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Appendix J. Using an Auto Level and Stadia Rod

A variety of leveling instruments can be used for laying out trail structures. The auto level (also referred to as a “dumpy level”) is one of the simplest, easy to use, and durable leveling instruments available. When used with a stadia rod, the auto level can be used over distances of several hundred feet with great accuracy.

When selecting a site to set up the auto level, choose a site that has: firm, stable ground; a clear view of what needs to be measured; is out of the way of construction and equipment; is higher than highest point being measured (so the view through the level scope is not beneath the location being measured); and is no higher than required to obtain all the elevation readings.

When the level’s tripod is erected, set the legs of the tripod firmly into the ground by stepping on the foot plates and pressing the metal points (“feet”) of the tripod into the ground. (See Figure J.1.) Note, if the ground is soft or spongy the elevation of the tripod legs may move when the person using the level steps close to one of the legs. Be sure the ground is firm and stable to prevent this problem. Adjust the height of the legs to level the base on which the level sits, as best as possible. The more level the tripod base is the easier it will be to level the auto level once it is attached to the tripod. Each leg of the tripod can be adjusted for length. Once in the correct position, the legs can be locked by a lever clamp or screw depending on the model.

The height of instrument must be low enough to allow the shortest person using the level to comfortably view through the scope but high enough to read all the required elevations.

Once the tripod is properly set up, attach the auto level to the tripod. (See Figure J.2.) The instrument’s base plate (“bottom plate”) is threaded to take the tripod screw. The tripod screw has a large head and is designed to be tightened and loosened by hand. Do not apply excessive force because it could damage the instrument’s base plate and the tripod’s head plate.

To level the instrument, align the telescope parallel to two of the three leveling screws. Look at the spherical (i.e., circular) level on the side of the auto level and locate the leveling bubble. (See Figures J2 and J3.) If the bubble is centered, the instrument is level over the axis of the two leveling screws. Usually the bubble will not be centered, but closer to one side indicating that side of the auto level is higher. To move the bubble to the center, turn the leveling screw on the lower side of the level clockwise to raise that side of the auto level while turning the leveling screw on the higher side of the level counter clockwise to lower that side of the auto level. Turn the leveling screws slowly while watching the bubble. Once the bubble is centered on this axis, it will be level in this direction. Note, do not over tighten these screws as it will make it difficult to make further leveling adjustments.

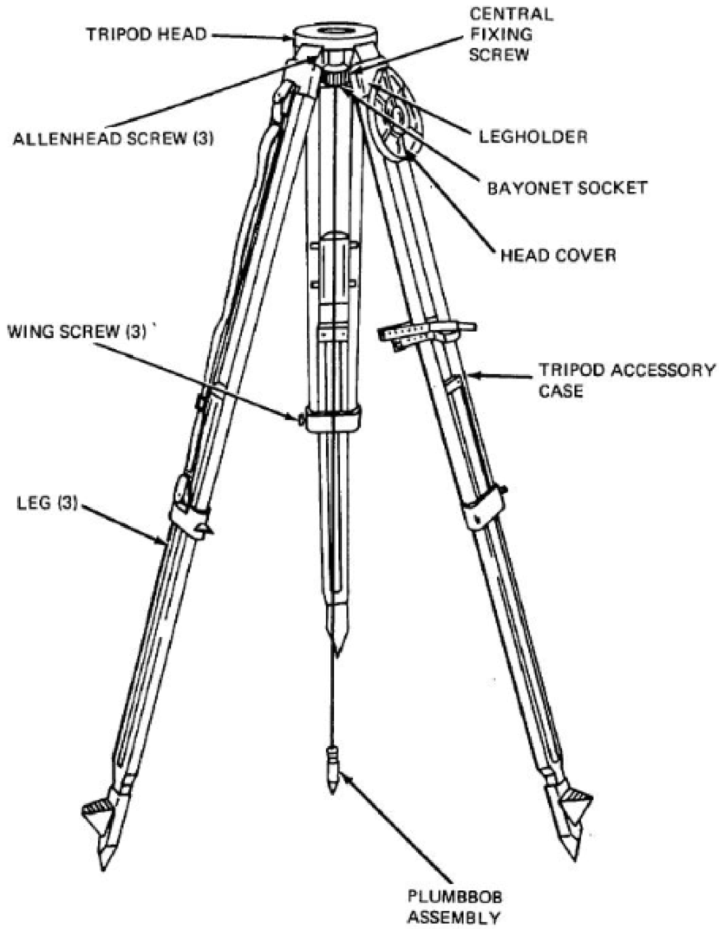

Figure J.1 – Illustration of a Tripod

At this point in the leveling process, the bubble will probably be against the side of the circular spirit level, because it is only level in one direction, and needs moving in to the center. The first two screws are level so they must not be touched. Using the left hand, adjust the third leveling screw to center the bubble. Raise or lower the leveling screw to draw the bubble into the center of the sphere. When the bubble is centered, the instrument should be level in all directions. To ensure the instrument is level in all directions, rotate the instrument through 90° turns. If necessary, re-level the original two leveling screws and repeat the rotation to check the third one. All leveling screws should be firmly tightened with finger pressure only. When training a crew, this point must be emphasized. Over-tightening any attachment or leveling screws can damage the screws, the instrument's base, or the tripod's head, rendering them unusable.

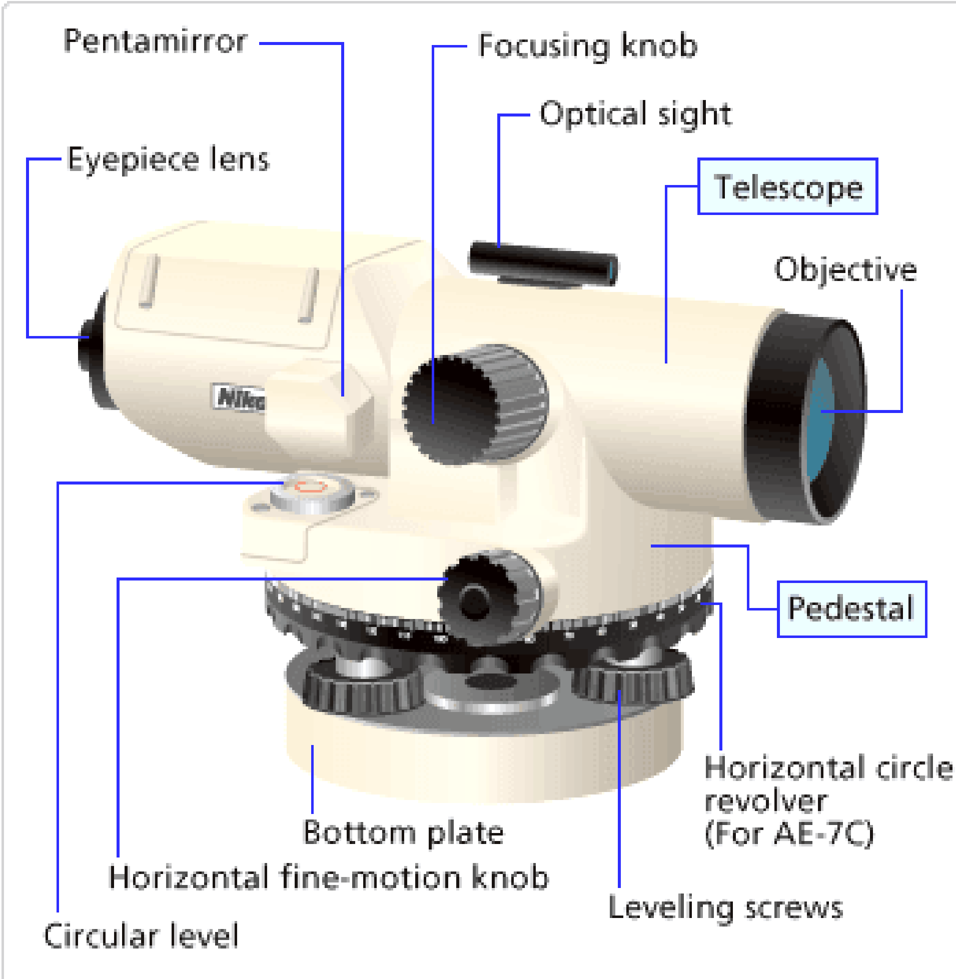

Figure J.2 – Illustration of an Auto Level

Once the instrument is leveled, turn the auto level in the direction of the stadia rod with one hand. Use the optical sight (i.e., "gun sight") on top of the auto level to line it up with the stadia rod. Once lined up with the stadia rod, use the horizontal fine motion knob to further line up the cross hairs in the auto level scope with the stadia rod. Use the focusing knob to obtain a clear view of the stadia rod and the cross hairs. It is important that the person sighting through or adjusting the auto level not touch or lean against the tripod. Also, keep feet away from the tripod's feet because even subtle pressure can cause the instrument to become out of level.

The person sighting through the instrument takes and records readings while another person moves the rod to various locations where elevation readings are needed. Stadia rods are telescopic, so it is important to make sure the rod is completely open and locked into place to avoid reading errors. It is critical that the readings are taken when the rod is vertical (plumb). If the rod is not vertical, the reading will be larger than it should be because the rod is being measured at an angle, which makes the rod appear to be higher than it is. Some rods are fitted with a spherical spirit level and handles to help the user keep it vertical. Even with a spirit level, it is difficult to hold a rod vertical, especially in wind.

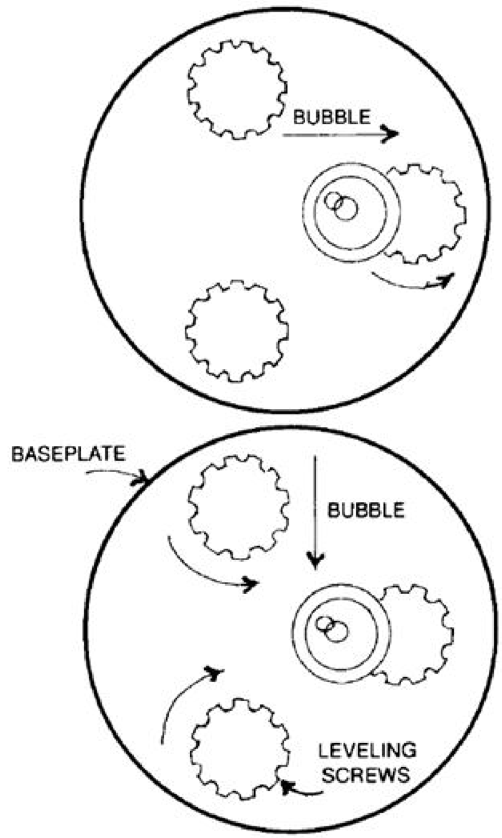

Figure J.3 – Illustration of Leveling Adjustment Screws

To ensure the rod is vertical, the surveyor uses the vertical reticle line (viewed through the scope) to direct the person with the rod to move the top of the rod to the left or right of the sight line until it lines up with the vertical reticule line. (See Figure J.4.) The person with the rod then slowly tilts the top of the rod toward and away from the instrument until a front to back vertical position can be obtained. As the rod is moved forward and back, note that the numbers move up and down in relation to the horizontal plan line. Look for the lowest reading on the rod at which point the rod is vertical.

Elevation measurements are taken by sighting through the auto level onto a stadia rod. When the eye piece is focused, a vertical and several horizontal lines can be seen dividing the field of view. The middle horizontal line marks the horizontal plane and is the reference point for all readings. (See Figure J.4.) The vertical reticle line is used to center and plumb the scope on the stadia rod. The top and bottom horizontal lines are used for determining linear elevations.

It is important to be able to accurately read the rod and understand what the different numbers mean, especially if taking a close shot where little of the rod is visible. (See Figure J.5.) Keep in mind that the rod is measuring the difference between the elevation of the level and the elevation of the ground at the rod location. A numerically larger reading indicates lower ground at the location of the rod (e.g., a reading of 4 feet is a lower elevation than a reading of 3 feet). Conversely, a numerically smaller reading indicates higher ground at the location of the rod (e.g., a reading of 2 feet is a higher elevation than a reading of 3 feet).

If the instrument gets moved, all readings must be taken again because the height of the auto level on which all previous measurements were based has been changed.

It is better to have more elevation readings than less and once the instrument is set up it only takes a few seconds to take each measurement. The more complete the picture of the abutment footprint, the easier it is to plan and control the excavation of the abutments.

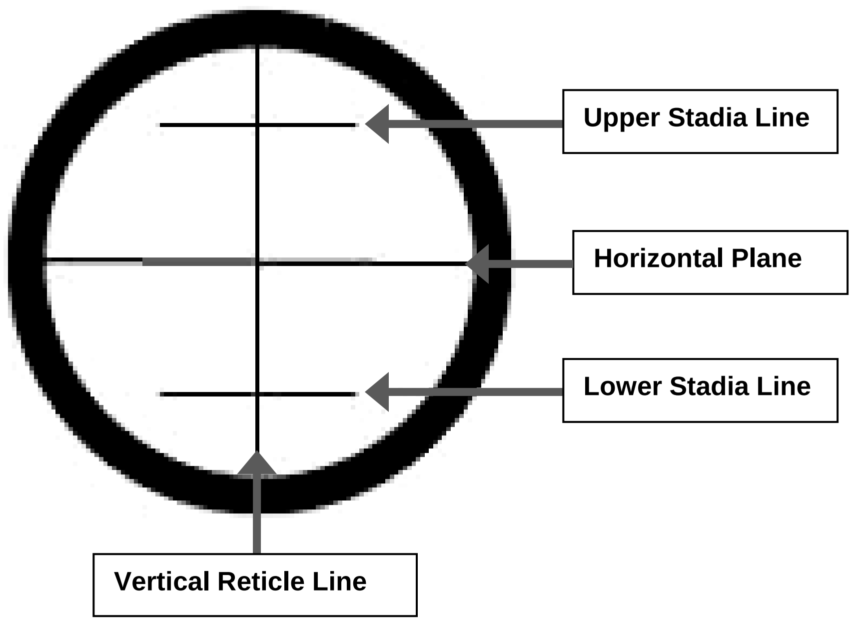

Figure J.4 – View Through an Auto Level Scope

The stadia rod is marked with a scale, either metric or English (also known as “imperial”). In trail work, the English scale (e.g., feet) is used because all construction measurements are English. Within the English system, stadia rods can come with an architect’s scale (e.g., measurements in feet, inches, and eighths of an inch) or engineer’s scale (e.g., measurements in feet, tenths of a foot, and hundredths of a foot). With most trail crews, the architect’s scale is the easiest to use because it is similar to a tape measure and workers are more accustomed to using inches instead of fractions of a foot.

Architect's Stadia Rod

On an architect's stadia rod, the red numbers identify feet, which are demarcated by long black lines. (See Figure J.5.) In between each foot, medium-length black lines with black numbers identify inches. Measurements are taken from the top of the lines adjacent to the numbers. In between each inch, short black lines demarcate an eighth of an inch. The width of every line, as well as the width of the white spaces between the lines, are each one eighth of an inch.

Engineer's Stadia Rod

On an engineer's stadia rod, the red numbers identify feet, which are demarcated by long black lines. (See Figure J.6.) In between each foot, medium-length black lines with black numbers identify tenths of a foot (i.e., 0.10 feet). Measurements are taken from the top of the lines adjacent to the numbers. In between the tenth of a foot numbers are short black lines identifying one hundredths of a foot. The width of each line, as well as the white spaces between the lines, are one hundredth of a foot.

As previously discussed, one of the problems in using a stadia rod with an engineer's scale is that trail workers are accustomed to measuring and working in feet, inches, and fraction of an inches. If the rod shows that one end of an earthen abutment needs to be excavated by 0.78 hundredths of a foot to be level with the other end of the abutment, the crew may not be able to visualize the depth of that excavation. The excavation can be monitored by taking regular elevation readings while the crew excavates the earthen abutment, but the crew could still easily over excavate the abutment. To solve this problem, it may be necessary to convert the decimal inches to fractions of an inch. The conversion can be estimated based on the principle that one hundredth of a foot is approximately equal to 1/8th of an inch. A chart converting hundredths of a foot to inches and fractions of an inch is provided below. (See Figure J.7.)

To determine a more precise conversion from decimal feet to inches and fractions of an inch, first multiply the numbers to the right of the decimal point (the tenths and hundredths of a foot) by 12 (the number of inches in a foot) to covert decimal feet to decimal inches. For example, an engineer's measurement of 5.65 feet is equivalent to 5 feet, 7.8 inches (i.e. 0.65 ft. * 12 in./ft. = 7.8 in.) Next convert 0.8 inches to fractions of an inch by multiplying 0.8 by 16 (i.e., the number of 1/16 inch in 1 inch; 0.8 in. x 16 = 12.8). In this example, 12.8 represents the number of 1/16s of an inch in the measurement. This number is then rounded up to 13 for a total of 13/16. The final conversion is 5 feet 7 13/16 inches.

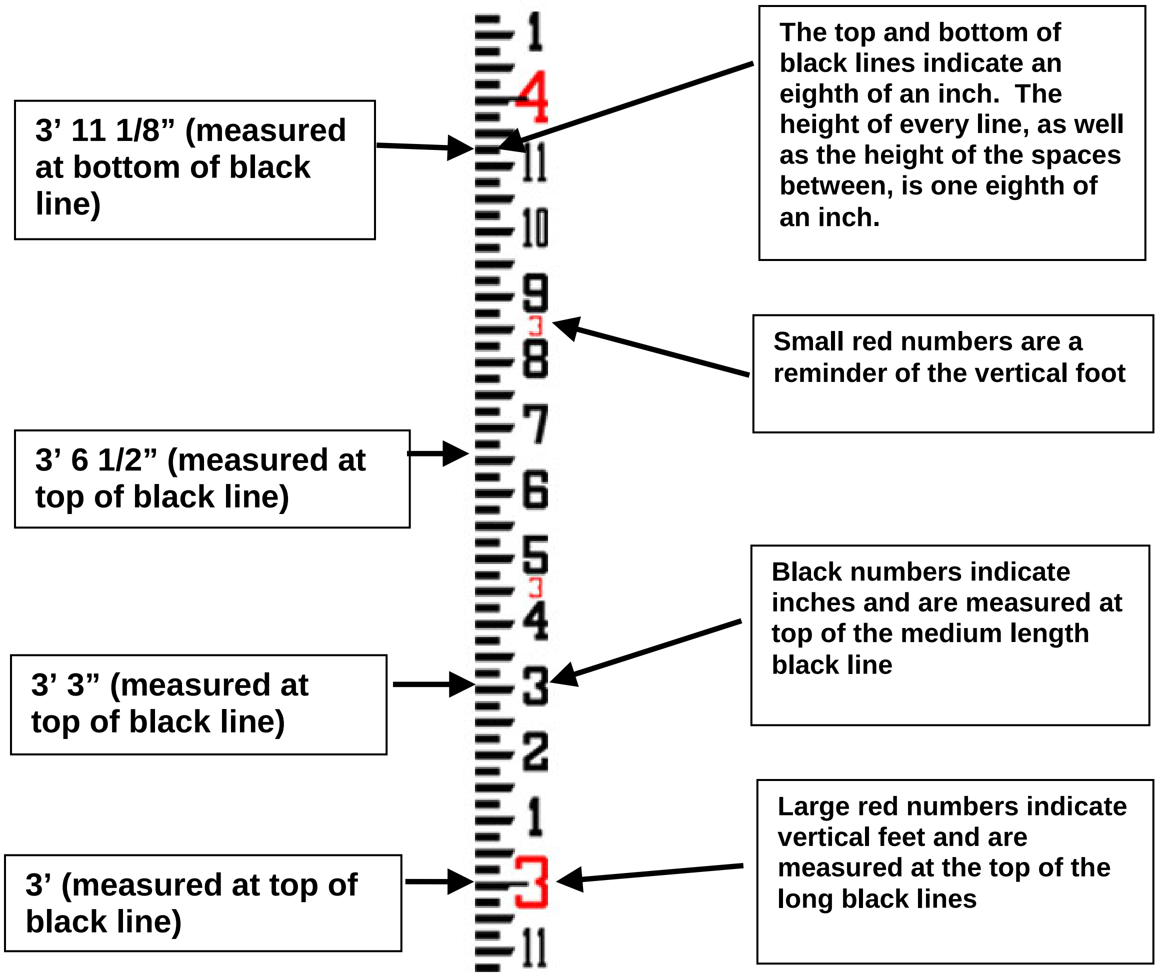

Figure J.5 – Architect’s Stadia Rod

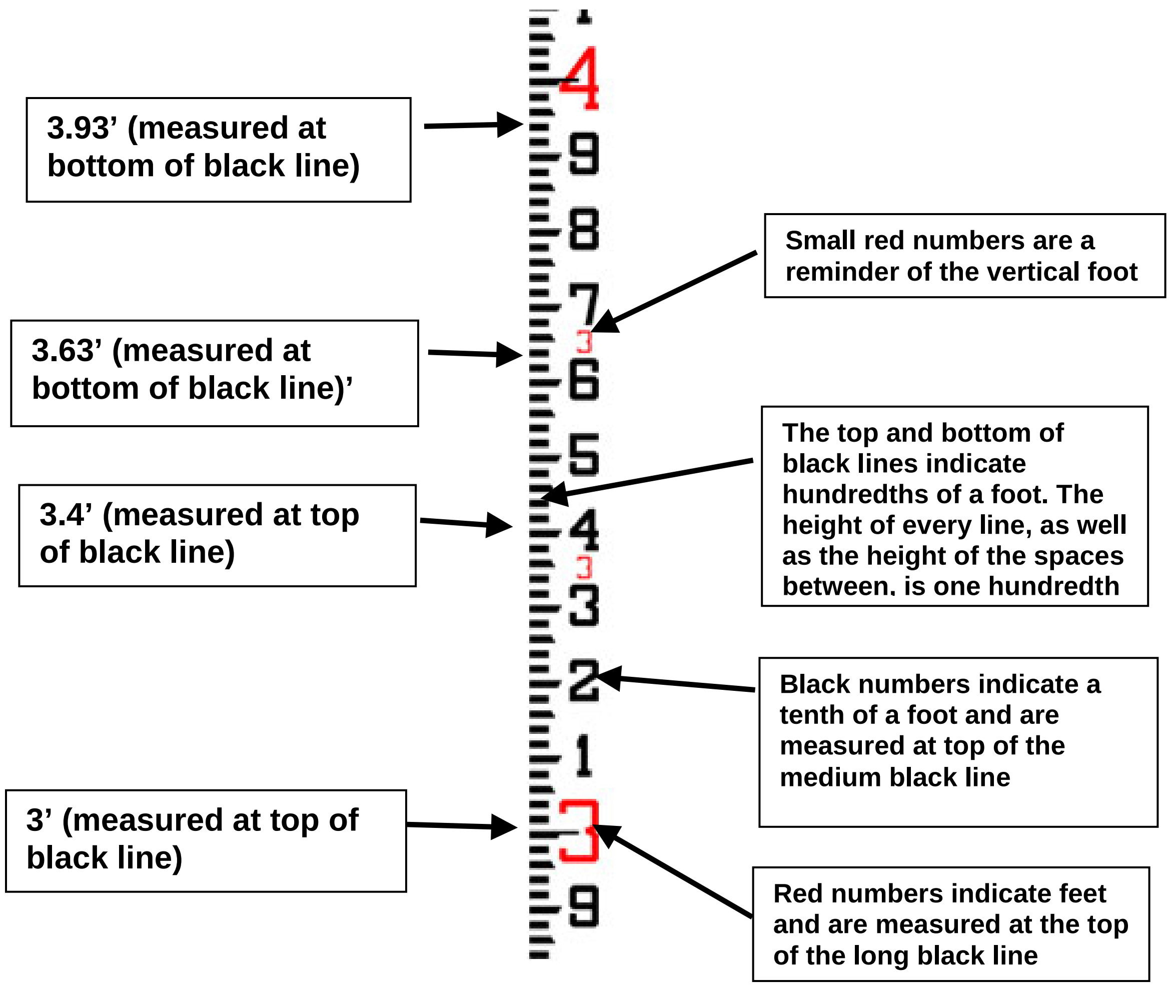

Figure J.6 – Engineer's Stadia Rod

.01 = 1/8"	.26 = 3 1/8"	.51 = 6 1/8"	.76 = 9 1/8"
.02 = 1/4"	.27 = 3 1/4"	.52 = 6 1/4"	.77 = 9 1/4"
.03 = 3/8"	.28 = 3 3/8"	.53 = 6 3/8"	.78 = 9 3/8"
.04 = 1/2"	.29 = 3 1/2"	.54 = 6 1/2"	.79 = 9 1/2"
.05 = 5/8"	.30 = 3 5/8"	.55 = 6 5/8"	.80 = 9 5/8"
.06 = 3/4"	.31 = 3 3/4"	.56 = 6 3/4"	.81 = 9 3/4"
.07 = 7/8"	.32 = 3 7/8"	.57 = 6 7/8"	.82 = 9 7/8"
.08 = 1"	.33 = 4"	.58 = 7"	.83 = 10"
.09 = 1 1/8"	.34 = 4 1/8"	.59 = 7 1/8"	.84 = 10 1/8"
.10 = 1 1/4"	.35 = 4 1/4"	.60 = 7 1/4"	.85 = 10 1/4"
.11 = 1 3/8"	.36 = 4 3/8"	.61 = 7 3/8"	.86 = 10 3/8"
.12 = 1 1/2"	.37 = 4 1/2"	.62 = 7 1/2"	.87 = 10 1/2"
.13 = 1 5/8"	.38 = 4 5/8"	.63 = 7 5/8"	.88 = 10 5/8"
.14 = 1 3/4"	.39 = 4 3/4"	.64 = 7 3/4"	.89 = 10 3/4"
.15 = 1 7/8"	.40 = 4 7/8"	.65 = 7 7/8"	.90 = 10 7/8"
.16 = ——	.41 = ——	.66 = ——	.91 = ——
.17 = 2"	.42 = 5"	.67 = 8"	.92 = 11"
.18 = 2 1/8"	.43 = 5 1/8"	.68 = 8 1/8"	.93 = 11 1/8"
.19 = 2 1/4"	.44 = 5 1/4"	.69 = 8 1/4"	.94 = 11 1/4"
.20 = 2 3/8"	.45 = 5 3/8"	.70 = 8 3/8"	.95 = 11 3/8"
.21 = 2 1/2"	.46 = 5 1/2"	.71 = 8 1/2"	.96 = 11 1/2"
.22 = 2 5/8"	.47 = 5 5/8"	.72 = 8 5/8"	.97 = 11 5/8"
.23 = 2 3/4"	.48 = 5 3/4"	.73 = 8 3/4"	.98 = 11 3/4"
.24 = 2 7/8"	.49 = 5 7/8"	.74 = 8 7/8"	.99 = 11 7/8"
.25 = 3"	.50 = 6"	.75 = 9"	1.00 = 12"

Figure J.7 – Conversion Chart: Hundredths of a Foot to Inches/Fractions of an Inch