Study of the Shape of the Historic Skowl Arm Haida Canoe

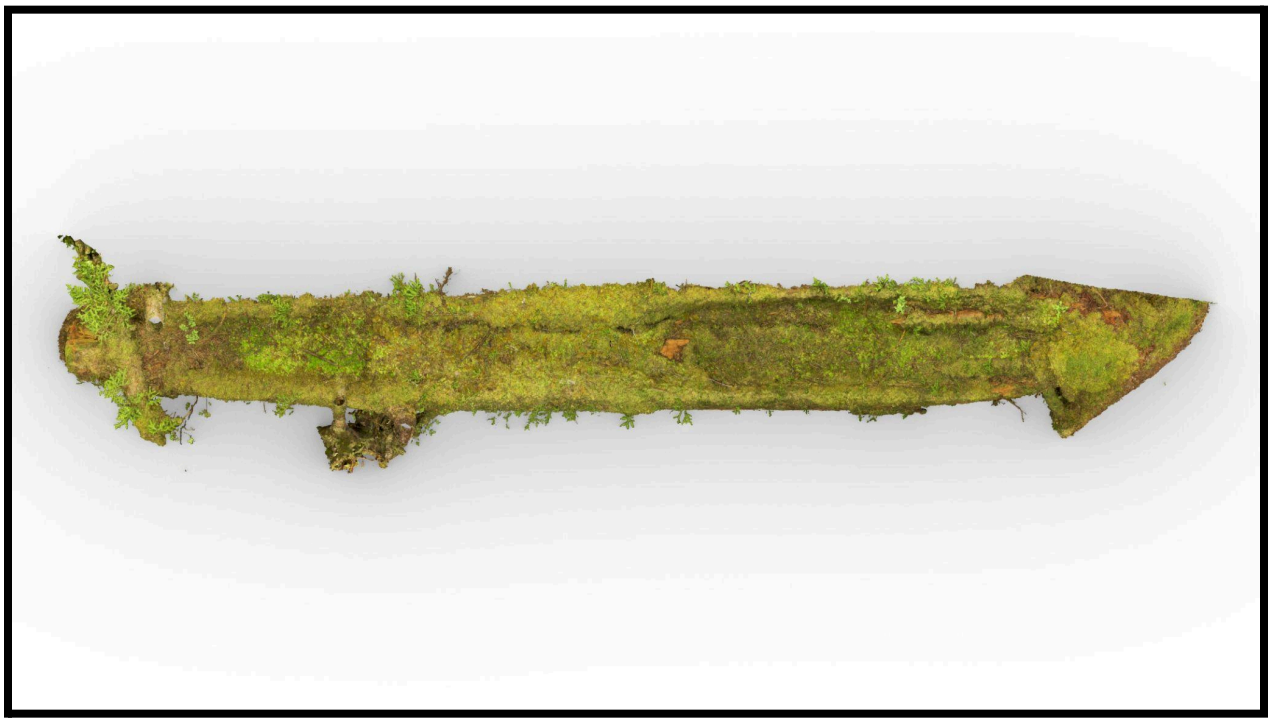
By V. Jason Rucker and the Haida Canoe Revitalization Group, 2025.

The objective of this report is to explain the modeling and drawing of this canoe clearly enough for others to understand, and to allow them to judge where alternative assumptions or interpretations could be made.

1. PART 1, INTRODUCTION TO THE CANOE
    a. The canoe is approximately 10.23 meters (33’ 7”) long and 1.15 meters (3’ 9-¼”) wide. That width is likely larger than when the canoe was originally carved due to the split in the canoe as described below. The length is approximate due to the deteriorated state of the ends of the canoe. The canoe’s stern is presumed to lie toward the stump from which it was cut as is customary for canoes of this size.

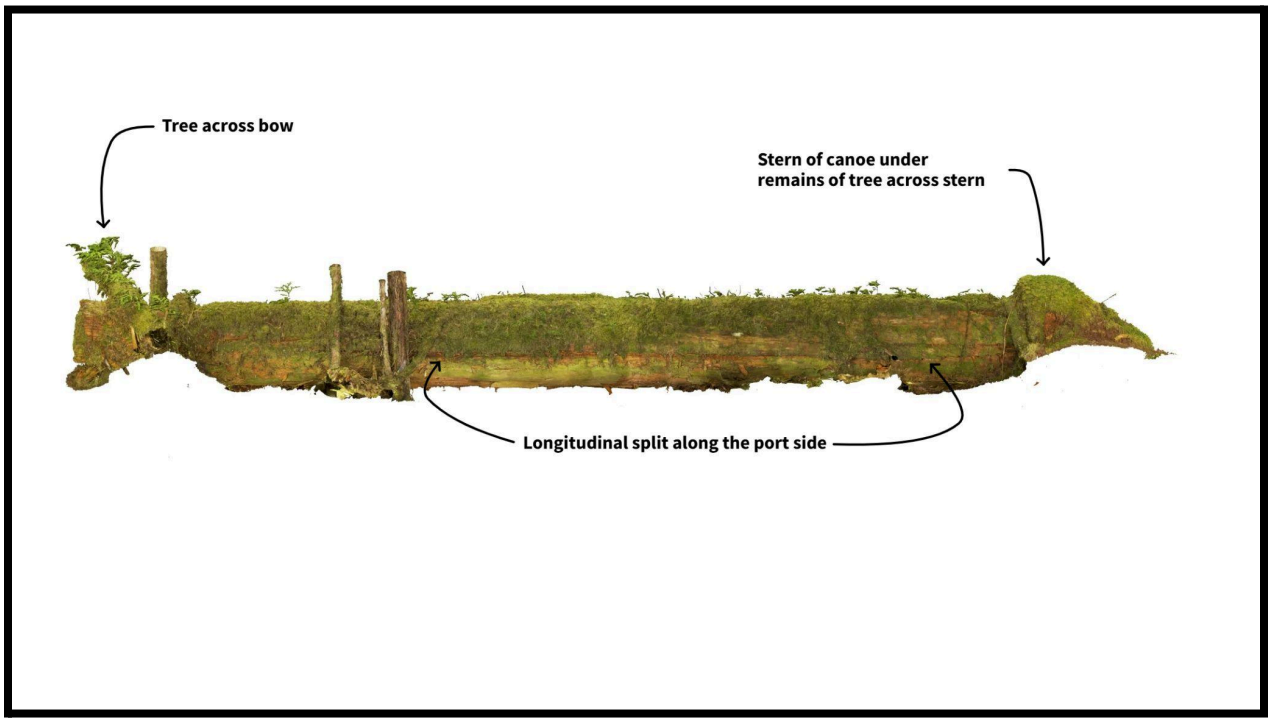
[Figure 1. Perspective view of canoe model. Stern is closer to viewer at the lower right.]

[Figure 2. Port side, profile view.]

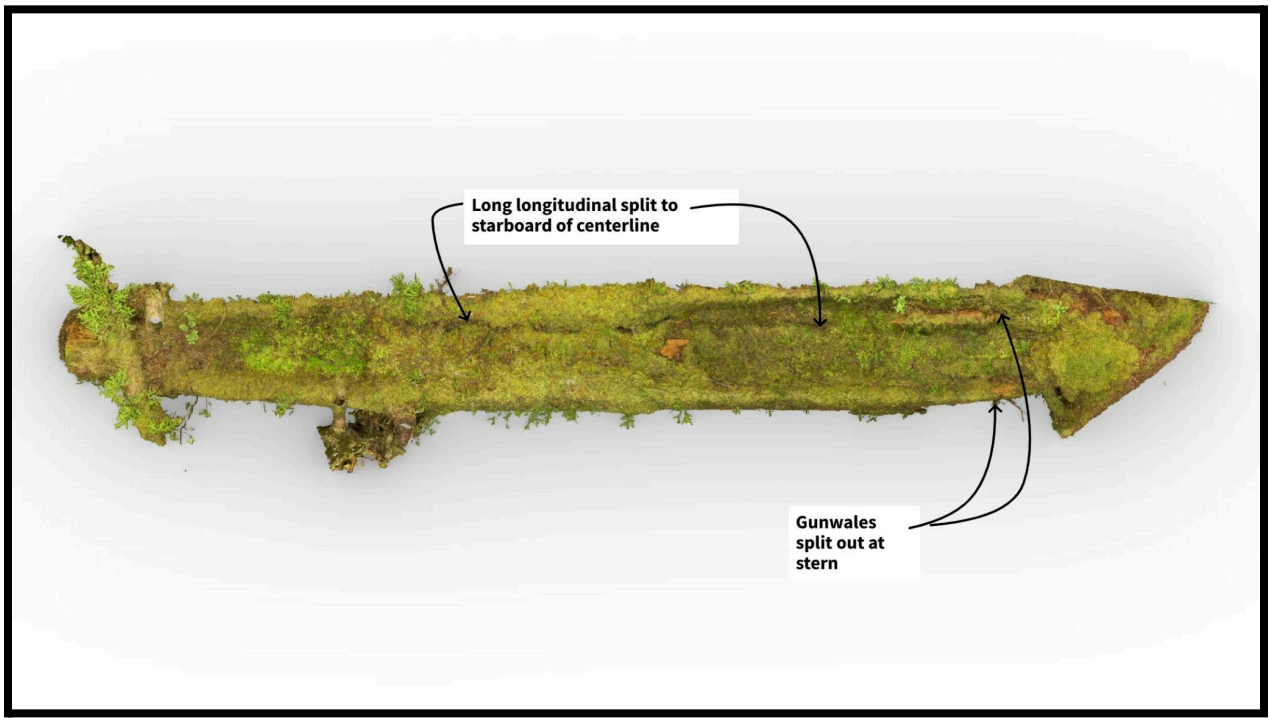


[Figure 3. Top or plan view.]

b. Damage and deterioration



[Figure 4. Port side, profile view, showing damage.]



[Figure 5. Plan view, stern on the right side, showing damage.]

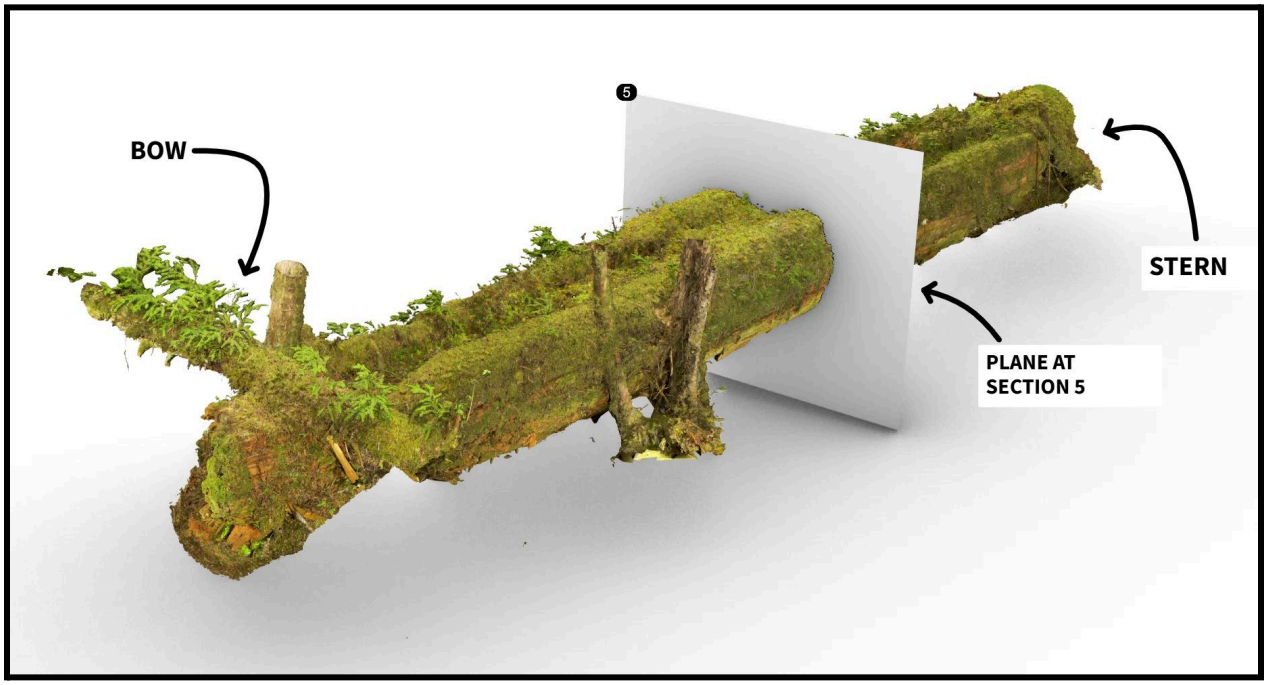
i. Both ends of the canoe are broken and rotten. A small tree has fallen across the bow, accelerating its deterioration. It appears as if a larger tree has fallen across the stern, likewise accelerating its deterioration. The tree across the stern is badly deteriorated itself, moss covered and broken down, almost unrecognizable, suggesting it fell longer ago than the one at the bow which is intact.
ii. The stern has collapsed aft of the tree that fell across it. In photos taken in 2011 a bit of the stern is still up off the ground. In 2024, the stern, aft of the fallen tree is on the ground covered in moss and difficult to recognize.
iii. The bow is still intact and off the ground, but the tree across it and a tree growing against the starboard side has accelerated its deterioration.
iv. On both sides, aft, the upper edge (or gunwale) looks as if it has split and sprung out away from the center. The split-out gunwales are visible in plan view just forward of the tree that fell across the stern.
    1. On the port side this split only affects the upper edge of the side of the canoe.
    2. On the starboard side the split is more significant. The split on the starboard side appears to continue vertically through the canoe. Much of the starboard side leans out away from the center of the canoe.
v. There is a longitudinal split that runs along the port side.
vi. The sheer at the ends has deteriorated enough to be unreliable.
vii. In the middle of the canoe, from section 3.5 at the forward end to section 8 aft, the port side is in far better condition than the rest of the canoe.

2. PART 2, How the 3D computer model was made:
    a. On May 14 and 15, 2024, Stephanie Hamar and Jason Rucker took 647 photos of the canoe with a Canon EOS 5D Mark III, and an EF24mm f/2.8 lens with an Alien Bees B1600 flash. Those photos were processed in Agisoft Metashape Professional by Mark Mudge of Cultural Heritage Imaging to produce the 3D model. In areas where photographs were impossible (e.g., beneath the canoe or where it touched the ground), the model shows no surface. Apparent holes in the model represent these unphotographable areas.

3. PART 3, Introduction to sections taken from model, how the sections were interpreted and an examination of section 5.
    a. Sections: Sections were created by drawing planes through the model perpendicular to its length. The intersection of one of those planes with the canoe creates a line representing the shape of the canoe at that plane.
    b. Sections are numbered with their distance in meters from the bow. Section 5 is 5 meters aft of the bow for instance.
    c. The same process was used at each section to study the shape of the canoe.

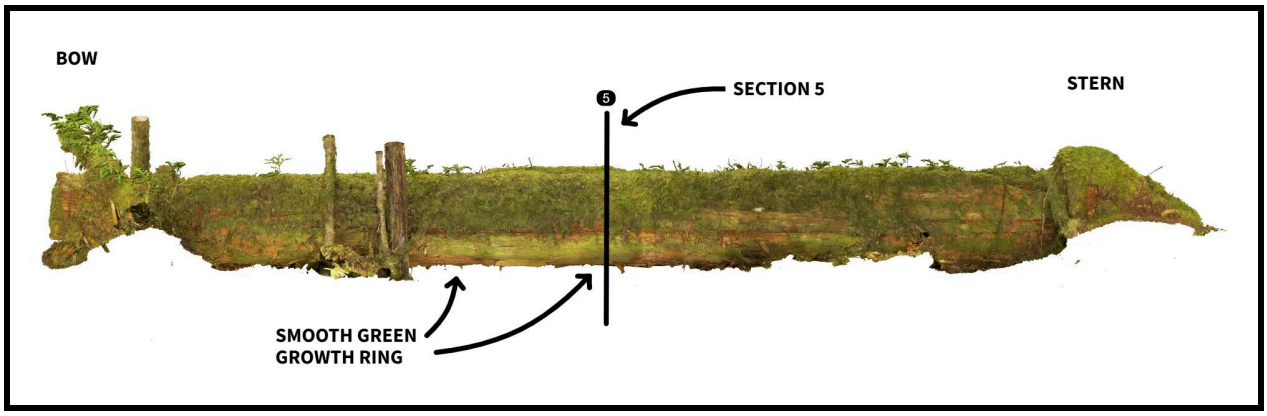
i. At each section there is a line representing the shape of the canoe including moss, roots, branches and other materials. We'll refer to this untouched representation of the canoe as the "As Found Section".
ii. From this As Found Section, lines were drawn to represent the canoe, under the moss and other distractions. This is called the "Cleaned Section".
iii. Examining the As Found Section and the Cleaned Section allowed us to see the variety of damage to the canoe, to guess at the causes and see the effects. With some understanding of the damage, we worked from the Cleaned Section to attempt to reconstruct an "As Carved Section", with the effects of splitting, rotting and other damage removed.
iv. Throughout this process, additional reference was made to the model, to neighboring sections, and to the photogrammetry photos of the canoe.

d. A close study of **Section 5**: Section 5 is approximately the midship section. We'll start by looking at Section 5 because it provides key information for understanding the shape of the canoe, how the canoe relates to the tree it was carved from and how we made our As Carved sections.



[Figure 6. View of port side of canoe, bow closer to viewer in lower left, showing plane at Section 5.]

i. When looking at the canoe or the model, the lower part of the port side is seen to be smooth and pale green. This pale green appears to be a single growth ring of the tree.

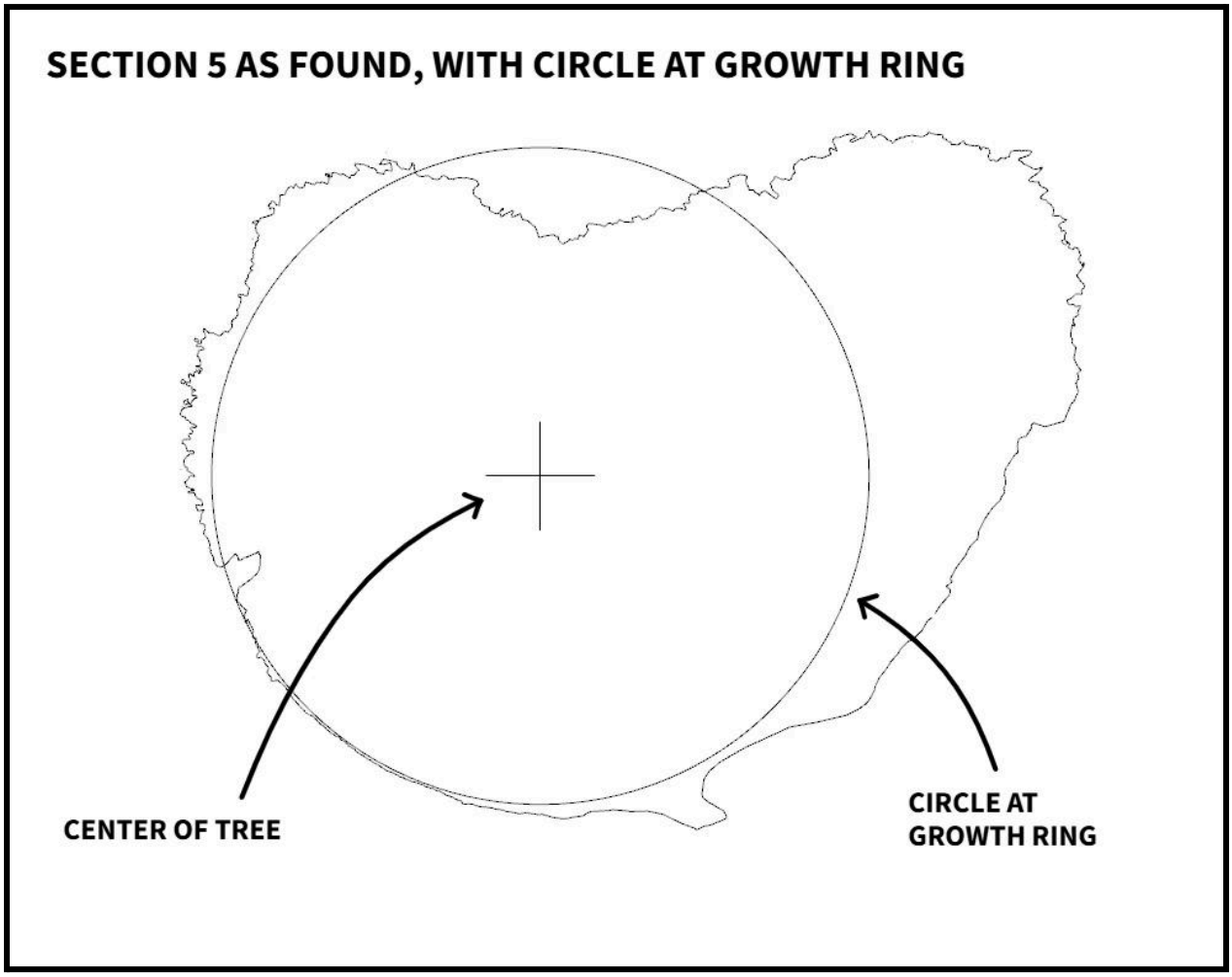


[Figure 7. Port side, profile view, showing Section 5 and smooth growth ring.]

ii. This smooth green growth ring shows up as a smooth arc on the lower port side in section 5 As Found

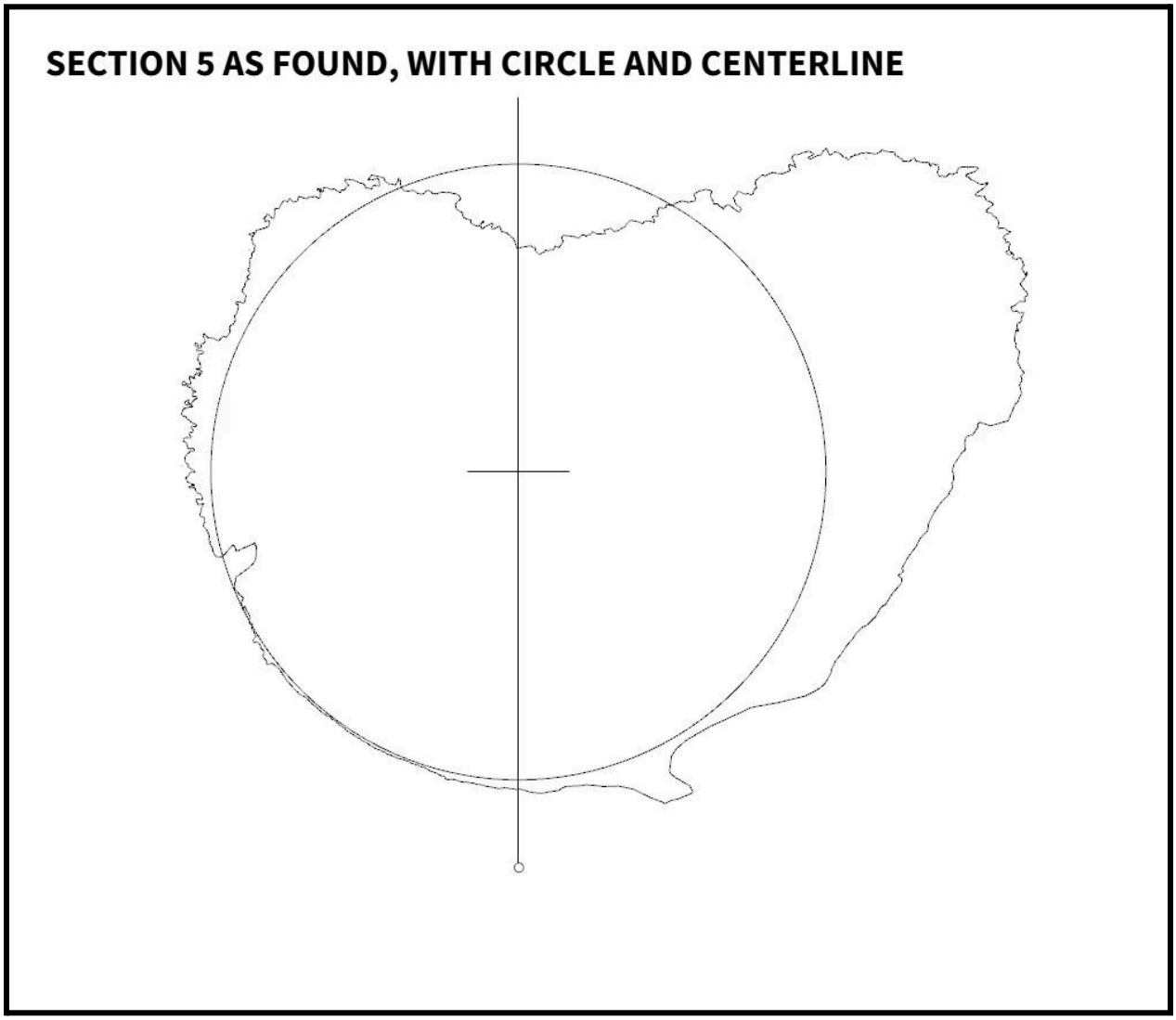
Figure 8. Section 5 As Found.]

iii. Extending the smooth arc of the growth ring in Section 5 produces a circle representing the entire growth ring of the tree. This circle then allows us to approximate the center of the tree at the center point of that circle.



[Figure 9. Section 5 As Found with circle at growth ring and center of tree.]

iv. If we take that center to be on the centerline of the canoe, then we can draw in that centerline and use it in the production of sectional drawings as described below.



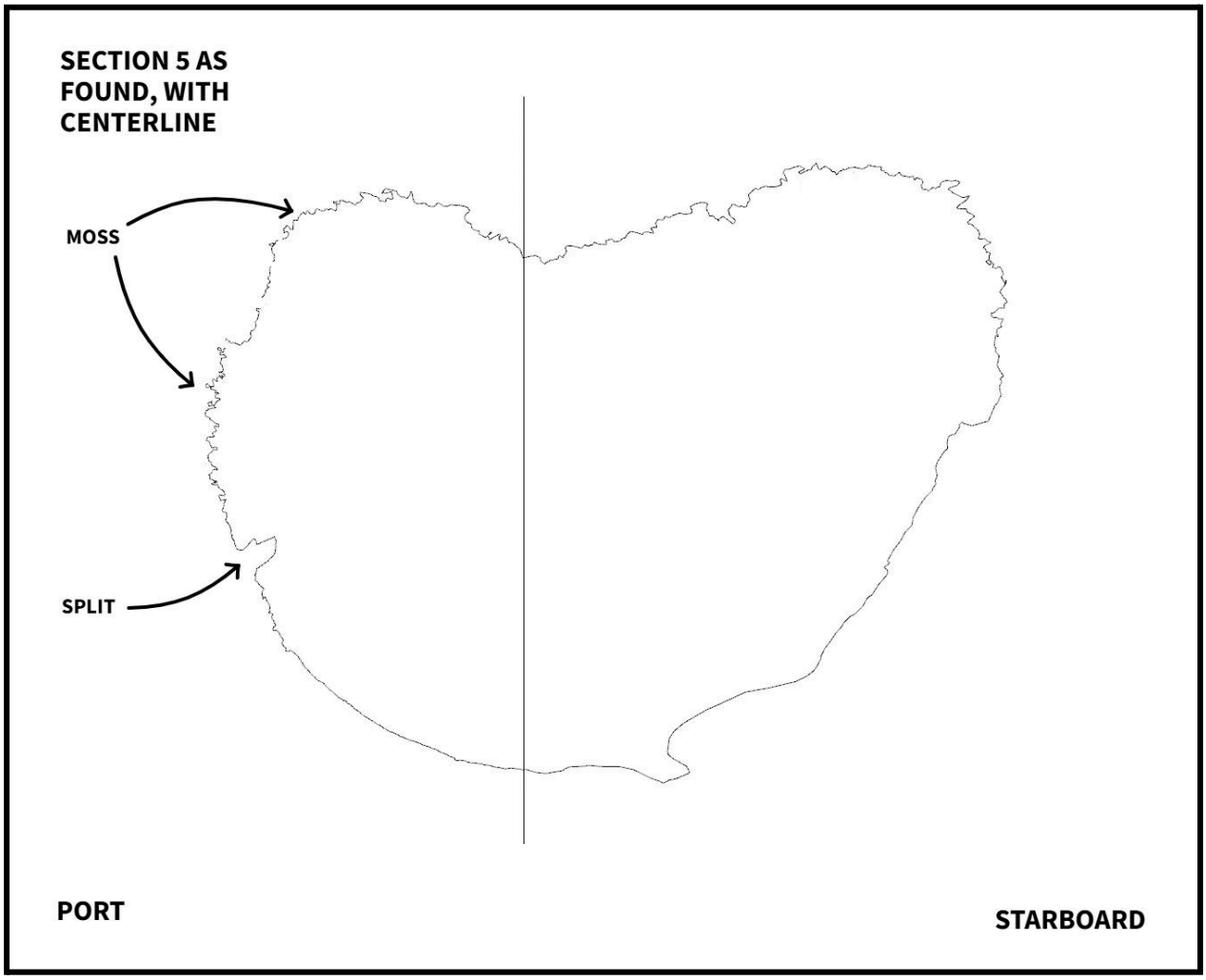
[Figure 10. Section 5 As Found with circle, center of tree and centerline.]

v. When we find the center of the tree at other sections in the same way we did for section 5, we're able to draw the center of the tree through the length of the canoe.

vi. Since we know the diameter of the butt cut at the stern end of the canoe and the diameter of the treetop at the bow end of the canoe, we're able to draw in a tapered cylinder superimposed over the canoe representing the tree that this canoe came from.

[Figure 11. Tapered cylinder representing the tree the canoe was carved from.]

vii. Study of the lines at station 5

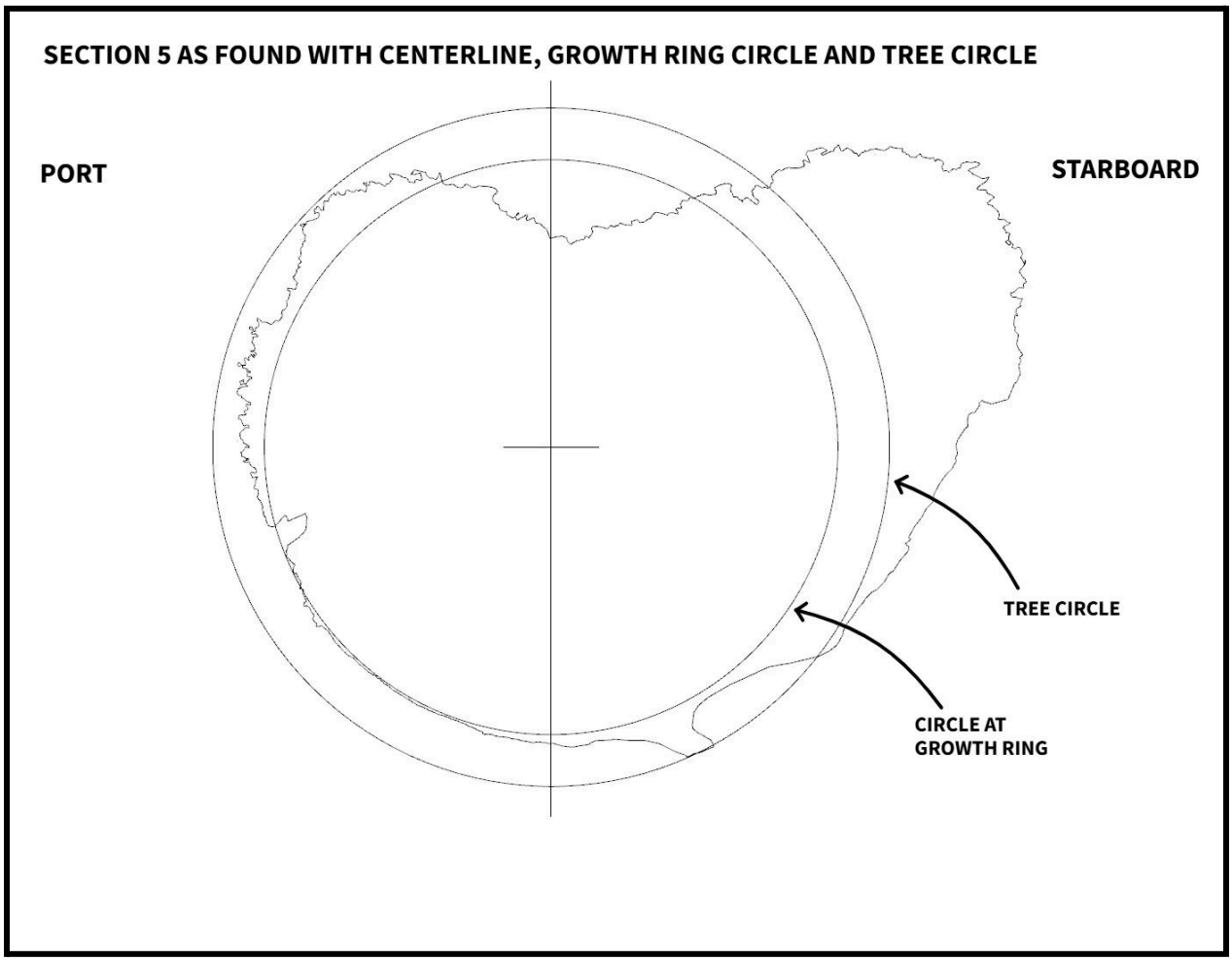


[Figure 12. Section 5 As Found with centerline.]

1. Looking at the As Found section, we see that Section 5 is in good condition relative to other sections in the canoe. It is in the middle portion of the canoe which is in better condition than the ends.
2. As described in Part 1b:
    a. the port side is in good condition. The starboard side is tilted out away from the centerline and is less useful to this study.
    b. On the port side about half way up from the bottom there is a split in the side of the canoe. Above this split, the canoe

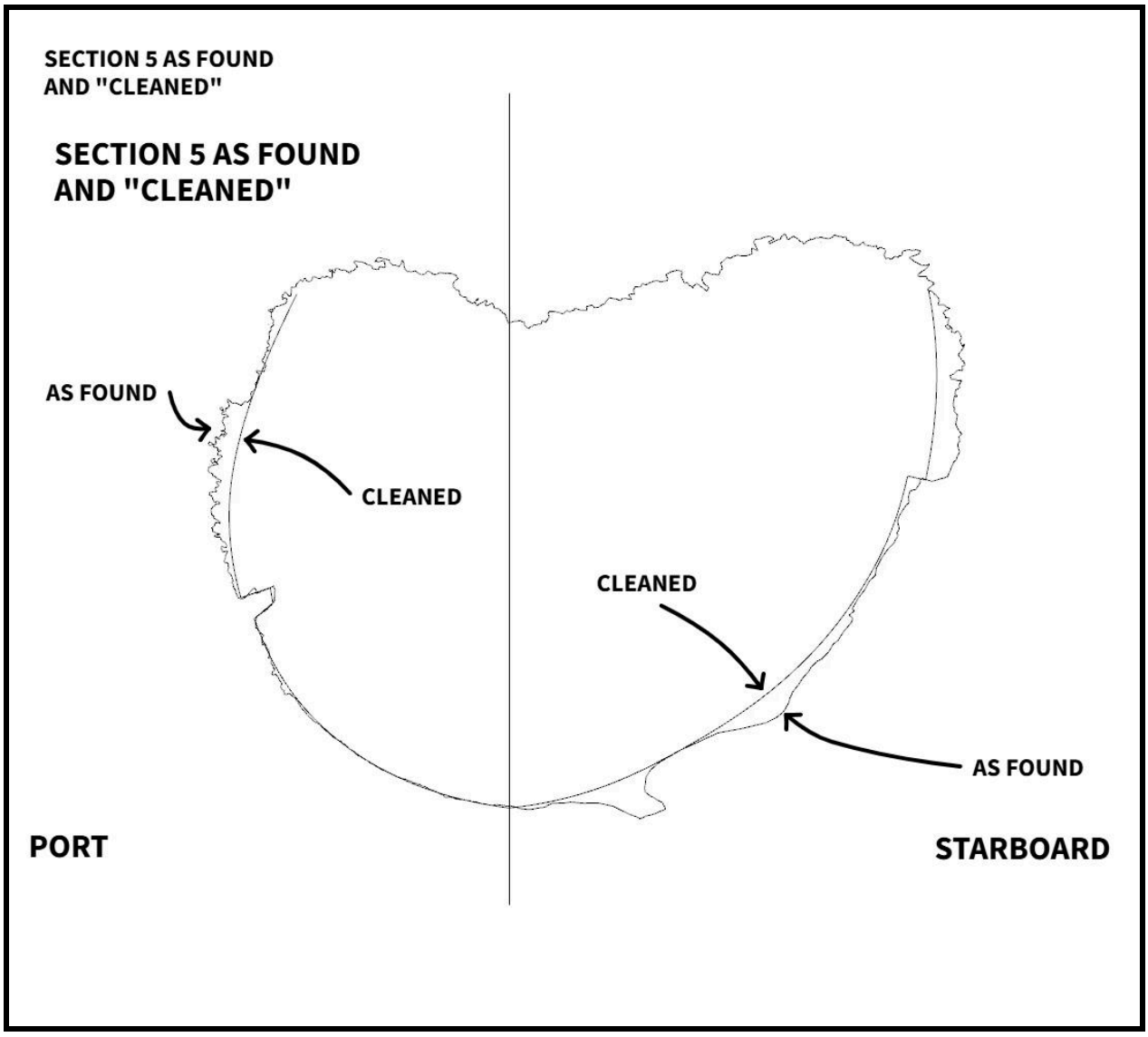
has sprung slightly out away from the rest of the canoe. This split springs out more towards the stern as can be seen in other sections.

c. Above the split, thick moss covers the side and the top edge.
d. Below the split the smooth growth ring can be seen as described in Part 3,d,i and ii.
e. On the starboard side the canoe has fallen out away from the centerline. From the tapered cylinder that we created to represent the tree that the canoe was carved from, we can approximate the size of the tree at this section. When we draw in the circle representing the tree at this section, we see that the starboard side falls outside that circle. This shows the amount to which the starboard side has moved.



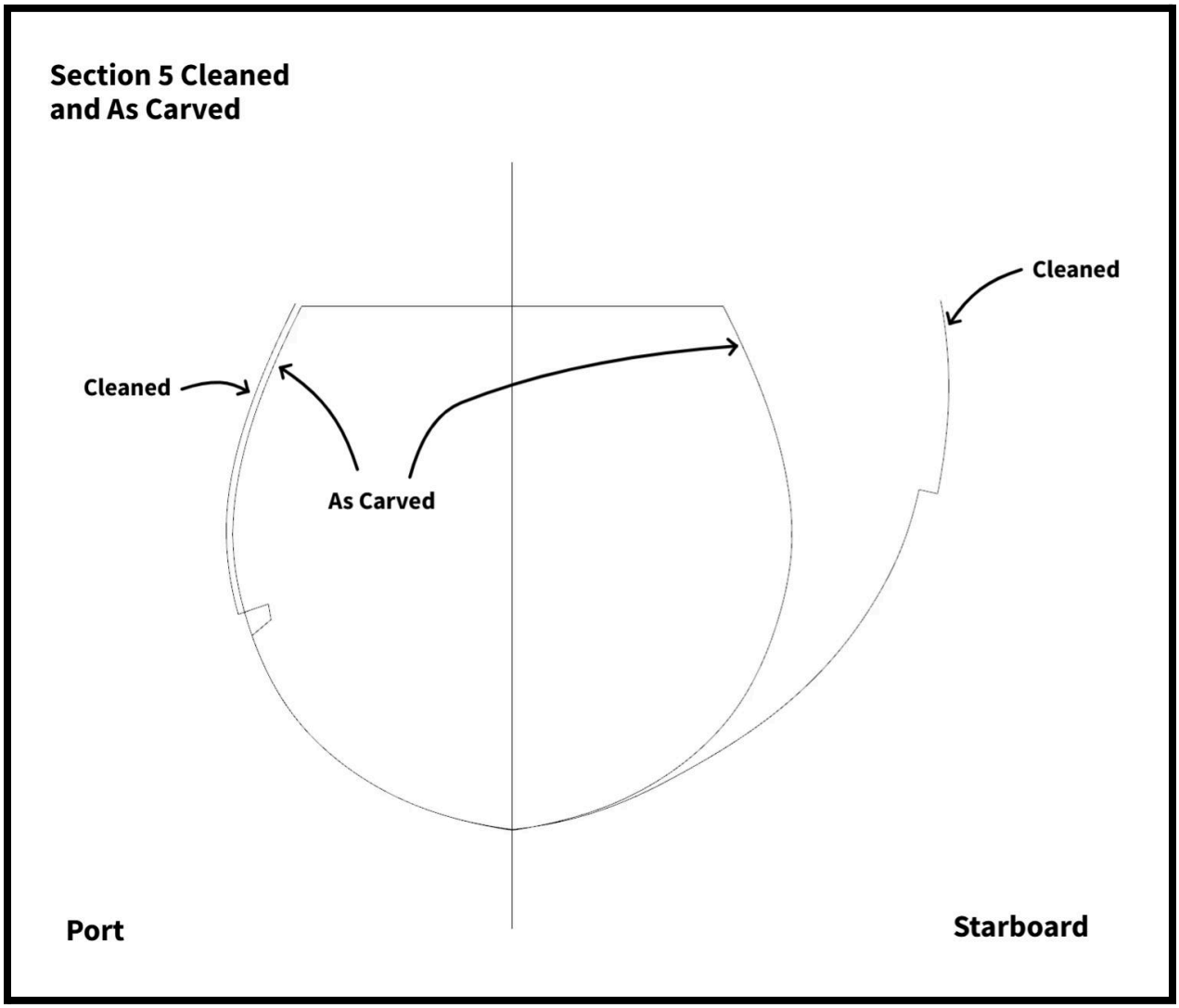
[Figure 13. Section 5 As Found with centerline, growth ring circle and tree circle.]

3. Referring again to this tapered cylinder representing the tree, we can estimate the size of the tree at Section 5. The “TREE CIRCLE” in this image represents the size of the tree at Section 5. The diameter of the tree at Section 5 is 1 meter. The diameter of the canoe is .84 meters. The difference in diameter is .16 meters. So, it appears that .08 meters or 3 ⅛” has been removed from each side of the canoe.
4. In the cleaned section we’ve drawn an estimation of the canoe’s shape now. We’ve drawn in the clean arc of the growth ring low on the port side. Above the split on the port side, we’ve drawn in an approximation of the curve under the moss. This upper portion is sprung out slightly from the centerline. On the starboard side we’ve also drawn lines approximating the shape of the canoe under the moss.



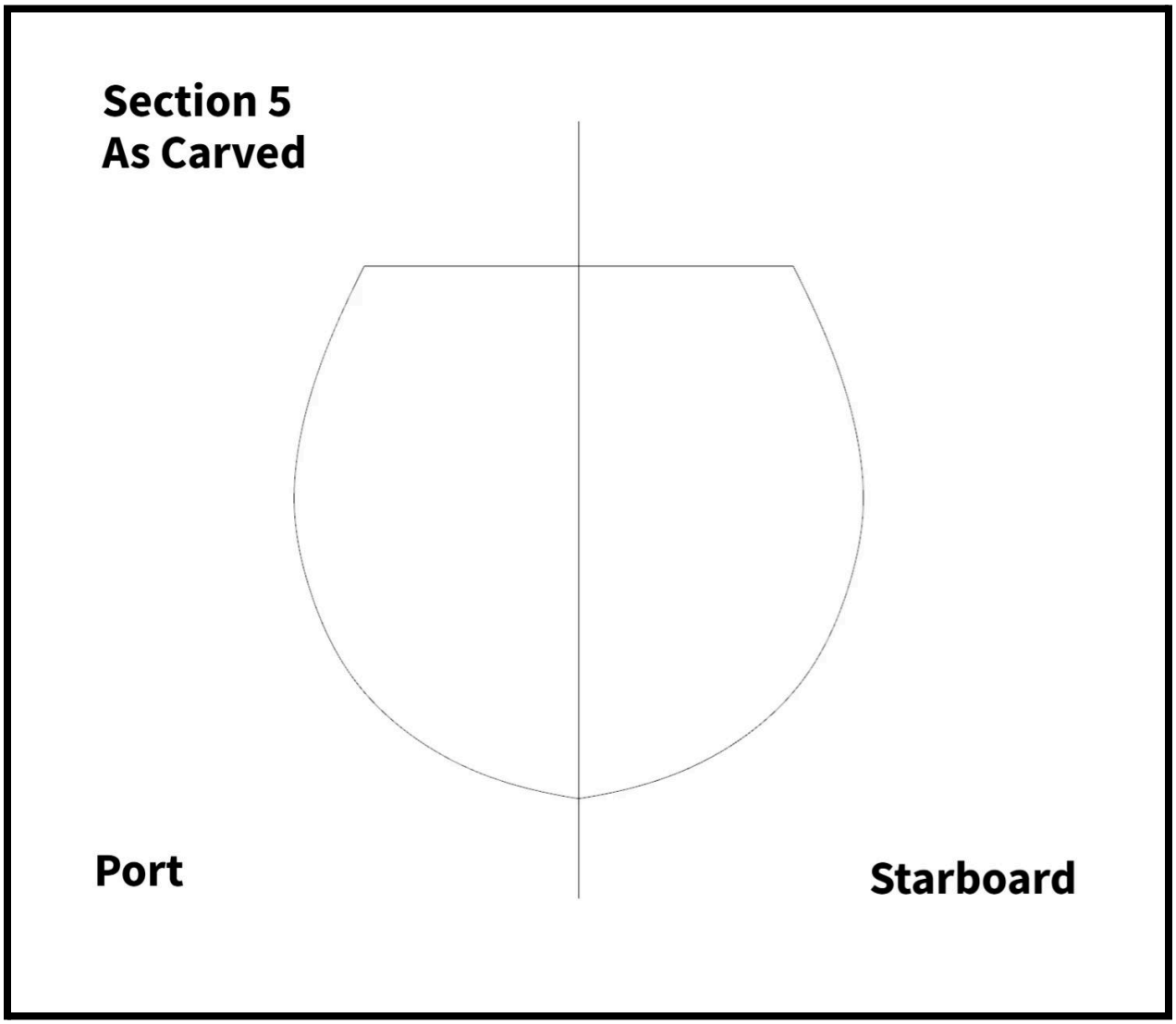
[Figure 14. Section 5 As Found and Cleaned.]

5. In the As Carved Section we've worked from the Cleaned Section. We've moved the upper part of the port side (which is split and sprung out) in to line up with the lower part of the curve. This approximates the original carved shape. Since the starboard side of the canoe has split out away from the canoe, we haven't used it. Instead, we've made a symmetrical curve on the opposite side of the centerline to represent the starboard side of the canoe.



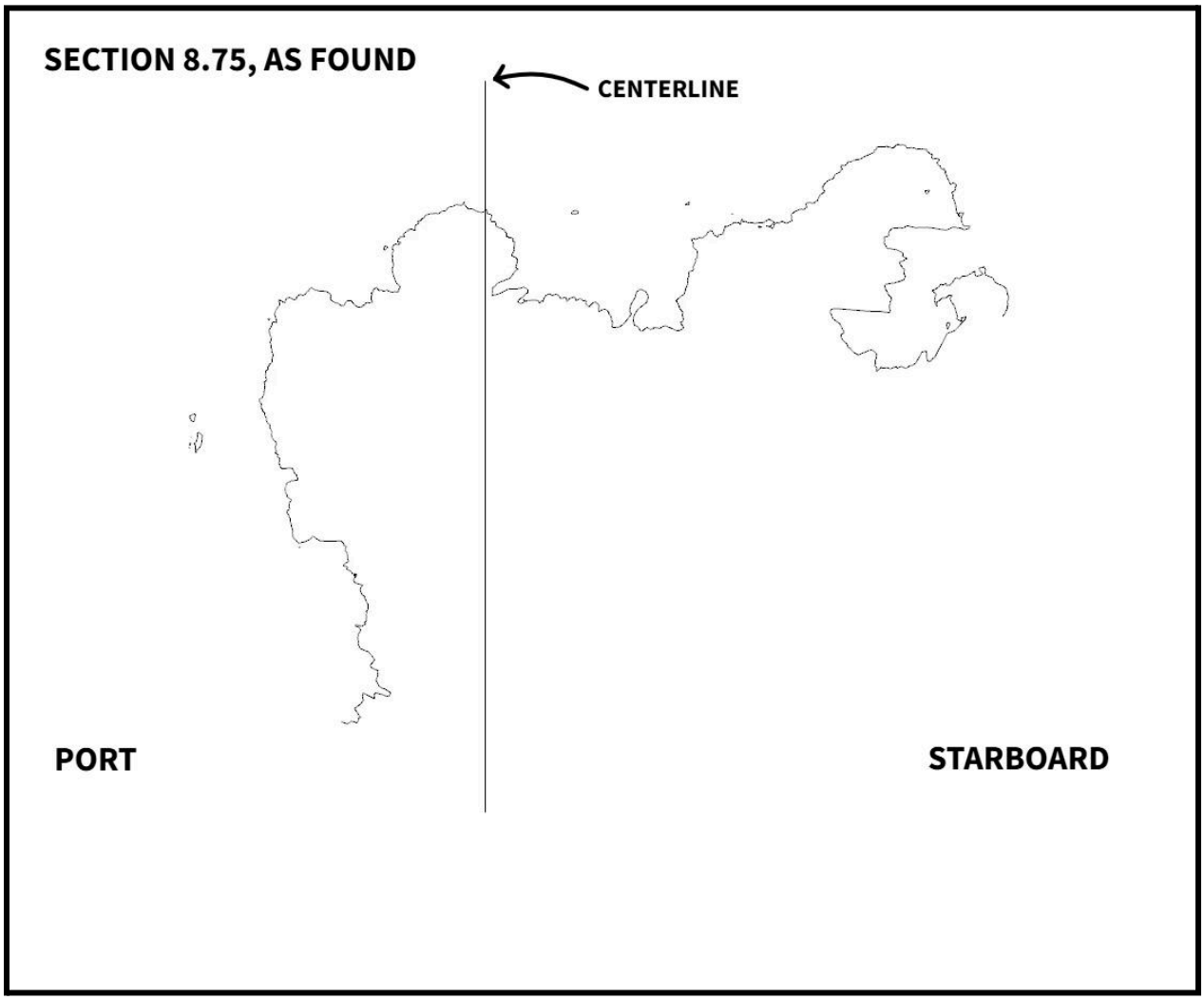
[Figure 15. Section 5, Cleaned and As Carved.]

6. In subsequent sections, similar techniques of referencing the centerline and fairing for moss and deterioration are used to study the As Found Section, create the Cleaned Section and finally the As Carved Section.



[Figure 16. Section 5 As Carved.]

4. PART 4, Explanation of the study of the rest of the sections (Starting from the stern)
    a. The rest of the sections were studied and drawn using similar methods to the work on Section 5.
    b. **<u>Section 8.75</u>**
        i. As Found Section

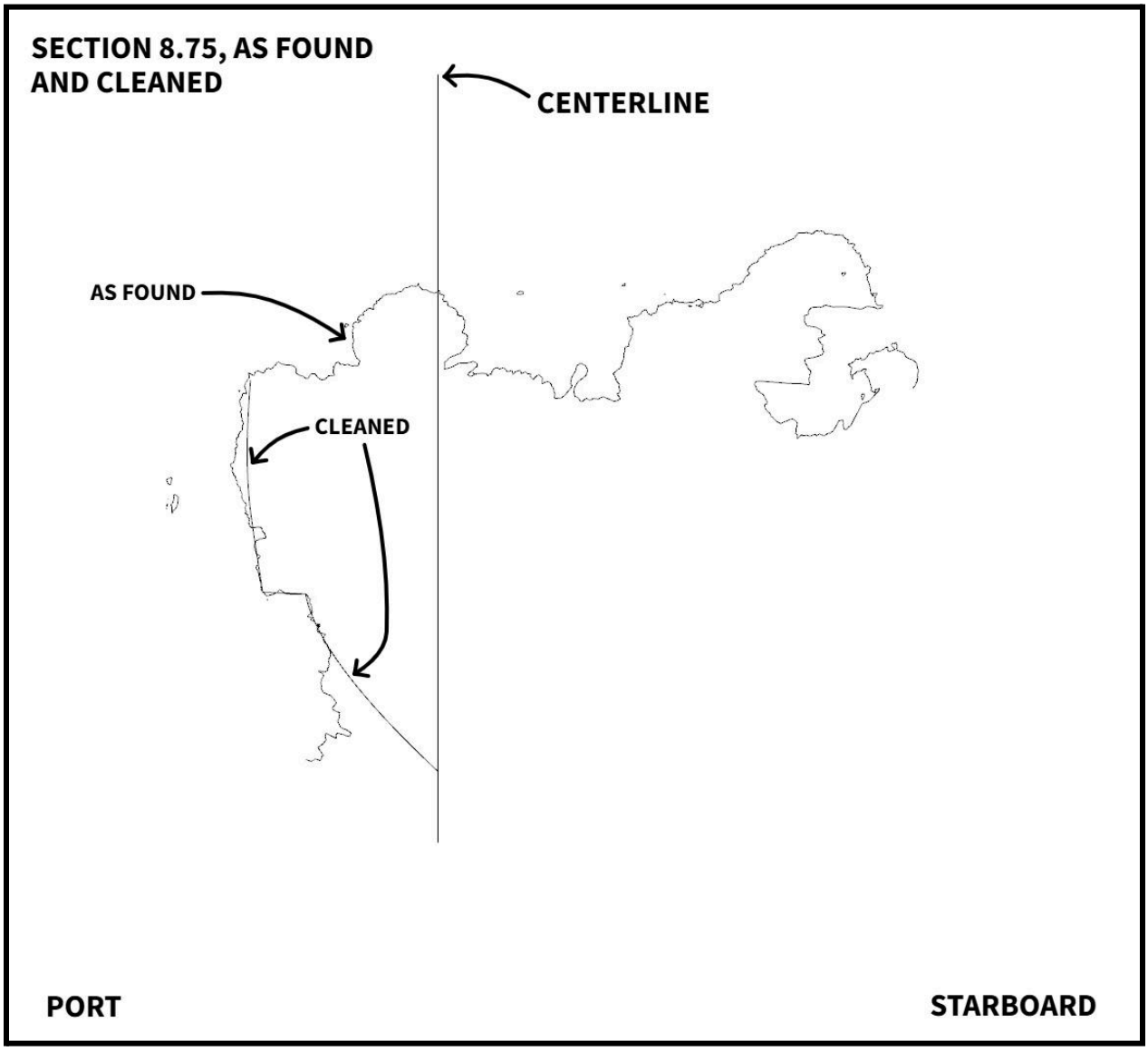


[Figure 17. Section 8.75, As Found.]

1. In the As Found section we can see evidence of some of the deterioration, defects and damage to the canoe.

a. On the port side there is evidence of the large split in the side of the canoe. The upper part of the port side has sprung out away from the lower part. The knob shape just port of centerline is a fore-and-aft ridge, a remnant of the gunwale from which the side has split away. (This is more apparent in the sections just forward of 8.75 and in the plan view of the model.)
b. On the starboard side the canoe is badly decayed and not much is discernible.

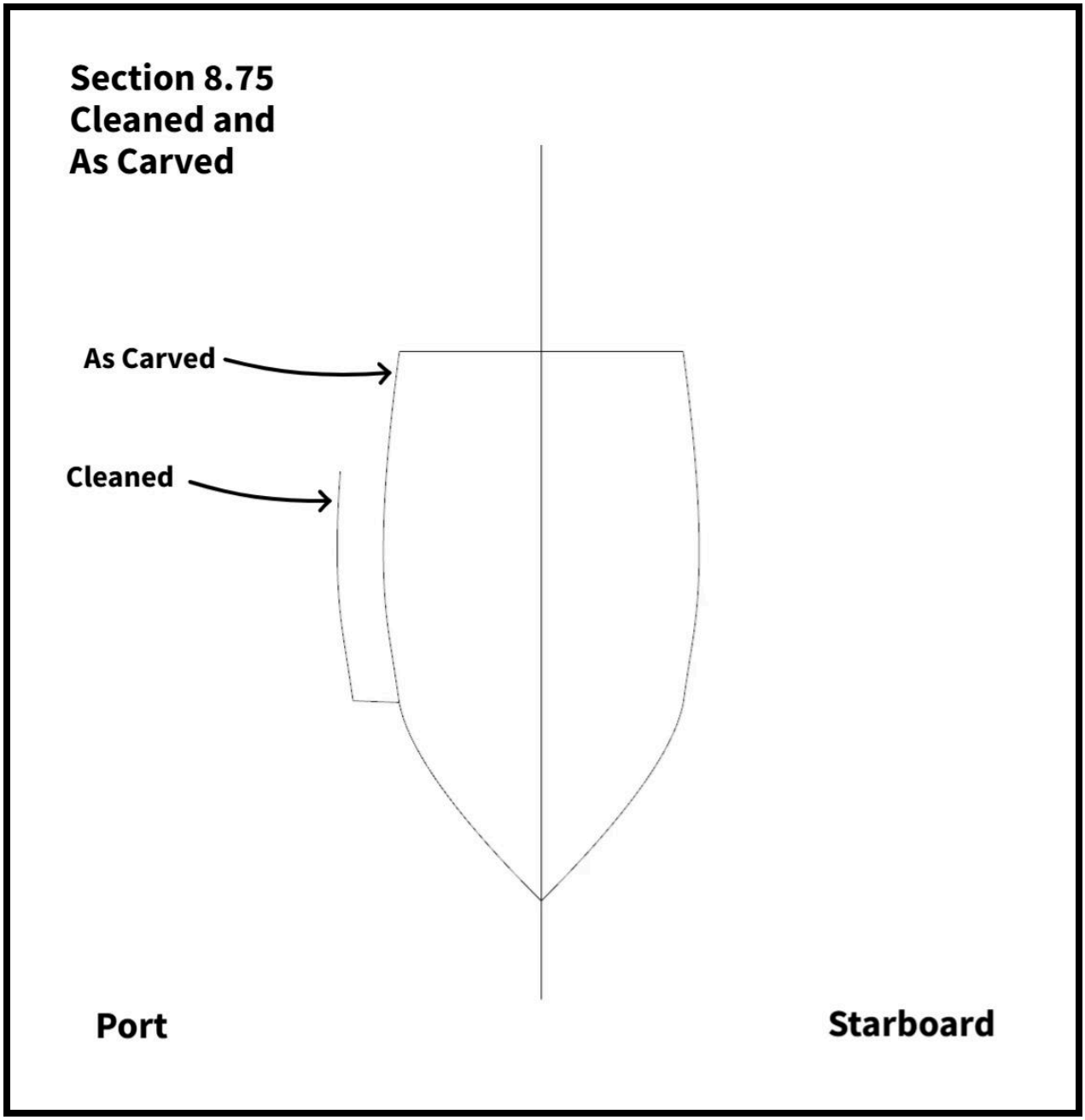
ii. Cleaned Section



[Figure 18. Section 8.75, As Found and Cleaned.]

1. In the cleaned section we've drawn an estimation of the canoe's shape now. We've used the known center of the tree to draw in the centerline of the canoe. On the port side we've drawn the upper part of the section to remove the lumps of moss and deterioration. The lower part (below the split out upper portion) follows the shape of the As Found section then arcs in to the centerline. This lower arc is an estimation necessitated by the obstruction of the earth around the bottom of the canoe. The estimation is based on an assumption that the shape would curve into that centerline, and on the shape of the section just forward (8.5) that is visible lower and that does in fact curve in to the centerline.

iii. As Carved Section

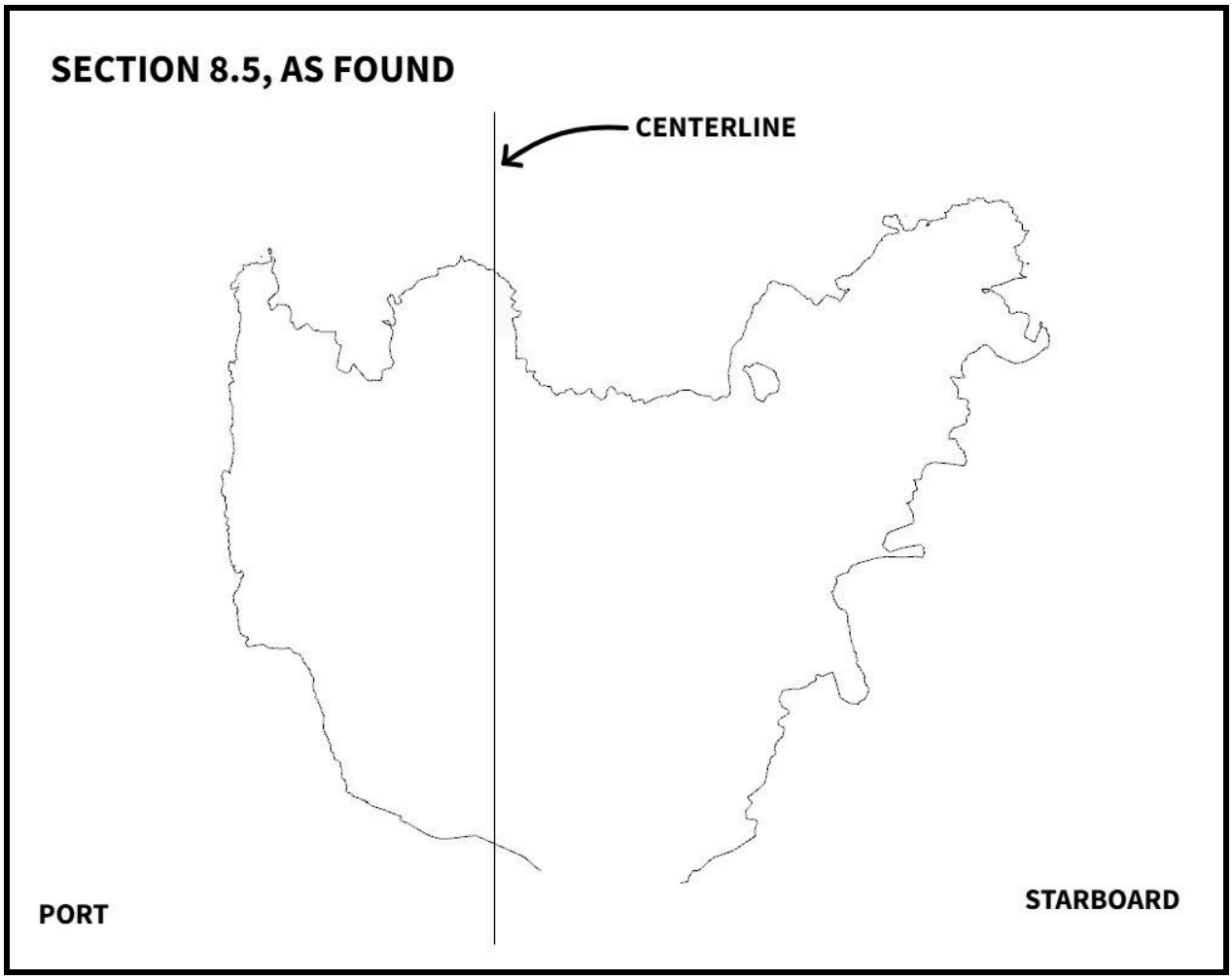


[Figure 19. Section 8.75, Cleaned and As Carved.]

1. In the As Carved Section, on the port side we've moved the split-out curve inboard to line up with the lower curve to approximate where it would have been. This curve now matches up pretty well with the "knob" of the gunwale that the outer portion split away from. We've assumed that that knob represents the upper portion of the gunwale, and that the outer portion has deteriorated to a lower level, so we've extended the curve to that

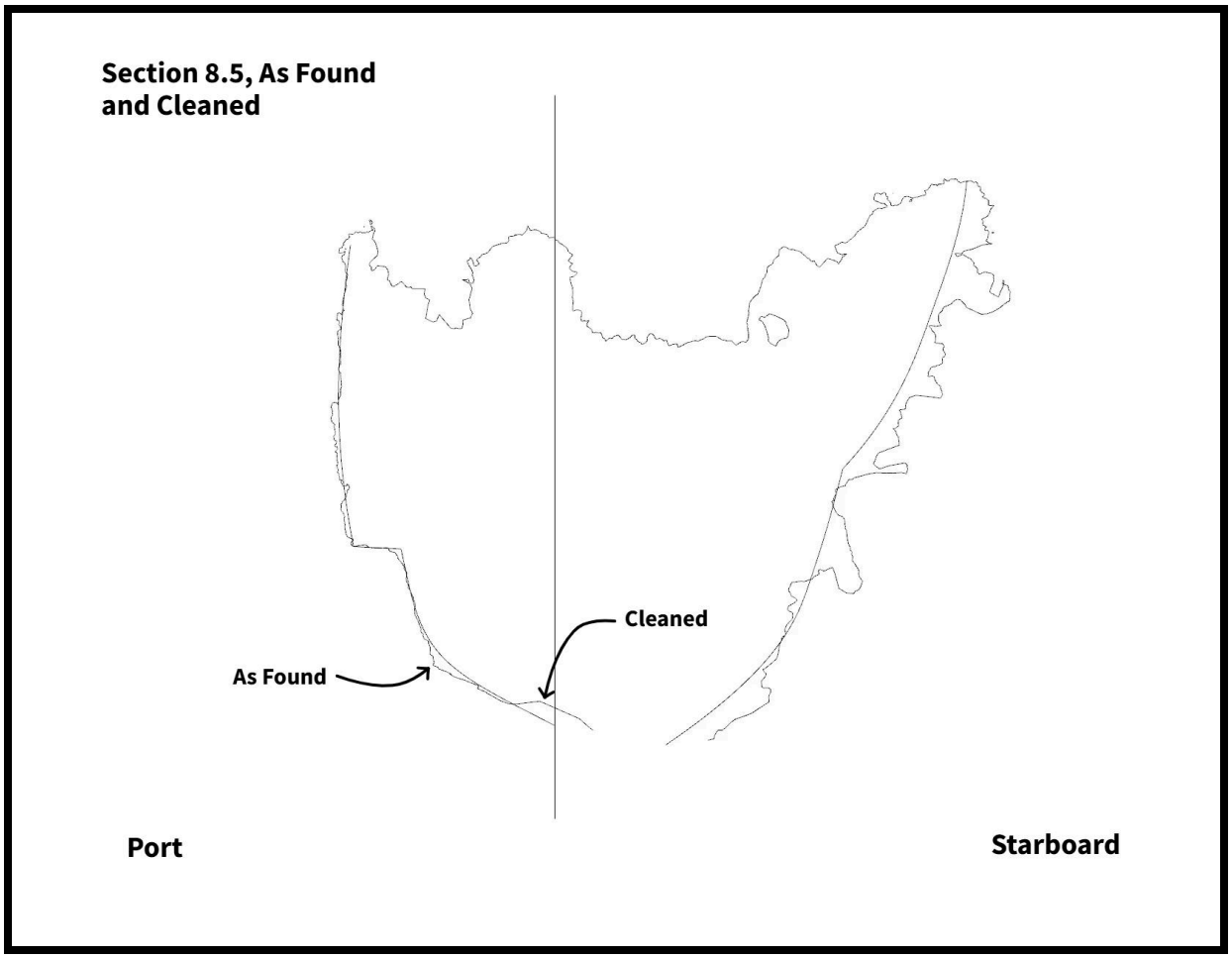
knob's height. Originally the gunwale was probably even higher, as deterioration of that upper edge is visible in profile. After creating this cleaned up line, we mirrored that line on the centerline to create a line for the starboard side. There is not much left on the starboard side to work with at this section. It is split out away from the center and has been subsumed by earth and branches and debris and the bulging base of a tree growing alongside the canoe.

c. **Section 8.5**
    i. As Found Section



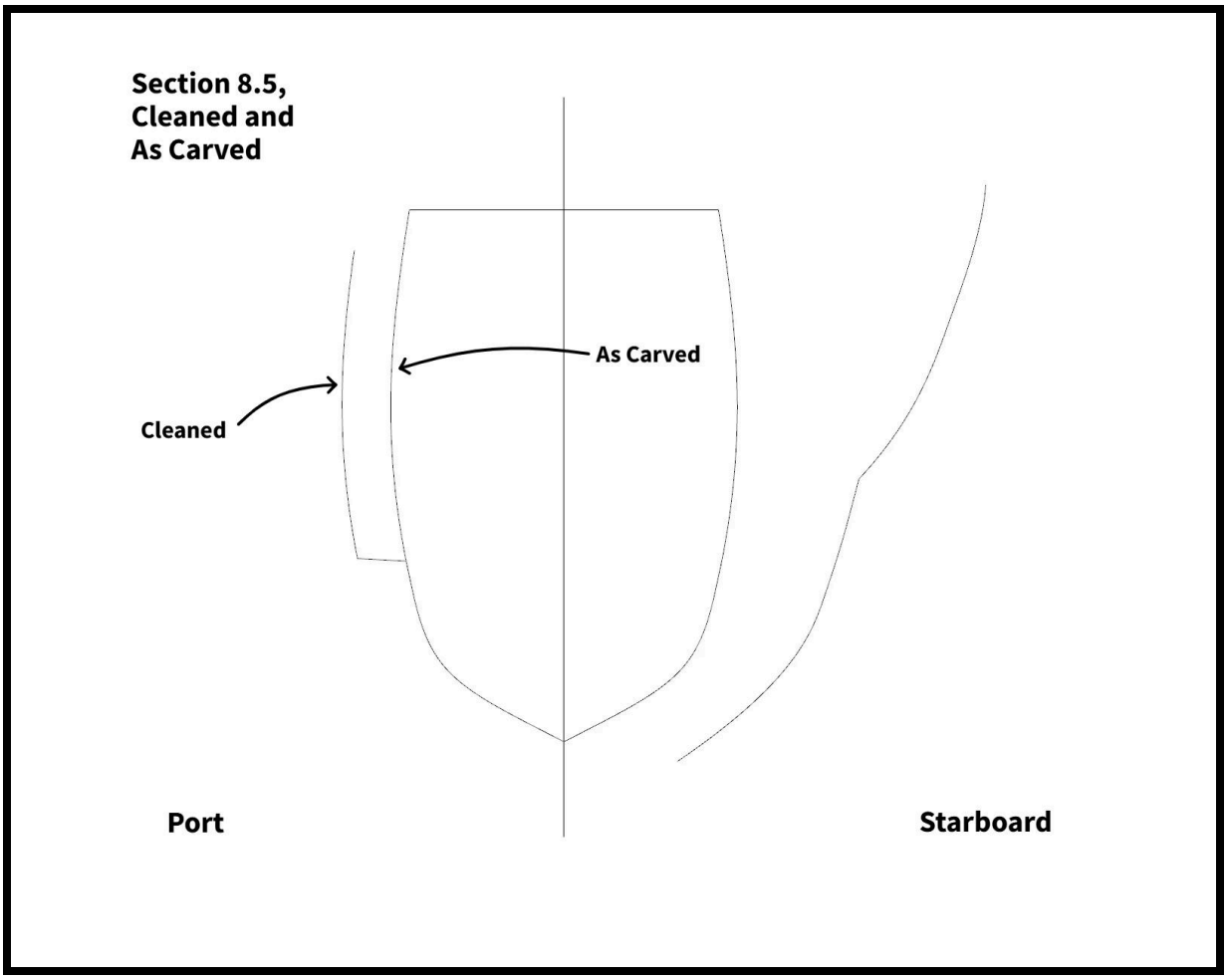
[Figure 20. Section 8.5, As Found.]

1. Section 8.5 shows further evidence of the deterioration of the stern of the canoe. The port side outboard edge is higher than in section 8.75 and is more obviously split away from the knob. The starboard side isn't as buried in debris, and so it shows the way that the arc of the side of the canoe curves in to the centerline. This section also shows the way that the starboard side has split away from the center of the tree and canoe.



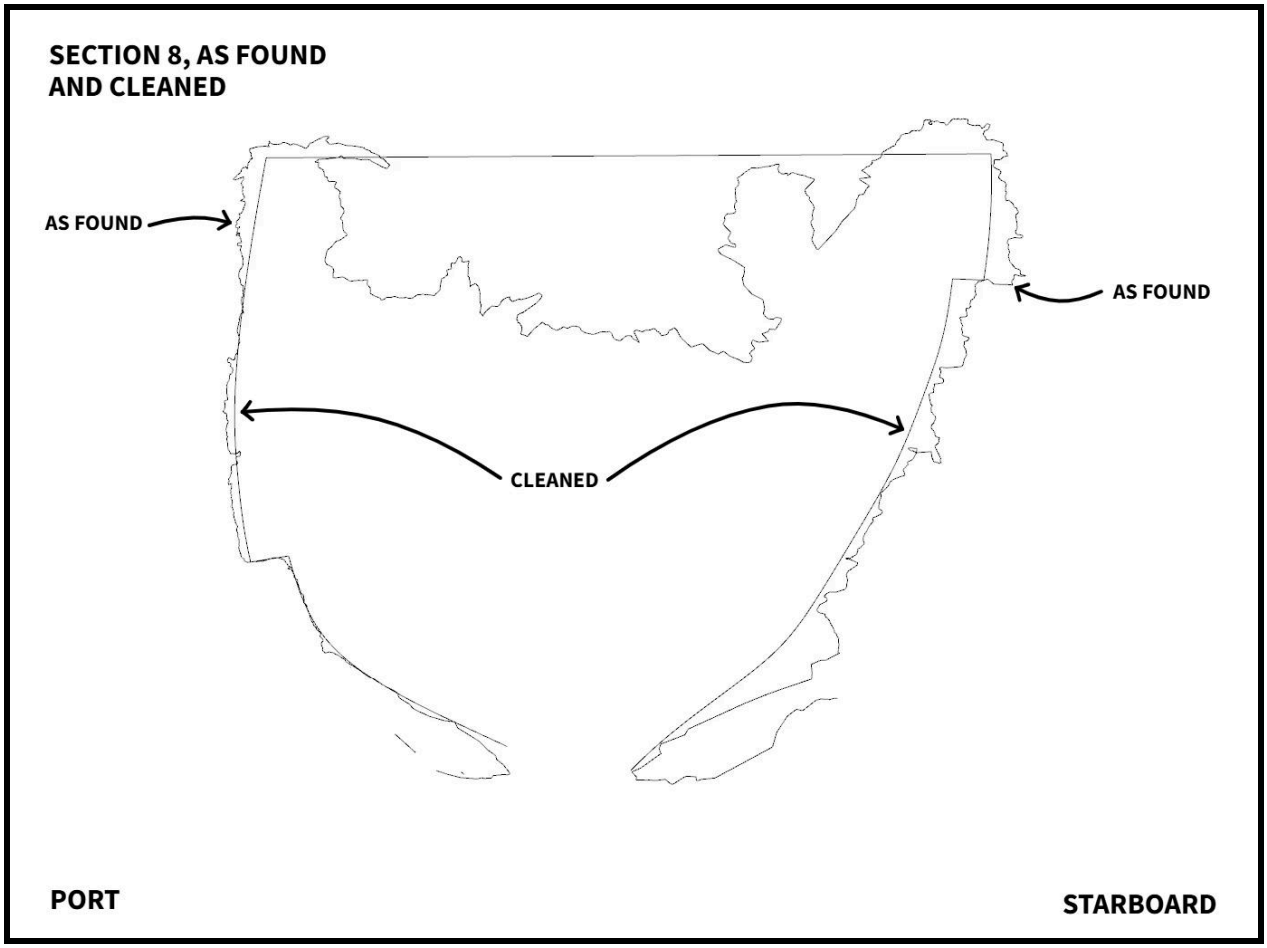
[Figure 21. Section 8.5, As Found and Cleaned.]

ii. The Cleaned and As Carved sections were developed as in Section 8.75, though here the lower portion is more visible, allowing greater confidence in the curve. As in Section 8.75, the upper edge is deteriorated and was probably originally higher.



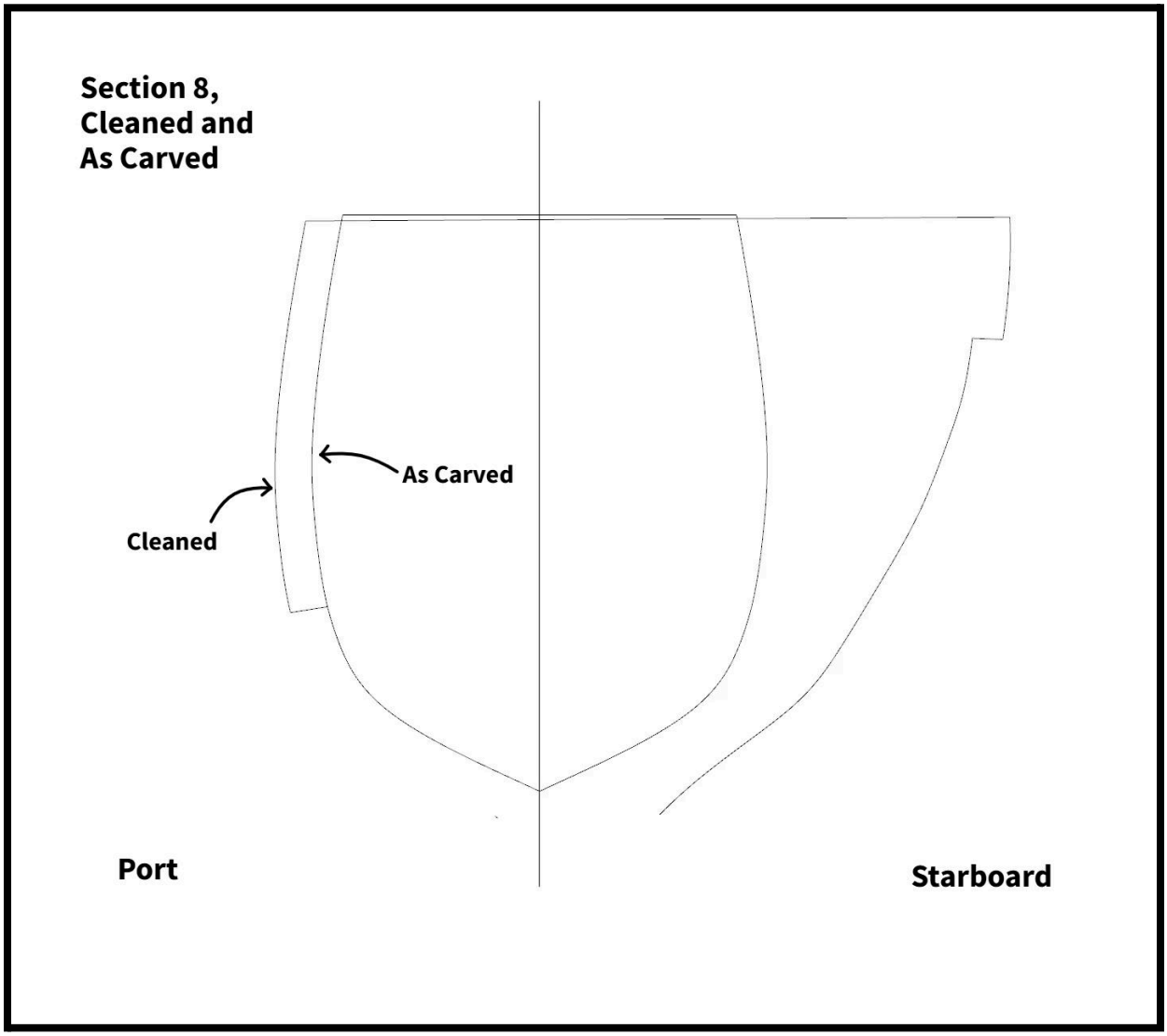
[Figure 22. Section 8.5, Cleaned and As Carved.]

d. **<u>Section 8</u>**
   i. As Found Section
      1. Section 8 continues to show the split in the port side with the upper portion sprung out away from the lower. On the starboard side, we see that the whole side is split and tilted out. We also see a remnant “knob” nearer the centerline where the side has split away from an original gunwale. (These knobs appear as ridges and are obvious in plan view.)



[Figure 23. Section 8, As Found and Cleaned.]

ii. Cleaned and As Carved sections were handled similarly to section 8.5.

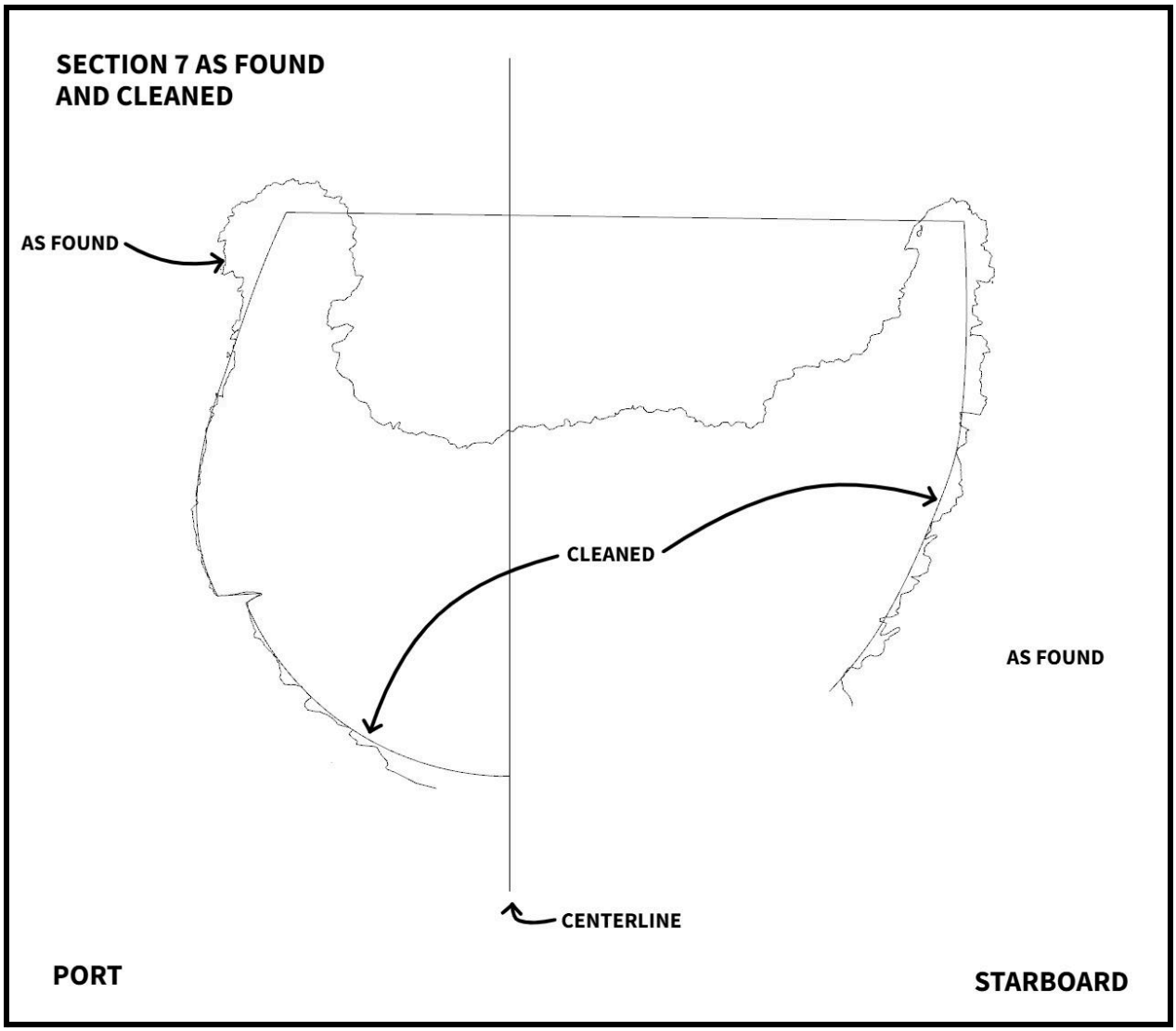


[Figure 24. Section 8, Cleaned and As Carved.]

e. <u>Section 7</u>

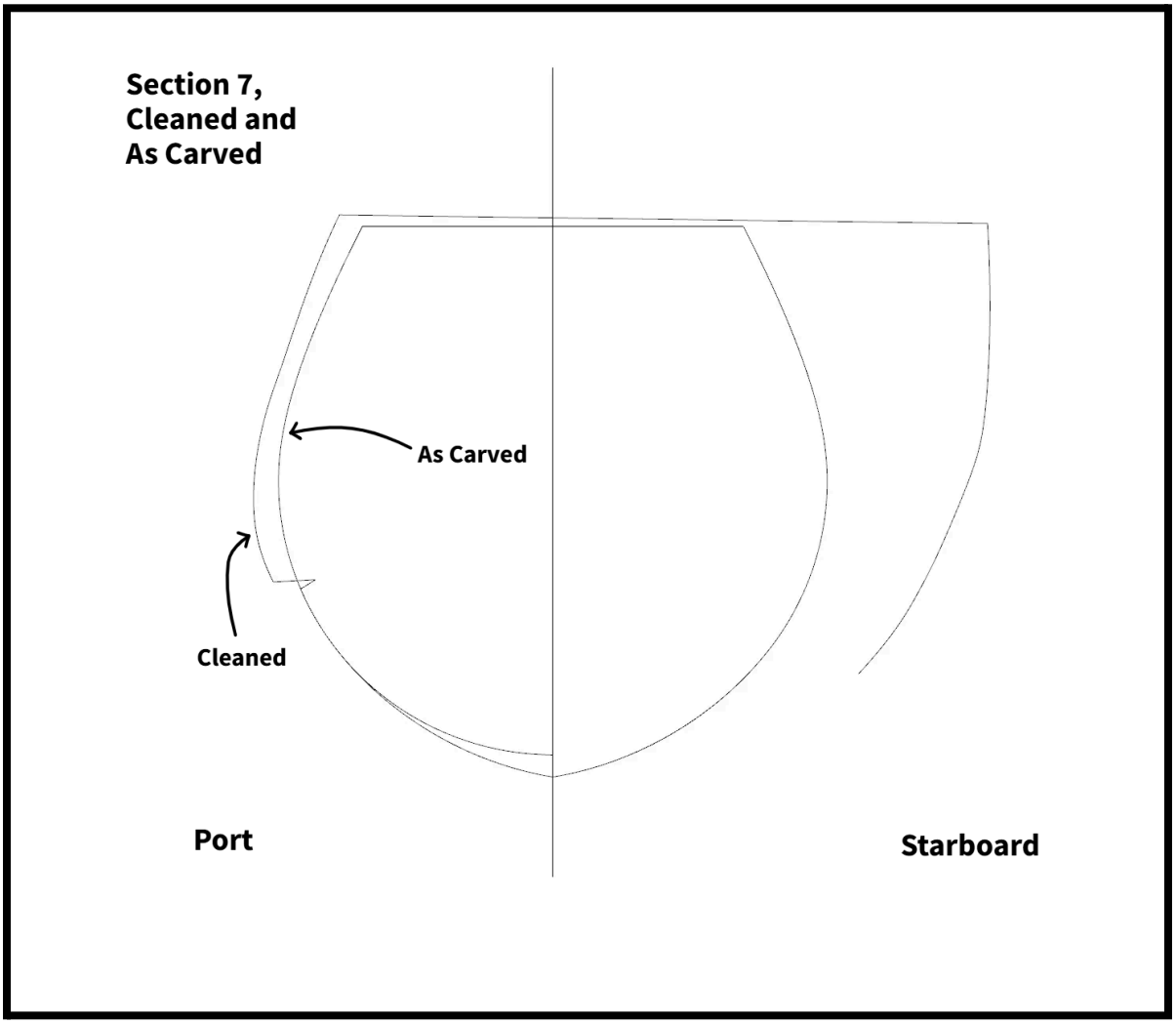
i. As Found Section

1. Section 7 is less deteriorated than sections 8, 8.5 and 8.75. We still see the starboard side badly split out away from the center, but the side is more intact. The port side is more obviously intact. It still has the split, with the upper portion sprung out, but it is not as badly sprung as sections 8 and 8.5. We also see the round shape of the midship portion of the canoe.



[Figure 25. Section 7, As Found and Cleaned.]

ii. Cleaned and As Carved sections were handled similarly to the previous sections.

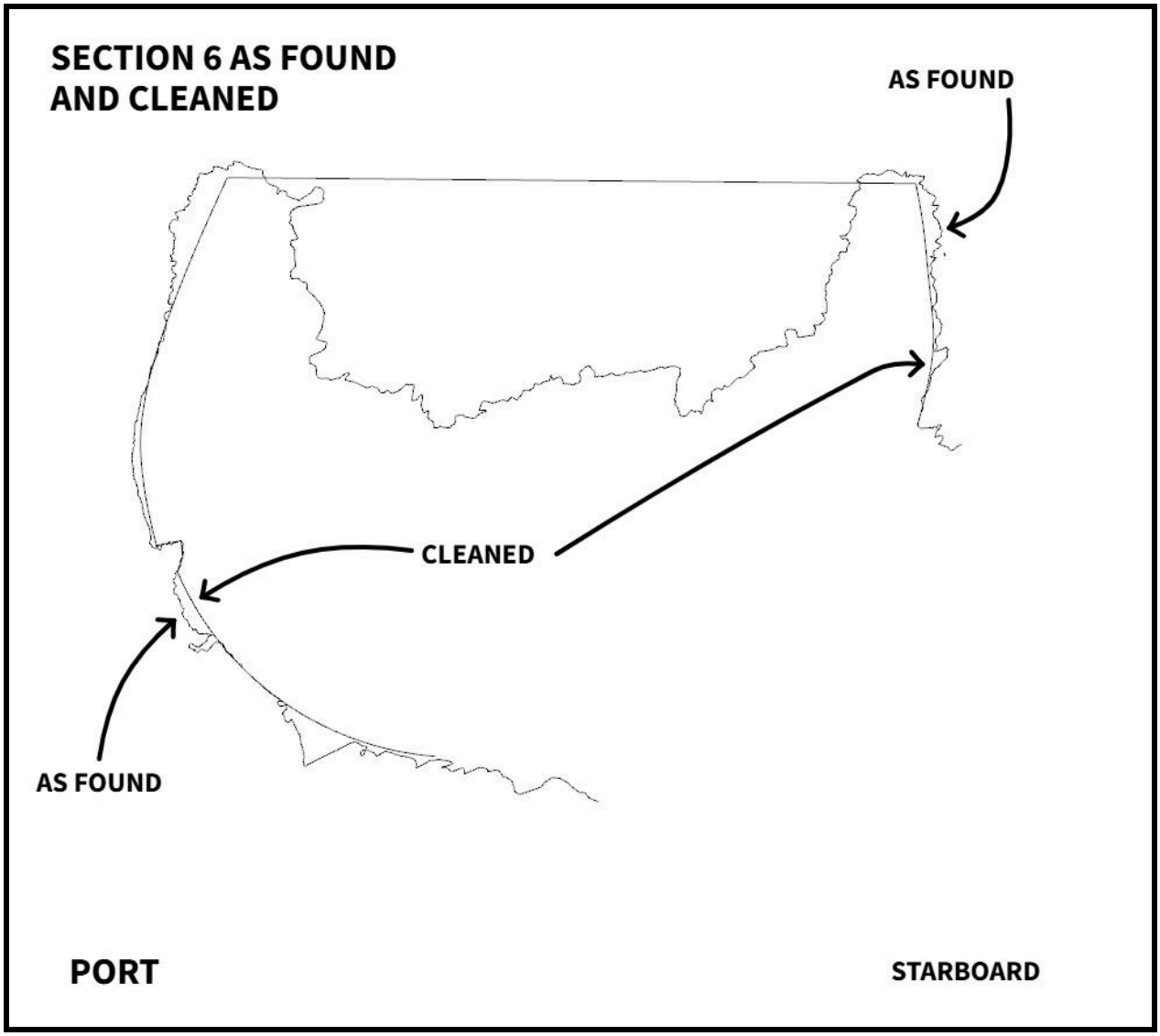


[Figure 26. Section 7, Cleaned and As Carved.]

f. <u>Section 6</u>

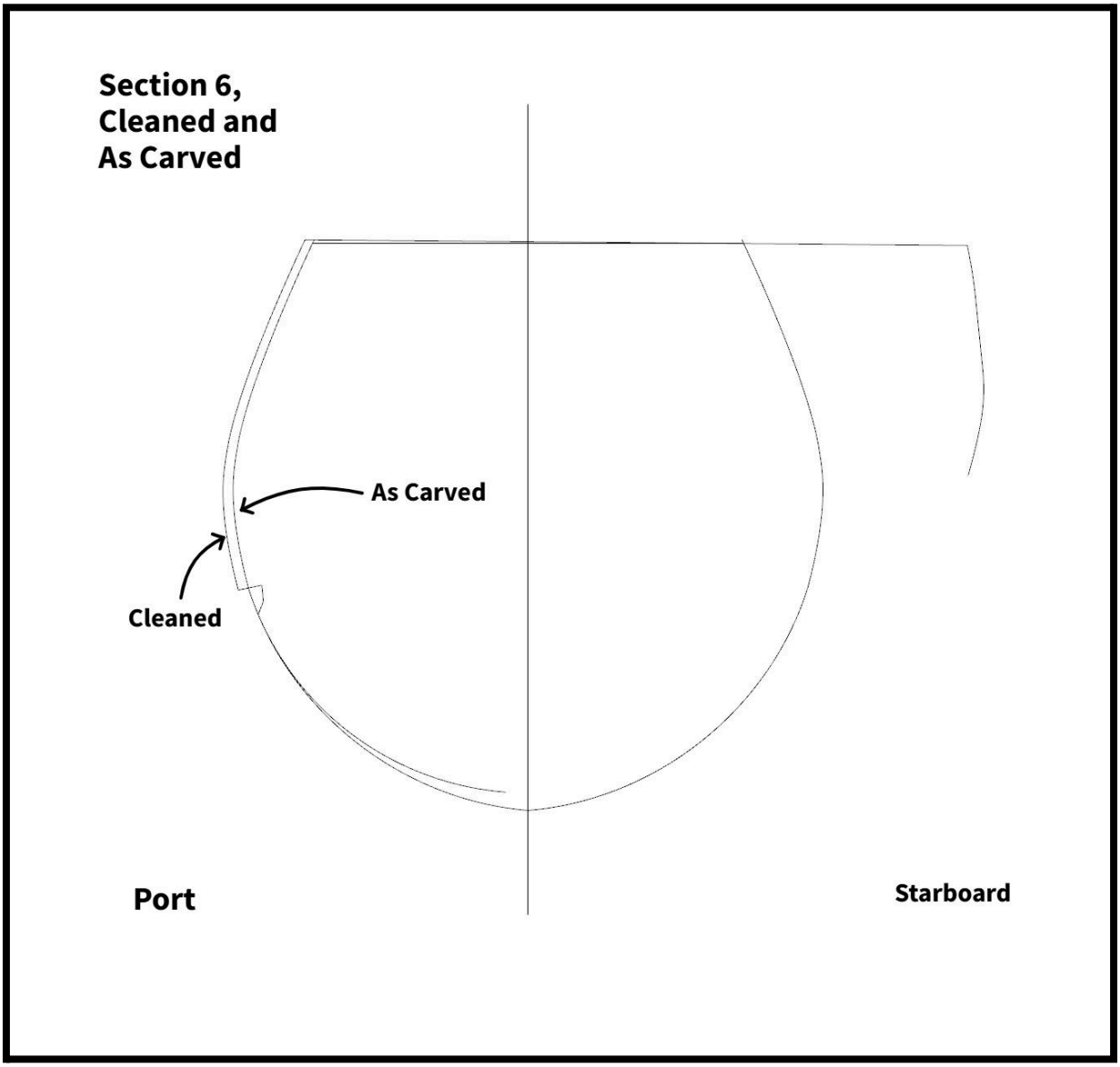
i. As Found Section

1. Section 6 is in relatively good shape. The port side shows the round shape of the midsection shape of the canoe, minimal springing out of the upper split portion. Starboard side is visible high, but obscured in its lower portions.



[Figure 27. Section 6, As Found and Cleaned.]

ii. Cleaned and As Carved sections handled as in other sections.



[Figure 28. Section 6, Cleaned and As Carved.]

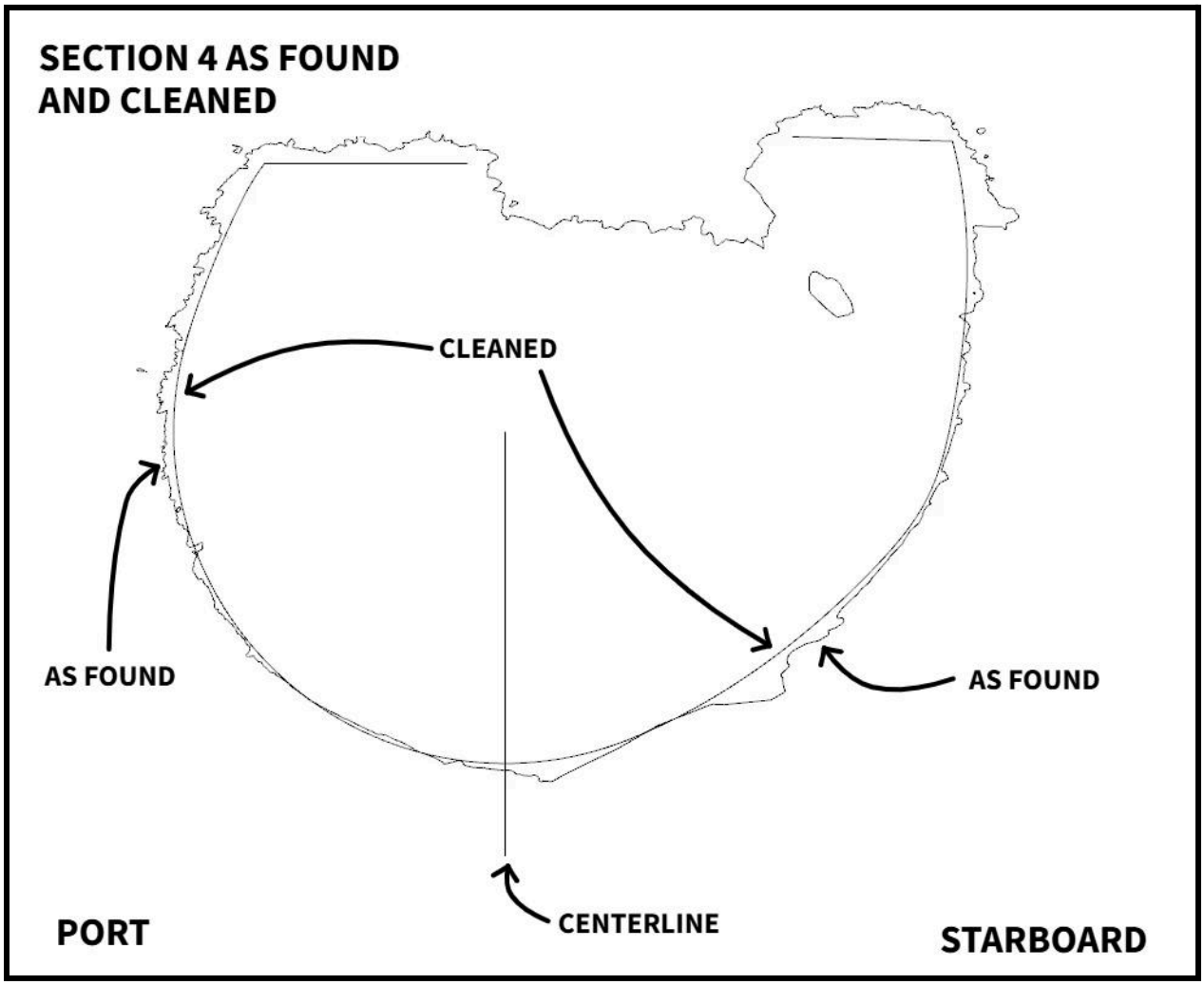
g. <u>Section 5</u>

i. Section 5 discussed at length in Part 3.

h. **Section 4**

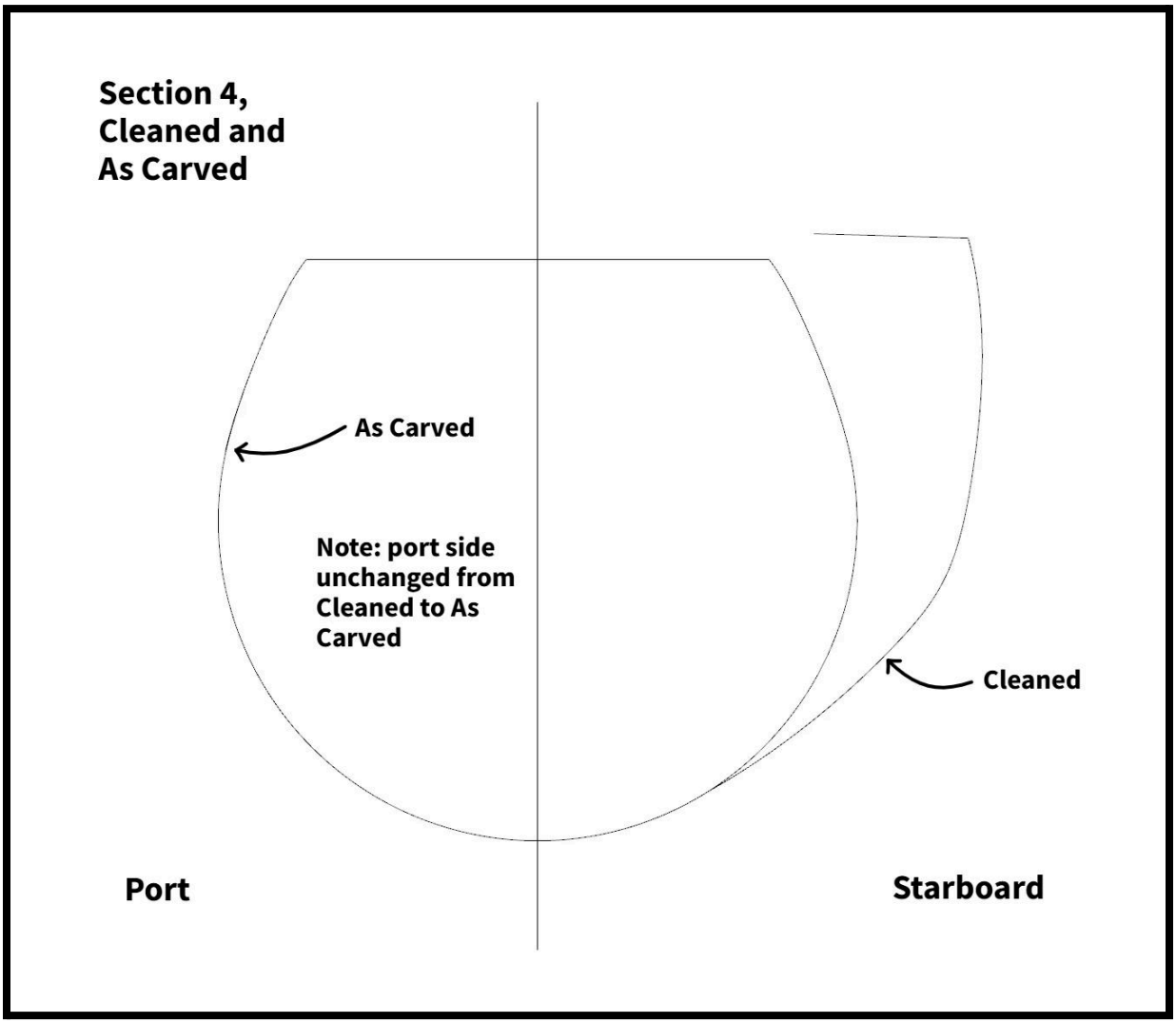
i. As Found Section

1. Section 4 is in relatively good condition. On the port side, the split is still present, but the side is not sprung out.



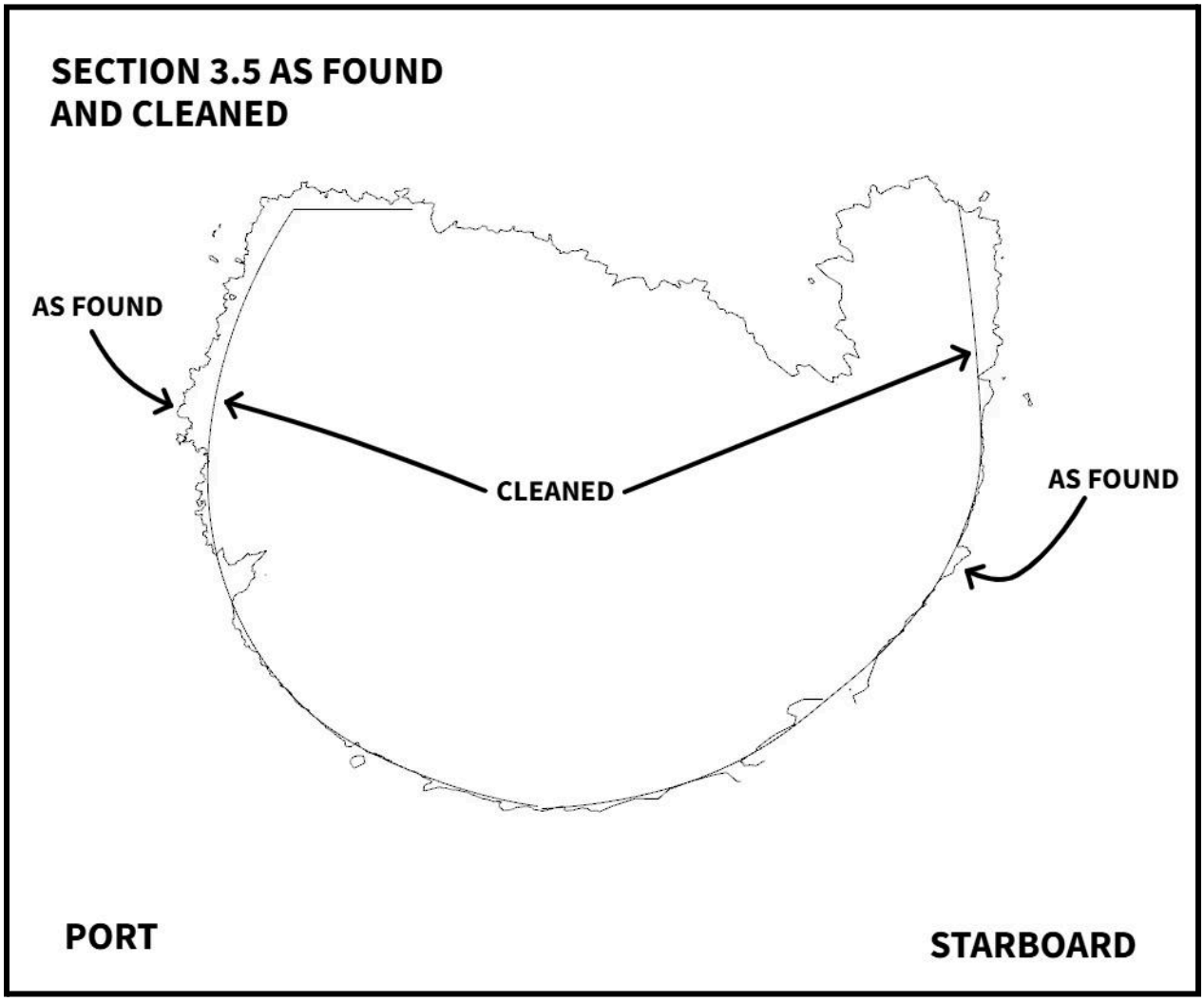
[Figure 29. Section 4, As Found and Cleaned.]

ii. Cleaned and As Carved sections handled as in other sections.



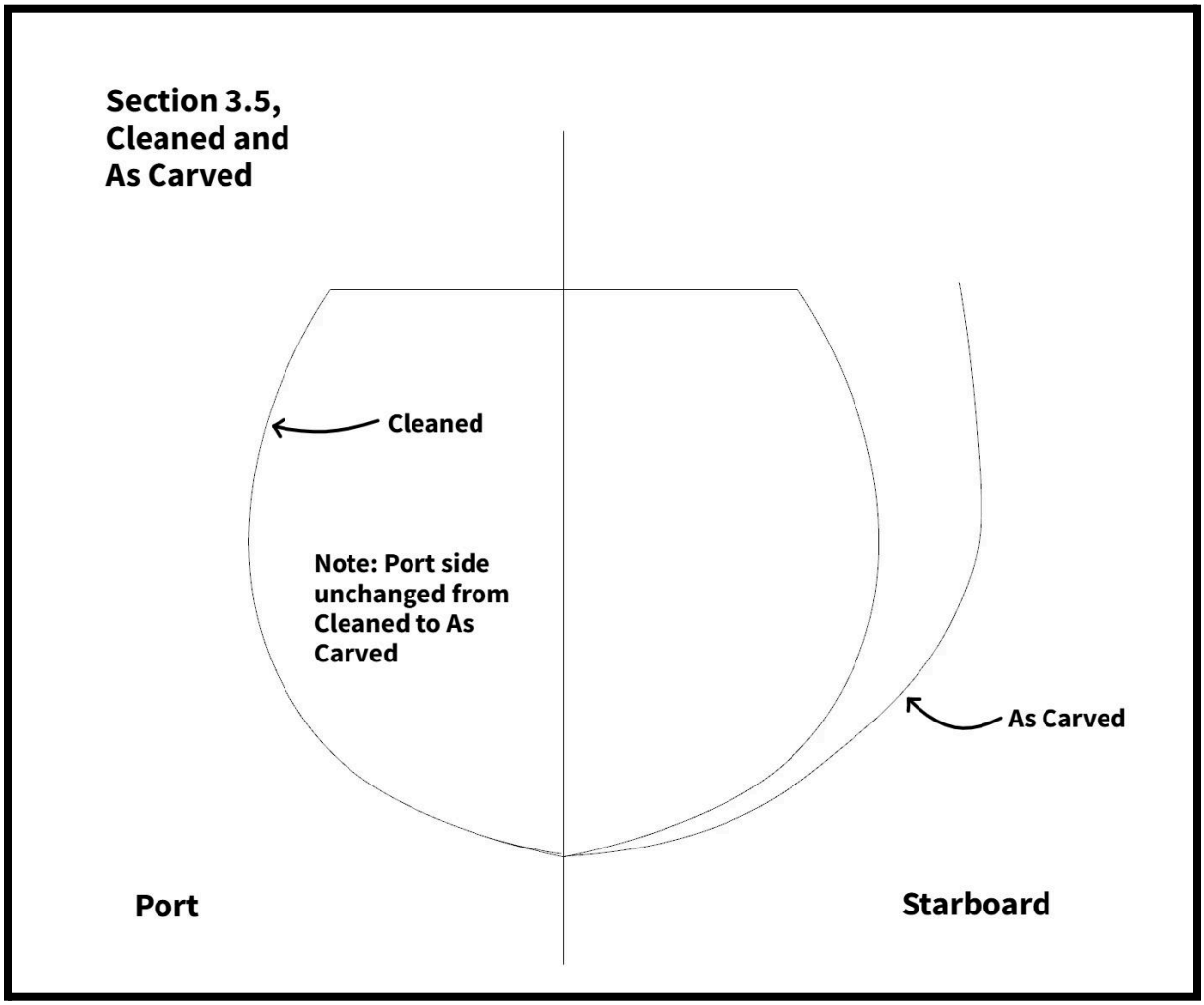
[Figure 30. Section 4, As Carved and Cleaned.]

i. **<u>Section 3.5</u>**
   i. As Found Section
      1. Section 3.5 is in relatively good condition. As in section 4, on the port side, the split is still present, but the side is not sprung out.



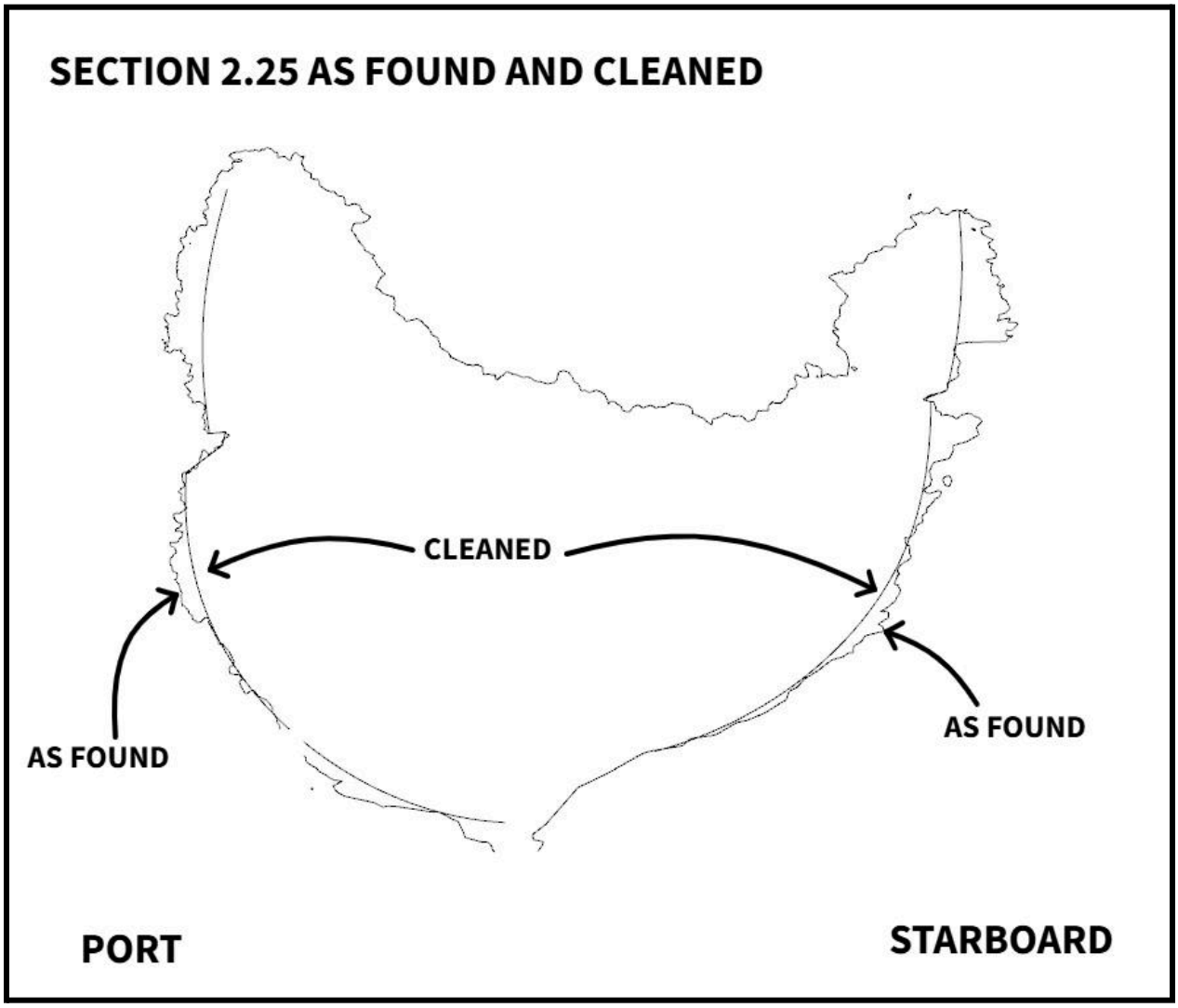
[Figure 31. Section 3.5, As Found and Cleaned.]

ii. Cleaned and As Carved sections handled as in other sections.



[Figure 32. Section 3.5, Cleaned and As Carved.]

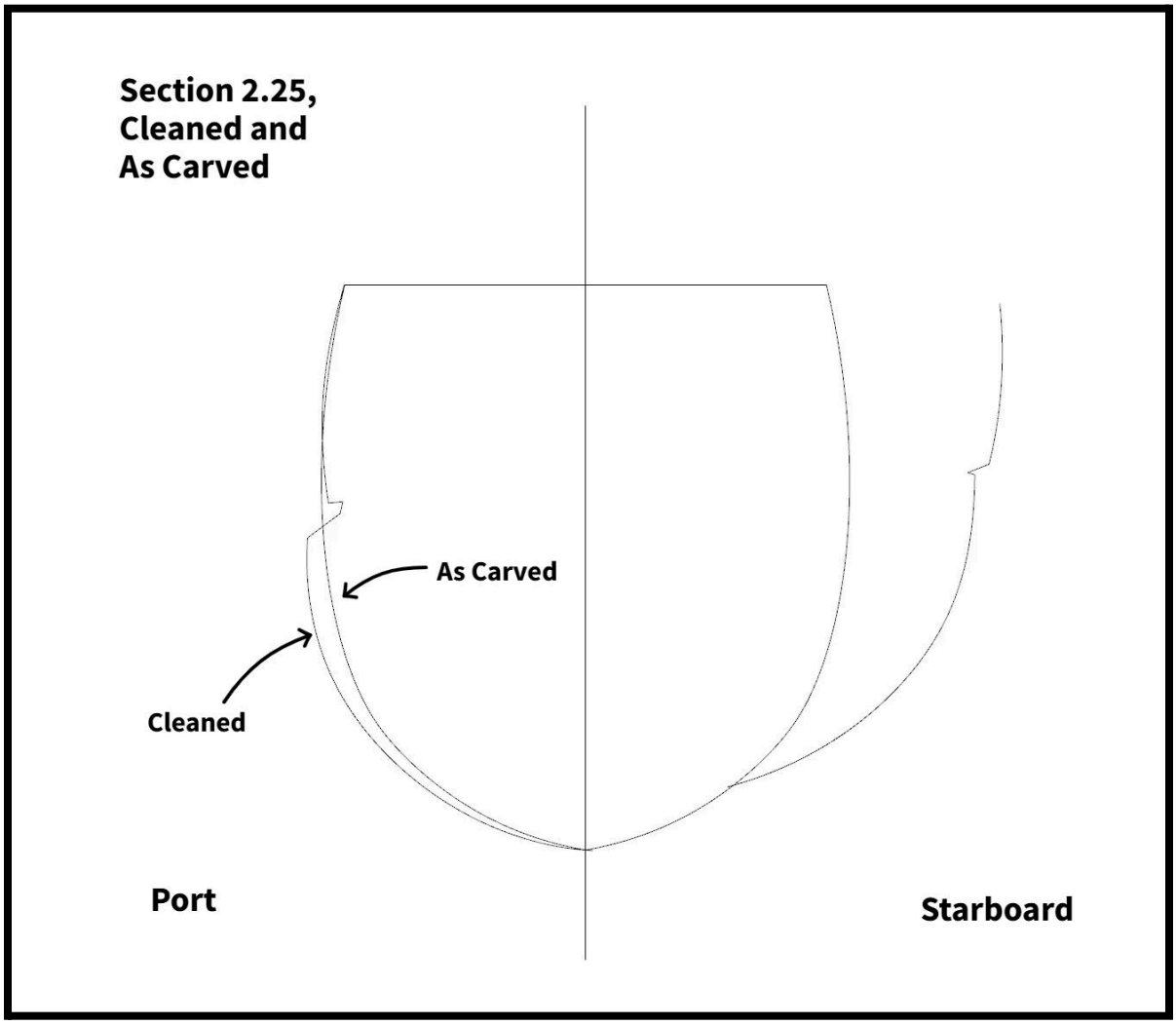
j. **Section 2.25**
   i. As Found Section
      1. In section 2.5 the split in the port side results in the lower portion springing outboard rather than the upper portion. We see the beginning of the transition from the round midship section to the hollow of the ends.



[Figure 33. Section 2.25, As Found and Cleaned.]

   ii. Cleaned section handled as in other sections.
   iii. As Carved Section

1. Since it appears that the port side has sprung outboard below the split rather than above the split, the lower portion of the curve has been brought inboard and aligned with the curved portion above.

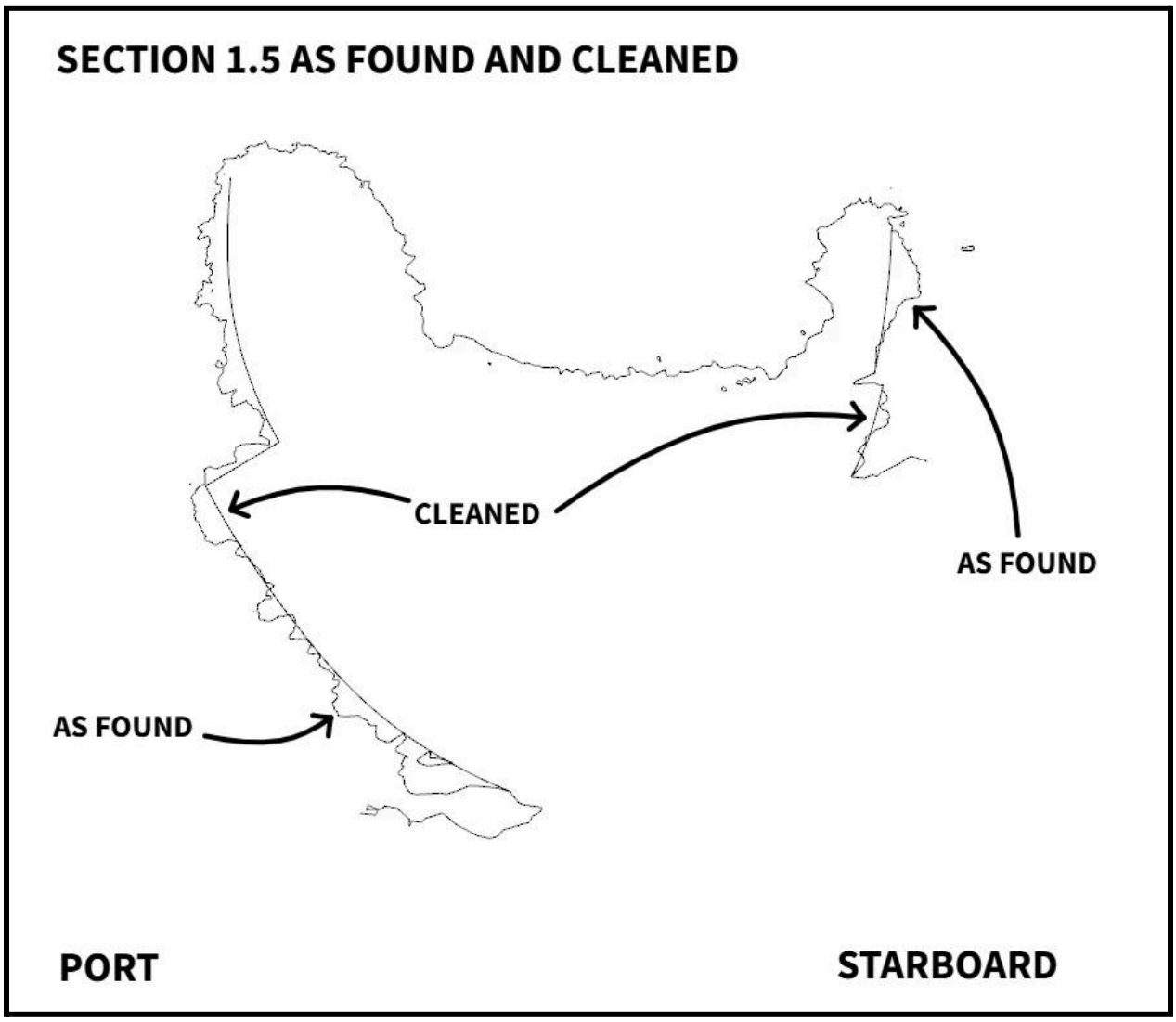


[Figure 34. Section 2.25, Cleaned and As Carved.]

k. <u>Section 1.5</u>

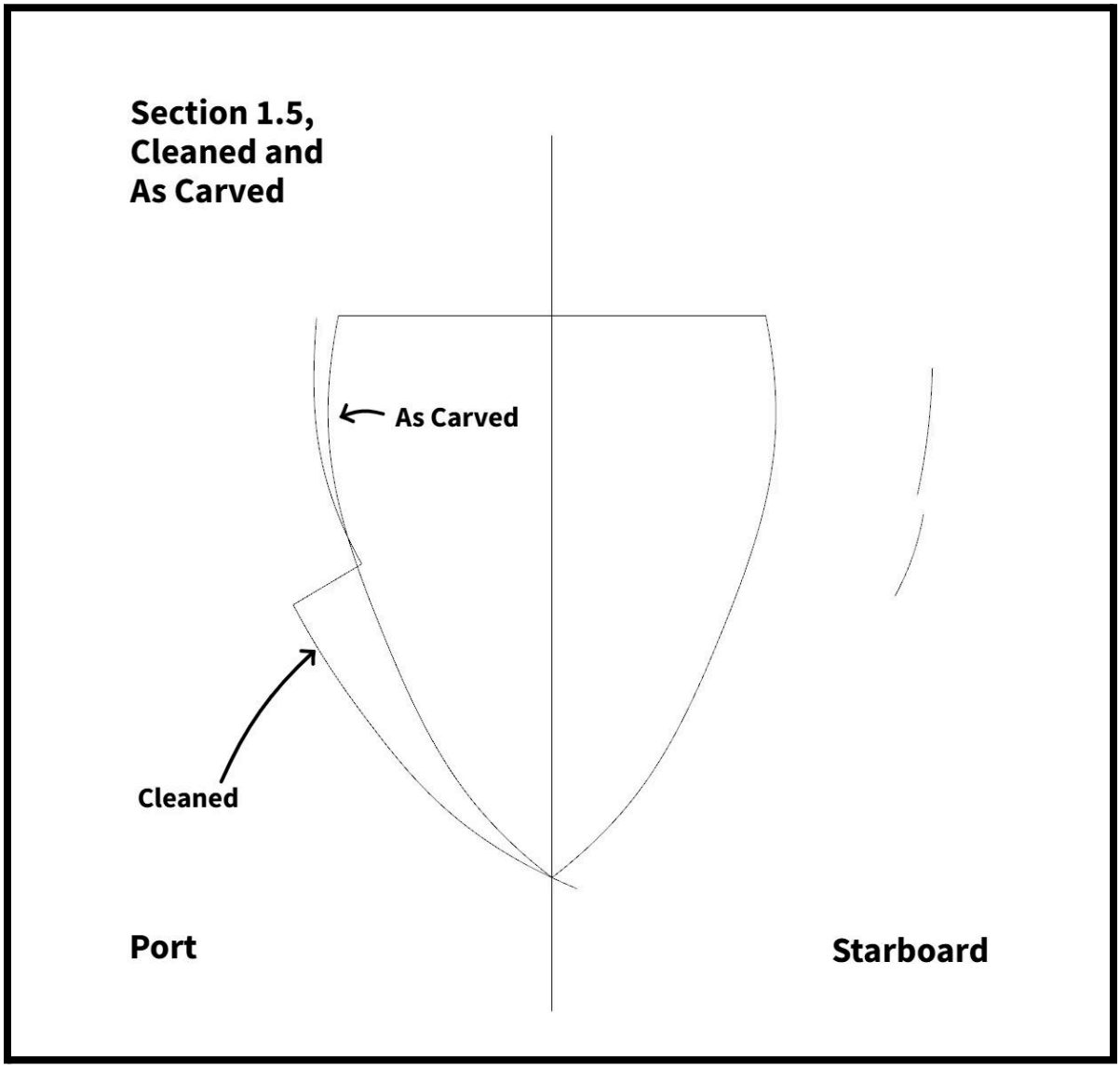
i. As Found Section

1. In section 1.5, the split in the port side results in the lower portion springing outboard as in section 2.25, only more dramatically. This section shows more of the transition from the round midship sections to the hollowed end of the canoe. The port side has been carved to more of a “V” shape.



[Figure 35. Section 1.5, As Found and Cleaned.]

ii. Cleaned section handled as with other sections.
iii. As Carved section handled as in section 2.25.



[Figure 36. Section 1.5, Cleaned and As Carved.]

PART 5: How the As Carved sections were used to make an As Carved Model.

1. The As Carved sections were used in Rhinoceros 8 to create a new model using the lofted surface function. This new surface is referred to as the As Carved model. Lines

were then taken from this As Carved model to create drawings representing an approximation of the canoe as it was originally carved.

2. That As Carved model and those As Carved drawings are the result of all of the assumptions and reconstructions described above and must be considered an interpretation or guess at the original shape. It is hoped that the above explanation lends legitimacy to the assumptions and reconstructions made. At the same time, it should give the reader an opportunity to question those decisions and explore other interpretations of the canoe's shape.

PART 6: Some things learned from this canoe, model and drawings.

1. The transition from convex round sections amidships to slack-bilged sections at each end.
    a. The midsection of the canoe is convex, round and log shaped as described above.
    b. Each end of the canoe is carved to a narrower more U or V-shaped bilge shape at each end, showing the transition from convex to the concave or hollow bilge shape we see in finished canoes.
        i. In the bow, this carved transition shows up in sections 2.25 and 1.5, which are the two sections forward of section 3.5.
        ii. In the stern the transition is evident in sections 8, 8.5 and 8.75, which are the three sections aft of section 7.
2. In Part 3d, above, the approximation of the shape of the tree that the canoe was carved from is described. The existence of the butt cut and treetop associated with the canoe allow for a study of how the canoe was placed within the log.
    a. It appears from this study that approximately 0.08 meters (3") in radius, or 0.16 meters (6") in diameter were removed from the log at the midsection of the canoe.
    b. The length of the stump and butt cut show where the canoe was taken, lengthwise, from the tree. The stump is 2.3 meters tall measured on the longer side (the stump is on a hillside, so the opposite side, uphill, is 1.4 meters tall). The butt cut is 2.4 meters long. Therefore, the height of the long side of the stump plus the length of the butt cut is approximately 4.7 meters and approximately 15'5".

Kasaan Canoe Documentation Project: Unlocking the Wisdom of an Ancient Canoe is being supported in part by the Maritime Heritage Grant Program administered by the National Park Service, Department of the Interior through the State of Alaska Historic Preservation Office and the Alaska State Museum. Opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the Department of the Interior.

SKOWL ARM XAADAS TLUWÁA – HAIDA CANOE

AS FOUND DRAWING - SHEET 1

General Notes

- This canoe lies in the forest where it was carved in the mid to later 1800's. It is on land owned and managed by Sealaska Corporation, and its precise location on the West side of Kasaan Bay, Prince of Wales Island, Alaska has been kept secret to protect the canoe.
- The canoe sits upright in a small grove of western red cedar that has not been logged. The canoe lies near the stump, butt cut and treetop of the tree that the canoe is made from.
- The end of the canoe nearest the butt cut and stump is presumed to be the stern of the canoe as is the custom with canoes of this size. Beyond the other end of the canoe, the treetop still exists as well.
- On May 14 through 17, 2024 a team from Haida Canoe Revitalization Group, led by Stormy Hamar, and including Stephanie Hamar, Jason Rucker, Dan Monteith, Sanjay Pyare and Luke Holton, traveled to the canoe to study the canoe and the canoe carving site.
- Jason Rucker and Stephanie Hamar took 654 photographs of the canoe with a Canon EOS 5D Mark III, a Canon EF24mm F/2.8 lens and an Alienbees B1600 flash. Mark Mudge of Cultural Heritage Imaging used those photographs to make a photogrammetry model of the canoe using Agisoft Metashape. See the Agisoft Metashape processing report.
- That model was analyzed in Rhinoceros 8. The drawings on these sheets are derived from that model. See individual sheets for more information on 3D and 2D modeling and drafting processes.

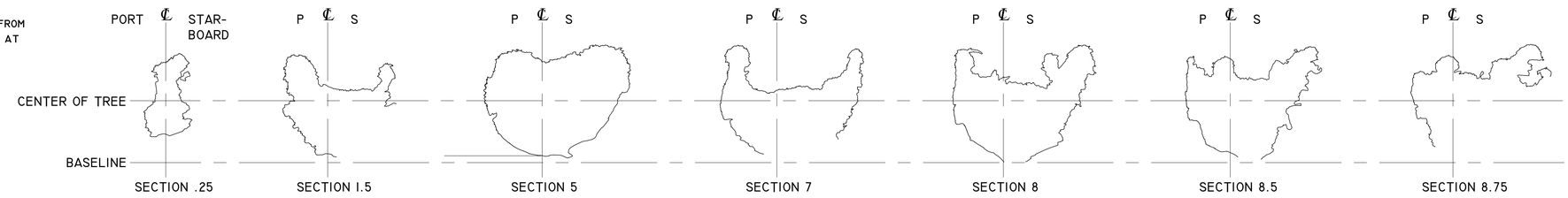
Sheet 1 Notes

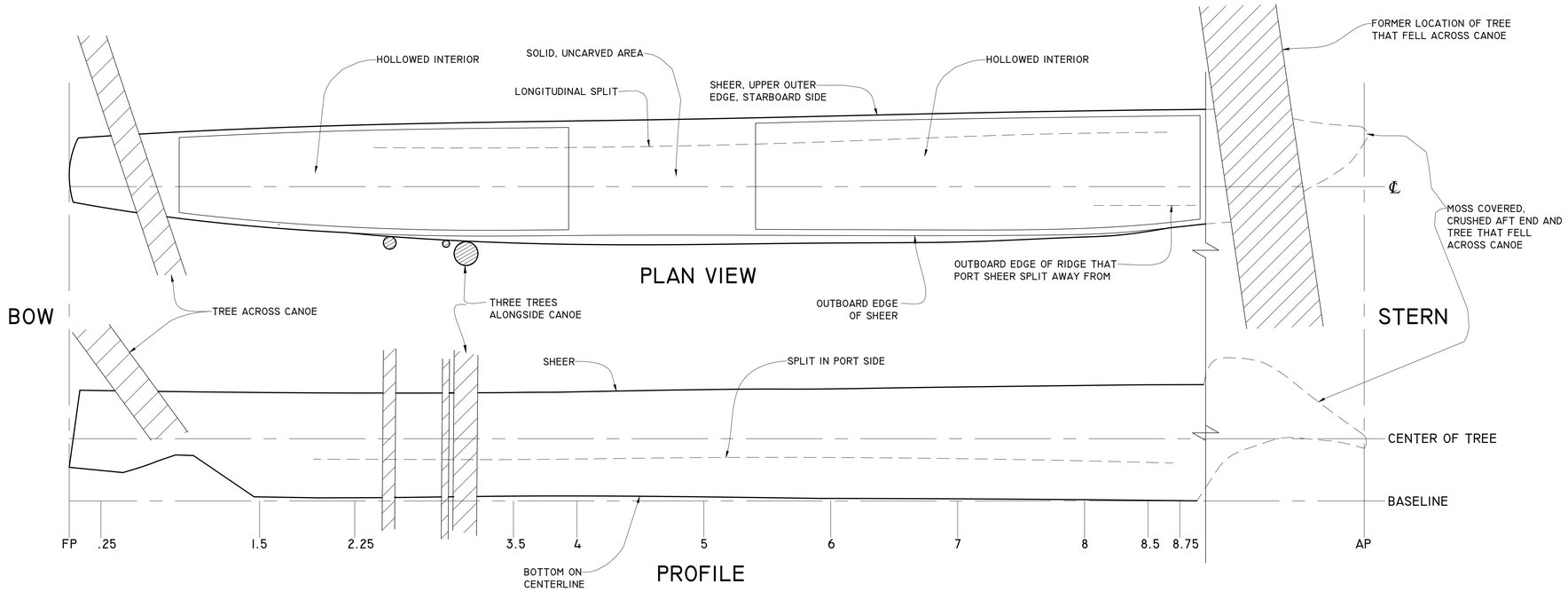
- The drawings on this sheet are meant as an introduction to the overall shape of the canoe and are referred to as the "As Found Drawings". The profile and plan views are sketches drawn to scale from the 3D computer model of the canoe. The bodyplan sections are sections perpendicular to the length of the canoe. They are numbered with their distance in meters aft of the forward perpendicular (FP) at the bow. These sections include the moss and tree roots growing on the canoe.
- The bodyplan sections shown here are some, but not all of the sections studied. Below the profile view, all of the sections studied (.25, 1.5, 2.25, 3.5, 4, 5, 6, 7, 8, 8.5 and 8.75) are indicated. These sections, the study of them, the reconstruction of them and the new model made from the reconstructed sections is discussed on sheets 2 and 3 and in greater detail in the report titled, "A Study of the Shape of the Historic Skowl Arm Haida Canoe."
- A variety of damage to the canoe is shown. Note the longitudinal split on the starboard side in plan view. Outboard of this split the whole starboard side has tilted out away from the rest of the canoe. In profile view, note the longitudinal split along the port side of the canoe. from the stern to the trees alongside the canoe, the side is sprung out above this split. This is most dramatic towards the stern and lessens towards the bow. At both ends, trees have fallen across the canoe, breaking it and accelerating its deterioration. All of this damage is discussed further on sheet 2.

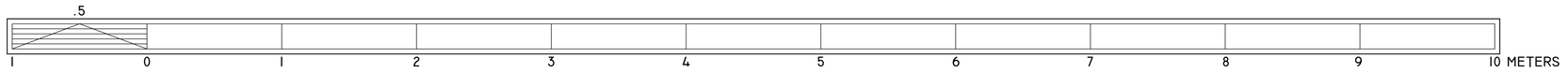
Basic dimensions as found

- Overall length, 10.2 meters.
- Greatest beam, 1.16 meters, at Section 5.
- Depth, .83 meters from gunwale to bottom at Section 5.

SELECT BODY PLAN SECTIONS







SHEET 1 OF 3

SKOWL ARM XAADAS TLUWÁA - HAIDA CANOE
KASAAN BAY
PRINCE OF WALES-HYDER CENSUS AREA
ALASKA

KASAAN

DELINEATED BY: V. JASON RUCKER 2025

HAIDA CANOE
RECORDING PROJECT
HAIDA CANOE REVITALIZATION GROUP
KASAAN, ALASKA

SKOWL ARM XAADAS TLUWÁA – HAIDA CANOE

RECONSTRUCTION OF SECTIONS - SHEET 2

SHEET 2 NOTES

- THIS SHEET ILLUSTRATES THE PROCESSES USED TO ATTEMPT TO RECONSTRUCT THE CANOE'S ORIGINAL SHAPE THROUGH A STUDY OF SELECT SECTIONS.
- A SURVEY WAS MADE OF THE VARIETY OF DAMAGE TO THE CANOE.
- AN ESTIMATION OF THE EFFECT OF THE MOVEMENT AND OTHER CHANGES TO THE SHAPE CAUSED BY THAT DAMAGE WAS MADE.
- THE MOVEMENT AND OTHER CHANGES TO THE CANOE WERE THEN REVERSED IN ORDER TO REPRESENT WHAT THE CANOE MIGHT HAVE LOOKED LIKE ORIGINALLY.
- FOR A MORE THOROUGH EXPLANATION OF THE REASONING USED TO ATTEMPT TO RECONSTRUCT THE CANOE, PLEASE SEE THE REPORT, "A STUDY OF THE SHAPE OF THE HISTORIC SCOWL ARM HAIDA CANOE." THIS SHEET ILLUSTRATES AND SUMMARIZES SOME OF THAT REPORT.
- SECTIONS WERE MADE THROUGH THE MODEL OF THE CANOE PERPENDICULAR TO ITS LENGTH.
- THE SHAPES OF ELEVEN OF THESE SECTIONS WERE STUDIED AND RECONSTRUCTED USING THE PROCESSES DESCRIBED HERE AND IN THE STUDY OF THE SHAPE OF THE HISTORIC SKOWL ARM HAIDA CANOE. THESE STATIONS ARE REFERRED TO BY THEIR DISTANCE FROM THE FORWARD PERPENDICULAR. THEY ARE, .25, 1.5, 2.25, 3.5, 4, 5, 6, 7, 8, 8.5 AND 8.75.
- THE RECONSTRUCTED OR "AS CARVED" SECTIONS WERE THEN USED TO MAKE A NEW MODEL REPRESENTING AN ESTIMATION OF THE ORIGINAL SHAPE OF THE CANOE. THE DRAWINGS ON SHEET 3 ARE TAKEN FROM THAT NEW MODEL.
- SECTION 5 IS APPROXIMATELY THE MIDSHIP SECTION. A STUDY OF SECTION 5 IS SHOWN HERE IN DETAIL. IT PROVIDES KEY INFORMATION FOR UNDERSTANDING THE SHAPE OF THE CANOE, HOW THE CANOE RELATES TO THE TREE IT WAS CARVED FROM AND HOW THE "AS CARVED" SECTIONS WERE MADE.

STUDY OF SECTION 5

- SECTIONS TAKEN DIRECTLY FROM THE ORIGINAL 3D MODEL OF THE CANOE ARE REFERRED TO AS "AS FOUND SECTIONS". SECTIONS WITH MOSS AND OTHER OBSTRUCTIONS REMOVED ARE REFERRED TO AS "CLEANED SECTIONS". SECTIONS WITH THE DAMAGE REVERSED ARE REFERRED TO AS "AS CARVED SECTIONS."
- LOOKING AT THE AS FOUND SECTION 5, WE SEE THAT THE SECTION IS IN GOOD CONDITION RELATIVE TO OTHER SECTIONS IN THE CANOE. IT IS IN THE MIDDLE PORTION OF THE CANOE WHICH IS IN BETTER CONDITION THAN THE ENDS. SEE FIG. A.
- THE PORT SIDE IS IN GOOD CONDITION. THE STARBOARD SIDE IS TILTED OUT AWAY FROM THE CENTERLINE AND IS LESS USEFUL TO THIS STUDY.
- WHEN LOOKING AT THE SURFACE OF THE CANOE OR MODEL, THE LOWER PART OF THE PORT SIDE IS SEEN TO BE SMOOTH AND PALE GREEN FOR APPROXIMATELY 1.9 METERS OF LENGTH IN THE MIDDLE OF THE CANOE. THIS PALE GREEN APPEARS TO BE A SINGLE GROWTH RING OF THE TREE. THIS GROWTH RING SHOWS UP AS A SMOOTH ARC ON THE LOWER PORT SIDE IN SECTION 5 AS FOUND.
- IF WE CONTINUE THE ARC OF THAT GROWTH RING WE CREATE A CIRCLE REPRESENTING THE WHOLE GROWTH RING OF THE TREE. THIS CIRCLE THEN ALLOWS US TO APPROXIMATE THE CENTER OF THE TREE AT THE CENTER POINT OF THAT CIRCLE. IF WE TAKE THAT CENTER TO BE ON THE CENTERLINE OF THE CANOE, THEN WE CAN DRAW IN THAT CENTERLINE AND USE IT IN THE PRODUCTION OF SECTIONAL DRAWINGS AS DESCRIBED BELOW. SEE FIG. B.
- ON THE PORT SIDE ABOUT HALF WAY UP FROM THE BOTTOM THERE IS A SPLIT IN THE SIDE OF THE CANOE. ABOVE THIS SPLIT, THE CANOE HAS SPRUNG SLIGHTLY OUT AWAY FROM THE REST OF THE CANOE. THIS SPLIT SPRINGS OUT MORE TOWARDS THE STERN AS CAN BE SEEN IN OTHER SECTIONS.
- ABOVE THE SPLIT, MOSS COVERS THE SIDE AND THE TOP EDGE.
- BELOW THE SPLIT THE SMOOTH GROWTH RING CAN BE SEEN.
- IN THE CLEANED SECTION WE'VE DRAWN AN ESTIMATION OF THE CANOE'S SHAPE NOW. WE'VE DRAWN IN THE CLEAN ARC OF THE GROWTH RING LOW ON THE PORT SIDE. ABOVE THE SPLIT ON THE PORT SIDE, WE'VE DRAWN IN AN APPROXIMATION OF THE CURVE UNDER THE MOSS. THIS UPPER PORTION IS SPRUNG OUT SLIGHTLY FROM THE CENTERLINE. ON THE STARBOARD SIDE WE'VE ALSO DRAWN LINES APPROXIMATING THE SHAPE OF THE CANOE UNDER THE MOSS. SEE FIGS. C AND D.
- IN THE " AS CARVED" SECTION WE'VE MOVED THE UPPER PART OF THE PORT SIDE (WHICH IS SPLIT AND SPRUNG OUT) INBOARD TO LINE UP WITH THE LOWER PART OF THE CURVE. THIS APPROXIMATES THE ORIGINAL CARVED SHAPE. ON THE STARBOARD SIDE WE'VE MADE A CURVE MIRRORING THE CURVE ON THE PORT SIDE.
- IN THE SUBSEQUENT SECTIONS, SIMILAR TECHNIQUES OF REFERENCING THE CENTERLINE AND FAIRING FOR MOSS AND DETERIORATION ARE USED TO STUDY THE " AS FOUND" SECTION, CREATE THE " CLEANED" SECTION AND FINALLY THE " AS CARVED" SECTION.

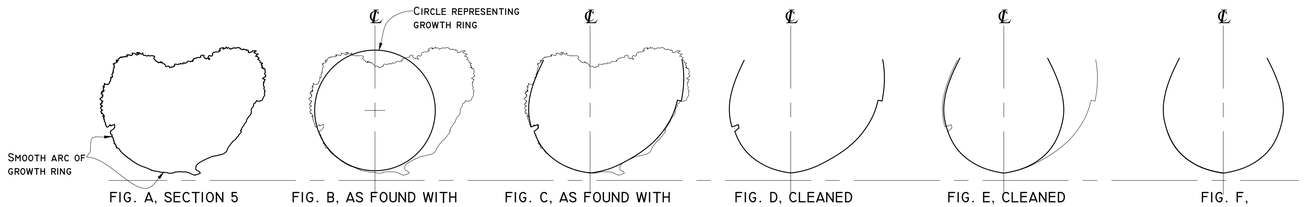


FIG. A, SECTION 5 AS FOUND

FIG. B, AS FOUND WITH GROWTH RING CIRCLE, TREE CENTER AND CENTERLINE

FIG. C, AS FOUND WITH CLEANED SECTION

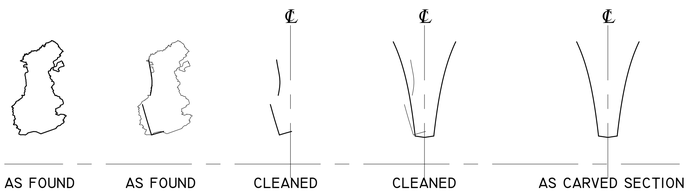
FIG. D, CLEANED SECTION

FIG. E, CLEANED SECTION WITH AS CARVED SECTION

FIG. F, AS CARVED SECTION

SECTION .25

- IN SECTION .25, A SPLIT ALLOWS THE LOWER PORTION OF THE CANOE TO SPRING OUT IN A SIMILAR WAY THAT THE UPPER PORTION SPRINGS OUT AMIDSHIPS AND AFT. INSTEAD OF BRINGING THE UPPER PORTION OF THE CLEANED SECTION INBOARD, THE LOWER PORTION IS BROUGHT INBOARD TO RECREATE THE AS CARVED SECTION.



AS FOUND

AS FOUND WITH CLEANED SECTION

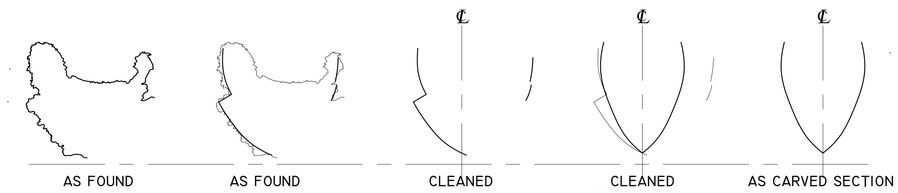
CLEANED SECTION

CLEANED SECTION WITH AS CARVED SECTION

AS CARVED SECTION

SECTION 1.5

- IN SECTION 1.5, AS IN SECTION .25 THE SPLIT ALSO CAUSES THE LOWER PORTION OF THE CANOE TO SPRING OUT.



AS FOUND

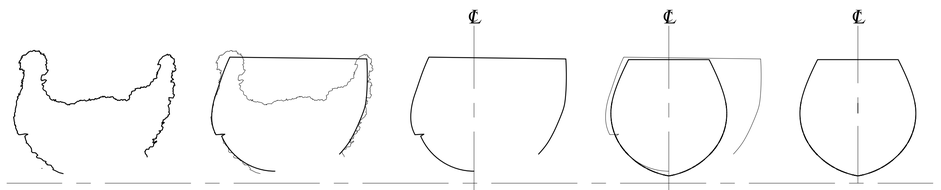
AS FOUND WITH CLEANED SECTION

CLEANED SECTION

CLEANED SECTION WITH AS CARVED SECTION

AS CARVED SECTION

SECTION 7



AS FOUND

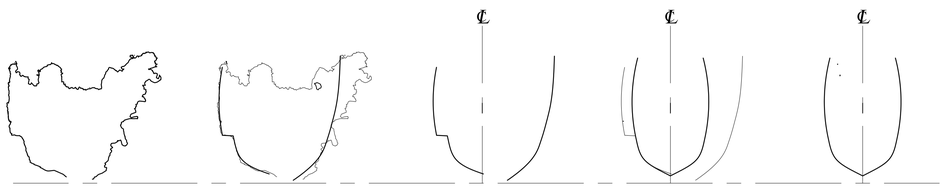
AS FOUND WITH CLEANED SECTION

CLEANED SECTION

CLEANED SECTION WITH AS CARVED SECTION

AS CARVED SECTION

SECTION 8.5



AS FOUND

AS FOUND WITH CLEANED SECTION

CLEANED SECTION

CLEANED SECTION WITH AS CARVED SECTION

AS CARVED SECTION

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HAIDA CANOE RECORDING PROJECT
HAIDA CANOE REVITALIZATION GROUP
KASAAN, ALASKA

SKOWL ARM XAADAS TLUWÁA - HAIDA CANOE
KASAAN BAY
PRINCE OF WALES-HYDER CENSUS AREA
KASAAN
ALASKA

SHEET 2 OF 3

SKOWL ARM XAADAS TLUWÁA – HAIDA CANOE

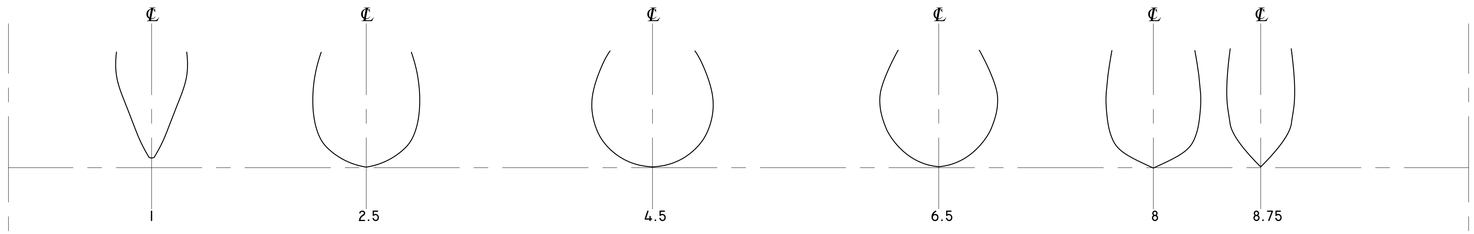
AS CARVED DRAWING - SHEET 3

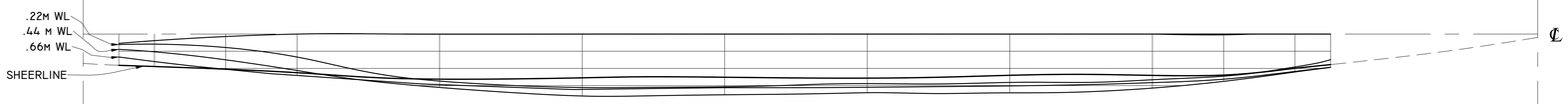
- This drawing is a reconstruction of what the canoe might have looked like when originally carved. The As Carved Sections described on Sheet 2 were used in Rhinocerous 8 to create a new model. These As Carved Drawings are taken from that new As Carved Model.
- efforts have been made to make logical decisions in the reconstruction of the canoe's shape, but this model should be considered an estimation of what the canoe might have looked like rather than a definitive representation of the actual canoe.
- The ends of the canoe are outlined with a dashed line in the plan and profile views. The aft-most 1.45 meters was too deteriorated to reconstruct. It was impossible to see the shape enough to make a model or a drawing. Similarly, the foreward-most .25 meters was not modeled or drawn. The dashed lines suggest a possible shape for reference.
- For a more thorough explanation of the reasoning used to attempt to reconstruct the canoe, please see the report, "A Study of the Shape of the Historic Scowl Arm Haida Canoe."

Basic dimensions as carved

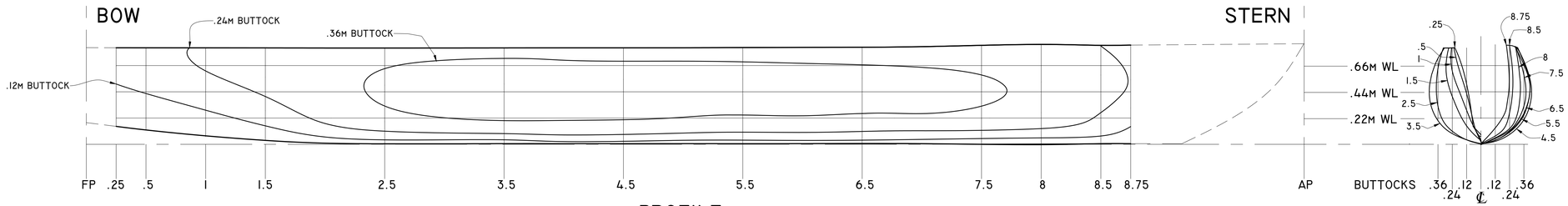
- Overall length, 10.2 meters.
- Greatest beam, .87 meters.
- Depth, .8 meters from gunwale to bottom at Section 4.5.

FULL SECTIONS BASED ON THE RECONSTRUCTION OF THE PORT SIDE OF THE CANOE



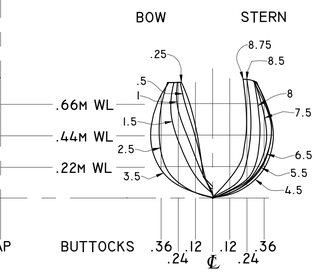


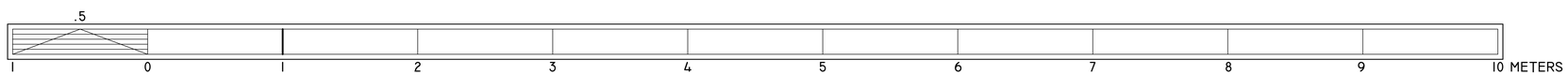
PLAN VIEW



PROFILE

BODY PLAN





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HAIDA CANOE
RECORDING PROJECT
HAIDA CANOE REVITALIZATION GROUP
KASAAN, ALASKA

KASAAN

SKOWL ARM XAADAS TLUWÁA - HAIDA CANOE
KASAAN BAY
PRINCE OF WALES-HYDER CENSUS AREA
ALASKA

SHEET 3 OF 3

SKOWL ARM HAIDA CANOE BUTT CUT

Documentation Notes

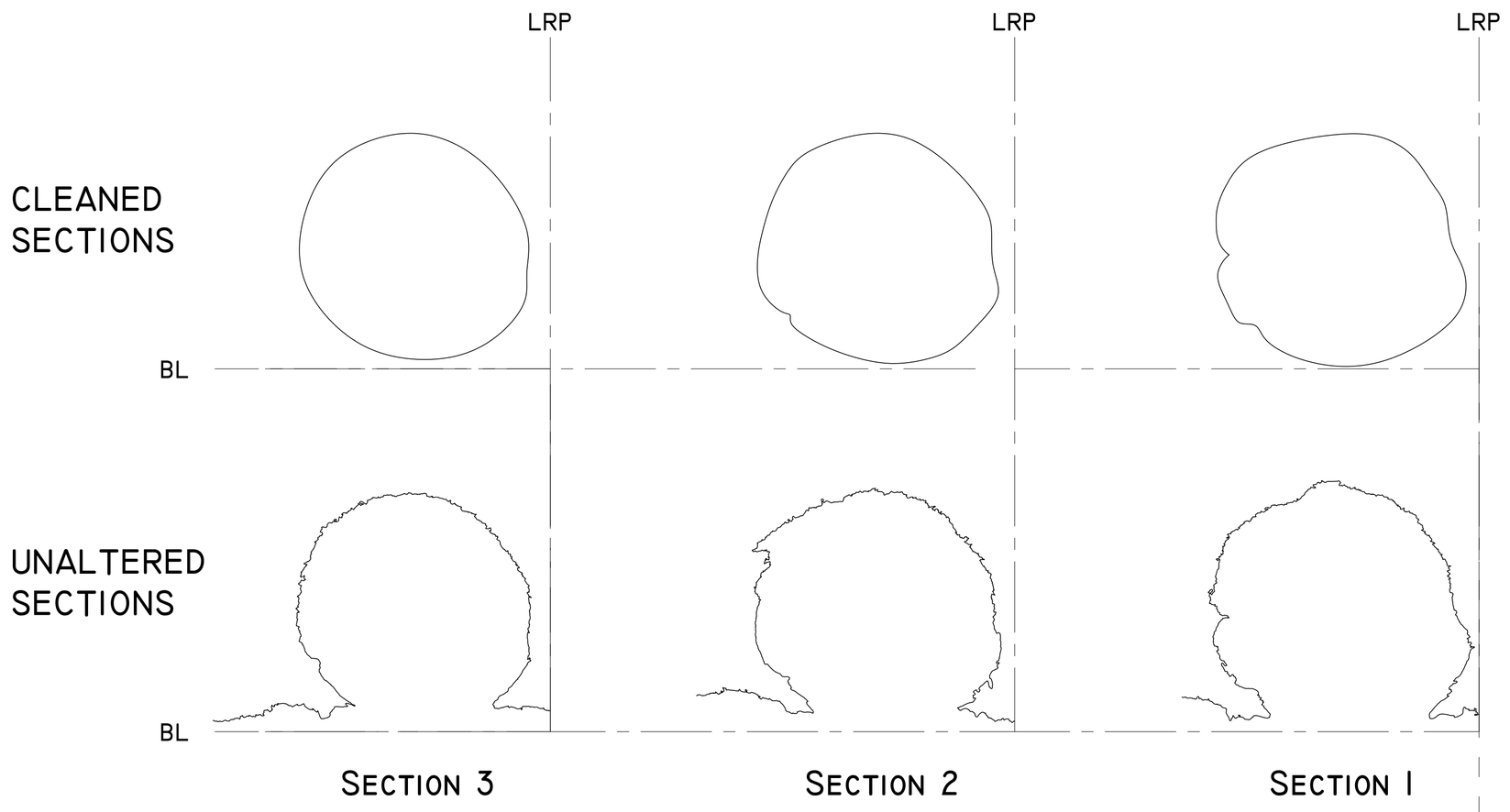
- This western red cedar butt cut lies in the forest where the tree it came from was felled in the mid to later 1800's. It is on land owned and managed by Sealaska Corporation on the West side of Kasaan Bay, Prince of Wales Island, Alaska.
- The butt cut is from the tree that the historic Skowl Arm Haida Canoe was created from. That canoe remains, unfinished in the forest near the butt cut.
- The butt cut is the lower end of the log, which was cut away from the rest of the log prior to the canoe being carved.
- May 14 through 17, 2024 a team from Haida Canoe Revitalization Group, led by Stormy Hamar and including Stephanie Hamar, Jason Rucker, Dan Monteith, Sanjay Pyare and Luke Holton, traveled to the canoe to study the canoe and the canoe carving site.
- Jason Rucker and Stephanie Hamar took 198 photographs of the butt cut with a Canon EOS 5D Mark III, a Canon EF24mm F/2.8 lens and an Alienbees B1600 flash. Jason used those photographs to make a photogrammetry model of the stump using Agisoft Metashape. See the Agisoft Metashape processing report.
- That model was analyzed and these lines were derived from that model in Rhinoceros 8.

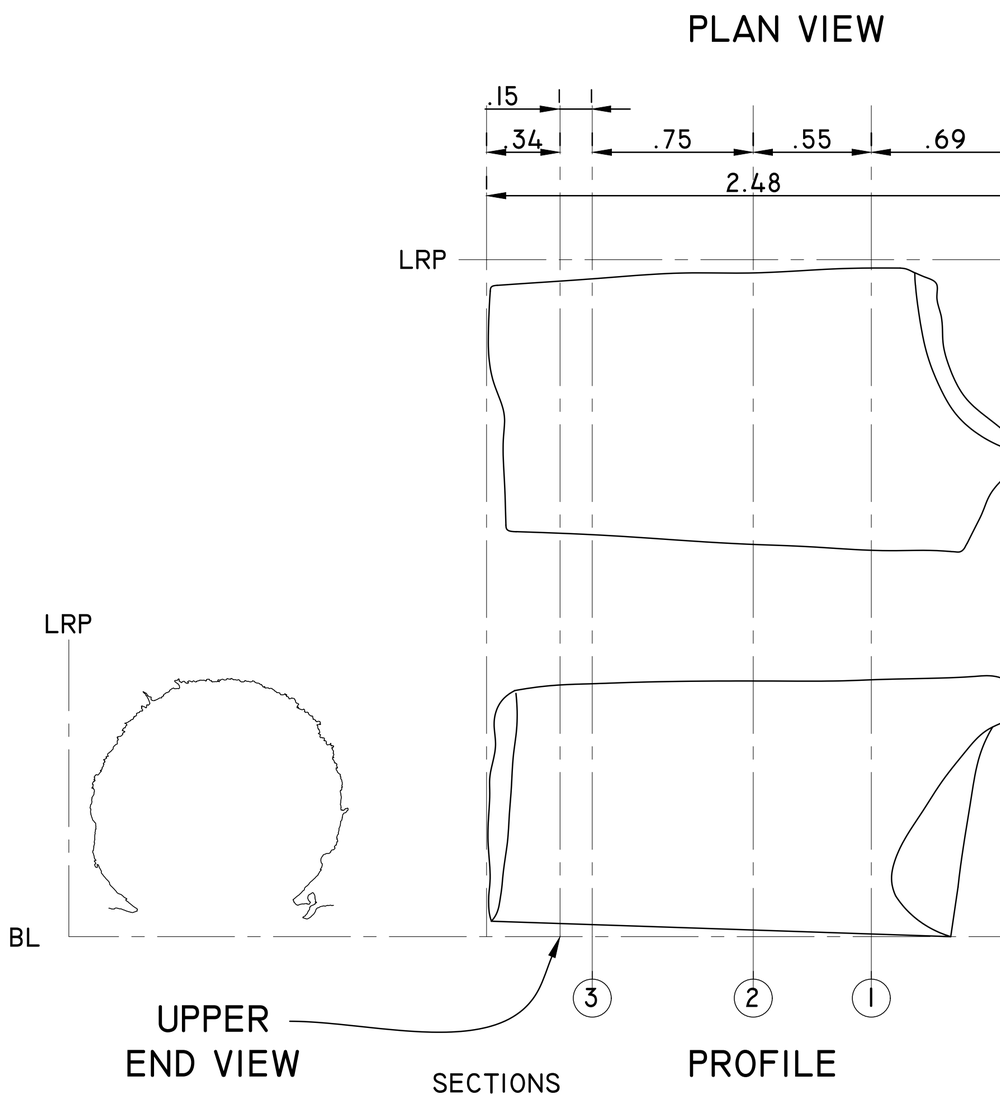
Butt Cut and Drawing Notes

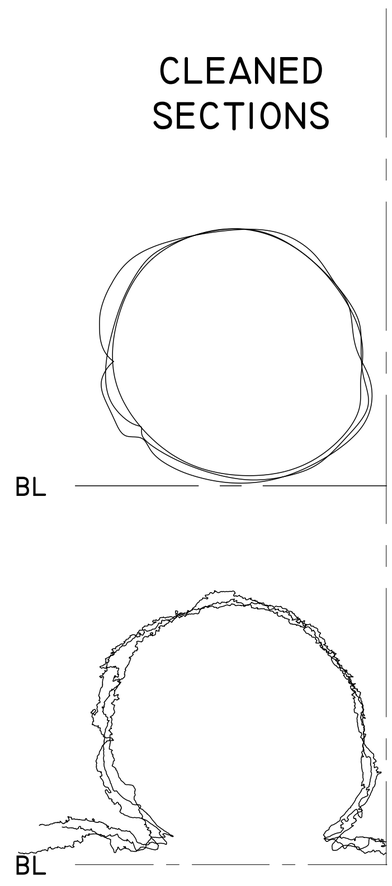
- The butt cut is slightly downhill from the stump and canoe. The profile and plan views here show it as it lies now. Its larger end is shown to the right on this sheet. Both of these views are made from an outline of the model.
- The unaltered sections are lines taken from planes intersecting the model of the butt cut at the locations indicated. the cleaned sections are an attempt to show the shape of the stump under the moss and other obstructions on the butt cut.
- The larger and lower end of the butt cut (to the right on this sheet) has tool marks and a v shape suggesting the tree was felled with an edge tool. Similar tool marks also appear on the stump associated with this butt cut. the upper end of the butt cut is square across, suggesting it was cut with a crosscut saw.
- The lower end view is made from an outline of the model and shows the apex of the v shape on the lower end of the butt cut. The upper end view is made from a section through the model at the line indicated with the arrow. It is an unaltered section through the model at the solid, intact point closest to the end.
- This drawing was made with AutoCAD LT.
- The Reference Perpendicular is abbreviated RP on the drawing. The Longitudinal Reference Plane is abbreviated LRP. The Baseline is abbreviated BL.

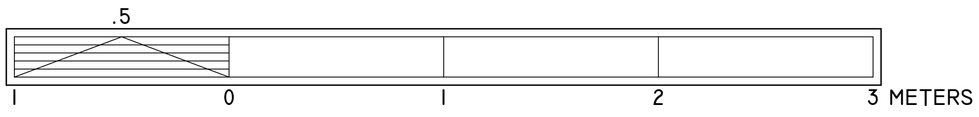
Basic measurements

- 2.48 meters or 8' 1-5/8" -- Approximate overall length.
- 1.50 meters or 8' 2-1/2" -- Approximate diameter at section 1
- 1.21 meters or 3' 11-1/4" -- Approximate diameter at section 3
- 1.1 meters or 3'7" -- Approximate diameter at upper end









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HAIDA CANOE RECORDING PROJECT HAIDA CANOE REVITALIZATION GROUP KASAAN, ALASKA	SKOWL ARM HAIDA CANOE BUTT CUT KASAAN BAY KASAAN PRINCE OF WALES-HYDER CENSUS AREA ALASKA	SHEET 1 OF 1	HCRG

SKOWL ARM HAIDA CANOE STUMP

Documentation Notes

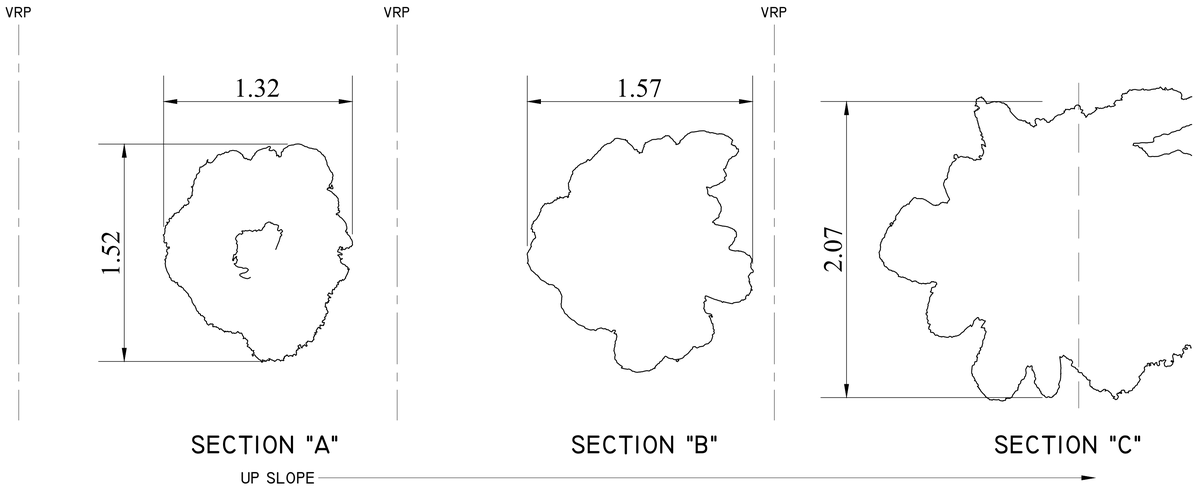
- This western red cedar stump stands in the forest where the tree was felled in the mid to later 1800's. It is on land owned and managed by Sealaska Corporation on the West side of Kasaan Bay, Prince of Wales Island, Alaska.
- The tree that was felled from this stump was used to carve a canoe that remains, unfinished in the forest next to the stump. The butt cut and top of the tree remain on the forest floor.
- May 14 through 17, 2024 a team from Haida Canoe Revitalization Group led by Stormy Hamar and including Stephanie Hamar, Jason Rucker, Dan Monteith, Sanjay Pyare and Luke Holton, traveled to the canoe to study the canoe and the canoe carving site.
- Jason Rucker and Stephanie Hamar took 208 photographs of the stump with a Canon EOS 5D Mark III, a Canon EF24mm F/2.8 lens and an Alienbees B1600 flash. Jason used those photographs to make a photogrammetry model of the stump using Agisoft Metashape. See the Agisoft Metashape photogrammetry report.
- That model was analyzed and these lines were derived from that model in Rhinoceros 8.

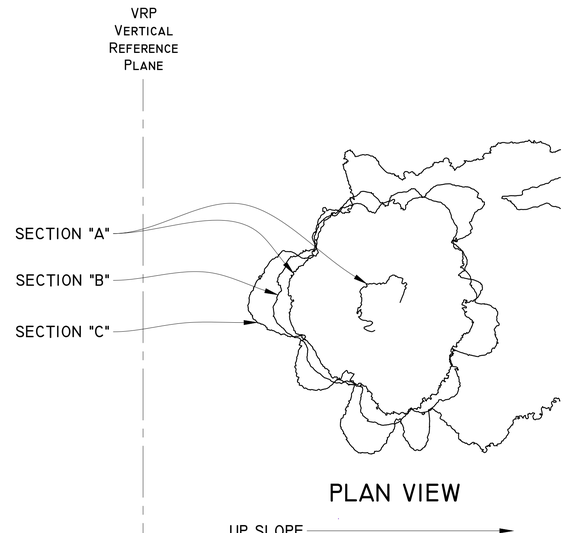
Stump and Drawing Notes

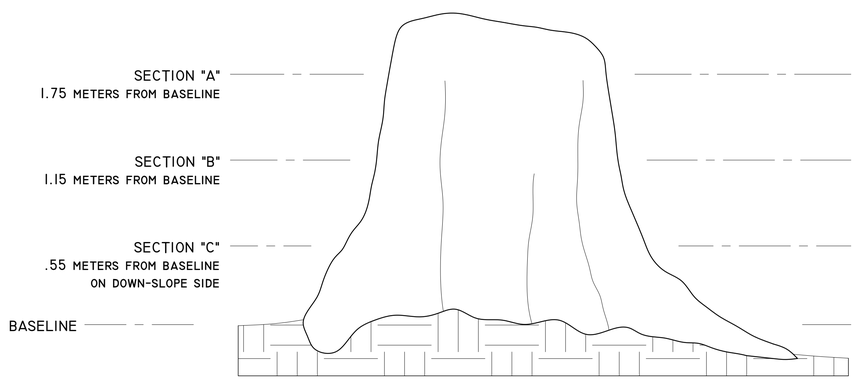
- The stump is on a hillside. Two profile views are shown here. The "Profile From Canoe" is a view looking roughly from the stern of the canoe towards the stump. The slope of the hill can be seen in this view. The other profile view, "Looking Up Slope" is a view standing downhill of the stump, looking uphill. Both of these views are made from an outline of the model. Some of the prominent ridges in the stump are shown.
- The sections are lines taken from planes intersecting the model of the stump at the heights indicated. The up slope portion of section "C" intersects the hill at approximately the dashed line, and does not represent the stump.
- The top of the stump has tool marks suggesting the tree was felled with an edge tool. This type of mark is also on the lower end of the butt cut.
- This drawing was made with AutoCAD LT.

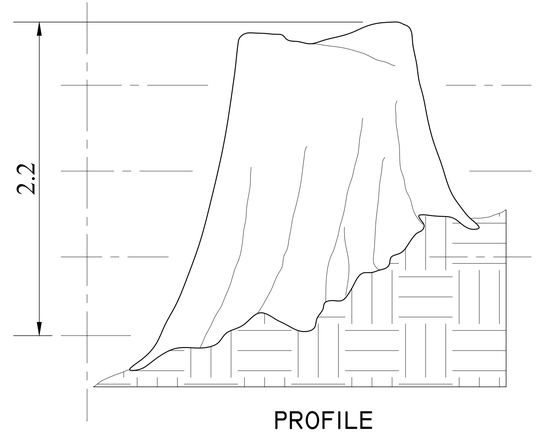
Basic measurements

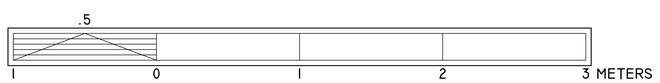
- 2.2 meters or 7' 2-1/2" -- Approximate overall height on the down-slope side.
- 1.32 meters or 4'4" -- Approximate diameter at section "A" near the top of the stump, when measured on the up & down slope axis.
- 1.52 meters or 5' -- Approximate diameter at section "A" when measured on the across slope axis.
- 1.57 meters or 5'2" -- Approximate diameter at section "B" near the middle of the height of the stump, when measured on the up & down slope axis.
- 2.07 meters or 6'9-1/2" -- Approximate diameter at section "C" near the bottom of the stump, when measured on the across slope axis.
- There is a hole in the top of the stump as seen in section "A". Its depth was not measured.











DELINEATED BY: V. Jason Rucker 2025

HAIDA CANOE
RECORDING PROJECT
HAIDA CANOE REVITALIZATION GROUP
KASAAN, ALASKA

KASAAN

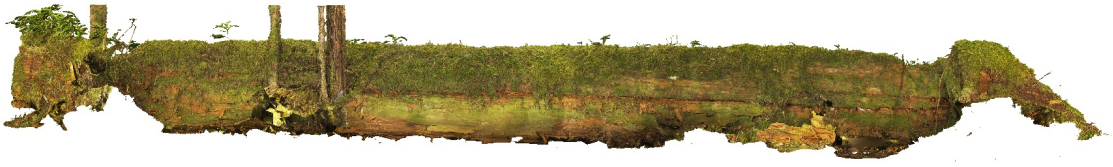
SKOWL ARM HISTORIC HAIDA CANOE TREE STUMP
KASAAN BAY
PRINCE OF WALES-HYDER CENSUS AREA
ALASKA

SHEET
1 OF 1

Historic Kasaan Canoe Photogrammetry Report

Processing Report

17 November 2024



Survey Data

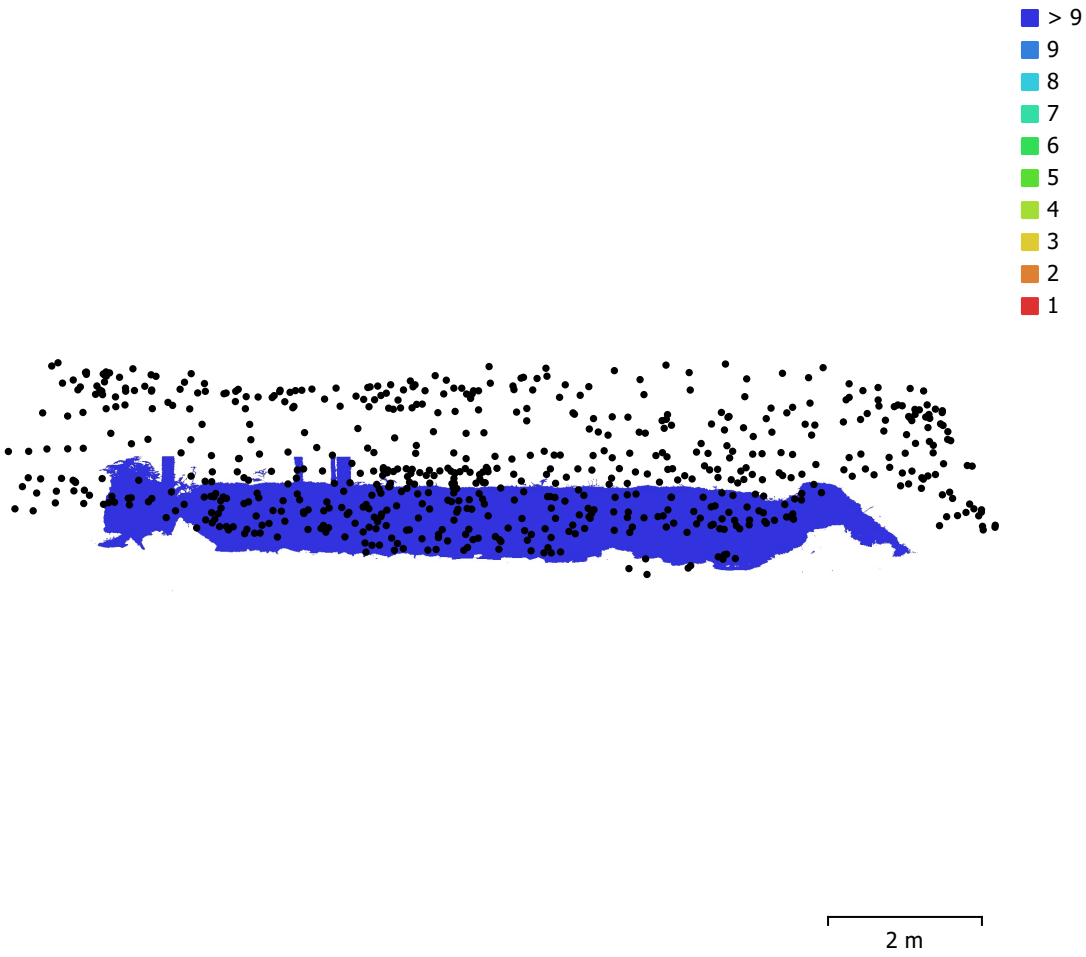


Fig. 1. Camera locations and image overlap.

Number of images:	654	Camera stations:	643
Flying altitude:	1.34 m	Tie points:	197,952
Ground resolution:	0.34 mm/pix	Projections:	460,935
Coverage area:	8.89 m²	Reprojection error:	0.165 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No

Table 1. Cameras.

Camera Calibration

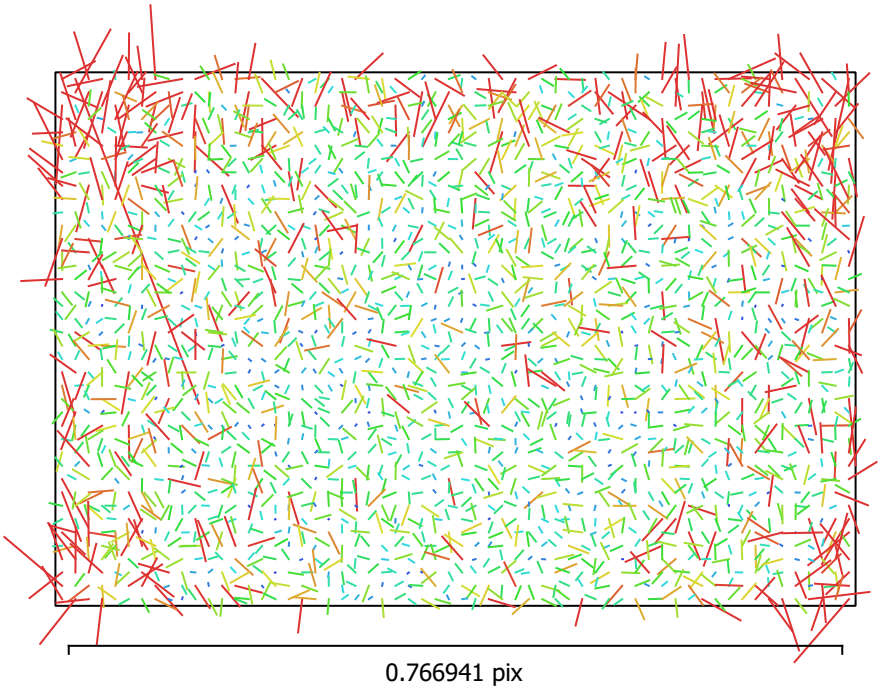


Fig. 2. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

377 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**3953.64**	0.34	1.00	-0.00	-0.01	-0.31	-0.01	-0.99	0.96	-0.92	0.87	-0.00	-0.02
Cx	**-15.9763**	0.15		1.00	-0.01	0.01	-0.13	0.01	-0.00	0.00	-0.00	0.98	-0.01
Cy	**-35.1797**	0.1			1.00	0.04	-0.00	0.01	-0.00	-0.00	0.01	-0.01	0.95
B1	**-0.40394**	0.025				1.00	-0.01	0.30	-0.29	0.26	-0.22	0.01	0.08
B2	**-0.343545**	0.016					1.00	0.01	-0.00	0.01	-0.01	-0.14	-0.01
K1	**-0.111729**	0.00071						1.00	-0.99	0.96	-0.92	0.00	0.02
K2	**0.126336**	0.0022							1.00	-0.99	0.96	-0.00	-0.01
K3	**-0.0571476**	0.003								1.00	-0.99	-0.00	0.01
K4	**0.0319898**	0.0015									1.00	0.00	-0.00
P1	**-8.67681e-07**	2.1e-05										1.00	-0.01
P2	**-1.50841e-05**	1.4e-05											1.00

Table 2. Calibration coefficients and correlation matrix.

Camera Calibration

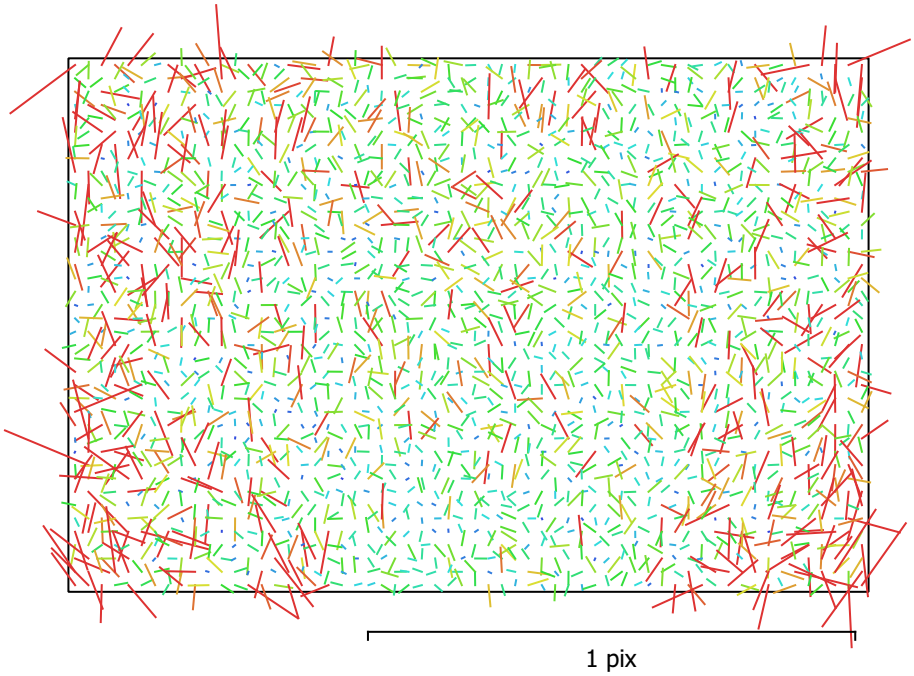


Fig. 3. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

64 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**3954.73**	0.64	1.00	0.09	-0.09	-0.32	-0.00	-0.98	0.96	-0.93	0.88	0.10	-0.09
Cx	**-17.899**	0.26		1.00	0.04	-0.02	-0.08	-0.10	0.11	-0.11	0.11	0.98	0.04
Cy	**-26.3257**	0.19			1.00	0.10	-0.08	0.08	-0.07	0.06	-0.05	0.03	0.97
B1	**-0.385089**	0.043				1.00	-0.01	0.31	-0.30	0.27	-0.22	-0.02	0.10
B2	**-0.269992**	0.027					1.00	-0.01	0.01	-0.01	0.00	-0.10	-0.10
K1	**-0.111529**	0.0014						1.00	-0.99	0.97	-0.93	-0.11	0.09
K2	**0.126044**	0.0043							1.00	-0.99	0.97	0.11	-0.08
K3	**-0.0573634**	0.0059								1.00	-0.99	-0.11	0.08
K4	**0.032395**	0.003									1.00	0.11	-0.07
P1	**-5.25418e-05**	3.8e-05										1.00	0.04
P2	**-4.48224e-05**	2.7e-05											1.00

Table 3. Calibration coefficients and correlation matrix.

Camera Calibration

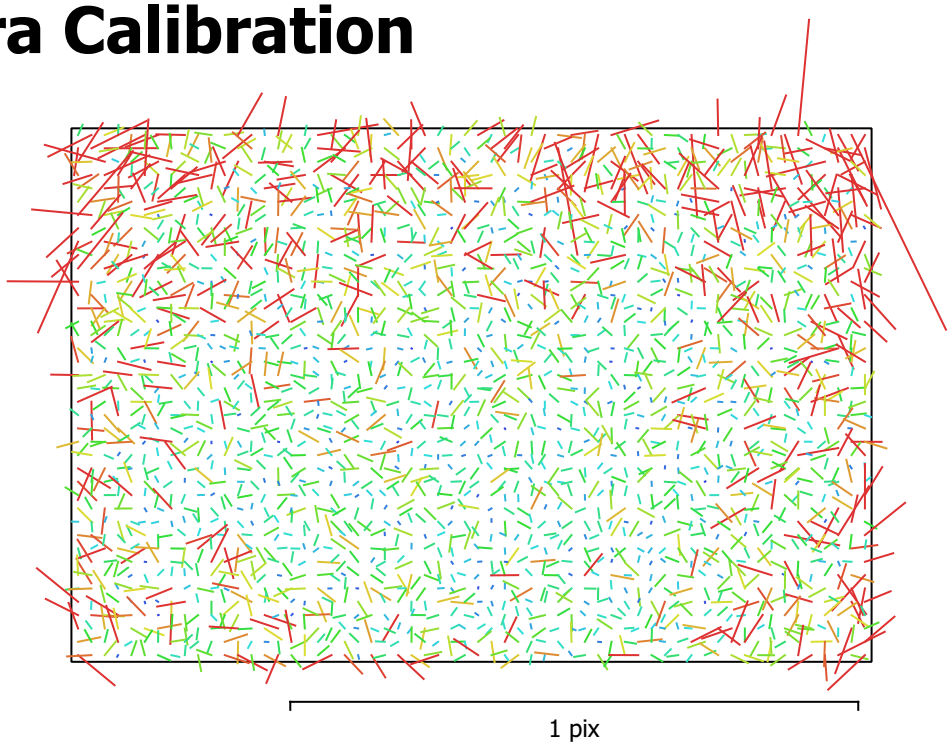


Fig. 4. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

102 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**4003.28**	0.66	1.00	-0.00	-0.04	-0.30	0.03	-0.99	0.97	-0.93	0.88	-0.00	-0.06
Cx	**-12.4279**	0.29		1.00	-0.00	0.02	-0.12	0.00	-0.01	0.01	-0.01	0.98	-0.02
Cy	**-34.2855**	0.2			1.00	0.11	-0.07	0.04	-0.03	0.03	-0.02	-0.00	0.95
B1	**-0.389466**	0.044				1.00	-0.02	0.31	-0.32	0.30	-0.27	0.01	0.13
B2	**-0.315163**	0.027					1.00	-0.02	0.01	-0.01	0.01	-0.14	-0.04
K1	**-0.111446**	0.0014						1.00	-0.99	0.97	-0.93	0.01	0.05
K2	**0.121569**	0.0043							1.00	-0.99	0.97	-0.01	-0.05
K3	**-0.0548998**	0.0057								1.00	-0.99	0.01	0.04
K4	**0.0309119**	0.0029									1.00	-0.01	-0.03
P1	**8.67699e-05**	3.9e-05										1.00	-0.02
P2	**3.82869e-05**	2.7e-05											1.00

Table 4. Calibration coefficients and correlation matrix.

Camera Calibration

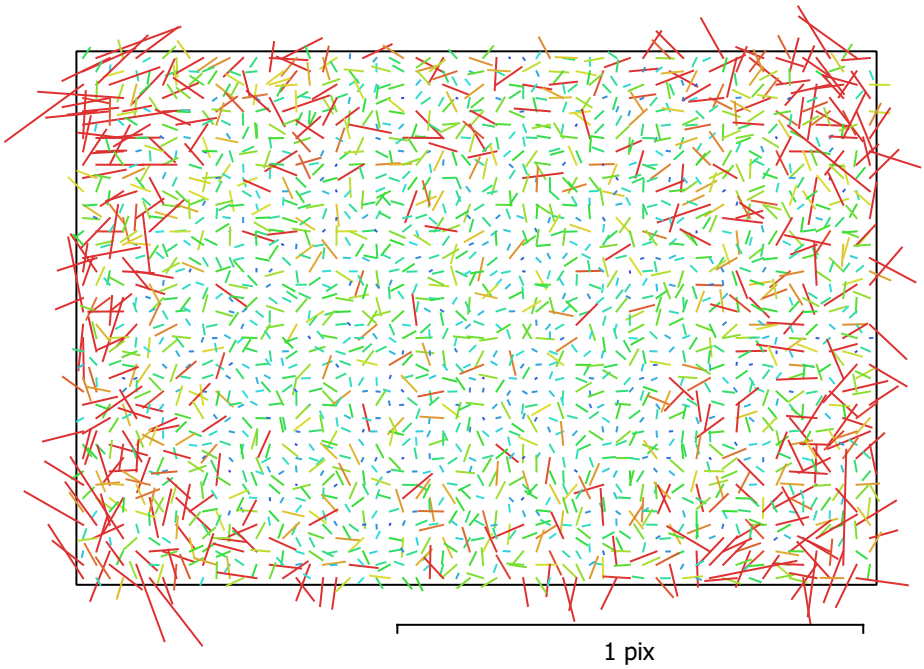


Fig. 5. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

104 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**4053.68**	0.98	1.00	0.00	-0.02	-0.30	0.00	-0.99	0.96	-0.92	0.86	0.01	-0.02
Cx	**-16.0266**	0.44		1.00	0.06	0.00	-0.06	-0.00	0.00	0.00	-0.00	0.98	0.06
Cy	**-32.4237**	0.33			1.00	0.00	-0.02	0.01	-0.01	0.01	-0.01	0.06	0.97
B1	**-0.501629**	0.065				1.00	0.01	0.32	-0.32	0.29	-0.25	0.00	0.03
B2	**-0.199946**	0.037					1.00	-0.01	0.01	-0.02	0.02	-0.08	-0.01
K1	**-0.119597**	0.0021						1.00	-0.99	0.96	-0.92	-0.01	0.01
K2	**0.13926**	0.0068							1.00	-0.99	0.96	0.01	-0.01
K3	**-0.0741944**	0.0095								1.00	-0.99	-0.00	0.01
K4	**0.0368846**	0.005									1.00	0.00	-0.02
P1	**-0.000362268**	5.8e-05										1.00	0.07
P2	**1.64837e-05**	4.4e-05											1.00

Table 5. Calibration coefficients and correlation matrix.

Scale Bars

Label	Distance (m)	Error (m)
target 68_target 69	0.249728	1.79828e-05
target 69_target 70	0.249836	2.62112e-05
target 36_target 37	0.249916	-8.39711e-05
Total		**5.18381e-05**

Table 6. Control scale bars.

Digital Elevation Model

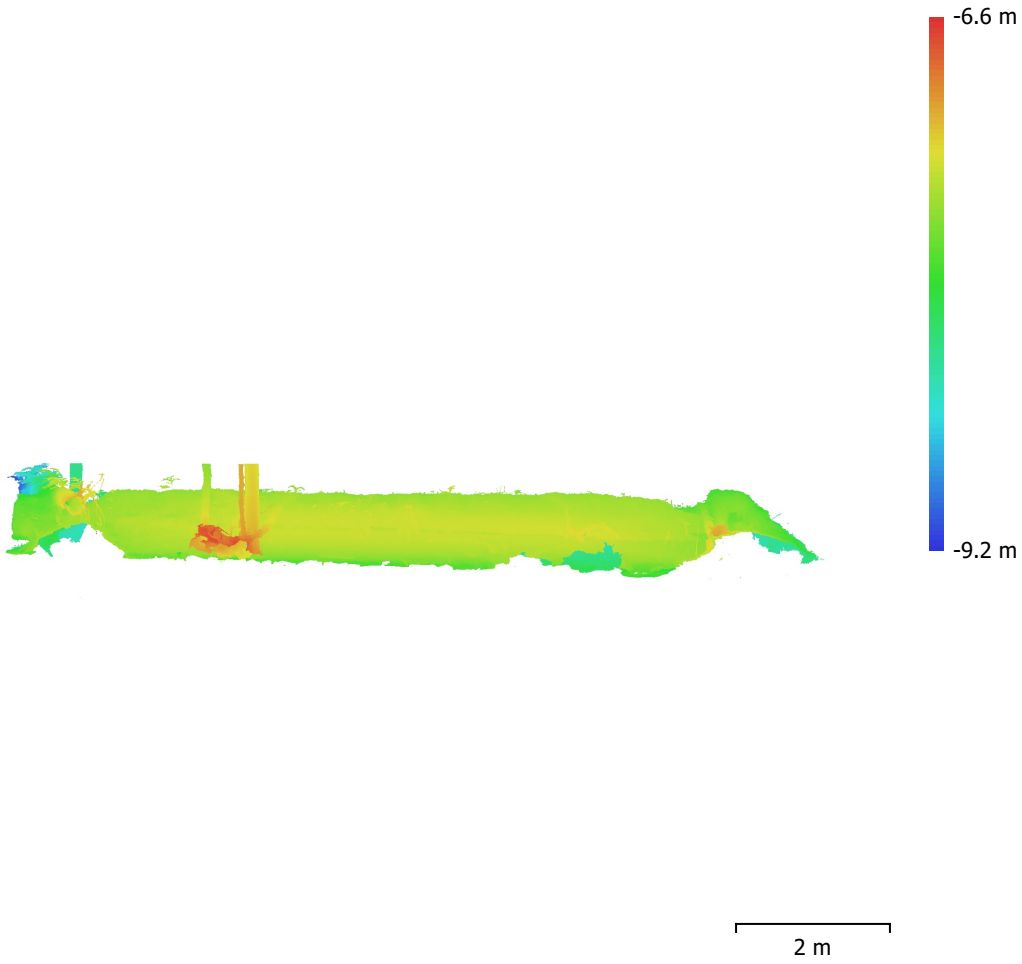


Fig. 6. Reconstructed digital elevation model.

Resolution:	2.01 mm/pix
Point density:	24.8 points/cm²

Processing Parameters

General	
Cameras	647
Aligned cameras	643
Markers	5
Scale bars	3
Tie Points	
Points	197,952 of 1,017,621
RMS reprojection error	0.0820537 (0.165292 pix)
Max reprojection error	0.391451 (0.478992 pix)
Mean key point size	2.4252 pix
Point colors	3 bands, uint8
Key points	3.07 GB
Average tie point multiplicity	2.45237
Alignment parameters	
Accuracy	Highest
Generic preselection	No
Reference preselection	No
Key point limit	60,000
Key point limit per Mpx	60,000
Tie point limit	60,000
Exclude stationary tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	2 hours 39 minutes
Matching memory usage	8.63 GB
Alignment time	1 minutes 40 seconds
Alignment memory usage	188.47 MB
Optimization parameters	
Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Fit additional corrections	Yes
Adaptive camera model fitting	No
Optimization time	15 seconds
Date created	2024:05:17 02:24:45
Software version	2.1.0.17532
File size	55.14 MB
Depth Maps	
Count	599
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 15 minutes
Memory usage	7.62 GB
Date created	2024:05:19 00:38:30
Software version	2.1.0.17532
File size	11.95 GB
Model	
Faces	6,078,723
Vertices	3,075,048
Vertex colors	3 bands, uint8

Texture	8,192 x 8,192, 3 bands, uint8
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	2 hours 15 minutes
Memory usage	7.62 GB
Reconstruction parameters	
Surface type	Arbitrary
Source data	Depth maps
Interpolation	Enabled
Strict volumetric masks	No
Processing time	2 hours 0 minutes
Memory usage	14.62 GB
Texturing parameters	
Mapping mode	Generic
UV mapping time	4 minutes 13 seconds
UV mapping memory usage	1.11 GB
Date created	2024:05:19 02:38:03
Software version	2.1.0.17532
File size	349.04 MB
System	
Software name	Agisoft Metashape Standard
Software version	2.1.0 build 17532
OS	Windows 64 bit
RAM	31.67 GB
CPU	12th Gen Intel(R) Core(TM) i7-12800H
GPU(s)	NVIDIA RTX A2000 8GB Laptop GPU

Historic Kasaan Canoe Photogrammetry Report

Processing Report

08 May 2025

Survey Data

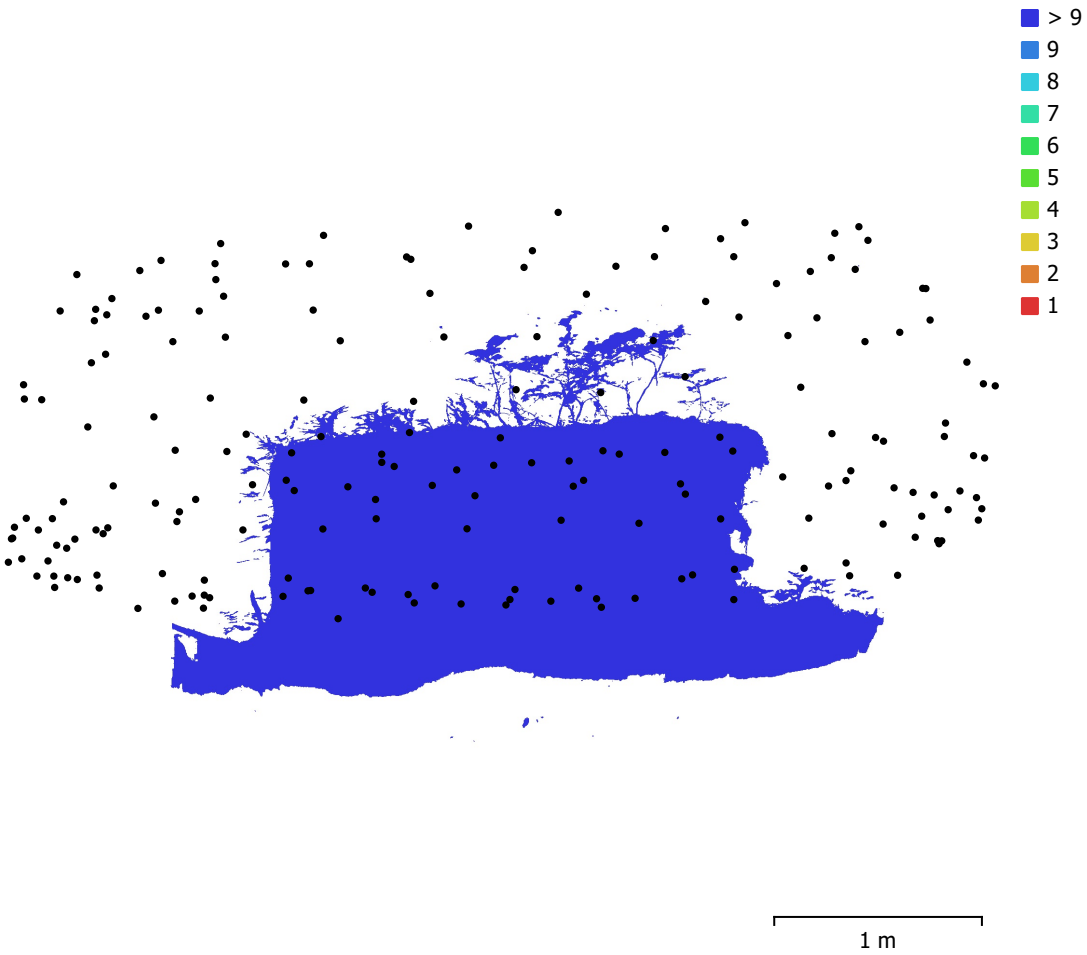


Fig. 1. Camera locations and image overlap.

Number of images:	198	Camera stations:	198
Flying altitude:	1.23 m	Tie points:	90,033
Ground resolution:	0.31 mm/pix	Projections:	220,258
Coverage area:	3.39 m²	Reprojection error:	0.157 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No

Table 1. Cameras.

Camera Calibration

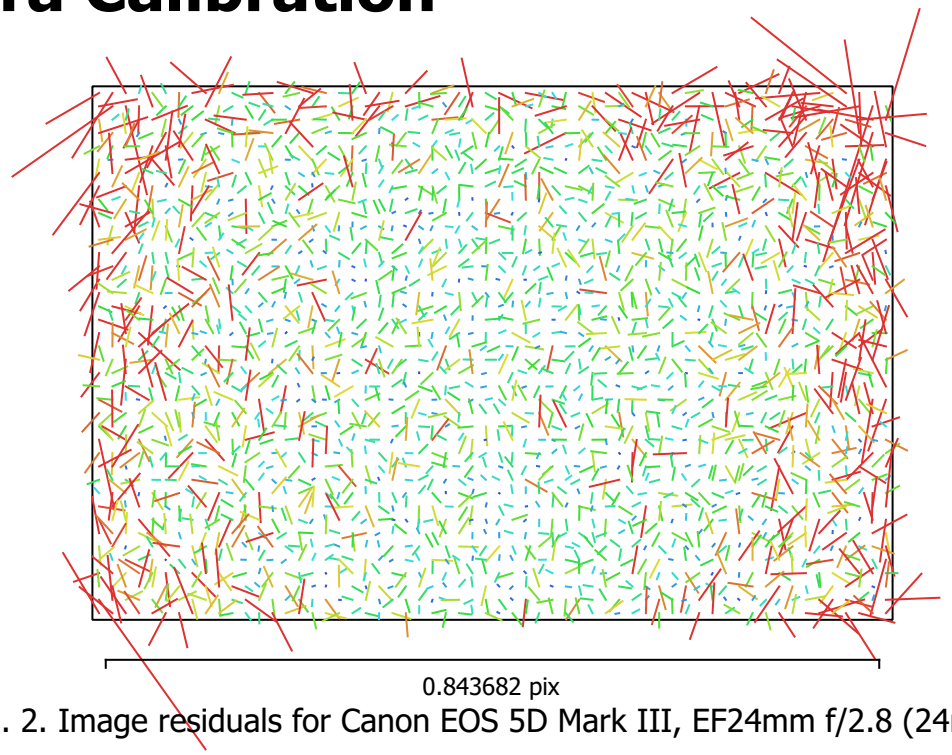


Fig. 2. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

198 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**3962.92**	0.35	1.00	0.02	-0.05	-0.36	-0.00	-0.98	0.96	-0.92	0.87	0.03	-0.06
Cx	**-18.1037**	0.15		1.00	0.06	0.02	-0.09	-0.03	0.04	-0.04	0.05	0.97	0.06
Cy	**-33.4736**	0.12			1.00	0.06	-0.04	0.04	-0.03	0.03	-0.02	0.06	0.94
B1	**-0.127505**	0.026				1.00	-0.02	0.34	-0.33	0.28	-0.23	0.02	0.09
B2	**-0.260244**	0.016					1.00	0.01	-0.01	0.02	-0.02	-0.12	-0.04
K1	**-0.108126**	0.00076						1.00	-0.99	0.96	-0.92	-0.04	0.06
K2	**0.113928**	0.0024							1.00	-0.99	0.96	0.04	-0.05
K3	**-0.0426131**	0.0034								1.00	-0.99	-0.05	0.05
K4	**0.0245367**	0.0017									1.00	0.05	-0.04
P1	**4.61447e-05**	2.1e-05										1.00	0.06
P2	**9.61343e-05**	1.5e-05											1.00

Table 2. Calibration coefficients and correlation matrix.

Scale Bars

Label	Distance (m)	Error (m)
target 68_target 69	0.249745	3.53026e-05
target 69_target 70	0.249879	6.90783e-05
target 37_target 38	0.250153	-6.71575e-05
target 36_target 37	0.249953	-4.6935e-05
Total		**5.64161e-05**

Table 3. Control scale bars.

Digital Elevation Model

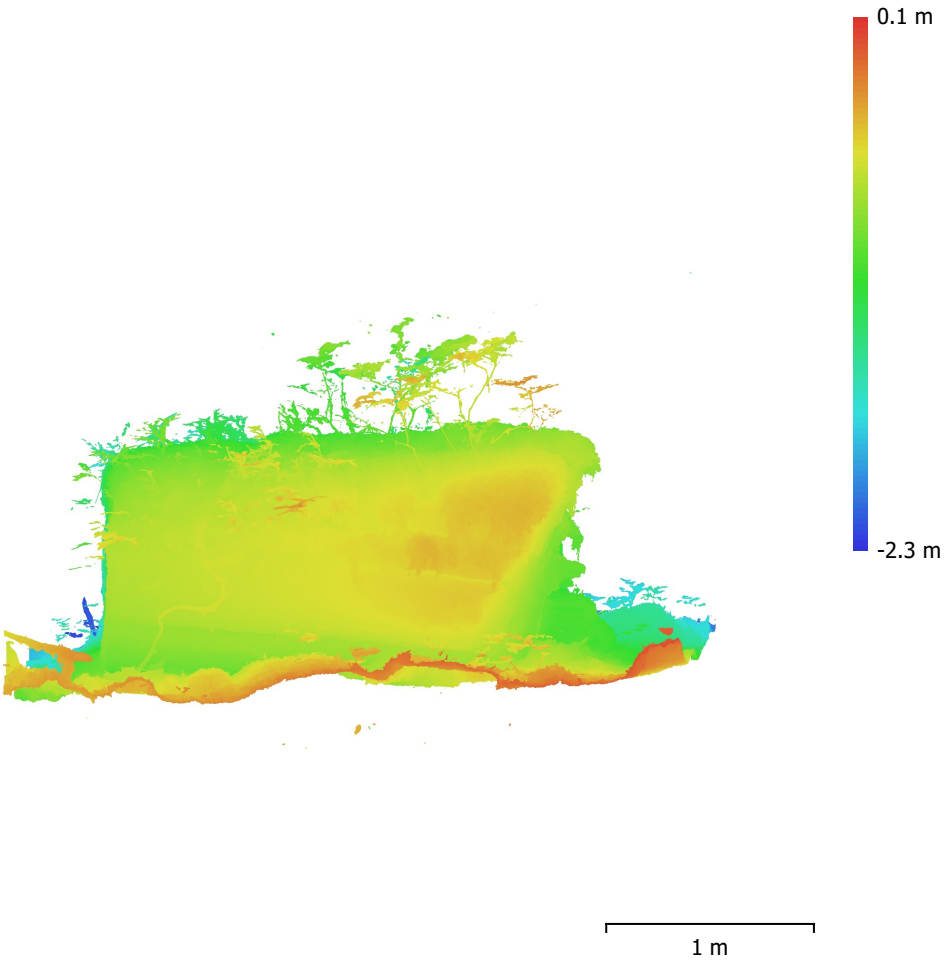


Fig. 3. Reconstructed digital elevation model.

Resolution:	5.13 mm/pix
Point density:	3.81 points/cm²

Processing Parameters

General	
Cameras	198
Aligned cameras	198
Markers	6
Scale bars	4
Tie Points	
Points	90,033 of 464,420
RMS reprojection error	0.066894 (0.157069 pix)
Max reprojection error	0.195107 (0.403014 pix)
Mean key point size	2.46323 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.62895
Alignment parameters	
Accuracy	High
Generic preselection	No
Reference preselection	No
Key point limit	60,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	1 hours 9 minutes
Matching memory usage	2.66 GB
Alignment time	1 minutes 0 seconds
Alignment memory usage	280.58 MB
Optimization parameters	
Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Fit additional corrections	Yes
Adaptive camera model fitting	No
Optimization time	4 seconds
Date created	2024:05:22 22:04:50
Software version	2.1.0.17532
File size	22.05 MB
Depth Maps	
Count	177
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	33 minutes 45 seconds
Memory usage	7.75 GB
Date created	2024:06:24 17:45:00
Software version	2.1.0.17532
File size	3.40 GB
Model	
Faces	1,499,999
Vertices	753,954
Vertex colors	3 bands, uint8

Depth maps generation parameters

Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	33 minutes 45 seconds
Memory usage	7.75 GB

Reconstruction parameters

Surface type	Arbitrary
Source data	Depth maps
Interpolation	Enabled
Strict volumetric masks	No
Processing time	33 minutes 57 seconds
Memory usage	16.18 GB
Date created	2024:06:24 18:16:03
Software version	2.1.0.17532
File size	32.26 MB

System

Software name	Agisoft Metashape Standard
Software version	2.1.0 build 17532
OS	Windows 64 bit
RAM	31.67 GB
CPU	12th Gen Intel(R) Core(TM) i7-12800H
GPU(s)	NVIDIA RTX A2000 8GB Laptop GPU

Agisoft Metashape

Processing Report

21 June 2024

Survey Data

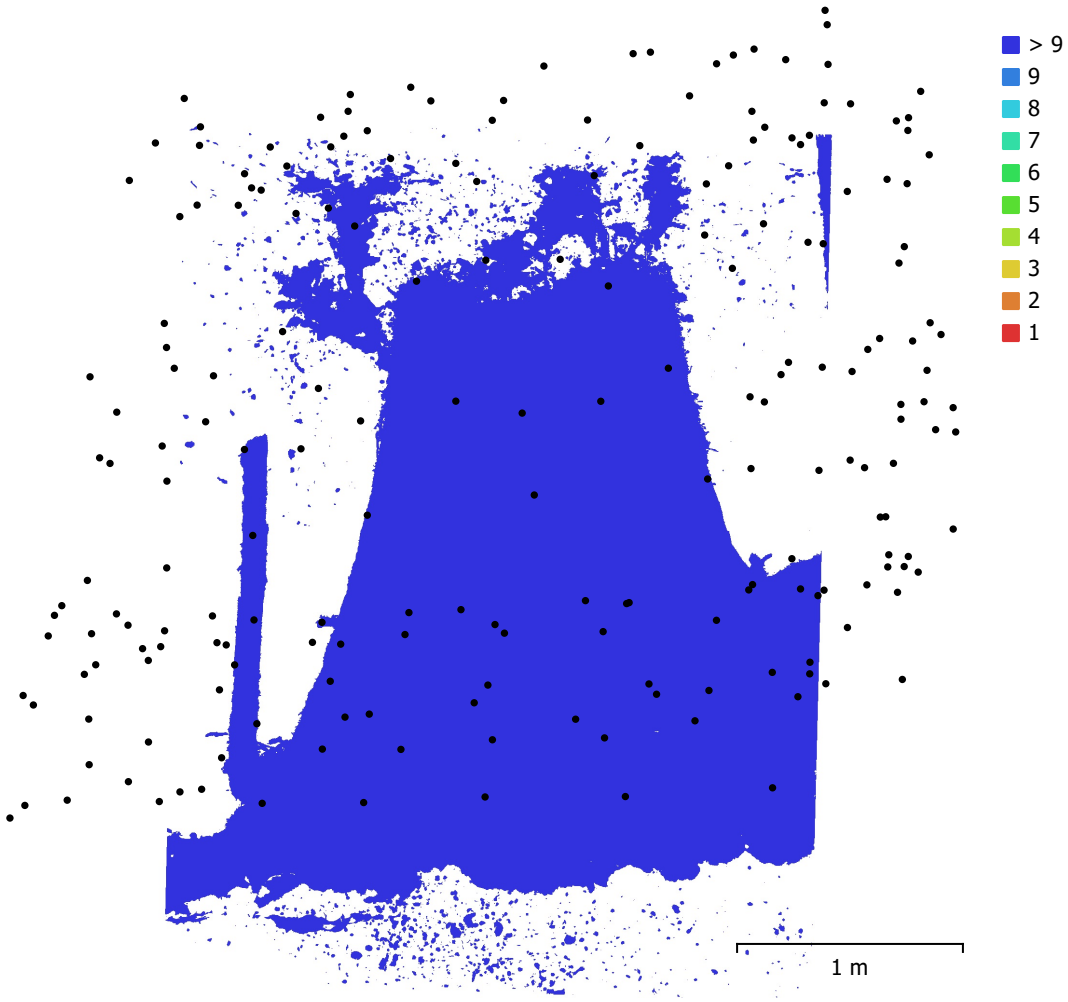


Fig. 1. Camera locations and image overlap.

Number of images:	208	Camera stations:	208
Flying altitude:	1.43 m	Tie points:	93,929
Ground resolution:	0.36 mm/pix	Projections:	225,891
Coverage area:	6.12 m²	Reprojection error:	0.144 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
Canon EOS 5D Mark III, E...	5760 x 3840	24 mm	6.25 x 6.25 µm	No

Table 1. Cameras.

Camera Calibration

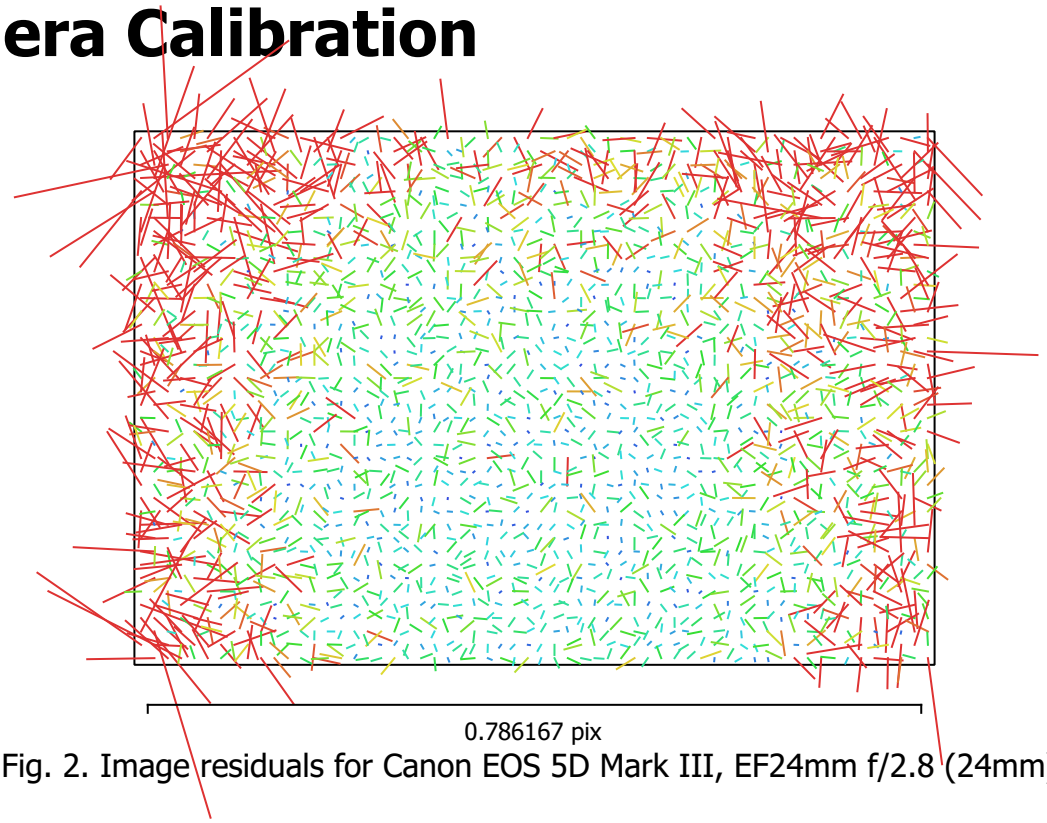


Fig. 2. Image residuals for Canon EOS 5D Mark III, EF24mm f/2.8 (24mm).

Canon EOS 5D Mark III, EF24mm f/2.8 (24mm)

208 images, additional corrections

Type	Resolution	Focal Length	Pixel Size
Frame	**5760 x 3840**	**24 mm**	**6.25 x 6.25 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	**3952.15**	0.36	1.00	0.05	-0.04	-0.35	-0.01	-0.98	0.96	-0.92	0.86	0.06	-0.06
Cx	**-18.0705**	0.16		1.00	0.02	-0.06	-0.12	-0.06	0.07	-0.08	0.09	0.98	0.02
Cy	**-25.3928**	0.12			1.00	0.06	-0.02	0.05	-0.05	0.06	-0.06	0.01	0.97
B1	**-0.423753**	0.03				1.00	-0.02	0.35	-0.34	0.30	-0.25	-0.05	0.10
B2	**-0.16429**	0.017					1.00	0.01	-0.01	0.01	-0.01	-0.15	-0.03
K1	**-0.108045**	0.00075						1.00	-0.99	0.96	-0.91	-0.06	0.06
K2	**0.113878**	0.0024							1.00	-0.99	0.96	0.07	-0.06
K3	**-0.0394092**	0.0032								1.00	-0.99	-0.08	0.06
K4	**0.0223683**	0.0016									1.00	0.09	-0.06
P1	**-3.71612e-05**	2.2e-05										1.00	0.01
P2	**-8.62794e-05**	1.7e-05											1.00

Table 2. Calibration coefficients and correlation matrix.

Scale Bars

Label	Distance (m)	Error (m)
target 68_target 70	0.499517	-3.41279e-06
target 36_target 37	0.24991	-8.98958e-05
target 23_target 24	0.250566	6.60651e-05
target 69_target 70	0.24983	1.96763e-05
Total		**5.66671e-05**

Table 3. Control scale bars.

Digital Elevation Model

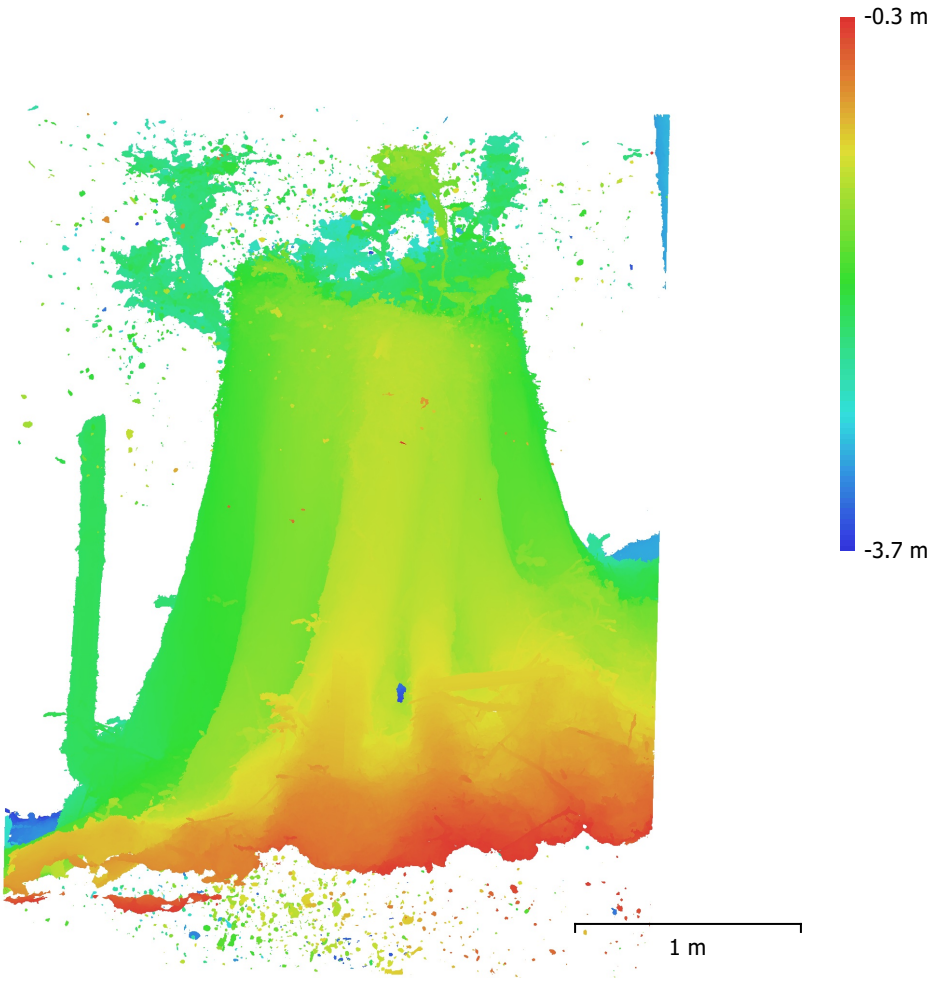


Fig. 3. Reconstructed digital elevation model.

Resolution:	0.36 mm/pix
Point density:	7.73 points/mm²

Processing Parameters

General	
Cameras	208
Aligned cameras	208
Markers	7
Scale bars	4
Tie Points	
Points	93,929 of 396,008
RMS reprojection error	0.0808567 (0.143605 pix)
Max reprojection error	0.340647 (0.378147 pix)
Mean key point size	1.90946 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.69776
Alignment parameters	
Accuracy	Highest
Generic preselection	No
Reference preselection	No
Key point limit	60,000
Key point limit per Mpx	1,000
Tie point limit	25,000
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	1 hours 18 minutes
Matching memory usage	2.45 GB
Alignment time	57 seconds
Alignment memory usage	263.04 MB
Optimization parameters	
Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Fit additional corrections	Yes
Adaptive camera model fitting	No
Optimization time	5 seconds
Date created	2024:05:19 00:30:59
Software version	2.1.0.17532
File size	19.61 MB
Depth Maps	
Count	199
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	40 minutes 6 seconds
Memory usage	8.54 GB
Date created	2024:06:20 14:38:34
Software version	2.1.0.17532
File size	3.47 GB
Point Cloud	
Points	269,528,969
Point attributes	
Color	3 bands, uint8

Normal	
Confidence	1 - 40
Point classes	
Created (never classified)	269,528,969
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	40 minutes 6 seconds
Memory usage	8.54 GB
Point cloud generation parameters	
Processing time	1 hours 57 minutes
Memory usage	26.56 GB
Date created	2024:06:20 16:36:19
Software version	2.1.0.17532
File size	3.77 GB
Model	
Faces	330,559,497
Vertices	165,629,110
Vertex colors	3 bands, uint8
Texture	8,192 x 8,192, 4 bands, uint8
Depth maps generation parameters	
Quality	Ultra High
Filtering mode	Mild
Max neighbors	16
Processing time	40 minutes 6 seconds
Memory usage	8.54 GB
Point cloud generation parameters	
Processing time	1 hours 57 minutes
Memory usage	26.56 GB
Reconstruction parameters	
Surface type	Arbitrary
Source data	Point cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	2 hours 16 minutes
Memory usage	26.79 GB
Texturing parameters	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	8,192
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	16 minutes 54 seconds
UV mapping memory usage	19.16 GB
Blending time	21 hours 14 minutes
Blending memory usage	13.72 GB
Date created	2024:06:20 18:35:01
Software version	2.1.0.17532
File size	12.54 GB
System	
Software name	Agisoft Metashape Standard
Software version	2.1.0 build 17532
OS	Windows 64 bit
RAM	31.67 GB
CPU	12th Gen Intel(R) Core(TM) i7-12800H

GPU(s)	NVIDIA RTX A2000 8GB Laptop GPU