PERFORMANCE OF A BORAX-COPPER HYDROXIDE REMEDIAL PRESERVATIVE WHEN APPLIED TO UNSEASONED PINE POSTS

10 YEAR REPORT

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Permanence and Diffusion of a Borax-Copper Hydroxide Remedial Preservative Applied to Unseasoned Pine Posts: 10 Year Update

ABSTRACT: In 1993 unseasoned pine posts were treated with groundline bandages containing 3.1% copper hydroxide and 40% sodium tetraborate decahydrate (borax). The soundness of the posts was periodically evaluated using a push test. After 3.5, 6.5 and 10 years two treated posts were sacrificed to determine borax retention and copper hydroxide retention in increments from cross sections ranging from 7 inches below ground to 14 inches above ground. After 3.5 years all untreated control posts had failed. After 6.5 and 10 years the remedially treated posts were generally sound at the groundline, but most suffered top decay. The average borax retention was 1.51, 0.99 and 0.66 lbs/ft^3 after 3.5, 6.5 and 10 years, respectively. The average copper hydroxide retention in the sampled increments was 0.23, 0.26 and 0.22 lbs/ft^3 after 3.5, 6.5 and 10 years, respectively. Although retentions varied among posts, in most cases the borax retentions were still above the threshold needed to prevent attack by decay fungi even 10 years after treatment.

INTRODUCTION

After many years in service the preservative in the groundline area of utility poles may become sufficiently depleted to allow surface attack by some types of decay fungi. To combat this surface decay and to extend the useful life of the pole, remedial preservatives may be applied to the groundline area. The components in a remedial formulation must be compatible with, and complimentary too, the original pressure treatment preservatives such as creosote and pentachlorophenol. The remedial treatments are designed to protect wood containing below threshold levels of creosote or pentachlorophenol. They are also intended to protect the untreated sapwood in occasional poles which failed to meet the original pressure treatment penetration specifications, as well as untreated heartwood. To be effective these remedial treatments must be mobile enough to move into the pole, while still maintaining enough permanence to provide long term protection.

One approach to achieving both diffusion and permanence is to use a formulation that contains one active ingredient that fixes in the wood and another that diffuses. The diffusible active moves with the water in the pole and may penetrate into the heartwood. It should be capable of preventing both decay and insect attack. The fixed active should be capable of moving well into the sapwood before becoming immobile. It is important that the fixed active be able to control creosote and pentachlorophenol tolerant decay fungi. The remedial treatment formulation reported here contains borax and copper hydroxide complexed with ethanolamine. Borax is a well-known diffusible preservative. In recent years ethanolamine complexes of copper have become familiar fixed active ingredients in wood preservatives. Use of borax with ethanolamine-copper buffers the alkalinity of the amine and allows for production of a remedial preservative requiring only a WARNING signal word on the labeling.

The literature contains considerable data which supports the performance of a combination of copper and borate compounds for general wood preservation. It is known that borate compounds leach readily from wood in contact with the ground whether or not the borates are combined with copper. To minimize borax losses in remedial groundline treatments, impermeable sheets are used to cover the preservative and contain the borax in the pole. These impermeable liners also help to prevent movement of creosote and pentachlorophenol out of the poles.

Evaluation of the efficacy of remedial treatments is challenging because they are applied to poles in a range of conditions and with varying types and contents of residual preservative treatment. The American Wood-Preservers' Association (AWPA) has considered standardizing a test for evaluation of these systems but has been unable to reach consensus on an appropriate method (AWPA, 1999). Perhaps the simplest approach is to evaluate the remedial treatments on untreated posts. In 1957 the USDA, Forest Products Laboratory established a trial comparing the ability of remedial treatment preservatives to protect unseasoned pine posts exposed at Harrison Experimental Forest (HEF) near Saucier, Mississippi (DeGroot, 1981). That trial led to commercial products which have performed well in service. However, performance on untreated posts should not be the sole indicator of performance. The remedial treatment actives must have the ability to penetrate into wood that has been treated with oil-type preservatives. The remedial actives may also be synergistic with, or at least complimentary to, the original pressure treatment preservative.

There is data indicating that the copper-borax formulation evaluated in this report is effective in combination with either creosote or pentachlorophenol. Fahlstrom (1964) reported synergism for borax and creosote, noting that wood treated with sub-threshold creosote levels could resist attack by creosote tolerant fungi with the addition of as little as 0.02 lbs/ft^3 anhydrous borax. Synergism of combinations of borax and pentachlorophenol have also been reported (Chapman, 1940), and combinations of copper and pentachlorophenol have also been reported to perform well (Hochman and Amundsen, 1980). Similarly, combinations of creosote and copper have a long history of successful wood protection. This historical data, in combination with other permanence and penetration studies on in-service utility poles, compliments this report on the performance of the remedial borax-copper treatment on untreated posts. A previous paper reported the retention and diffusion of copper and borax in the posts after 3.5 and 6.5 years of exposure (Abbott, et al, 2001). This report provides an update on the study after 10 years of exposure.

MATERIALS AND METHODS

The remedial preservative used in this study contained 3.1% copper hydroxide and 40% sodium tetraborate decahydrate as active ingredients. The inert ingredients consisted of ethanolamine, water, and thickeners. The test method followed was that described in FPL 409 except six additional posts were treated and installed for periodic removal, examination and preservative assay. The posts were cut and peeled within one week of treatment and installation. They measured an average circumference of 18.9 inches at the base. One-fourth inch of borax-copper hydroxide paste was applied to a vinyl sheet 18 inches tall and equal in circumference to the base circumference of the post. Then the bandage was tightly pressed around the base of the post. In June, 1993, shortly after treatment, the posts were installed in post holes of 16 inch depth.

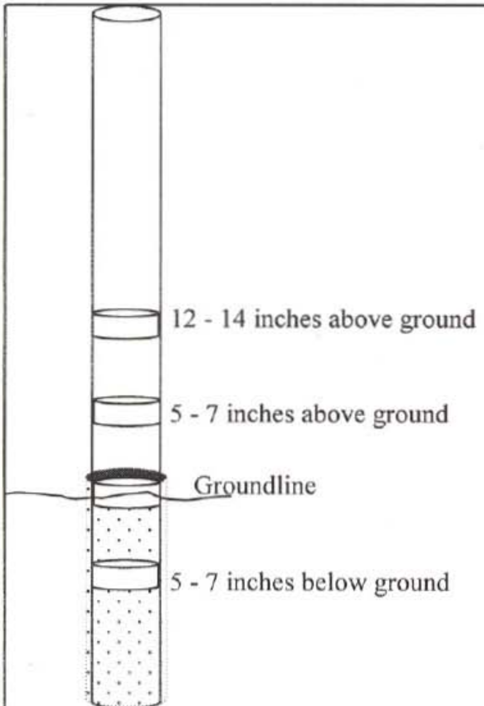

Figure 1. Locations of cross section removal for assay.

Each year the posts were given a push test and the results recorded. After 3.5, 6.5 and 10 years two posts were removed and cross sections cut from 5 - 7 inches below ground, 1 inch below ground to 1 inch above ground, 5 - 7 inches above ground, and 12 – 14 inches above ground (Figure 1). The sections were cut into assay zones corresponding to the outer 0 – 0.5 inches, and 0.5 – 1.0 inches and 1.0 - 2.0 inches from the post surface. The samples were sent to an independent laboratory where they were oven-dried, ground, mixed and assayed for copper and boron. The percentages of borax and copper hydroxide were calculated, and converted to a weight per unit volume basis using the AWPA Standard A12-03 density for Southern Yellow Pine of 32 lbs/ft^3 (AWPA, 2003).

RESULTS AND DISCUSSION

All untreated controls had failed when the first two treated posts were removed after 3.5 years. There was no visible evidence of insect attack or decay where the cross sections were cut from the remedially treated posts after either 3.5, 6.5 or 10 years of exposure. After 6.5 years the top of each remedially treated post was essentially destroyed by decay. Some decay extended down the posts, but remained above the treated zone.

Results for copper hydroxide and borax concentrations in the sampled sections of the treated posts are given in Table 1 and Figures 2 and 3. It is evident that chemical levels in the two posts removed at each time point vary greatly. Visual examination growth-rings in the posts suggested that this variability was caused by differences in density.

Although the variability between replicates makes it difficult to form definitive conclusions, some trends are apparent. The greatest borax retentions were generally found in the in the cross-section removed from 5 – 7 in. above ground, regardless of assay zone (Figure 2). It is also evident that the borax is diffusing into the posts, as the average retention in the second half-inch assay zone (1.16 lb/ft^3) was only slightly below that in the outer half-inch (1.35 lb/ft^3). There does appear to be some depletion of borax from the posts over time. The average borax retention was 1.51, 0.99 and 0.66 lbs/ft^3 after 3.5, 6.5 and 10 years, respectively. However, even after 10 years the average borax concentration in the posts is several times greater than the toxic threshold for decay fungi. Fahlstrom (1964) evaluated the toxicity of borax to five decay fungi and reported that the toxic thresholds ranged from 0.5 – 0.18 lbs/ft^3.

Trends in copper hydroxide retention differed from those of borax. The effect of vertical location appeared to depend on assay zone, with higher retentions occurring above-ground in the 0.0-0.5 in. assay zone and higher retentions occurring below ground in the two inner assay zones (Figure 3). Diffusion of copper hydroxide into the wood was also more limited than that of borax. The average copper hydroxide retention in the 0.5 - 1.0 in. assay zone (0.19 lb/ft^3) was less than half of that in the outer 0 - 0.5 in. assay zone (0.44 lb/ft^3). Not surprisingly, the copper hydroxide also appeared to be more permanent than the borax. Years in test did not have a noticeable effect on average copper hydroxide retention, with levels of 0.23, 0.26 and 0.22 lbs/ft^3 after 3.5, 6.5 and 10 years, respectively.

CONCLUSIONS

A borax-copper groundline treatment has protected the lower half of otherwise untreated pine posts for 10 years. Borax from the groundline treatments has most effectively diffused into the posts, while the copper appears to be less mobile but more permanent. Although variability between replicates makes definitive conclusions difficult, it appears that the retentions of borax and copper remaining in the wood are sufficient to prevent attack by decay fungi and termites. This study indicates that evaluation on untreated posts can be a valuable part of the overall assessment of a groundline treatment's efficacy.

LITERATURE CITED

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Table 1. Borax and copper hydroxide retentions in the three assay zones as a function of location on po and years of exposure.

Years in Test	Post	Vertical Location	Assay zone	Borax (pcf)	Copper Hydroxide (pcf)
3.5	1	5 - 7 in. BG	0 – 0.5 in.	0.52	0.47
3.5	2	5 - 7 in. BG	0 – 0.5 in.	0.12	0.30
6.5	3	5 - 7 in. BG	0 – 0.5 in.	0.21	0.33
6.5	4	5 - 7 in. BG	0 – 0.5 in.	0.03	0.25
10	5	5 - 7 in. BG	0 – 0.5 in.	0.36	0.34
10	6	5 - 7 in. BG	0 – 0.5 in.	0.07	0.37
3.5	1	1 in. BG - 1 in. AG	0 – 0.5 in.	0.76	0.58
3.5	2	1 in. BG - 1 in. AG	0 – 0.5 in.	0.34	0.35
6.5	3	1 in. BG - 1 in. AG	0 – 0.5 in.	0.53	0.41
6.5	4	1 in. BG - 1 in. AG	0 – 0.5 in.	0.09	0.35
10	5	1 in. BG - 1 in. AG	0 – 0.5 in.	1.67	0.34
10	6	1 in. BG - 1 in. AG	0 – 0.5 in.	0.25	0.38
3.5	1	5 - 7 in. AG	0 – 0.5 in.	8.16	0.50
3.5	2	5 - 7 in. AG	0 – 0.5 in.	2.50	0.43
6.5	3	5 - 7 in. AG	0 – 0.5 in.	2.25	0.41
6.5	4	5 - 7 in. AG	0 – 0.5 in.	1.84	0.54
10	5	5 - 7 in. AG	0 – 0.5 in.	2.19	0.38
10	6	5 - 7 in. AG	0 – 0.5 in.	0.51	0.64
3.5	1	12 - 14 in. AG	0 – 0.5 in.	1.58	0.35
3.5	2	12 - 14 in. AG	0 – 0.5 in.	3.90	0.62
6.5	3	12 - 14 in. AG	0 – 0.5 in.	2.99	0.52
6.5	4	12 - 14 in. AG	0 – 0.5 in.	0.77	0.85
10	5	12 - 14 in. AG	0 – 0.5 in.	0.13	0.13
10	6	12 - 14 in. AG	0 – 0.5 in.	0.50	0.72
3.5	1	5 - 7 in. BG	0.5 – 1.0 in.	0.42	0.35
3.5	2	5 - 7 in. BG	0.5 – 1.0 in.	0.11	0.15
6.5	3	5 - 7 in. BG	0.5 – 1.0 in.	0.20	0.39
6.5	4	5 - 7 in. BG	0.5 – 1.0 in.	0.03	0.15
10	5	5 - 7 in. BG	0.5 – 1.0 in.	0.33	0.35
10	6	5 - 7 in. BG	0.5 – 1.0 in.	0.07	0.31
3.5	1	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.53	0.28
3.5	2	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.25	0.13
6.5	3	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.47	0.28
6.5	4	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.08	0.12
10	5	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.97	0.11
10	6	1 in. BG - 1 in. AG	0.5 – 1.0 in.	0.22	0.14

Table 1 (continued)

Years in Test	Post	Vertical Location	Assay zone	Borax (pcf)	Copper Hydroxide (pcf)
3.5	1	5 - 7 in. AG	0.5 – 1.0 in.	5.34	0.28
3.5	2	5 - 7 in. AG	0.5 – 1.0 in.	2.55	0.16
6.5	3	5 - 7 in. AG	0.5 – 1.0 in.	2.42	0.22
6.5	4	5 - 7 in. AG	0.5 – 1.0 in.	1.44	0.17
10	5	5 - 7 in. AG	0.5 – 1.0 in.	4.19	0.25
10	6	5 - 7 in. AG	0.5 – 1.0 in.	0.60	0.07
3.5	1	12 - 14 in. AG	0.5 – 1.0 in.	1.05	0.05
3.5	2	12 - 14 in. AG	0.5 – 1.0 in.	1.75	0.15
6.5	3	12 - 14 in. AG	0.5 – 1.0 in.	4.14	0.27
6.5	4	12 - 14 in. AG	0.5 – 1.0 in.	0.33	0.04
10	5	12 - 14 in. AG	0.5 – 1.0 in.	0.08	0.05
10	6	12 - 14 in. AG	0.5 – 1.0 in.	0.36	0.02
3.5	1	5 - 7 in. BG	1.0 – 2.0 in.	0.39	0.11
3.5	2	5 - 7 in. BG	1.0 – 2.0 in.	0.04	0.05
6.5	3	5 - 7 in. BG	1.0 – 2.0 in.	0.23	0.29
6.5	4	5 - 7 in. BG	1.0 – 2.0 in.	0.04	0.06
10	5	5 - 7 in. BG	1.0 – 2.0 in.	0.34	0.17
10	6	5 - 7 in. BG	1.0 – 2.0 in.	0.07	0.18
3.5	1	1 in. BG - 1 in. AG	1.0 – 2.0 in.	0.45	0.09
3.5	2	1 in. BG - 1 in. AG	1.0 – 2.0 in.	0.25	0.03
6.5	3	1 in. BG - 1 in. AG	1.0 – 2.0 in.	0.40	0.19
6.5	4	1 in. BG - 1 in. AG	1.0 – 2.0 in.	0.07	0.04
10	5	1 in. BG - 1 in. AG	1.0 – 2.0 in.	1.04	0.08
10	6	1 in. BG - 1 in. AG	1.0 – 2.0 in.	0.20	0.06
3.5	1	5 - 7 in. AG	1.0 – 2.0 in.	2.96	0.10
3.5	2	5 - 7 in. AG	1.0 – 2.0 in.	1.02	0.02
6.5	3	5 - 7 in. AG	1.0 – 2.0 in.	1.97	0.14
6.5	4	5 - 7 in. AG	1.0 – 2.0 in.	0.94	0.01
10	5	5 - 7 in. AG	1.0 – 2.0 in.	0.95	0.06
10	6	5 - 7 in. AG	1.0 – 2.0 in.	0.61	0.01
3.5	1	12 - 14 in. AG	1.0 – 2.0 in.	0.80	0.03
3.5	2	12 - 14 in. AG	1.0 – 2.0 in.	0.45	0.01
6.5	3	12 - 14 in. AG	1.0 – 2.0 in.	2.28	0.11
6.5	4	12 - 14 in. AG	1.0 – 2.0 in.	0.11	0.00
10	5	12 - 14 in. AG	1.0 – 2.0 in.	0.06	0.01
10	6	12 - 14 in. AG	1.0 – 2.0 in.	0.13	0.01

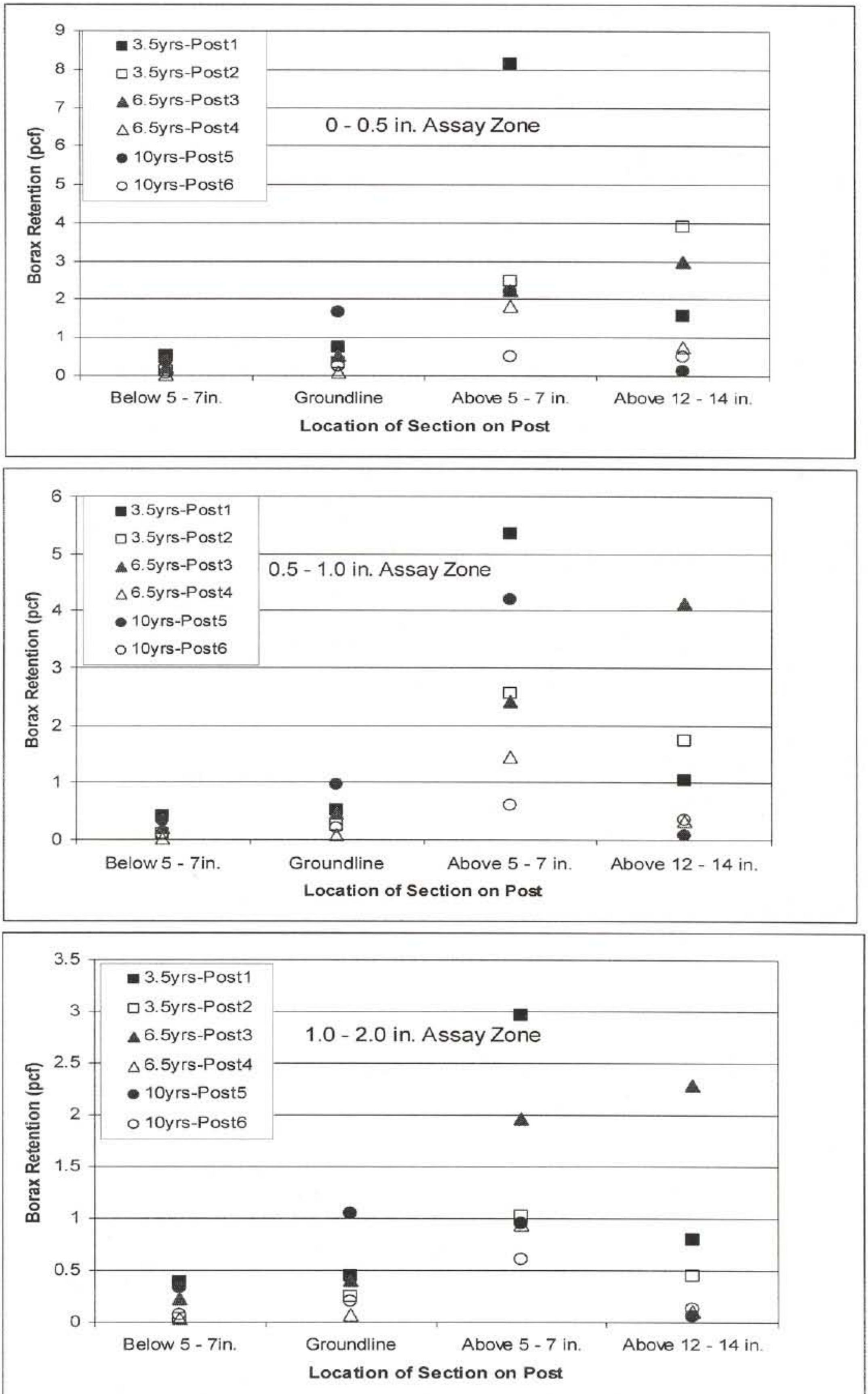

Figure 2. Borax retentions in the three assay zones as a function of location on post and years of expos

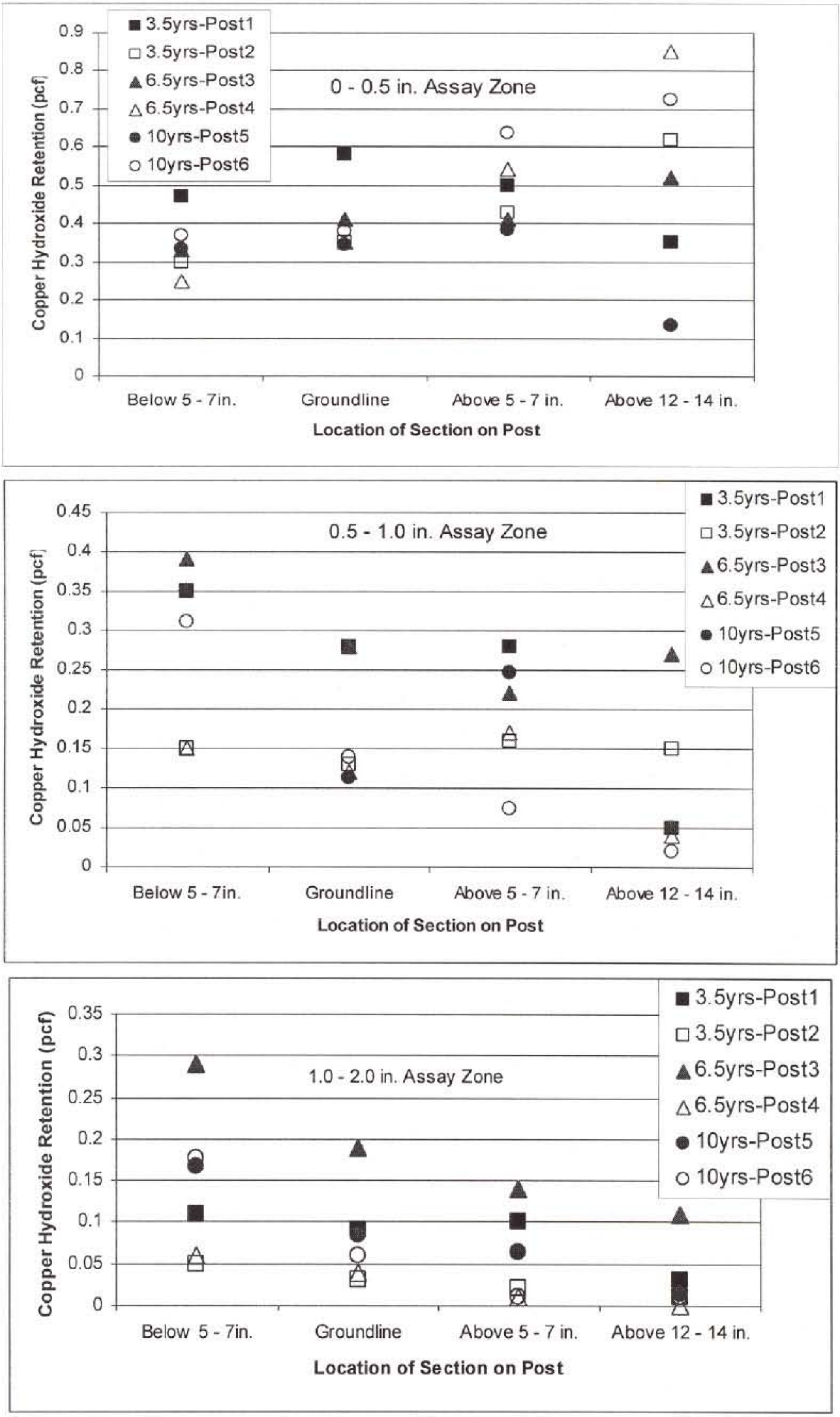

Figure 3. Copper hydroxide retentions in the three assay zones as a function of location on post and yea
of exposure.

CU-BOR 10 YEAR PHOTOS

6/11/03

Photos by Randy S. Gross

SITE

Southern Mississippi, AWPA (American Wood-Preservers' Assoc.) Zone 5

MATERIAL

SYP (Southern Yellow Pine) Posts

- Notice decayed tops and post that failed push test above ground

PHOTOS

ZONES

Posts cut into 4 zones

POST #10

5" to 7" below groundline

4 ZONES POST #59

* Notice heartwood holes from wood boring bees

4 ZONES POST #10