HO-037 Two-staff water-level and offset-transfer kit

Compare two support heights and transfer a known low-level mark by measuring offsets from a shared, visible water plane, even when a direct sight line between the two stations is blocked.

Two held staffs and one continuous tube form one nonpowered cold-water height-comparison kit. It creates a temporary common water plane, not a certified elevation, building permit, drainage design or replacement for required construction-survey control. No drinking-water use, mouth suction, pressure connection or standing/climbing on a staff.

US inches/feet control; metric figures are references. Original unbuilt instructional design; no field accuracy, soil stability, load or physical fabrication trial has been performed.

Before cutting

Read the four plates. Receive the actual cold-water-compatible tubing before drilling the guides.

Both end supports are hand held by two adults. There is no freestanding base or claim that a staff will remain upright unattended.

Use plain water at uniform ordinary temperature. Any scale/reading threshold is a practice acceptance condition, not a survey certification.

Materials and actual cuts

Part	Qty	Actual size	Material and special cut
A Straight reference staff	2	60 x 2 1/2 x 3/4 in 1524.00 x 63.50 x 19.05 mm	Straight, sound dry wood, with listed ACTUAL dimensions. Reject splits and twist. Ordinary finished cuts within 1/32 in (0.79 mm); dimensions are not nominal lumber labels. Nominal 1 x 3. Sole is square and flat; the 60 in dimension runs vertically in use. Mark measurements from this actual sole, not from the end of a glued-on tape.
B Open-bore tube guide block	8	1 1/2 x 1 1/4 x 1 in 38.10 x 31.75 x 25.40 mm	Straight, sound dry wood, with listed ACTUAL dimensions. Reject splits and twist. Ordinary finished cuts within 1/32 in (0.79 mm); dimensions are not nominal lumber labels. Actual X1 1/2, Y 1 1/4, Z 1 in; cut from sound straight-grained hardwood. Drill 5/8 in vertically through Z at local X3/4, Y 5/8. Two separate#8 screw axes through Y at local X1/4 and 1 1/4, Z 1/2.
T Continuous transparent tube	1	600 x 1/2 x 1/16 in 15240.00 x 12.70 x 1.59 mm	New clear flexible tube labeled by its maker for plain cold-water service; nominal 3/8 in ID x 1/2 in OD. Received OD .485..515 in and clear round ID .360..390 in. No unknown salvaged hose. 50 ft retained; width is nominal OD and thickness is wall, not square stock. Do not splice. All installed bends must meet the actual maker minimum and be at least 6 in radius in this original routing example.
S Soft removable retaining strap	4	12 x 1/2 x 1/16 in 304.80 x 12.70 x 1.59 mm	Nonabrasive hook-and-loop strap, 1/2 in wide, about 12 in usable length. Thickness is a maximum stock envelope, not a shim. Two per staff, around the staff and tube at Z12 and 48. At least 2 in overlap, no metal teeth or pinched bore. Actual static retention and free communication are checked, not assumed from strap length.

Hardware and tools

16 x Stainless flat-head #8 wood screw, 1 3/4 in OVERALL, length within 1/32 in, major <= .164 in, head OD <= 5/16 in. Two per B guide, from its front toward the staff. No loose washers, nuts or exposed rear tips.

1 x Small open funnel, spout OD<.360 in. Temporary filling tool only; neither end is capped during readings. No hose-thread or pressurized connection.

1 x Clean plain room-temperature water, have 2 US qt available plus a catch basin. Actual fill is determined by the visible menisci, not a recipe or a preset 2 qt charge. Drain after use.

2 x Two fractional-inch rules or checked 60 in measuring tapes. Compare with an independent steel rule before marking the staff. Printed page scaling is not a measurement reference.

Saw and backed drill, square, fractional-inch rule, clamps, matching countersink, depth stop and sandpaper. Additional field tools are named in the method. Wear protection appropriate to the actual tool and stock.

Measured assembly reference

ONE representative staff: X across 2 1/2 in width, Y outward from A front, Z up from its sole. Four B guide-block positions are full blocks BEFORE the vertical 5/8 in bore is removed. T is circular flexible tubing, not a rectangular solid. Duplicate this staff for the complete kit.

This table locates one representative station or staff in its own local coordinates. Repeated units and field positions are identified on the plates; quantities in the cut list cover the complete kit.

Part / instance	Origin x, y, z	Size dx, dy, dz / rotation
A / 1	0, -3/4, 0 in 0.00, -19.05, 0.00 mm	2 1/2 x 3/4 x 60 in
B / 1	1/2, 0, 7 1/2 in 12.70, 0.00, 190.50 mm	1 1/2 x 1 1/4 x 1 in
B / 2	1/2, 0, 23 1/2 in 12.70, 0.00, 596.90 mm	1 1/2 x 1 1/4 x 1 in
B / 3	1/2, 0, 39 1/2 in 12.70, 0.00, 1003.30 mm	1 1/2 x 1 1/4 x 1 in
B / 4	1/2, 0, 51 1/2 in 12.70, 0.00, 1308.10 mm	1 1/2 x 1 1/4 x 1 in

Numbered assembly

01. Receive one continuous 50 ft transparent tube and its material/cold-water instructions. Measure uncompressed ID/OD at accessible ends: this design accepts OD .485..515 in, ID .360..390 in. Reject cloudy, oval, cut or contaminated tube. Keep the bought bore uninterrupted: no joints, glass endpieces, one-way valve or tap connection are added.

02. Cut two A staffs 60 x 2 1/2 x 3/4 in from straight nominal 1 x 3 stock. One 96 in board yields one staff; buy two. Square the soles and identify their contact edges as A and B. Reject a bowed face that prevents a vertical rule comparison; smooth handling edges without rounding a sole.

03. Cut eight guide blanks with actual X1 1/2, Y 1 1/4, Z 1 in. Start with hardwood already at least 1 1/2 x 1 1/4 in section and at least 12 in long; eight 1 in crosscuts plus eight 1/8 in kerfs and 1/4 in end trim need 9 1/4 in. Record the actual section. Do not substitute a nominal 1 x 2 board, which is too thin for this block.

04. On each B top mark its vertical tube bore at X3/4, Y 5/8 in. Drill 5/8 in through the 1 in Z height over backing, with its axis square within 1/4 degree. Receive bore diameter .625..640625 in and center within 1/64 in. Remove splinters and lightly ease only the two bore lips; never make sharp contact edges that can nick the tube.

05. Mark B screw centers on its FRONT face at local X1/4 and 1 1/4 in, Z 1/2. Drill 3/16 in clearance through its 1 1/4 in Y depth and countersink for the actual flat head. Do not drill on the central tube-bore axis. The two screw axes lie 1/2 in to either side of that bore center; their complete shanks must remain outside it.

06. Lay one A front upward. Use localX across its 2 1/2 in width, Y outward from its front, Z up from the sole. Center four B blocks at global X1 1/4, Z 8, 24, 40, 52 in; each block spans X1/2..2, Y 0..1 1/4, Zcenter-1/2..center+1/2. Mark its two screw positions on A at X3/4 and 1 3/4, at the block center height. Repeat on the second staff.

07. Clamp B in position to transfer the centers, then remove B. Drill 1/8 in receiving pilots into A, 5/8 in FULL cylindrical depth from its front; receive bit-point length <= .040 in and depth within 1/64 in. Deepest point is .680625 in, leaving at least .038125 in in the received minimum .71875 in staff. Drill the bare staff rather than forcing a short bit through the guide.

08. Refit each B with two 1 3/4 in screws, all 16 total. Seat heads flush; do not crush B. Worst screw entry is 1.78125-1.21875 = .5625 in, leaving at least 5/32 in at the minimum .71875 in staff. Witness each joint. Check with a light and a scrap tube that no metal edge enters any 5/8 in bore.

09. Lay the two completed staffs side by side on equal-height, firm sole contacts. The flat front faces should be in the same plane. Check each with a reliable level in two directions. Mark a continuous central reference line at

X1 1/4 in and small staff-scale ticks every 1/8 in between Z20 and 48, using the same independent rule. Label whole inches large enough to read; verify 12 in against a second rule.

10. Pass one T end upward through the four bores of one staff, starting at the 8 in guide; do not pull a kink through a bore. Position its open mouth at Z56 in, 4 in above the 52 in guide. Repeat with the other end on the second staff. Keep the unjoined 50 ft middle length on the ground in broad curves; the straight tube axis is X1 1/4, Y 5/8 on each staff.

11. Put one S strap at Z12 and another at 48 on each staff, with its closure on the back/side of the wood. Wrap the tube and staff gently enough that the clear bore stays round, with at least 2 in overlap. The four bored blocks locate the tube; the broad straps restrain its slow static slip. Receive that restraint by actual handling checks: recheck the 56 in end marks after each move. No quantified friction or holding-force rating is inferred.

12. Use two adults and keep the staffs upright, side by side. Arrange the entire lower tube below the intended menisci, in broad unpinched curves with no raised loop, fold or point support. Protect it from feet and traffic. Place the catch basin where accidental water can be collected. Keep both mouths fully open to room air.

13. With the funnel held loosely at one mouth, pour clean plain room-temperature water slowly while the other person watches the opposite end. Stop while both menisci are around 36 in from their soles and ALWAYS below 48 in. The 2 US qt supply is not the fill amount. Inspect the entire wetted length for bubbles; gently raise a low section toward an open end to move a bubble out, maintaining broad bends. If a bubble cannot be removed, drain and restart. No mouth suction, blowing, caps or pressure are used.

14. Remove the funnel and let the water settle. Read the BOTTOM of each concave meniscus at eye level, with the staff upright and both mouths open. The actual bottom and at least 1/4 in of tube immediately above and below it must be plainly visible in front view. A B wood guide or S strap is opaque: never read through one or guess a hidden level. Side-by-side on equal-height contacts, the readings should agree within 1/8 in for this original practice criterion. Lift and replace each staff on its same contact, then repeat. This repeatability criterion is not a certified accuracy specification. Correct bubbles, slip, sole dirt or scale errors before field comparisons.

15. For a comparison place one sole on each of two firm support points, with a helper holding each staff upright. This example permits at most 25 ft horizontal separation and 12 in difference between support heights, subject to the actual tube remaining low, unstrained and visible. Keep each actual meniscus between 20 and 48 in and at least 8 in below its 56 in mouth. The 20..48 in envelope is not one continuously visible scale: B guides cover 23 1/2..24 1/2 in and 39 1/2..40 1/2 in, while a nominal 1/2 in S strap centered 48 in covers 47 3/4..48 1/4 in. Preserve the 1/4 in visible margin from each actual obstruction edge at BOTH staffs. If either meniscus is obscured, return both staffs to the same level starting contacts, adjust water by a slow open-end refill or controlled drain, then repeat bubble removal, settling and equal-height checks. Return to the field contacts and read BOTH menisci and ALL reference offsets anew; do not reuse a reading taken before the fill changed. Reduce span or choose different support points if these conditions cannot all be met.

16. Read hA and hB from each staff sole SIMULTANEOUSLY after settling, and record them. The support-height difference is elevationB-elevationA = hA-hB. Example: hA = 37 1/4 in, hB = 33 1/2 in means supportB is 3 3/4 in HIGHER than supportA. Do not subtract in the reverse order or compare readings taken before and after moving a staff.

17. To transfer an existing low-level reference mark R, hold staffA beside it. Measure signed offset a from R UP to the settled water plane: positive when the water is above R, negative when below. At stationB mark the SAME offset below its meniscus. Example: waterA is 2 1/4 in above R; mark 2 1/4 in BELOW waterB. If waterA is 1 1/2 in below R, mark 1 1/2 in ABOVE waterB. This offset method transfers R without trying to fill the hose to a particular graduation.

18. The reference operator continues watching A while the target mark is made. If its meniscus shifts, stop and read the new offset before marking B. Return both staffs to the original equal-height bench contacts after the field pair; repeat the side-by-side 1/8 in agreement check. Also reverse the staffs between the two field contacts and repeat the signed height calculation. Investigate a disagreement rather than averaging away an air bubble or slipping tube.

19. Before moving a staff, coordinate with the other person, keep both mouths above the liquid and protect the complete tube route from snags. Stop if a guide loosens, a strap pinches, the water approaches an end or a staff cannot be held plumb. This is an attended low-level method; it has no claim for hazardous slopes, work at height or a specified construction tolerance.

20. After use drain both ends into the catch basin, release the four straps and slide the tube out of the bores without dragging grit through them. Drain/rinse/dry the tube according to its maker instructions; store in broad loops. Dry the wood and inspect all 16 screws, bores, soles, scale marks and witnesses. Reassemble and repeat the equal-height checks before the next session.

Acceptance and intermediate checks

Complete kit: 2 staffs, 8 boredguides, 1 continuous 50 fttube, 4 softstraps and 16 guide screws; not two separate water-level projects.

Guide centers are 8/24/40/52 in from each sole; tube mouths 56 in. Full 5/8 in bores remain clear and free of metal.

Actual pilot, bit-point and screw-tip margins meet methods 7-8; drill the staff with its guide removed.

Received hose is round, unjoined and bubble-free throughout its wetted route; both ends are OPEN to the same atmosphere during all readings.

Actual menisci 20..48 in and at least 8 in below each mouth; both bottoms plus 1/4 in above/below are actually visible outside opaque B/S bands. After any refill/drain, repeat bubble/equal-height checks and take new simultaneous readings/offsets. Tube end marks do not slip and lower route stays below the water plane.

Equal-height return and reversal checks repeat within 1/8 in under the stated practice conditions. Readings are simultaneous and the height-difference sign agrees with the worked example.

Use and maintenance

Two held staffs and one continuous tube form one nonpowered cold-water height-comparison kit. It creates a temporary common water plane, not a certified elevation, building permit, drainage design or replacement for required construction-survey control. No drinking-water use, mouth suction, pressure connection or standing/climbing on a staff.

Drain/dry after each use and keep the tube dedicated to nonpotable measurement.

Replace damaged hose, straps, split guide blocks or unreadable scales; recheck the whole setup after replacement.

Measured interface notes

Metric references: 60 in = 1524 mm; 50 ft = 15.24 m; 25 ft = 7.62 m; 3/8 in ID = 9.525 mm; 1/2 in OD = 12.7 mm; 1/8 in = 3.175 mm. Received tolerances remain inch-controlled.

One staff is shown in the local assembly table; make both identically. A front Y0 and wood Y-3/4..0; tubeaxis Y5/8. Guide center X1 1/4, with screw X3/4 and 1 3/4.

For nominal 3/8 in ID, the full 600 in tube volume is 600*pi*(.375/2)^2 = 66.267970 in^3, about 1.086 L. This is a geometric capacity reference, not the actual fill: two dry 20 in upper legs at a 36 in meniscus reduce the nominal water-column length to 560 in. Actual bore, route and menisci determine the fill.

At equal liquid density and equal atmospheric pressure, connected stationary water surfaces provide a common horizontal plane. Uneven heating, bubbles, blocked ends, water loss and tube motion can invalidate a reading. There is no adopted FAO accuracy rating or completed field test.

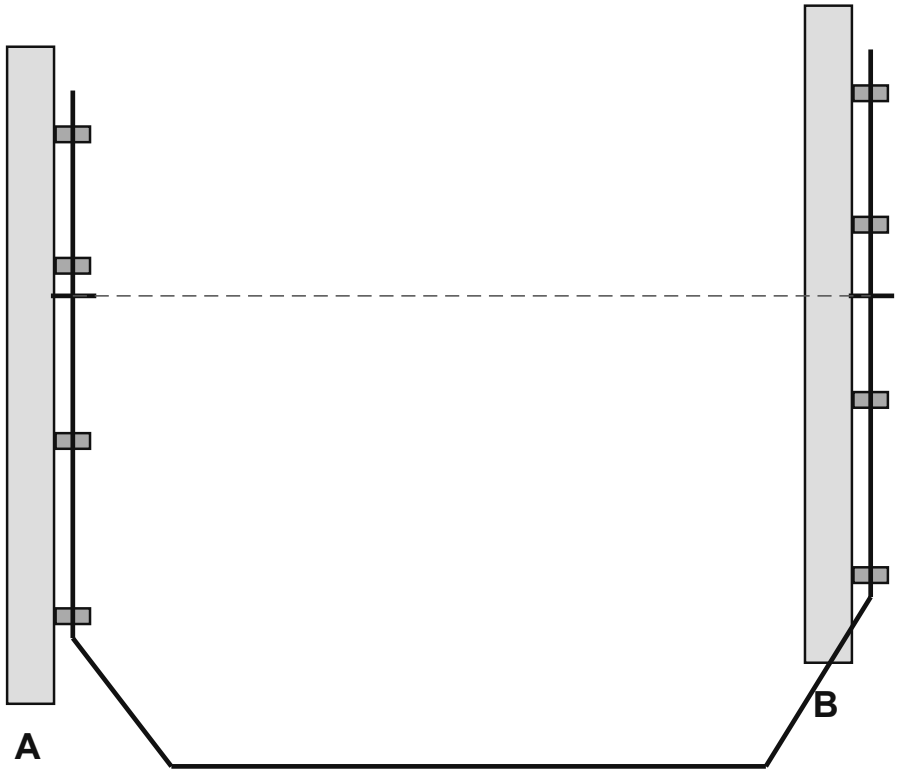
Staff scales are transferred from an independent checked rule, not from a printed full-scale template. If 1/8 in cannot be resolved consistently, record the larger actual uncertainty and use an appropriate instrument for the real job.

Primary context references

H2: FAO, Simple Methods for Aquaculture: Measuring Height Differences, section 5.3. Context only: a two-person flexible water tube compares heights using connected water columns open to the atmosphere. No published accuracy rating is transferred to this original kit. https://www.fao.org/fi/static-media/FI/CDrom/FAO_Training/FAO_Training/General/x6707e/x6707e05.htm

HO-037 | One water plane, two held staffs

Both ends OPEN; one continuous 50 ft tube. Staff height 60 in; mouths 56 in above their soles.



No raised hose loop above either meniscus.

No bubbles or pinched bore anywhere.

25 ft example span max.
Two adults hold vertical.

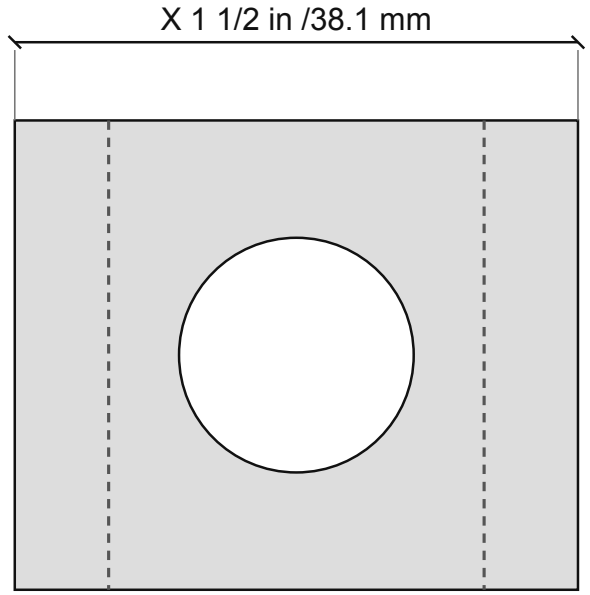
hA37 1/4; hB33 1/2
B is 3 3/4 in HIGHER.

Route is diagrammatic: keep the complete wetted hose below the water plane in broad 6 in-or-larger bends.

Original B/W measured drawing - not a full-scale template - unbuilt / untested

HO-037 | Bore and screw axes stay separate

One B block: X 1 1/2, Y 1 1/4, Z 1 in. Bore vertically through Z; screws travel through Y.





PLAN: X/Y. Borecenter(3/4, 5/8)in.

Screw axes X1/4 and 1 1/4 in; Z 1/2 in.

Bore 5/8 in, received .625..640625 in.

SIDE: A3/4 in; B1 1/4 in.

#8 x 1 3/4 in enters A about 1/2 in.

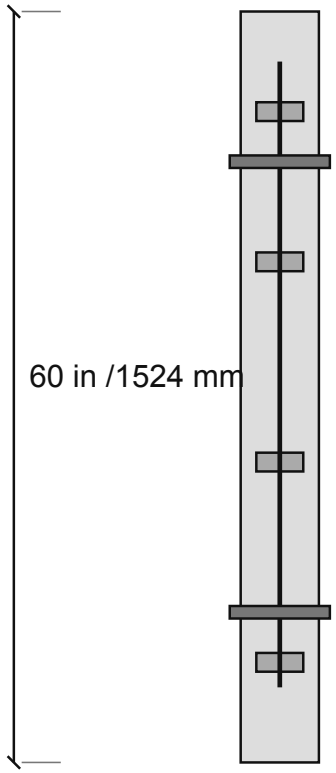
Guide removed for A pilot 5/8 in.

Two #8 screws per B, 16 total. Actual head OD <= 5/16 in; heads flush; no washer or nut in the bore.

Original B/W measured drawing - not a full-scale template - unbuilt / untested

HO-037 | Mark each staff from its actual sole

FRONT AND SIDE, one staff shown. Duplicate it; do not count the two staffs as separate projects.



Open mouth 56 in

Guide center 52 in

Soft strap 48 in

Guide center 40 in

Guide center 24 in

Soft strap 12 in

Guide center 8 in

Read 20..48 in only
where BOTH menisci
are actually visible.
Keep 1/4 in clear above
and below each bottom.

B bands: 23 1/2..24 1/2
and 39 1/2..40 1/2 in.
S at 48 is also opaque.
Refill/drain: restart checks.
Read new offsets.
Mouth clearance >= 8 in.

Screw axes on staff: X 3/4 and 1 3/4 in at each guide height. Guide blocks stand out 1 1/4 in from A front.

Original B/W measured drawing - not a full-scale template - unbuilt / untested

HO-037 | Difference, offset transfer and return check

Read simultaneously after settling; keep both ends open and each staff upright.

1 COMPARE SUPPORTS

hA37 1/4 in; hB33 1/2 in

B-A = hA-hB = +3 3/4 in

A positive result means B is higher.

2 TRANSFER A KNOWN MARK

Water at A is 2 1/4 in ABOVE R.

At B mark 2 1/4 in BELOW its water.

If water is below R, reverse the offset.

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3 WATCH THE REFERENCE

Reference operator keeps watching A.

If water moves, stop and read a new offset.

Do not use an old reading after moving a staff.

4 RETURN AND REVERSE

Bring soles to the same original bench.

Require side-by-side agreement within 1/8 in.

Reverse staffs on field contacts and repeat.

The 1/8 in criterion is an original practice repeatability check, not a certified survey accuracy.

Drain and dry after use. Keep scales, soles, tube mouths and all 16 fasteners inspectable.

Original B/W measured drawing - not a full-scale template - unbuilt / untested