicates significance at 0.01 level; ** Indicates significance at 0.05 level.

Equations can be developed using these data to predict R, block wipe value and hand value as a function of region and age of the deck. For example, for arsenic,

Log(R) for the south = -3.275- 0.2985 x Age + 0.01684x(Age)^2

Log(R) for the north = (-3.275- *0.2099*) + (-0.2985 + 0.3138)xAge + (0.01684 - 0.01924)x(Age)^2

= -3.4849 + 0.0153xAge - 0.0024x(Age)^2

(Here statistically insignificant terms are in italics.)

The R value can be calculated as a function of age from these models. Likewise, from the tables above,

Log(Y) for the south = -3.4553 + *0.01102*xAge - *0.00107*x(Age)^2

Log(Y) for the north = (-3.45536 + 0.7243) + (*0.01102* - *0.01998*)xAge + (- *0.00107* + *0.00046*x(Age)^2

= -2.736 - 0.0089xAge - 0.01024x(Age)^2

Log(X) for the south = *-0.1795* + 0.3052xAge - 0.01767x(Age)^2

Log(X) for the north = (-*0.1795* + 0.924) + (0.3052 - 0.3238)xAge + (-0.01767 + 0.01914x(Age)^2

= 0.7445 - 0.0186xAge + 0.00147x(Age)^2

Values calculated using these equations are given in Table 9-10. Though some terms are not statistically significant, assumptions made in using the particular models require that they be used in the calculations. One can see that the values for Y (south) and Y (north) both decrease with age, as predicted by the correlation analyses. The values for X (south) seem to increase and then decrease while the values for X (north) are relatively constant and then increase. These trends are generally supported by Figures 9-4 through 9-7 , which show geometric means for the block wipe and hand values for the three different age groups from the categorical analysis. That is, there is curvature that leads to a quadratic equation yielding changing directions with age. As noted, the values for the north are again higher than the values for the south. Figures 9-8 and 9-9 show such curvature for the transfer reduction factor as well.

Table 9-10. Values for Y and X for South and North from Predictive Equations

Age	log(Y), south	Y South, μg/cm^2	log(X) south	X South, μg/cm^2	log(Y) north	Y North, μg/cm^2	log(X) north	X North, μg/cm^2
1	-3.44535	0.032	0.10803	1.114	-2.75514	0.064	0.72737	2.070
2	-3.43754	0.032	0.36022	1.434	-2.79476	0.061	0.71318	2.040
5	-3.42695	0.032	0.90475	2.471	-3.0365	0.048	0.68825	1.990
10	-3.4521	0.032	1.1055	3.021	-3.849	0.021	0.7055	2.025
15	-3.53075	0.029	0.42275	1.526	-5.1735	0.006	0.79625	2.217
20	-3.6629	0.026	-1.1435	0.319	-7.01	0.001	0.9605	2.613

9.6 Cr(VI) Analysis Results

Some 145 hand rinsate samples were analyzed for Cr(VI) using ion chromatography. Of these samples, only three had concentrations above the method detection limit of 0.25 µg/L or 0.035 µg/hand. Two of these samples came from recently treated deck wood (0.644 and 0.28 µg/L) and one sample was from a 1-year old deck from the Pittsburgh area (0.279 µg/L). These values correspond to 0.09, 0.04, and 0.04 µg Cr(VI) per hand rinse.

Table 9-11. Summary Statistics by Deck for Arsenic - X Term Calculated as µg/cm^2 Block Wipe

STUDY=Mini and Full ANALYTE=Arsenic

AGE	REGION	DECKID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.14792	0.007563	0.14402	0.005499	0.046999	0.038182
0	South	GANC[(a)]	2.63637	0.042870	2.60259	0.035673	0.017796	0.013707
1	South	GAG[(a)]	1.38373	0.021483	1.23693	0.019147	0.017612	0.015479
1.5	South	GAE[(a)]	1.63898	0.022017	1.55918	0.019550	0.014548	0.012539
4	South	GAD[(a)]	2.41212	0.026955	2.00115	0.021378	0.011598	0.010683
15	North	PAO[(a)]	3.05952	0.032809	2.48761	0.027653	0.012600	0.011116
23	North	PAJ[(a)]	2.34098	0.027639	1.99569	0.017159	0.010503	0.008598
.	South	FLUn	0.1828	0.01489	0.1393	0.01039	0.11404	0.074636
.	South (?)	NCUn	0.1359	0.01354	0.1314	0.00975	0.09054	0.074198
0	South	FLFG	6.8720	0.21929	5.5195	0.14436	0.03456	0.026154
0	South	FLFR	3.0872	0.14297	2.5394	0.09245	0.05515	0.036406
0	North	PAPF	9.1900	0.42972	8.4725	0.29278	0.05080	0.034557
0	North	PAPS	73.6609	3.74476	40.0306	1.57058	0.06049	0.039235
0.6	North	PAP	1.5248	0.06134	1.4321	0.04881	0.04129	0.034084
0.7	North	PAQ	1.7551	0.08119	1.6954	0.06685	0.04646	0.039429
0.9	North	PAR	2.2125	0.06574	1.9927	0.04975	0.03815	0.024964
1	South	FLT	1.5299	0.05573	1.4221	0.03870	0.04623	0.027211
1	South	FLY	1.1618	0.03492	1.1135	0.02728	0.03246	0.024496
1	South	FLZ	1.0599	0.04410	1.0224	0.03704	0.04533	0.036228
1	North	PAM	3.7766	0.20304	3.3403	0.11173	0.04619	0.033450
1	North	PAX	2.0294	0.06541	1.9163	0.04950	0.03230	0.025830
1.1	South	FLAA	1.0678	0.03207	0.9864	0.02498	0.03298	0.025328
1.3	South	FLAB	12.9267	0.24214	12.4611	0.18577	0.01999	0.014908
5	South	FLV	2.6696	0.04211	2.2576	0.03885	0.01960	0.017208
5	North	PAL	3.6693	0.09898	3.4152	0.06997	0.02745	0.020488
6	South	FLW	3.3034	0.03576	3.0056	0.02648	0.01640	0.008810
6	North	PAI	2.2738	0.08644	1.9671	0.05849	0.04688	0.029735
8	North	PAH	1.7055	0.10622	1.6137	0.07692	0.06887	0.047666
15	South	FLAC	1.9428	0.04010	1.7928	0.02738	0.01972	0.015274
15	South	FLS	2.4141	0.05884	2.1528	0.03826	0.02729	0.017774
15	South	FLU	1.1013	0.03287	0.9188	0.02467	0.03563	0.026854
15	North	PAN	2.0420	0.04699	1.7721	0.03414	0.03117	0.019263
21	North	PAK	3.3740	0.06891	3.0599	0.04592	0.02139	0.015007

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) Mini Study Decks

Table 9-12. Summary Statistics by Deck for Chromium - X Term Calculated as µg/cm^2 Block Wipe

STUDY= Mini and Full ANALYTE=Chromium

AGE	REGION	DECK ID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.13688	0.007231	0.13194	0.005393	0.050280	0.040876
0	South	GANC[(a)]	2.60849	0.047156	2.55574	0.039033	0.020130	0.015273
1	South	GAG[(a)]	1.87017	0.026992	1.70214	0.023469	0.017054	0.013788
1.5	South	GAE[(a)]	1.85983	0.024969	1.78547	0.020999	0.014446	0.011761
4	South	GAD[(a)]	2.76959	0.029686	2.45306	0.023327	0.010778	0.009509
15	North	PAO[(a)]	3.78313	0.038380	3.18847	0.031705	0.011576	0.009944
23	North	PAJ[(a)]	3.58715	0.045368	3.03438	0.022639	0.010091	0.007461
.	South	FLUn	0.1624	0.01145	0.1357	0.00817	0.088015	0.060228
.	.	NCUn	0.1241	0.00923	0.1186	0.00747	0.077393	0.063024
0	South	FLFG	6.8962	0.20245	5.6845	0.13385	0.032502	0.023547
0	South	FLFR	3.5256	0.13933	2.9581	0.08941	0.047959	0.030224
0	North	PAPF	8.4177	0.32088	7.9373	0.22155	0.039923	0.027913
0	North	PAPS	47.4968	1.87078	29.2227	0.86571	0.043931	0.029625
0.6	North	PAP	1.3122	0.04383	1.2348	0.03471	0.034315	0.028110
0.7	North	PAQ	2.1064	0.07689	2.0203	0.06343	0.037406	0.031395
0.9	North	PAR	3.6941	0.07844	3.4127	0.05951	0.024199	0.017438
1	South	FLT	1.8090	0.04837	1.6565	0.03392	0.033732	0.020480
1	South	FLY	1.8639	0.04118	1.8190	0.02975	0.023167	0.016355
1	South	FLZ	0.9943	0.03397	0.9594	0.02811	0.036792	0.029302
1	North	PAM	3.8640	0.16409	3.4888	0.09034	0.035944	0.025893
1	North	PAX	3.1780	0.07544	3.0148	0.05573	0.023870	0.018486
1.1	South	FLAA	1.5529	0.03066	1.4877	0.02496	0.020925	0.016775
1.3	South	FLAB	13.1093	0.19692	12.7015	0.14900	0.015624	0.011731
5	South	FLV	2.6207	0.02960	2.2430	0.02552	0.013854	0.011379
5	North	PAL	4.8331	0.09361	4.4774	0.06472	0.019329	0.014455
6	South	FLW	4.3337	0.03303	4.0257	0.02458	0.009704	0.006107
6	North	PAI	4.3320	0.08784	3.0006	0.06049	0.033601	0.020159
8	North	PAH	2.5479	0.12156	2.4489	0.08180	0.048431	0.033402
15	South	FLAC	2.1510	0.03702	1.9739	0.02277	0.015967	0.011535
15	South	FLS	3.0030	0.05321	2.6927	0.03309	0.019967	0.012290
15	South	FLU	1.4098	0.02703	1.2511	0.02061	0.021949	0.016473
15	North	PAN	2.0476	0.03523	1.8752	0.02531	0.022006	0.013497
21	North	PAK	3.9327	0.06097	3.5780	0.03997	0.015704	0.011171

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) Mini Study Decks

Table 9-13. Summary Statistics by Deck for Copper - X Term Calculated as µg/cm^2 Block Wipe

STUDY= Mini and Full ANALYTE=Copper

AGE	REGION	DECK ID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.08967	0.009571	0.08304	0.007500	0.10545	0.090309
0	South	GANC[(a)]	1.55215	0.039389	1.52072	0.035015	0.02719	0.023025
1	South	GAG[(a)]	1.05326	0.027471	0.97473	0.025826	0.02995	0.026496
1.5	South	GAE[(a)]	0.77980	0.020308	0.74951	0.018347	0.02877	0.024478
4	South	GAD[(a)]	1.32755	0.022176	1.16355	0.021200	0.02023	0.018220
15	North	PAO[(a)]	1.21126	0.024980	1.07353	0.021077	0.02487	0.019634
23	North	PAJ[(a)]	0.98163	0.021585	0.92286	0.019097	0.02343	0.020694
.	South	FLUn	0.1002	0.01447	0.0876	0.01190	0.18338	0.13585
.	.	NCUn	0.0903	0.01068	0.0827	0.00996	0.13613	0.12041
0	South	FLFG	3.8073	0.13275	3.1809	0.09308	0.04008	0.02926
0	South	FLFR	2.3362	0.13004	2.1848	0.08821	0.07030	0.04037
0	North	PAPF	3.9859	0.17612	3.7195	0.12730	0.04762	0.03422
0	North	PAPS	22.4205	1.13276	13.0588	0.52291	0.07441	0.04004
0.6	North	PAP	2.1021	0.08248	1.8889	0.06452	0.04183	0.03416
0.7	North	PAQ	2.9655	0.13297	2.7861	0.10615	0.04562	0.03810
0.9	North	PAR	1.6746	0.05436	1.6156	0.04305	0.03598	0.02665
1	South	FLT	2.2604	0.09762	2.1953	0.06633	0.05048	0.03021
1	South	FLY	3.3618	0.08331	3.0735	0.06094	0.02801	0.01983
1	South	FLZ	1.1730	0.05768	1.1315	0.04836	0.05330	0.04274
1	North	PAM	1.4710	0.08134	1.3707	0.05613	0.05629	0.04095
1	North	PAX	1.2713	0.05111	1.2153	0.04034	0.04044	0.03320
1.1	South	FLAA	2.9157	0.07267	2.5679	0.05731	0.02840	0.02232
1.3	South	FLAB	4.5377	0.09813	4.3789	0.07979	0.02305	0.01822
5	South	FLV	0.8910	0.02576	0.7923	0.02287	0.03504	0.02887
5	North	PAL	1.6094	0.05221	1.5010	0.04021	0.03371	0.02679
6	South	FLW	1.2652	0.03112	0.9573	0.02369	0.03598	0.02475
6	North	PAI	1.0590	0.05640	0.9935	0.03933	0.05977	0.03959
8	North	PAH	1.1213	0.06661	1.0667	0.04999	0.06194	0.04687
15	South	FLAC	1.6596	0.03522	1.5677	0.02758	0.02288	0.01759
15	South	FLS	1.3587	0.03706	1.2493	0.02882	0.02996	0.02307
15	South	FLU	0.7380	0.02569	0.6754	0.02128	0.03956	0.03151
15	North	PAN	1.5278	0.04508	1.3598	0.03236	0.03570	0.02380
21	North	PAK	1.7583	0.04106	1.7118	0.03201	0.02497	0.01870

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) Mini Study Decks

Table 9-14. Summary Statistics by Deck for Arsenic - X Term Calculated as µg/cm^2 Coupon

STUDY= Mini and Full ANALYTE=Arsenic

AGE	REGION	DECK ID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.01893	0.007563	0.01843	0.005499	0.36718	0.29830
0	South	GANC[(a)]	0.33746	0.042870	0.33313	0.035673	0.13903	0.10708
1	South	GAG[(a)]	0.17712	0.021483	0.15833	0.019147	0.13760	0.12093
1.5	South	GAE[(a)]	0.20979	0.022017	0.19958	0.019550	0.11366	0.09796
4	South	GAD[(a)]	0.30875	0.026955	0.25615	0.021378	0.09061	0.08346
15	North	PAO[(a)]	0.39162	0.032809	0.31841	0.027653	0.09844	0.08685
23	North	PAJ[(a)]	0.29965	0.027639	0.25545	0.017159	0.08206	0.06717
.	South	FLUn	0.02340	0.01491	0.01783	0.01044	0.89217	0.58552
.	.	NCUn	0.01740	0.01354	0.01682	0.00975	0.70733	0.57967
0	South	FLFG	0.87961	0.25740	0.70649	0.16832	0.29737	0.23825
0	South	FLFR	0.39516	0.14454	0.32504	0.09300	0.43511	0.28613
0	North	PAPF	1.17631	0.43983	1.08448	0.30954	0.40611	0.28543
0	North	PAPS	9.42859	3.76795	5.12391	1.64018	0.48487	0.32010
0.6	North	PAP	0.19517	0.06150	0.18331	0.04890	0.32317	0.26675
0.7	North	PAQ	0.22465	0.08120	0.21702	0.06685	0.36303	0.30805
0.9	North	PAR	0.28320	0.06605	0.25507	0.05038	0.29952	0.19752
1	South	FLT	0.19583	0.05524	0.18203	0.03818	0.35840	0.20974
1	South	FLY	0.14871	0.03593	0.14253	0.02753	0.26019	0.19317
1	South	FLZ	0.13567	0.04428	0.13086	0.03708	0.35506	0.28337
1	North	PAM	0.48341	0.20354	0.42755	0.11216	0.36224	0.26234
1	North	PAX	0.25976	0.06541	0.24529	0.04950	0.25234	0.20180
1.1	South	FLAA	0.13668	0.03261	0.12626	0.02542	0.26057	0.20138
1.3	South	FLAB	1.65461	0.24854	1.59502	0.19660	0.15957	0.12326
5	South	FLV	0.34171	0.04184	0.28897	0.03861	0.15266	0.13361
5	North	PAL	0.46967	0.10331	0.43715	0.07280	0.22097	0.16653
6	South	FLW	0.42283	0.03563	0.38471	0.02622	0.12796	0.06815
6	North	PAI	0.29105	0.08640	0.25179	0.05846	0.36592	0.23218
8	North	PAH	0.21830	0.10664	0.20655	0.07781	0.54016	0.37671
15	South	FLAC	0.24868	0.03974	0.22948	0.02688	0.15302	0.11712
15	South	FLS	0.30900	0.05883	0.27555	0.03825	0.21322	0.13881
15	South	FLU	0.14097	0.03196	0.11761	0.02376	0.26640	0.20199
15	North	PAN	0.26137	0.04741	0.22683	0.03469	0.24472	0.15293
21	North	PAK	0.43187	0.06892	0.39167	0.04590	0.16714	0.11720

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) MiniStudy Decks

Table 9-15. Summary Statistics by Deck for Chromium - X Term Calculated as µg/cm^2 Coupon

STUDY= Mini and Full ANALYTE=Chromium

AGE	REGION	DECK ID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.01752	0.007231	0.01689	0.005393	0.39281	0.31934
0	South	GANC[(a)]	0.33389	0.047156	0.32713	0.039033	0.15727	0.11932
1	South	GAG[(a)]	0.23938	0.026992	0.21787	0.023469	0.13323	0.10772
1.5	South	GAE[(a)]	0.23806	0.024969	0.22854	0.020999	0.11286	0.09188
4	South	GAD[(a)]	0.35451	0.029686	0.31399	0.023327	0.08420	0.07429
15	North	PAO[(a)]	0.48424	0.038380	0.40812	0.031705	0.09043	0.07768
23	North	PAJ[(a)]	0.45916	0.045368	0.38840	0.022639	0.07883	0.05829
.	South	FLUn	0.02078	0.01146	0.01737	0.00820	0.68811	0.47189
.	.	NCUn	0.01588	0.00923	0.01518	0.00747	0.60463	0.49237
0	South	FLFG	0.88271	0.22731	0.72762	0.15208	0.27151	0.20901
0	South	FLFR	0.45128	0.13790	0.37864	0.08859	0.36951	0.23397
0	North	PAPF	1.07747	0.32888	1.01597	0.23438	0.31844	0.23070
0	North	PAPS	6.07959	1.88236	3.74051	0.90099	0.35096	0.24087
0.6	North	PAP	0.16797	0.04337	0.15805	0.03445	0.26587	0.21798
0.7	North	PAQ	0.26962	0.07616	0.25860	0.06320	0.28949	0.24439
0.9	North	PAR	0.47285	0.07848	0.43683	0.06002	0.18932	0.13740
1	South	FLT	0.23156	0.04756	0.21203	0.03281	0.25944	0.15476
1	South	FLY	0.23858	0.04166	0.23284	0.02988	0.18277	0.12832
1	South	FLZ	0.12727	0.03387	0.12280	0.02800	0.28678	0.22798
1	North	PAM	0.49459	0.16407	0.44657	0.09024	0.28084	0.20207
1	North	PAX	0.40679	0.07544	0.38590	0.05573	0.18648	0.14442
1.1	South	FLAA	0.19877	0.03140	0.19043	0.02576	0.16781	0.13526
1.3	South	FLAB	1.67799	0.19804	1.62579	0.15412	0.12254	0.09480
5	South	FLV	0.33545	0.02987	0.28710	0.02580	0.10863	0.08987
5	North	PAL	0.61864	0.09607	0.57311	0.06655	0.15449	0.11613
6	South	FLW	0.55471	0.03221	0.51529	0.02400	0.07437	0.04657
6	North	PAI	0.55449	0.08760	0.38407	0.06023	0.26146	0.15681
8	North	PAH	0.32612	0.12163	0.31347	0.08229	0.37905	0.26250
15	South	FLAC	0.27533	0.03656	0.25266	0.02234	0.12337	0.08842
15	South	FLS	0.38438	0.05317	0.34467	0.03302	0.15593	0.09581
15	South	FLU	0.18045	0.02617	0.16014	0.01979	0.16461	0.12355
15	North	PAN	0.26209	0.03496	0.24002	0.02497	0.17072	0.10404
21	North	PAK	0.50339	0.06052	0.45798	0.03964	0.12136	0.08655

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) Mini Study Decks

Table 9-16. Summary Statistics by Deck for Copper - X Term Calculated as µg/cm^2 Coupon

STUDY= Mini and Full ANALYTE=Copper

AGE	REGION	DECK ID	MEAN X µg/cm^2	MEAN Y µg/cm^2	GEOM MEAN X µg/cm^2	GEOM MEAN Y µg/cm^2	MEAN R	GEOM MEAN R
.	South	GAUn[(a)]	0.01148	0.009571	0.01063	0.007500	0.82385	0.70554
0	South	GANC[(a)]	0.19868	0.039389	0.19465	0.035015	0.21239	0.17989
1	South	GAG[(a)]	0.13482	0.027471	0.12476	0.025826	0.23395	0.20700
1.5	South	GAE[(a)]	0.09981	0.020308	0.09594	0.018347	0.22478	0.19124
4	South	GAD[(a)]	0.16993	0.022176	0.14893	0.021200	0.15802	0.14234
15	North	PAO[(a)]	0.15504	0.024980	0.13741	0.021077	0.19433	0.15339
23	North	PAJ[(a)]	0.12565	0.021585	0.11813	0.019097	0.18301	0.16167
.	South	FLUn	0.01283	0.01448	0.01121	0.01192	1.43539	1.06317
.	.	NCUn	0.01156	0.01068	0.01059	0.00996	1.06353	0.94072
0	South	FLFG	0.48733	0.14874	0.40716	0.10469	0.32786	0.25711
0	South	FLFR	0.29904	0.12990	0.27965	0.08870	0.54391	0.31719
0	North	PAPF	0.51019	0.18002	0.47610	0.13273	0.37904	0.27880
0	North	PAPS	2.86983	1.14139	1.67152	0.55137	0.59344	0.32986
0.6	North	PAP	0.26906	0.08193	0.24178	0.06426	0.32526	0.26579
0.7	North	PAQ	0.37959	0.13115	0.35662	0.10563	0.35087	0.29619
0.9	North	PAR	0.21434	0.05471	0.20679	0.04370	0.28298	0.21131
1	South	FLT	0.28933	0.09672	0.28099	0.06544	0.39131	0.23287
1	South	FLY	0.43031	0.08497	0.39341	0.06126	0.22049	0.15573
1	South	FLZ	0.15014	0.05724	0.14483	0.04810	0.41438	0.33215
1	North	PAM	0.18829	0.08157	0.17545	0.05640	0.44108	0.32146
1	North	PAX	0.16273	0.05111	0.15556	0.04034	0.31593	0.25935
1.1	South	FLAA	0.37320	0.07215	0.32869	0.05709	0.22108	0.17368
1.3	South	FLAB	0.58083	0.10054	0.56050	0.08357	0.18360	0.14909
5	South	FLV	0.11405	0.02584	0.10141	0.02296	0.27431	0.22636
5	North	PAL	0.20601	0.05361	0.19213	0.04135	0.26958	0.21524
6	South	FLW	0.16194	0.02910	0.12254	0.02288	0.26814	0.18670
6	North	PAI	0.13556	0.05639	0.12717	0.03931	0.46689	0.30916
8	North	PAH	0.14352	0.06688	0.13653	0.05046	0.48608	0.36958
15	South	FLAC	0.21243	0.03483	0.20066	0.02710	0.17680	0.13505
15	South	FLS	0.17391	0.03711	0.15991	0.02890	0.23446	0.18070
15	South	FLU	0.09447	0.02471	0.08645	0.02044	0.29683	0.23638
15	North	PAN	0.19556	0.04373	0.17406	0.03133	0.27085	0.18001
21	North	PAK	0.22506	0.04091	0.21912	0.03189	0.19420	0.14552

Note: Recently treated board set PAPS and Deck FLAB were determined to be outliers and are not included in the statistical analyses (see Section 9.5.1).

(a) Mini Study Decks

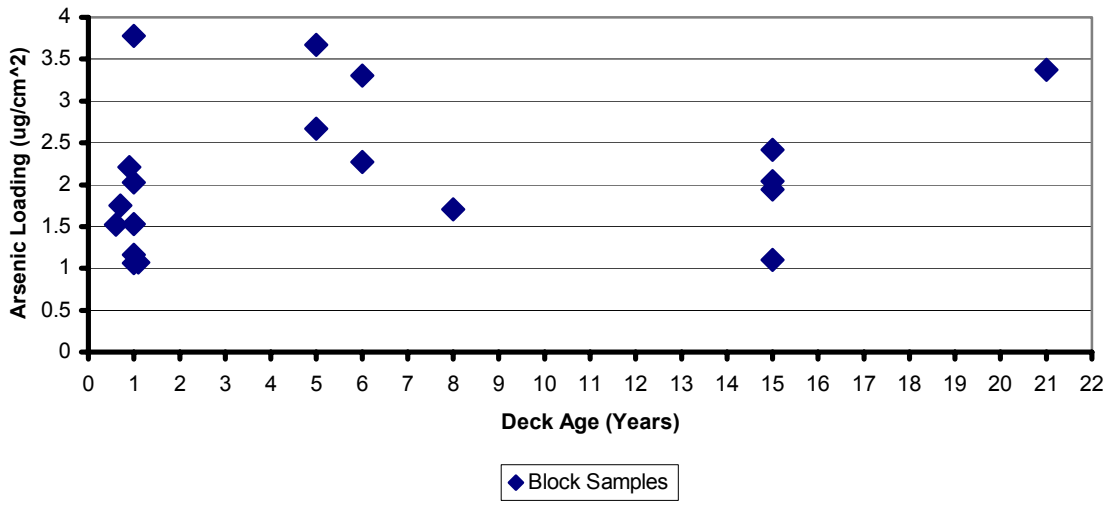


Figure 9-1. Block Wipe Loading as a Function of Deck Age for Arsenic

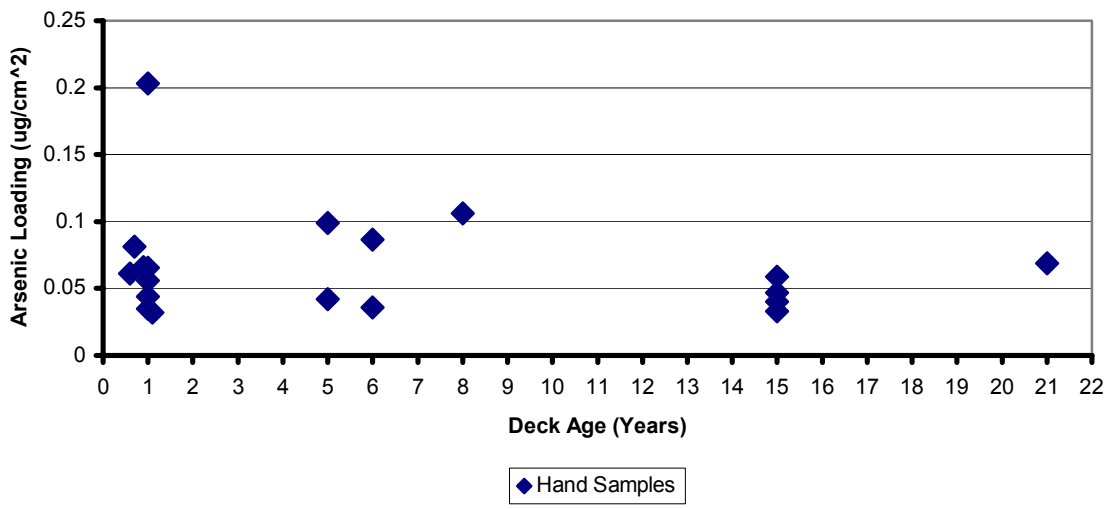


Figure 9-2. Hand Loading as a Function of Deck Age for Arsenic

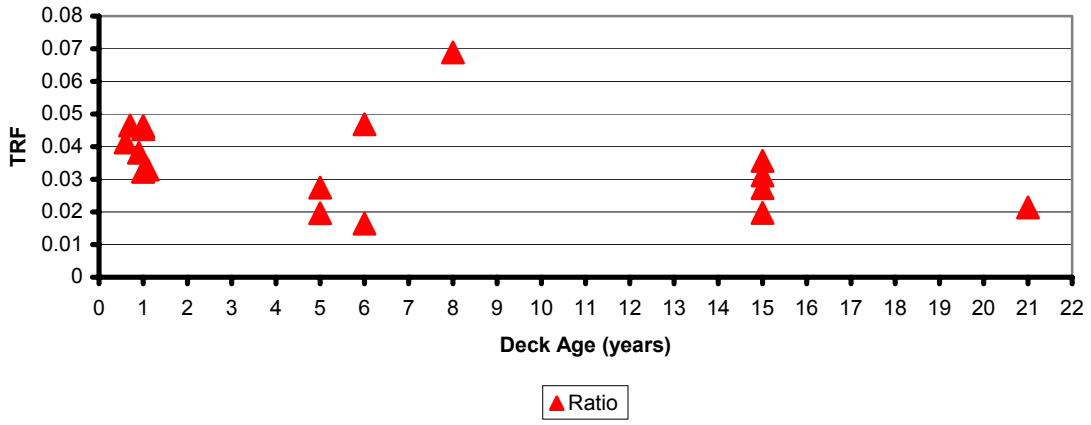


Figure 9-3. Transfer Reduction Factor, R, as a Function of Deck Age for Arsenic

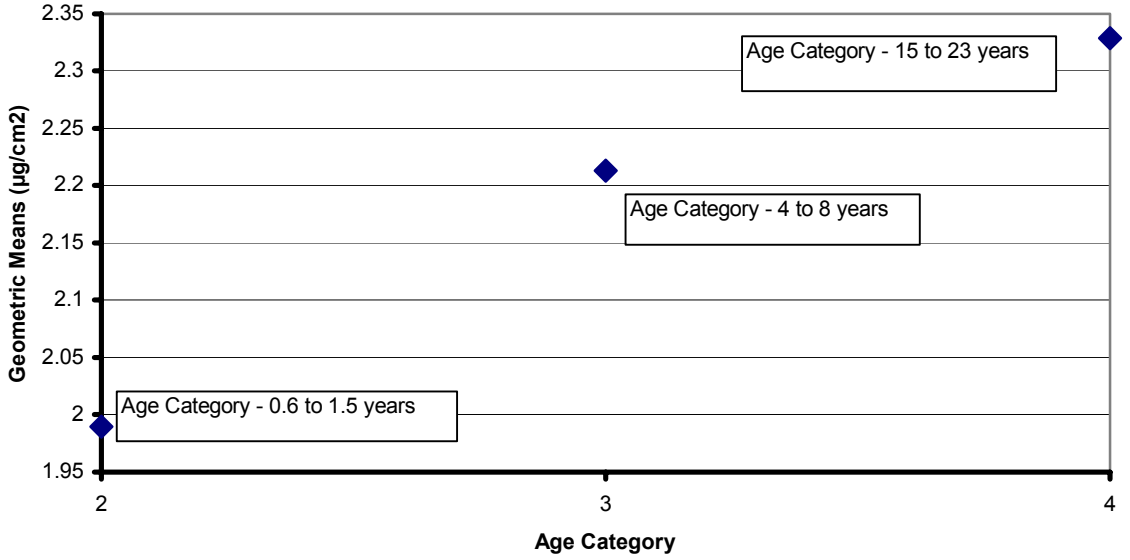


Figure 9-4. Geometric Mean of Block Wipe Arsenic Results as a Function of Age Category for Decks from North Region

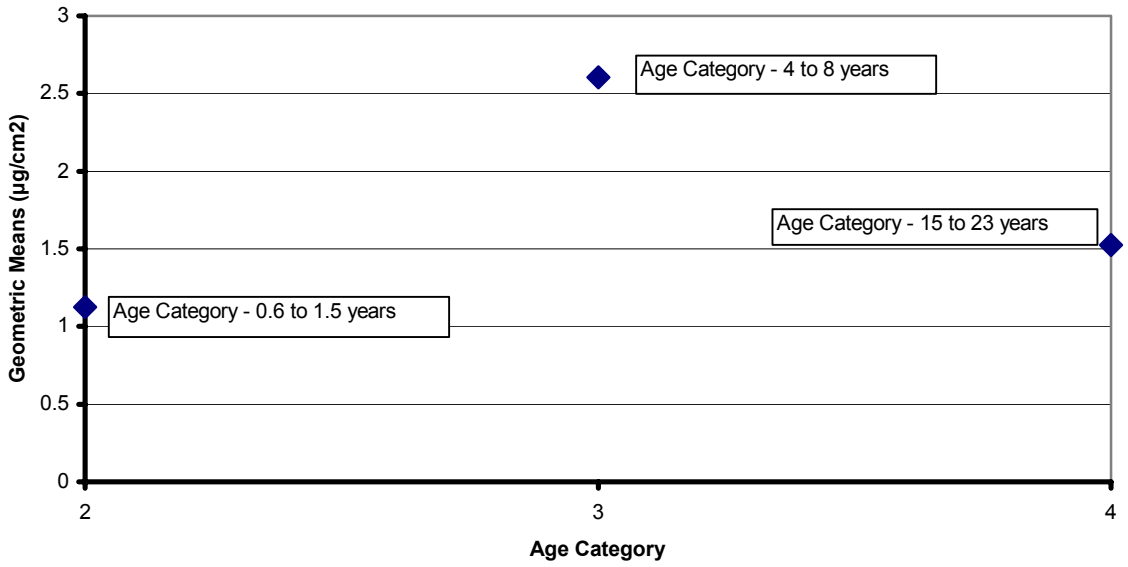


Figure 9-5. Geometric Mean of Block Wipe Arsenic Results as a Function of Age Category for Decks from South Region

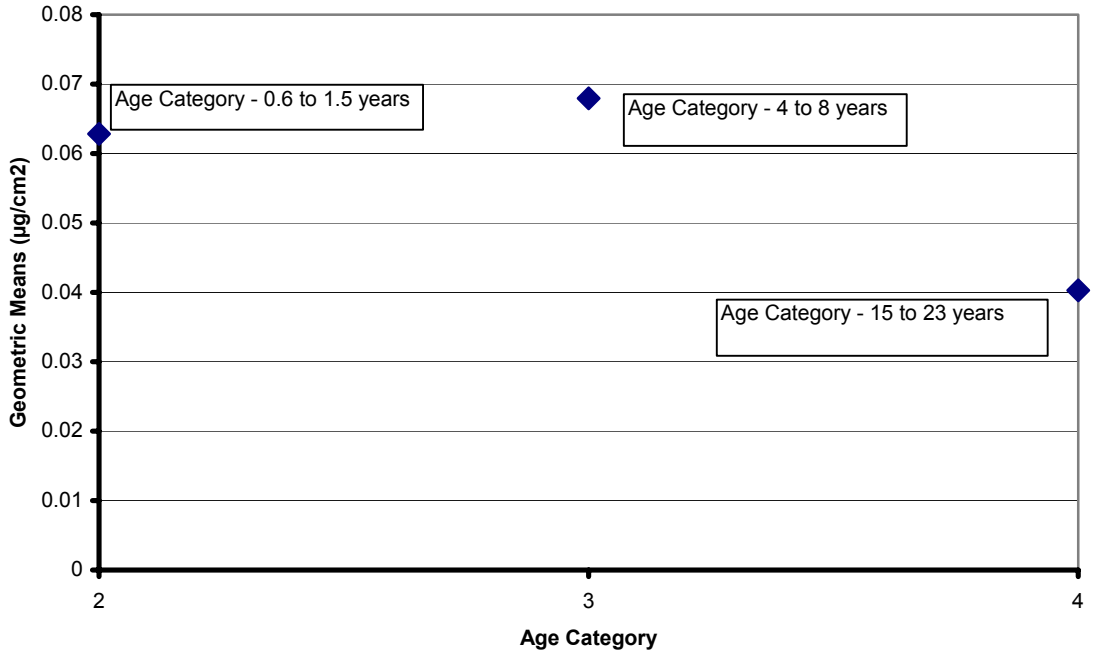


Figure 9-6. Geometric Mean of Hand Sample Arsenic Results as a Function of Age Category for Decks from North Region

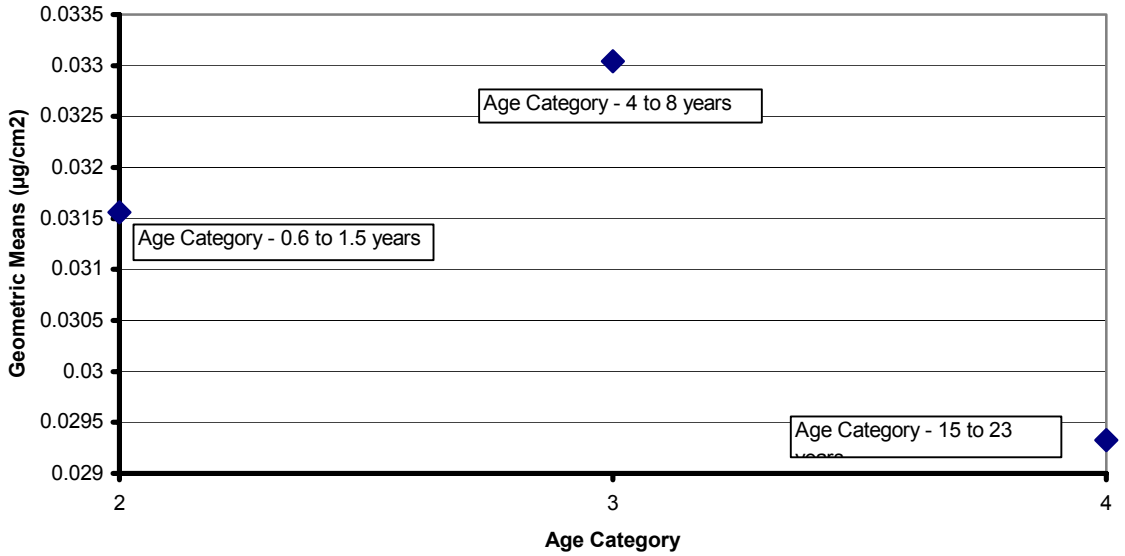


Figure 9-7. Geometric Mean of Hand Sample Arsenic Results as a Function of Age Category for Decks from South Region

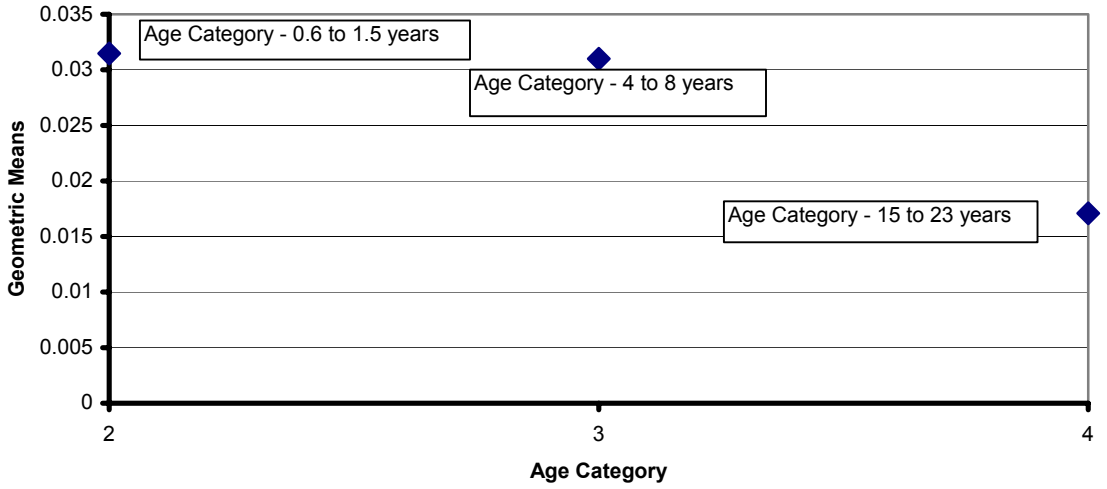


Figure 9-8. Geometric Mean of Transfer Reduction Factor for Arsenic as a Function of Age Category for Decks in North Region

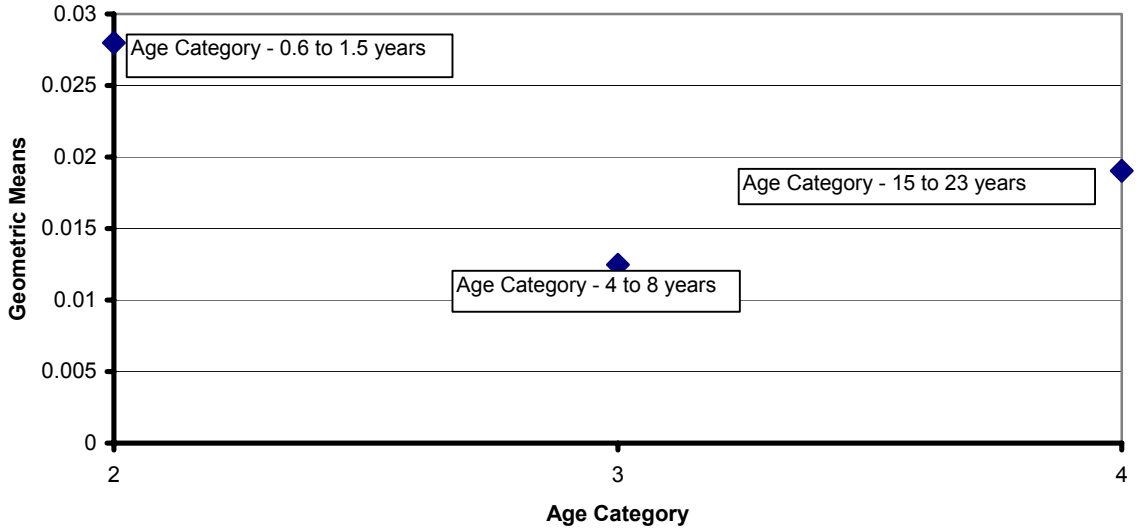


Figure 9-9. Geometric Mean of Transfer Reduction Factor as a Function of Age Category for Decks in South Region

10.0 SUMMARY AND CONCLUSIONS

The overall study for assessing exposure to metals in CCA-preserved wood involved four distinct steps: (1) protocol and quality assurance project plan preparation and approval; (2) pilot studies; (3) a Mini Study; and (4) a Full Study.

10.1 Study Protocols, Quality Assurance Project Plan and IRB Approval

This study to assess exposure to metals in CCA-preserved wood was conducted in three major phases: Pilot Study, Mini Study, and Full Study. Protocols for the Pilot/Mini Studies and the Full Study (Gradient 2002 and 2003) were prepared and approved for use by the industry's CCA Task Force and government agencies. A quality assurance project plan that included all QA/QC elements required by the U.S. Environmental Protection Agency as well as all standard operating procedures for field and laboratory activities was prepared and approved (RTI, 2003a). RTI's Institutional Review Board (IRB) approved all relevant study documentation and procedures for use of human subjects in the hand sampling methodology.

10.2 Pilot Study

In the pilot study, a series of tests and experiments were performed to develop and/or evaluate methods for collecting decks in the field, preparation of coupons for sampling, performing block wipe and hand rub sampling, and chemical analysis using appropriate digestion methods and measurement for total CCA using ICP/AES and ICP/MS and Cr(VI) using IC. Results and conclusions from the Pilot Studies are reported in RTI's report to the American Chemistry Council, "Assessment of Exposure to Metals in CCA-Preserved Wood" (American Chemistry Council, 2003) and Section 2.0 of this Report. The procedures and methods developed in the Pilot Studies were applied in a Mini Study in which approximately 120 CCA-treated deck board coupons from 5 locations were sampled by 8 volunteers.

10.3 Findings From the Mini Study

In the Mini Study, about 120 coupons from untreated wood, recently treated wood and five decks were subjected to block wipe testing and hand rubbing using the procedures described in Section 3.0. Eight volunteers performed the hand rubbing. The deck age ranged from 1 to 23 years. The block wipes were collected by one staff member. The block wipe, hand rinse, and hand wipe samples were analyzed following the procedures described in Section 7.0. Details of the Mini Study are presented in RTI's report to the American Chemistry Council, "Assessment of Exposure to Metals in CCA-Preserved Wood" (American Chemistry Council, 2003).

The Mini Study analytical data were subjected to statistical analysis. The outcome included:

- Summary statistics for each element for each type of wood and deck
- Regression analyses that relate block wipe values, the sum of hand rinse plus hand wipe values, and age of the wood/deck.
- One-way ANOVA analyses to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metal complex.

For As, the mean wipe block values ranged from 88.6 to 195.8 µg and the mean sum of hand rinse plus hand wipe values ranged from 2.97 to 6.14 µg. For Cr, the mean wipe block values ranged

from 119 to 242 µg and the mean sum of hand rinse plus hand wipe values ranged from 3.54 to 6.78 µg. For Cu, the mean wipe block values ranged from 50.5 to 90.6 µg and the mean sum of hand rinse plus hand wipe values ranged from 2.85 to 5.62 µg.

The ratios of mean sum of hand rinse plus hand wipe values to mean of block wipe values, *i.e.*, the TRFs, were 0.027, 0.026, and 0.048 for As, Cr, and Cu, respectively. (Note: These are presented as the inverse in the current version of the Mini Study report.) The standard deviations are relatively high and thus the values for these ratios are relatively uncertain. Regression analyses were performed using both non-log and log functions. The dependent variables in these analyses were the hand rinse value and the sum of the hand rinse plus the hand wipe value; that is, these values were modeled as a function of block wipe value and age, and also secondary effects of these two parameters. The best fit for As, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value and age
- Using log terms, function parameters are – intercept, log of block wipe value, age, and log of block wipe value squared.

The best fit for Cr, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value, age, block wipe value times age, and block wipe value squared
- Using log terms, function parameters are – intercept, log of block wipe value, age, and log of block wipe value squared.

The best fit for Cu, as indicated by lowest probability values, was achieved as follows:

- Using non-log terms, function parameters are – intercept, block wipe value, age, and block wipe value squared
- Using log terms, function parameters are – intercept, log of block wipe value, and age.

Similar to the correlational analysis, ANOVA analyses performed on the log-transformed data to test the effect of aging on block wipe and hand rinse/wipe levels of dislodgeable metals did not show consistent relationships between aging and block wipes and hand rinse/wipe results. Key findings from the ANOVA analyses were as follows:

- Although not always statistically significant, mean levels of dislodgeable metal complex are nearly always greatest for the recently treated (age=0) wood type, when either block wipe or hand rinse/wipe data are evaluated.
- Multiple comparisons of population means do not show a consistent trend between metal levels and age.

10.4 Findings From The Full Study

The purposes of the full study were to implement the sampling and chemical analysis procedures developed in the project's pilot study, to expand on the findings from the smaller Mini Study, and to develop more reliable information and data to achieve the following study objectives:

- Provide reliable estimates of the amount of dislodgeable metal complex removed by hand and by wipe sampling of CCA-preserved wood
- Determine if a statistically significant reduction in the amount of dislodgeable metal complex occurs between recently treated and aged CCA-preserved wood and with region, *i.e.*, north vs south
- Provide information from which a reliable transfer reduction factor (TRF) may be derived to adjust the amount of metal complex removed using a wipe sampling technique to the amount of metal complex removed using a hand sampling technique
- Test for the presence of Cr(VI) in the hand sample rinse solutions.

The full study included the use of coupons from twenty (20) residential decks, 10 from the Pittsburgh, Pennsylvania, area (north) and 10 from the Gainesville, Florida, area (south). Half of the decks from each city had been in service for approximately one year, and half had been in service for five or more years. The newer decks ranged in age from 0.6 to 1.3 years while the older decks ranged in age from five to 21 years. Recently treated 0.4 pcf CCA wood deck boards were purchased directly from two treatment facilities near these same cities. Untreated deck boards were obtained directly from a lumberyard in Concord, North Carolina, to serve as control blanks. About 750 coupons were sampled using the block wipe and hand sampling methods (see Section 9.4) developed and optimized in the pilot study. Twenty-one volunteers performed the hand sampling; a single RTI employee performed all block wipe sampling.

10.4.1 Data Treatment – Statistical Tests

The principal goals of the statistical analysis were: (1) to derive reliable estimates of the amounts of CCA complex removed by hand and wipe sampling; (2) to calculate a transfer reduction factor; and (3) to evaluate the effect of wood age on levels of dislodgeable metals collected *via* hands and block wipe by region (north and south). The statistical models also included variables such as the effects of the deck, region (north, south), volunteer, and hand (left, right) on levels of dislodgeable metals.

There are several possible choices regarding how the hand and block wipe results are presented for statistical analysis and used to derive a TRF. Two approaches are described below. The first approach is to assume that the sampling procedures used reach a state of equilibrium between the amount of dislodgeable material on a coupon and on a sampling device, *i.e.*, a volunteer's hand or the block wipe. Results from both the RTI Pilot Study and the recent CPSC study (CPSC, 2003; Levenson, 2003a and 2003b) indicate that the amount of dislodgeable arsenic collected on a block wipe or a hand does not increase after about 10 to 15 passes on a test board, and that increasing the weight of the block or the weight on the hand does not significantly increase the amount collected. Also, based on experiments in the CPSC (2003) study, once equilibrium is achieved, even sampling a larger surface area of treated wood does not significantly increase levels of dislodgeable arsenic on a sampling device. If equilibrium is achieved, then it is appropriate to divide the mass of dislodged metal by the surface area of the sampling device. Thus, when a hand is used, the mass of dislodged metal is divided by the measured size of a volunteer's palm, and when a block wipe is used the mass of dislodged metal is divided by the size of the block-sampling device. When normalized this way, the hand load results are reported as $\mu g/cm^2$ of hand surface, and the block wipe results are reported as $\mu g/cm^2$ of block area. These values are then subjected

to statistical analysis. Using this approach, statistical analyses were performed using the load or amount collected on a hand divided by the area of a hand, which averaged about 140 cm^2, and the load collected on a block wipe divided by 64 cm^2, the surface of the block that contacts the wood coupon during sampling.

An alternative approach is to treat the hand samples as having achieved equilibrium, but to assume that the block wipe samples have not achieved equilibrium. That is, the block wipe loading is assumed to increase with an increase in the amount of wood surface rubbed. Although there are reasons why it may be easier for a hand to achieve equilibrium than a wipe (*e.g.*, a wipe has greater absorption capacity than a hand, more friction with a wipe, *etc.*), the results of the CPSC (2003) and RTI pilot studies indicate that the hand and block wipe sampling procedures used in these studies achieved equilibrium for both types of sampling devices. In this alternative approach, the hand sample results are still represented as $\mu g/cm^2$ of hand surface, but the block wipe results are represented as $\mu g/cm^2$ of board area sampled. In the RTI study, the board (coupon) area sampled was 500 cm^2. Statistical analyses were also performed using this alternative approach.

The statistical analyses to test for these effects and relationships were performed using routines in SAS Version 8.2, a statistical software package. Three basic types of analyses were done. These are:

- Summary statistics: to provide descriptive statistics summarizing the central tendency and variability of the hand results, block results, and transfer reduction factors (TRFs).

- Correlations: to quantify the relationship between hand and block data, and between hand and block results and deck age, without controlling for other parameters.

- Mixed model analyses: to describe the effects of deck parameters such as age and region on TRFs, hand results, and block results, while controlling for other parameters.

The analysis variables are as follows:

Y=hand sample result = sum of hand rinse and wipe
LY=log(Y)
X=block sample result
LX=log(X)
R=Y/X
LR=log(Y/X)

10.4.2 Findings from the Full Study

10.4.2.1 Summary Statistics

The first goal of the full study was to develop reliable estimates of the amount of dislodgeable metal complex removed by hand and block wipe sampling and also the transfer reduction factor, R. Hand and block wipe sampling were performed on the coupons from the north and the south. The results of these tests for the mini study and full study combined are as follows.

Table 10-1. Summary of Mean and Geometric Mean Block and Hand Wipe Values for Both Approaches to Data From the Combined Full and Mini-study Data Sets

	Mean Block Wipe, μg/cm² Block Wipe	Mean Block Wipe, μg/cm² Coupon	Geom. Mean Block Wipe, μg/cm² Block Wipe	Geom. Mean Block Wipe, μg/cm² Coupon	Mean Hand, μg/cm² Hand	Geom. Mean Hand, μg/cm² Hand	Mean Ratio, R (Based on μg/cm² Block Wipe)	Mean Ratio, R (Based on μg/cm² Coupon)
As	2.15	0.276	1.81	0.231	0.061	0.039	0.032	0.251
Cr	2.74	0.351	2.29	0.294	0.058	0.036	0.024	0.185
Cu	1.59	0.204	1.35	0.173	0.053	0.037	0.038	0.293

The mean deck block wipe (X) values for arsenic in the full study were generally less than about 4 μg/cm^2 block wipe, with one exception (Deck FB) (assuming equilibrium were achieved for both block wipe and hand samples). The mean hand (Y) values (rinse + wipe) for arsenic were generally less than 0.1 μg/cm^2 hand, except for Decks PAM and FLAB. The mean X values were above 4 μg/cm^2 block wipe for three of the recently treated wood sets and the mean Y values were above 0.1 μg/cm^2 hand for all four of the recently treated wood sample sets. The geometric means [calculated as e^x where x = log(X)], are also provided. The mean block wipe values for chromium in the full study were generally less than 4 μg/cm^2, except again for Decks PAM and FLAB; the mean hand values were again generally less than 0.1 μg/cm^2. The copper values parallel the arsenic and chromium values, but are lower. The standard deviations are not presented because results presented below strongly suggest a log-normal distribution for the X and Y values. In such a case, the conventional standard deviation has little meaning. Another result of this finding is that the geometric means are more representative of the data sets than the means.

Assuming equilibrium is achieved for the hand samples, but not the block wipe samples, the mean deck block wipe (X) values for arsenic in the full study were generally less than about 0.5 μg/cm^2 coupon, with one exception (Deck FB). The mean hand (Y) values (rinse + wipe) for arsenic were the same for both approaches, that is, less than 0.1 μg/cm^2 hand, except for Decks PAM and FLAB. The mean X values were above 0.5μg/cm^2 coupon for three of the recently treated wood sets.

The difference in μg/cm^2 block wipe and μg/cm^2 coupon is simply the result of multiplication by the constant, (64 cm^2 block wipe area)/(500 cm^2 coupon area). One can see that the geometric mean values are about 20% less than the arithmetic means, further supporting the occurrence of right-skewed distributions in the data sets. The values for R given in this table cannot be compared as they are defined by different terms; one is defined as (μg/cm^2 hand)/(μg/cm^2 block wipe) whereas the other is defined as (μg/cm^2 hand)/(μg/cm^2 coupon). The values for the geometric means for the R values would be about 35% less than the arithmetic means presented in Table 10-1.

It is informative to consider the distribution of the values for the parameters, R, block wipe, and hand. Calculations for the distributions were performed. Table 10-2 presents a summary of the distribution of transfer reduction factors, or R values, calculated for each coupon. Here again, the median value is less than the mean, indicating a skewed distribution. As before, this conclusion is supported by the fact that the mean in not close to halfway between the 5% and 95% quantiles, which suggests that the median is a better indicator of central tendency than the mean.

Table 10-2. Distribution of R Values for the Combined Full and Mini-study Data Sets for Both Approaches to Equilibrium

	Mean Ratio, R (Based on μg/cm^2 Block Wipe)	Median Ratio, R (Based on μg/cm^2 Block Wipe)	5% Quantile (Based on μg/cm^2 Block Wipe)	95% Quantile (Based on μg/cm^2 Block Wipe)	Mean Ratio, R (Based on μg/cm^2 Coupon)	Median Ratio, R (Based on μg/cm^2 Coupon)	5% Quantile (Based on μg/cm^2 Coupon)	95% Quantile (Based on μg/cm^2 Coupon)
As	0.0321	0.0196	0.00550	0.0943	0.251	0.153	0.043	0.736
Cr	0.0237	0.0146	0.00379	0.0692	0.185	0.114	0.030	0.541
Cu	0.0375	0.0257	0.00889	0.1057	0.293	0.201	0.070	0.826

10.4.2.2 Correlation Analyses

Correlation analyses were performed to test the relationship between hand and block data, between hand and block results and deck age, and between hand and block results and region from which the deck was taken. Pearson tests were performed on the log's of the data (*i.e.*, transformed data) while Spearman tests were performed on the untransformed data. As shown in Table 10-3, Spearman correlation coefficients for the combined dataset show statistically significant inverse relationships between age and hand sample results for each of the dislodgeable metals. For the hand results, statistically significant (p-value<0.0001) Spearman correlation coefficients of -0.17, -0.19, and -0.38 were obtained for As, Cr, and Cu, respectively, with age. The relationship between age and block wipe results was positive for As and Cr, but negative for Cu. For the block results, smaller but statistically significant Spearman correlation coefficients of 0.15, 0.16, and -0.32 were obtained for As, Cr, and Cu, respectively, with age. Thus, without controlling for other parameters, these results suggest that significant reductions in dislodgeable metals levels occur on the hands with increasing deck age. The reason for the increase with age with the block wipes is uncertain.

Table 10-3. Summary of Spearman Correlation Coefficients for the Combined Full and Mini-study Data Sets

	Arsenic	Chromium	Copper
Block Wipe vs Hand	0.313	0.343	0.434
Age vs Block Wipe	0.154	0.157	-0.321
Age vs Hand	-0.168	-0.193	-0.380
Age vs R	-0.266	-0.298	-0.178

Because the only difference in the data sets developed with the two different assumptions about sampling equilibrium is multiplication of the block value in μg/cm^2 block area by 64/500 to arrive at block value in μg/cm^2 coupon area, there is no difference in the correlation results for the two sets of the data.

These correlation results should be treated with caution not only because they are based on the combined data sets (mini- and full studies), but also because they treat coupon-level observations as independent observations when, in fact, they are not independent. The degrees of freedom associated with the tests of significance of the correlations are thus too large and result in overstating their significance. (The mixed-model approach attempts to appropriately account for the dependence among the observations.)

10.4.2.3 Mixed Effects Modeling

Modeling was performed to describe the effects of deck parameters such as age and region on transfer reduction factors (R), hand results, and block results, while controlling for other parameters. Mixed effect modeling was performed only with coupons from 19 decks from the full study. Age was treated in two ways; it was treated as a continuous effect in one set of models, and as a categorical variable in a second set of models. The age categories are 0.6 to 1.5, 4 to 8, and 15 to 23 years. The dependent variables in these models are log(R), log(Y) and log(X). The fixed effects are region and age. The only differences in the fixed effects for the two different assumptions about equilibrium are the intercept values for the mathematical models. That is, the intercept values associated with the first assumption, equilibrium for both block and hand samples, for the models for log(R) (*i.e.*, log[hand/block]), are different than the intercept values associated with the second assumption, equilibrium for the hand but not the block samples, for the models for log(R), (*i.e.*, log[hand/coupon]); this difference is equal to log(500/64). Likewise, the intercept values for the models for log(block) are different than the intercept values for the models for log(coupon); this difference is equal to log(64/500).

The random effects for which variance components were estimated are Stack, DeckID, Stack*HandID (left or right), and Residual. The fixed effect values for log(R), log(hand) and log(block) are given in Table 10-4, along with indications of statistical significance. One notes that age and region have a significant effect on R for As and Cr but not for Cr. For log(hand), age and region have a significant effect for Cu but only region has an effect for As and Cr. For log(block), age and region have a significant effect for As and Cr, but only age seems to have a significant effect for Cu.

Table 10- 4. Fixed Effects for Log(R), Log(hand) and Log(block) for As, Cr, and Cu for Full Study for Approach to Equilibrium using Wipe Block as µg/cm^2 Block Wipe

Mixed Model Analysis for Log(R)			
Effect	**As**	**Cr**	**Cu**
Intercept	-3.275*	-3.5875*	-3.5943*
Region, North	-0.2099	-0.1576	0.2133
Age	-0.2985*	-0.3201*	-0.00262
Age*Age	0.01684*	0.01797*	-0.00060
Age*Region, North	0.3138*	0.3098*	0.02632
Age*Age*Region, North	-0.01924*	-0.01923*	-0.00200
Mixed Model Analysis for Log(Hand)			
Effect	**As**	**Cr**	**Cu**
Intercept	-3.4553*	-3.4932*	-2.5727*
Region, North	0.7243*	0.7035*	-0.2001
Age	0.01102	-0.04366	-0.2957*
Age*Age	-0.00107	0.001938	0.01488*
Age*Region, North	-0.01998	0.03880	0.2176**
Age*Age*Region, North	0.000460	-0.000314	-0.01260**

Mixed Model Analysis for Log(Block)			
Effect	**As**	**Cr**	**Cu**
Intercept	-0.1795	0.09099	1.0218*
Region, North	0.9240*	0.8528**	-0.4092
Age	0.3052*	0.2742**	-0.2945*
Age*Age	-0.01767*	-0.01587**	0.01552**
Age*Region, North	-0.3238*	-0.2637	0.1948
Age*Age*Region, North	0.01914*	0.01566	-0.01081

* Indicates significance at 0.01 level; ** Indicates significance at 0.05 level.

These constants can be used to generate equations for calculating R, block wipe, and hand values as a function of age of the decks for north and south. This was done for the age range of 1 to 20 years. Results from these calculations indicated that the values for hand (Y) for the south and the north both decrease with age, as predicted by the correlation analyses. The values for block wipe for the south seem to increase and then decrease while the values for block wipe for the north are relatively constant and then increase.

10.5 Cr(VI) Analysis

One of the goals of the research was to determine if chromium, in oxidation state +6, was present in the rinsate from the hand rubbing experiments. Some 145 hand rinsate samples were analyzed for Cr(VI) using ion chromatography. Of these samples, only three had concentrations above the method detection limit of 0.25 μg/L or 0.035 μg/hand. Two of these samples came from recently treated deck wood (0.644 and 0.28 μg/L) and one sample was from a 1-year old deck from the Pittsburgh area (0.279 μg/L). These values correspond to 0.09, 0.04, and 0.04 μg Cr(VI) per hand rinse.

10.6 Conclusions

There are several conclusions that can be drawn from this study. These are as follows:

- The relationship between the level of dislodgeables on a board sample and the level on a sampling device after 20 passes across the board may or may not represent a state of equilibrium. Experimental evidence collected by RTI and CPSC suggest that a state of equilibrium exists between these levels for both the block wipe and hand sampling.
- All data indicate that the distributions of the block wipe and hand sample data are near-log normal, or right skewed.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for As is about 2 $\mu g/cm^2$ block wipe and about 0.04 $\mu g/cm^2$ hand.
- Assuming that a state of sampling equilibrium exists for the hand samples but not the block wipe samples, the median value for As on the block wipe is about 0.2 $\mu g/cm^2$ board (coupon) and about 0.04 $\mu g/cm^2$ hand.
- Assuming that a state of sampling equilibrium exists for both the block wipe and the hand samples, the median value for the transfer reduction factor for As is about 0.02.
- The levels of CCA recovered from the deck surfaces are higher in the north than the south.
- It is unclear whether the levels of CCA collected on block wipes increase or decrease with deck age.
- The levels of CCA collected on hand surfaces decrease with the age of the decks.
- Cr(VI) is virtually non-existent in hand rinse samples.

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