

Willets Canoe Repair & Refurbish Notes

So, I was very fortunate to get a very good condition Willets. It needs some R & R, which is okay, that's a big part of the fun of older boats. Plus, she will be a gorgeous boat when I am done with her (heck, she is pretty right now) and will be joy to paddle. This will be a working boat not a wall queen, and will spend lots of time on the lakes of the BWCA and Quetico.

I was also very fortunate to meet Paul Miller (actually the boat came from his most awesome collection canoes needing some fixin' up) and I have to say thank you to him for sharing his time, knowledge and expertise about canoe repair and the proper treatment of a Willets. I spent a half a day or more with Paul taking notes on how to repair and refurbish this boat he had entrusted to me. This write-up is my effort to straighten out the many pages of fast scribbled notes. I thought, since this write-up is done, why not share Paul's knowledge with others? So here is just a bit of his incredible expertise.

But first, here is the boat (seats removed). Paul had previously striped and cleaned the boat. Then it lived in his garage rafters amongst other works in process until I came along. Lucky me...



1. **General preparation** (assuming you start with a boat with all varnish stripped off)

- 1.1. Don't use sandpaper on a Willets! Or at least, use it very sparingly. Sand paper can/will sand down the soft brass tack heads. No tack head means nothing is holding the plank to the rib which means leaks in the hull. And it makes for unsightly appearance. The below picture shows normal size tack heads and small-to-no tack heads that were sanded down during the previous fiberglass repair. You can also see white filler that will be removed.



- 1.2. Speaking of unsightly appearance, Willets used a tack that is not available today. Today's tacks have a head that is slightly and noticeably larger. To get a comparable tack head diameter, put the tack into a drill, turn on the drill, and place against a smooth file. The file action will turn down the tack head. Do this to all tacks before using. – Yes, this is time consuming and rather picky. But Paul Miller has high standards.



1.3. Any tacks with no heads must be replaced. This boat had a cheesy fiberglass repair and they did sand down some of the tack heads. To remove a tack:

1.3.1. If you are going to replace a rib, you don't have to be careful to not damage that rib. So, working from the rib side, use a flat blade of a screw driver and dig into the wood (remember the rib is only 5/32" thick soft wood) to find the clinched-over tack end. Pull up the tack end so it is straight. Clip off the narrow pointy end of the tack, leaving some of the meat of the tack. Using a small nail punch, gently push the tack out away from the plank. Then from the plank side pull the tack completely out of the plank. Don't push the nail punch into the rib or plank thereby enlarging the tack hole.



1.3.2. You can also remove a tack working from the plank side but you have to be careful to avoid damage to the rib. Damage can occur if you pull the tack out the rib side to forcefully and pull the clinched end of the tack thru the rib and plank. As shown, use small side cutters, and use a putty knife as backup to avoid denting the plank. Gently pulling the tack can help straighten the clinched end.



Also, gently pulling the tack with some rotation can have the clinched end follow into the tack hole versus pulling straight. But you have to 'feel' the tack as you gently pull to determine how the clinched end is bent so you can rotate the tack in the right direction as you pull the clinched end thru the tack hole.

Now, as I found out, it's real easy to bugger up the wood as you try and remove the tacks. So only do it when you have to. As you can see in this picture it got pretty ugly and I stopped removing tacks unless absolutely necessary.



Instead of removing old tacks that had no head (from over zealous sanding) I had to resort to simply adding new tacks next to the old tacks.

The closer I looked at the boat, the more no-head tacks I discovered.



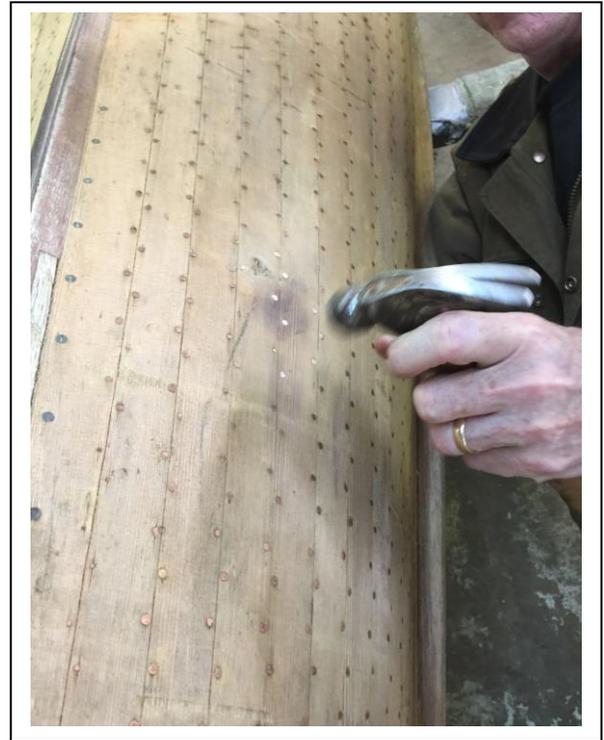
Here is where you can get them from. Or you can get them from Patrick Chapman.



1.4. All tacks should be re-clinched. Now, there are some (I have been told, I did not count them) 7,000 tacks on the Willets canoe so this is not a small effort. But for a rebuild to last another 30 years, take the time and re-clinch all tacks.

Hammer on the tack head, use a clinching iron on the rib side.

Then use boiling water on a rag to hot-water soak the wood around each tack to swell the wood and remove the hammer bloom.



1.5. Remove any fiberglass residue or epoxy residue. - Use a heat gun and a flat scraper. Gentle heat, warm up the epoxy and scrape off. Be careful not to heat burn the wood, I found out it's easy to do.

Here is some of the fiberglass residue left in my boat that must be removed.



1.6. Remove any previous fillers in cracks or dinks. - Use a heat gun and a scraper or dental pick. Gentle heat, warm up the filler and scrape off or out. Be careful not to heat burn the wood.

Here is some of the filler used by the previous owner. I will pick it all out



2. Fix the dinks and divots and punched spots.

These are repair spots small enough to not require replacement of the plank or rib.

2.1. Remove brass tacks in the area of the repair. Remove enough tacks so the damage area can be pushed back into original shape without being constrained by nearby tacks.

2.2. Carefully clean the repair area. Use tweezers and/or a dental pick to remove any loose wood chips that would interfere or prevent the wood from being pushed back into original shape.

2.3. Soak the repair area using a boiling hot wet rag. Re-heat the rag and reapply if necessary to get the wood wet and hot.

2.4. Remove the wet rags. Using a clinching steel on the damaged side, gently hammer on the opposite side to push the damage area back into original shape.

2.5. Sometimes you can use wood blocks and clamps on both sides to push the damage area back into the original shape.

2.6. If the damage is noticeable only on one side, you can use a boiling water hot wet rag and soak that side only. Place the clinching iron against the wet side, hammer gently on the dry side to push the wet side into original position.

2.7. Let the damage area dry out for several days. Review and consider if a second effort is required.

2.8. Once dry, replace the removed tacks. Be careful to place the tacks in their original positions. Additional tacks can be used but this is frowned upon as it interrupts the original tack pattern and draws attention to the repair area. Instead we will apply a clear epoxy (West Systems clear epoxy) to the repair area to bind the damage edges. Note, this is done after application of CPES, not beforehand. See below item #7 for CPES application.

Actually, I had no luck putting new tacks into the old holes. The wood was just too disturbed from removing the old tacks.

2.9. Use epoxy to bind the cracks and filling any divot that remains after the above steps:

2.9.1. After step 7, application of CPES, do this process to the repaired areas. West Systems clear epoxy is recommended.

2.9.2. Apply clear epoxy sparingly, too much will spread beyond the area. Use a heat gun to warm the epoxy. The warm epoxy will flow into the cracks and corners.



Another actually,,,,, I found the heat gun created bubbles in the epoxy that could not be removed so I stopped using the heat gun. And using heat did not seem to make the epoxy flow any better. So I just used several light coats of epoxy to gradually fill in the area.

2.9.3. Apply masking tape or metal-foil HVAC tape over the warm epoxy to smooth the top. – I did not do this, it seemed the epoxy kept sinking down into the wood. I did use metal foil tape on the bottom side to keep the epoxy from falling thru the cracks in the wood.

2.9.4. You may do this process twice or more to fill and not exceed the divot. – it's more like three or four or five times. And you need to have the fill area 'level' so the epoxy does not slump. I was continually rotating the canoe to a different position to have 'level' at the fill area. A canoe rotisserie would have been helpful.

2.10. If epoxy application does not bind the repair area adequately, then use additional tacks as needed. Note, for a new tack (one not in an existing tack hole) always pre-drill for the tack using a 'teensy weensy' drill bit, like 1/32" or so. Pre-drill the plank side; pre-drilling the rib side is not required but is not a problem if you drill thru both plank and rib (when using a 1/32" drill).

3. Replace the cracked and/or broken ribs.

Original Willets repair instructions were to do a partial replacement of just the damaged area of a wood part versus replacement of the whole wood part. In this instance, due to the particular kind of damage, I will replace two entire ribs and use a 'girdle' to bring the planks back in to original shape. The planks are barely out of shape but since I am fixing the ribs I will fix the planks as well. The adjacent ribs that show cracking will have CPES applied into the cracks to bind those crack edges (see step 7).



3.1. Remove one rib. Use the steps in 1.3 to remove all tacks holding the rib.

3.1.1. Double check that all tacks are removed before trying to remove the rib. Any remaining tacks will damage the plank.

3.1.2. Removing the rib will be complicated by the sticky cloth sandwiched between the plank and rib. The cloth used a 'marine glue' for adhesion and water sealing. You may rip and pull up the cloth as you (gently) remove the rib.

3.1.3. With the rib removed you can then shape the replacement rib. Use properly dried quarter sawn western red cedar 5/32" thick.

3.1.3.1. Cut the replacement rib about 2" longer one each end.

3.1.3.2. Use the old rib to size the replacement rib to the correct width. Or, if the old rib is wreaked from the removal, use the space between the ribs to size the new rib to correct width. Rough cut the rib to 1/8" over width. Then sand it down to exact fit.

The replacement rib may be flexible enough to bend in to place for the fit up process. If not you can soak the rib overnight and then bend it into place for the fit up process. Steaming the rib should not be required.

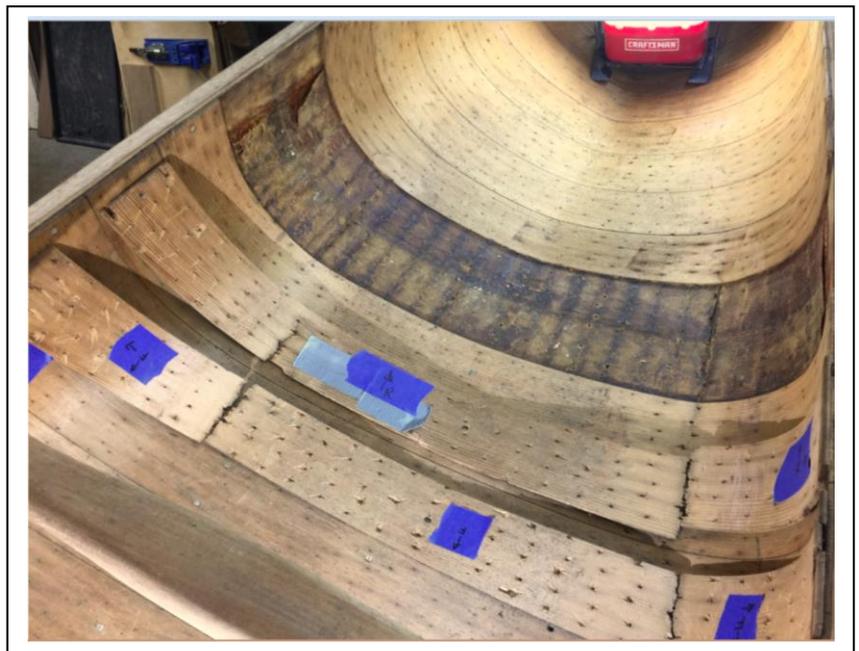
When you have the rib sized to fit clamp it at the gunwales to hold it in place.

Caution – the rib has different width in the middle and at the ends. And the resulting gap should be as tight as done by the Willets brothers. So go slow and careful. Measure three times, cut once.

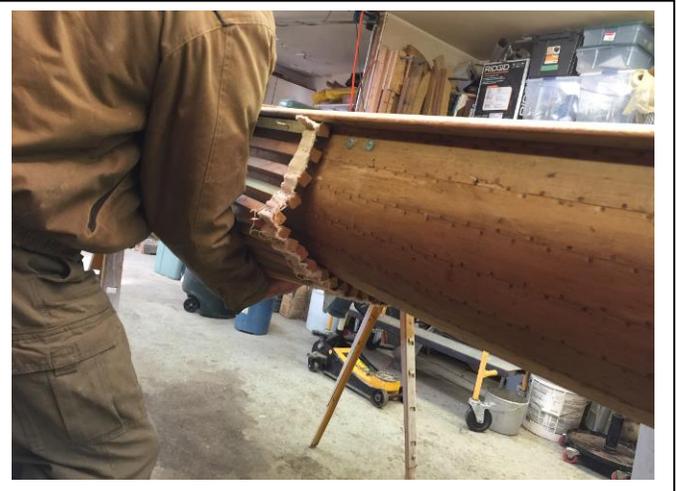
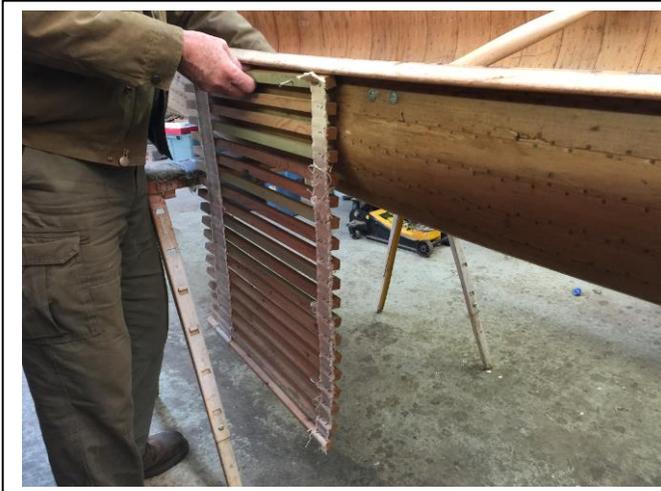
3.2. Remove the second rib using the above steps.

3.2.1. With the first replacement rib in place, fit and shape the second rib using the above steps.

So instead of removing one rib at a time per instructions, I remove the two ribs. I marked them and used as patterns for the new ribs.



The next step is to use the girdle to pull the planks back into shape at this repair area. Apply the girdle while the replacement ribs are in place and clamped to the gunwale. Two girdles are used, one on each side. Two ratchet straps are used to hold the girdles in place.



3.2.2. First remove the replacement ribs and soak again if needed.

3.2.3. Soak the planks using the boiling hot wet rag method. Having the boat upside down will help this step.

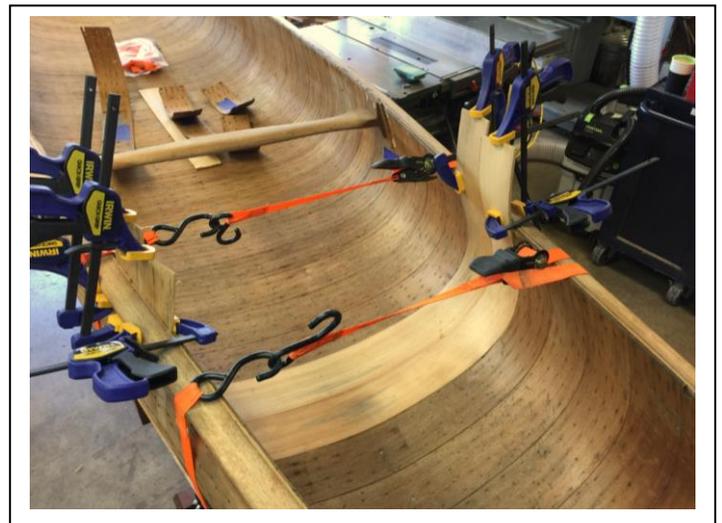
3.2.4. Reinstall the replacement ribs, clamp them to the gunwale.

Note, you do not use marine glue or anything similar applied to the fabric as the Willets brothers originally did.

Note, you do not have to replace any fabric that was torn or removed during the rib replacement process. Smooth out or trim any fabric ends to not create a lump between plank and rib.

3.2.5. Install the girdles, both sides, and tighten the ratchet straps. This should pull the planks into position. Loosen and re-clamp the replacement ribs if needed to allow the planks to settle and allow the ribs to fit properly. Gently tapping on the effected area of the planks may also help them settle back into original place.

Also, use the two screws on the girdle top-bar to hold the ratchet straps in place. The straps will want to slide toward the end of the boat as you tighten them.



3.2.6. With the girdles in place and the replacement ribs properly in place and clamped to the gunwale, allowed several days for the ribs to fully dry.

3.3. When the ribs are fully dry remove the girdle.

3.4. Tack and clinch the ribs. Carefully use the original tack holes in the planks to place the new tacks. (Remember to turn down the tack heads for the diameter to match the original tack heads.)

3.5. Remove the excess 2" of rib length above the gunwales.

This process was tougher than I thought it would be. The soaked ribs were still stiff and difficult to set into place and then to hold them in place against the planks. You can see the clamps I had to use. You can't hear the words of encouragement I had to use.

But it all worked out, the fit was good and close.

Actually, there was a fit problem. I cut the ribs for a very tight fit. Soaking them caused swelling so I had to trim some to fit. Because of the tapering hull the ribs tended to shift and push hard to the middle of the boat that created a gap closest to the front. And then the ribs dried and shrank and some slight gaps opened up. Except the one gap was noticeably large. – oh well. I see it. Nobody else has, yet (Paul will).



And, considering the damage area and what was needed to push it back into place, and replacing just two ribs, I thought I could get along with this instead of using Paul's girdle.

It worked okay.

Full disclosure: The planks did not look so good after the rib repair. I ended up adding tacks to the repair area. It doesn't look good. And Paul won't approve. But it's not the end of the world.



4. **Replace a small section of rib.**

I did not talk about this step with Paul Miller other than to ask about the replacement piece edge. Paul's thought was that you do not need to cut the edges at a 30 degree angle a simple straight 90 degree cut is okay.

Patrick Chapman's book 'The Willits Brothers and their Canoes' has a reprint of "Instructions for Repairing Planking" as written by the Willets brothers that is a good reference that I will use for this repair.



This is how it looked when repaired.
Close enough.



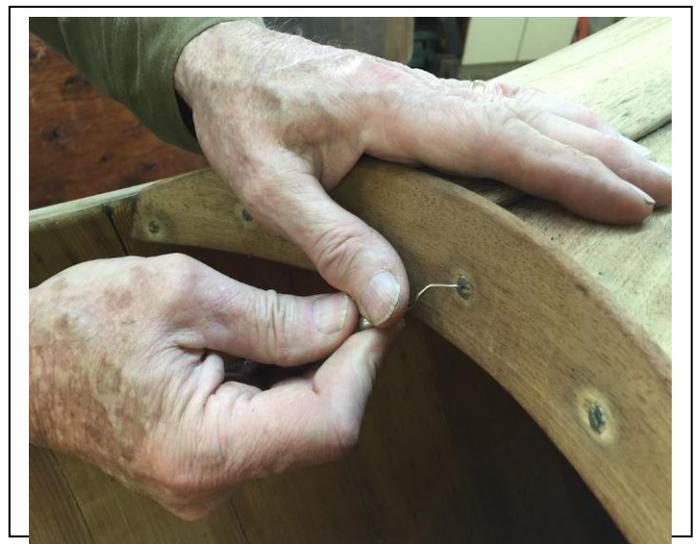
Replace brass hardware.

Over many years salt water can corrode brass screws and loosen their fit in wood threads. On this canoe I am replacing all brass hardware with new (do it right Paul said).

Silicon bronze screws were not available when this boat was built so I will use brass screws.

4.1. To remove a screw, first carefully scrape all debris and varnish from the screw drive slot. You need a good fit between screw and screw driver. Then tighten the screw a 1/8 turn before loosening the screw. First tightening seems to help the loosening process.

4.2. To help the new screw fit snugly into the old hole, place a part of a tooth pick into the hole. Glue or epoxy is not needed. Simply drop in a piece of a tooth pick, then screw in the new hardware.



4.3. Appearance, remember? Always align the screw slots (all horizontal or all vertical, but all in the same direction).

4.4. If you break off a screw head during removal you need to use a special wood screw easy-out to get the screw body out of the wood. It's easy, just use the right size in a drill and go slow and careful.



4.5. Replacement of the keel screws.

4.5.1. Remove the screws.

4.5.2. Remove the keel, or keels in this case. This boat has bilge keels.

4.5.3. Clean the keels. Re-attach.

4.5.4. Keel bedding compound is not required. For a Willets, the CPES and varnish seals the planks and keels.



So, when reattaching the keels I learned the lesson to 'exactly' match the existing screw lengths.... My close-enough wood screws were just a bit longer than original. Close enough I thought. After installing the first bilge keel I stepped back to admire my work. Ran my hand along the keel and ouch, a protruding screw tip.

5. The 1-2-3 clean and stain removal procedure.

Do these steps one after another. Do both the inside of the boat and the outside. Don't let the wood dry out in between steps. This should be a 30 or 60 minute process to do the 1-2-3 steps.

5.1. Lye mixture. This procedure is for dirt and stain removal. – Mix about three tablespoons of lye mixture (the 100% lye drain opener is an example), into hot, almost boiling water. Apply liberally to the wood (inside and outside of the canoe, thwarts, seats, etc.) using a synthetic paint brush (lye can destroy a bristle brush). You can even use a scrub brush to scrub the wood. Then rinse thoroughly with lots of



water.

5.2. Phosphoric acid. This procedure lightens the wood. – Using a 50/50 phosphoric acid pre-mix (the Behr cleaner & etcher is an example), dilute in hot, almost boiling water for a 50/50 mix that would yield a 25% dilution. Apply liberally to the wood (inside and outside of the canoe, thwarts, seats, etc.) using an old paint brush. Re-heat the water as needed to keep it very hot. Then rinse thoroughly with lots of water.

5.3. Oxalic acid. – Mix about two tablespoons of oxalic acid into hot, almost boiling water. Apply liberally to the wood (inside and outside of the canoe, thwarts, seats, etc.) using an old paint brush. Then rinse thoroughly with lots of water.

5.4. Info – the 50/50 phosphoric acid pre-mix can be used to acid clean brass hardware.

So this method worked okay. I still had some iron stains that would not come out. Maybe I should have done the process a few more times but I was getting antsy to finish the boat and get it in the water. And this boat is a user, not a garage queen. So I stopped here. As you will see in the finished pictures, it looks just fine.



6. Application of CPES, Clear Penetrating Epoxy Sealer.

This procedure will seal the wood against moisture and contrary to some opinions, provides strength and flexibility to the wood.
– Apply 2 or 3 coats of CPES.

- 6.1. Typically two quarts of CPES are required for one coat to the outside and inside of the canoe.
- 6.2. You do not have to sand or scuff the surface between applications of CPES.
- 6.3. Vacuum clean the canoe. Then use damp micro-fiber cloths to pick up any remaining dust on the canoe.

TIP: Use a different brush for application inside the bow and stern areas. These areas can accumulate dirt and dust that is hard to completely remove when cleaning. The brush will pick up this and transfer to other parts of the canoe as you paint. So use different brushes.

6.4. First coat.

- 6.4.1. Use tinted CPES for the first coat. Tint to preference to bring out the wood color. After many trials, the Paul Miller color formula is 3 drops Brown, 2 drops Orange, and 2 drops Red Brown, per 1 ½ oz of CPES. Scale up this formula for two quarts or more.



- 6.4.2. Apply to entire surface. Some areas will absorb the CPES quickly and become 'dull' versus 'shiny'. Re-apply CPES to the 'dull' areas until the entire surface is 'shiny'. Let dry overnight.

6.5. Second coat. – If the color is acceptable then the second coat can be clear non-tinted CPES. If additional color is wanted then use tinted CPES. The Miller and Mueller color formula can be used for the second coat. Like the first coat, apply to entire surface. Some areas may absorb the CPES and become 'dull' versus 'shiny'. Re-apply CPES to the 'dull' areas until the entire surface is 'shiny'. Let dry overnight.

6.6. Third coat. – Typically the color is acceptable by the second coat. The third coat can be clear, non-tinted, CPES. Like the second coat, apply to entire surface. Some areas may absorb the CPES and

become 'dull' versus 'shiny'. Re-apply CPES to the 'dull' areas until the entire surface is 'shiny'. Let dry overnight.

So, I ended up doing four coats. Not sure why, maybe the fumes were getting to me. But, four coats of this stuff, and then four coats of varnish. It looks great!

I did have some trouble with the above instructions. The tinted CPS soaks into the dry wood like water into a dry sponge. If you keep applying until the 'dull' area becomes 'shiny' you will over-apply the stuff. I started on the bottom and created a dark patch until I figured out that was a problem. So concentrate on even application, not dull versus shiny.

And, I think the tint formula is a bit too dark. I lightened it up. But that's just my opinion.



7. 'Float in' epoxy into repaired areas to adhere and help bind the crack lines.

This is a final step in fixing the divets or damaged areas.

- 7.1. Always, first apply the tinted CPES to color the wood. Then float in the epoxy. Use slow-dry clear epoxy. I used the West clear two-part dispensers.
- 7.2. Apply the epoxy to the damage area and use a heat gun to warm the epoxy and adjacent wood. Similar to how warm solder wicks into a pipe joint when sweating a copper pipe fitting, when the epoxy and wood reach a warm temperature the epoxy will 'wick' into the edges of the wood cracks. Again, I had no luck with using the heat gun and did not use it.
- 7.3. Use just enough epoxy, not too much. Apply masking tape or HVAC metal foil tape over the warm epoxy to hold it in place and to create a smooth surface. The tape will not stick to the epoxy. After curing, if necessary, additional epoxy can be applied to 'build up' the surface to level.

Again, again, I did not use the tape except to back up the bottom side to prevent epoxy from sinking thru the hull to the opposite side. I did keep rotating the canoe so the repair area was level and thus the epoxy would settle level in the divot area.

Go slow, this process takes many days. Every night after work I did this for, heck, a while...

Mix small amounts of epoxy in a disposable cup.

8. Varnish

Proper application of varnish is something I am not good at. Paul Miller, however, is extremely good at it. And since he will, eventually, see this boat, I am more than a bit concerned about this step. Below are Paul's notes. But I think I'll have to do a bunch of alternate reading before I get to varnishing this boat.

8.1. When using CPES for undercoats, only 3 or 4 coats of varnish will be required.

8.2. Use scotch bright pads to scratch the varnish surface before re-applying. Don't use sandpaper.

8.3. To clean the surface before varnishing, use a damp micro-fiber cloth. This is better than using cheesecloth as cheesecloth can leave behind a tacky residue.

8.4. Use a good quality thin profile badger-bristle varnish brush.

8.5. Total Boat marine spar varnish seems to work pretty good. Apply the first three coats using 'Lust'. Apply the top coat using 'Gleam', either gloss or satin.

8.6. Epifanes varnish is also another choice.



9. DONE. Get the boat in the water!

A picture of two of the finished project



And how is it that a boat designed in 1910 is the equal of, if not better than, a modern Bell/Northstar and perfect for the BWCA?



My thanks again to Paul Miller.