This design guide covers simple cantilevered temporary sheet piling design. Sheet piling which requires a bracing system is a more complex case and falls into the category “Temporary Soil Retention System.” See Section 3.13.1 of the Bridge Manual for further information. Aids or charts for the design of simple cantilevered temporary sheet piling are given just prior to a design example at the end of this design guide. A procedure for using the charts is given below followed by the limitations and assumptions associated with them. Figures 3.13.1-1 and 3.13.1-2 in the Bridge Manual illustrate examples for how temporary sheet piling designs and temporary soil retention systems, respectively, should be shown on the contract plans.

Temporary Sheet Piling Design Procedure Using Charts

First determine the Retained Height at a particular design section of the sheeting and assume an embedment depth.

1. If cohesive soil conditions are indicated in the nearest boring log within the assumed embedment depth elevations, use the charts for the cohesive material case as follows:
    a. Calculate the average Unconfined Compressive Strength (Qu) used in the Required Embedment chart as the minimum of the following:
        i. The average of the Qu values within the assumed embedment depth.
        ii. The average of the Qu values in the upper 50% of the assumed embedment depth.
    b. Find the Required Embedment using the average Unconfined Compressive Strength determined above (in a.) and the retained height. If the required embedment depth obtained from the chart is different than assumed, re-calculate the average Unconfined Compressive Strength using an adjusted embedment depth until the assumed embedment depth used in calculating the average Unconfined Compressive Strength equals the resulting embedment depth from the chart.

   c. Calculate the average Unconfined Compressive Strength (Qu) used in the Required Section Modulus chart as the average of the Qu values in the upper 33% of the required embedment determined above.
   d. Find the Required Section Modulus directly using the average Unconfined Compressive Strength (from c.) and the retained height.
2. If granular soil conditions are indicated in the nearest boring log within the assumed embedment depth elevations, use the charts for the granular material case as follows:
   a. Calculate the average Standard Penetration Blow Count (N-value) used in the Required Embedment chart as the minimum of the following:
      i. The average of the N-values within the assumed embedment depth.
      ii. The average of the N-values in the upper 50% of the assumed embedment depth.
   b. Find the Required Embedment using the average Standard Penetration Blow Count determined above (in a.) and the retained height. If the required embedment depth obtained from the chart is different than assumed, re-calculate the average Standard Penetration Blow Count using an adjusted embedment depth until the assumed embedment depth used in calculating the average Standard Penetration Blow Count equals the resulting embedment depth from the chart.
   c. Calculate the average Standard Penetration Blow Count (N-value) used in the Required Section Modulus chart as the average of the N-values in the upper 33% of the required embedment determined above.
   d. Find the Required Section Modulus directly using the average Standard Penetration Blow Count (from c.) and the retained height.
3. If both cohesive and granular soil layers are indicated in the nearest boring log within the assumed embedment depth elevations, use the charts as follows:
   a. Multiply the Qu values (in tsf) for each cohesive sample by 10 to determine an equivalent granular N-value.
   b. Using the equivalent granular N-values for the cohesive layers together with the N-values in the granular layers, treat the soils as granular and follow the steps in Part 2.

Temporary Sheet Piling Design Charts Limitations

1. The design charts are only applicable for temporary soil retention.
2. The design charts are only applicable to cut retention situations since the compaction forces at large fill locations results in higher than active conditions not assumed in the charts.
3. If the required embedment falls below soil layers with a Qu value larger than 4.5 tsf, an N-value larger than 45 blows, or rock, the charts cannot be used since the sheet piling may not penetrate these layers.
4. If the average Qu value in the lower half of the upper ⅓ of the embedment (2nd sixth of embedment from the top) is more than twice as large as the average Qu value in the upper half of the upper ⅓ of the embedment (top sixth of embedment), the section modulus from the chart shall be increased by the following factors:

$\frac{\text{Average Qu in lower half of upper 1/3 embedment}}{\text{Average Qu in upper half of upper 1/3 embedment}}$	2	3	4	5	6
Section Modulus Amplification Factor	1.0	1.1	1.2	1.3	1.4

5. The design charts can only be used at locations where at least one boring is available and located within a reasonably close distance to the sheet piling. In addition to distance, the user shall consider the general topography and site conditions to confirm that the soil conditions indicated in the boring log are likely to be present at the sheeting location.
6. When following the design procedures for the charts results in an embedment or section modulus which falls on a blank location within a chart, design using the charts is not permitted.
7. A level ground surface shall exist behind and in front of the sheet piling.
8. If any of the site conditions do not meet or are not consistent with the assumptions given below, use of the design charts is not permitted.

Temporary Sheet Piling Design Charts Development Assumptions

1. The soil unit weight used throughout the retained height is 120 pcf.
2. The soil unit weights used below the excavation depth were determined using general S.P.T. N-value vs. unit weight correlations. In the cohesive material case, the average Qu was multiplied by 10 to obtain an equivalent S.P.T. N-value and the correlation between S.P.T. N-value and unit weight was used.
3. A uniform vertical surcharge of 240 psf was used to account for the traffic live load.
4. In addition to the traffic surcharge load (which results in a uniform laterally distributed pressure of 80 psf), an equivalent fluid pressure of 40 pcf was used throughout the retained height.
5. Coulomb's earth pressure theory was used in the development of the granular material case, assuming a wall friction angle of ⅓ ϕ. The friction angles were determined using typical published relationships between the S.P.T. N-value vs. friction angle.
6. A minimum active earth pressure coefficient of 0.25 was used below the retained height.
7. For the cohesive material case, the assumption was made that the shear strength (c) is equal to ½ of the average unconfined compressive strength (Qu).
8. The factor of safety for embedment was obtained by reducing the calculated passive pressure diagram by 33%, which resulted in an increase in embedment ranging from 26% to 35% for the granular case and 43% to 80% for the cohesive case. To avoid over-reliance on the strength of only a few samples, the minimum embedment used in the charts was limited to no less than 75% percent of the retained height.
9. The required section modulus has been computed using a 33% reduction of passive soil pressures and the relationship f_b = .66 x f_y, where the sheet piling yield stress (f_y) was taken as 38,500 psi.

TEMPORARY SHEET PILING DESIGN CHART-COHESIVE MATERIAL CASE

REQUIRED EMBEDMENT DEPTH (FT.)

		RETAINED HEIGHT (FT.) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	0.4	6.5	10.0															
	0.5	5.1	6.8	9.0	13.1													
	0.6	4.3	5.7	7.2	9.1	11.6	16.1											
	0.7	3.8	4.9	6.2	7.7	9.4	11.4	14.2	19.1									
	0.8	3.8	4.5	5.5	6.8	8.3	9.9	11.6	13.9	16.7	22.1							
	0.9	3.8	4.5	5.3	6.1	7.4	8.8	10.3	12.0	13.9	16.3	19.5	25.2					
	1.0	3.8	4.5	5.3	6.0	6.8	8.0	9.3	10.8	12.4	14.2	16.3	18.8	22.3	28.2			
	1.1	3.8	4.5	5.3	6.0	6.8	7.5	8.5	9.9	11.3	12.9	14.5	16.4	18.7	21.3	25.2	31.3	
AVERAGE	1.2	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.1	10.4	11.8	13.4	15.0	16.7	18.7	21.1	23.7	28.1
UNCONFINED	1.3	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	11.0	12.4	13.8	15.4	17.1	18.9	21.1	23.5
COMPRESSIVE	1.4	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.5	12.9	14.4	15.9	17.5	19.2	21.2
STRENGTH -	1.5	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.1	13.5	14.9	16.4	17.9	19.6
"Qu" (T.S.F.)	1.6	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	14.0	15.4	16.9	18.4
	1.7	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.6	15.9	17.4
	1.8	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.1	16.5
	1.9	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.0	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.1	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.2	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.3	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.4	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8
	2.5	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8

REQUIRED SECTION MODULUS (IN^3/FT.)

		RETAINED HEIGHT (FT.) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	0.4	1.4	2.4	4.7														
	0.5	1.3	2.1	3.3	5.1	8.3												
	0.6	1.2	2.0	3.0	4.5	6.4	9.0	13.5										
	0.7	1.1	1.8	2.8	4.1	5.9	8.1	10.9	14.8	20.5								
	0.8	1.1	1.8	2.7	3.9	5.5	7.5	10.1	13.2	17.0	22.3	29.6	42.8					
	0.9	1.1	1.7	2.6	3.8	5.3	7.2	9.5	12.4	15.9	20.1	25.2	31.9	41.1	55.2			
	1.0	1.0	1.7	2.5	3.7	5.1	6.9	9.1	11.8	15.1	19.0	23.6	29.0	35.1	44.5	55.4		
AVERAGE	1.1	1.0	1.6	2.5	3.6	4.9	6.7	8.8	11.4	14.5	18.2	22.5	27.6	33.5	40.3	49.0	59.3	
UNCONFINED	1.2	1.0	1.6	2.4	3.5	4.8	6.5	8.6	11.0	14.0	17.5	21.6	26.4	32.0	38.4	45.7	54.1	
COMPRESSIVE	1.3	1.0	1.6	2.4	3.4	4.7	6.4	8.4	10.8	13.6	17.0	21.0	25.5	30.8	36.9	43.9	51.7	60.6
STRENGTH -	1.4	1.0	1.6	2.4	3.4	4.7	6.3	8.2	10.5	13.3	16.6	20.4	24.8	29.9	35.7	42.3	49.8	58.3
"Qu" (T.S.F.)	1.5	1.0	1.6	2.3	3.3	4.6	6.2	8.1	10.3	13.0	16.2	19.9	24.2	29.1	34.7	41.1	48.3	56.4
IN UPPER 1/3	1.6	1.0	1.5	2.3	3.3	4.5	6.1	7.9	10.2	12.8	15.9	19.5	23.7	28.4	33.9	40.0	47.0	54.8
OF REQUIRED	1.7	1.0	1.5	2.3	3.3	4.5	6.0	7.8	10.0	12.6	15.7	19.2	23.2	27.9	33.2	39.1	45.9	53.4
EMBEDMENT	1.8	1.0	1.5	2.3	3.2	4.4	5.9	7.7	9.9	12.5	15.4	18.9	22.8	27.4	32.5	38.4	44.9	52.2
	1.9	0.9	1.5	2.3	3.2	4.4	5.9	7.7	9.8	12.3	15.2	18.6	22.5	27.0	32.0	37.7	44.1	51.2
	2.0	0.9	1.5	2.2	3.2	4.4	5.8	7.6	9.7	12.2	15.1	18.4	22.2	26.6	31.5	37.1	43.4	50.3
	2.1	0.9	1.5	2.2	3.2	4.3	5.8	7.5	9.6	12.1	14.9	18.2	22.0	26.3	31.1	36.6	42.7	49.6
	2.2	0.9	1.5	2.2	3.2	4.3	5.8	7.5	9.5	12.0	14.8	18.0	21.7	26.0	30.7	36.1	42.2	48.9
	2.3	0.9	1.5	2.2	3.1	4.3	5.7	7.4	9.5	11.9	14.6	17.9	21.5	25.7	30.4	35.7	41.6	48.3
	2.4	0.9	1.5	2.2	3.1	4.3	5.7	7.4	9.4	11.8	14.5	17.7	21.3	25.5	30.1	35.3	41.2	47.7
	2.5	0.9	1.5	2.2	3.1	4.3	5.7	7.3	9.4	11.7	14.4	17.6	21.2	25.2	29.8	35.0	40.8	47.2

TEMPORARY SHEET PILING DESIGN CHART-GRANULAR MATERIAL CASE

REQUIRED EMBEDMENT DEPTH (FT.)

AVERAGE STANDARD PENETRATION RESISTANCE - "N-VALUE" (BLOW COUNT PER FT.)	Retained Height (FT.) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	12.1	13.9	15.7	17.5	19.3	21.0	22.9	24.6	26.4	28.2	30.0	31.7			
5	11.3	13.0	14.6	16.3	18.0	19.7	21.4	23.0	24.7	26.3	28.0	29.7	31.3		
6	10.7	12.3	13.8	15.4	17.0	18.6	20.2	21.8	23.4	24.9	26.5	28.1	29.6		
7	10.2	11.7	13.2	14.7	16.2	17.7	19.3	20.8	22.3	23.8	25.3	26.8	28.3		
8	9.7	11.2	12.7	14.1	15.6	17.0	18.5	19.9	21.4	22.8	24.3	25.7	27.1		
9	9.4	10.8	12.2	13.6	15.0	16.4	17.8	19.2	20.6	22.0	23.4	24.8	26.2		
10	9.1	10.4	11.8	13.2	14.5	15.9	17.3	18.6	20.0	21.3	22.6	24.0	25.3	26.7	
11	8.8	10.1	11.5	12.8	14.1	15.4	16.8	18.1	19.4	20.7	22.0	23.3	24.6	25.9	
12	8.6	9.9	11.2	12.4	13.7	15.0	16.3	17.6	18.8	20.1	21.4	22.7	23.9	25.2	
13	8.3	9.6	10.9	12.1	13.4	14.6	15.9	17.1	18.4	19.6	20.9	22.1	23.3	24.6	
14	8.1	9.4	10.6	11.8	13.1	14.3	15.5	16.7	18.0	19.2	20.4	21.6	22.8	24.0	
15	8.0	9.2	10.4	11.6	12.8	14.0	15.2	16.4	17.6	18.8	19.9	21.1	22.3	23.5	
16	7.8	9.0	10.2	11.3	12.5	13.7	14.9	16.0	17.2	18.4	19.5	20.7	21.9	23.0	
17	7.7	8.8	10.0	11.1	12.3	13.4	14.6	15.7	16.9	18.0	19.2	20.3	21.4	22.6	23.7
18	7.5	8.7	9.8	10.9	12.1	13.2	14.3	15.5	16.6	17.7	18.8	19.9	21.1	22.2	23.3
19	7.4	8.5	9.6	10.7	11.8	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9
20	7.3	8.4	9.5	10.6	11.7	12.7	13.9	14.9	16.0	17.1	18.2	19.3	20.4	21.5	22.5
21	7.1	8.2	9.3	10.4	11.5	12.5	13.6	14.7	15.8	16.8	17.9	19.0	20.0	21.1	22.2
22	7.0	8.1	9.2	10.3	11.3	12.4	13.5	14.5	15.6	16.6	17.7	18.7	19.8	20.8	21.9
23	7.0	8.0	9.1	10.1	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6
24	6.9	7.9	9.0	10.0	11.0	12.1	13.1	14.2	15.2	16.2	17.2	18.3	19.3	20.3	21.4
25	6.8	7.8	8.9	9.9	10.9	11.9	13.0	14.0	15.0	16.0	17.1	18.1	19.1	20.1	21.1

REQUIRED SECTION MODULUS ($IN^3/FT.$)

AVERAGE STANDARD PENETRATION RESISTANCE - "N-VALUE" (BLOW COUNT PER FT.) IN UPPER 1/3 OF REQUIRED EMBEDMENT	Retained Height (FT.) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	4.0	6.1	8.9	12.4	16.7	21.8	27.9	35.0	43.2	52.5					
5	3.7	5.6	8.2	11.4	15.3	20.0	25.6	32.1	39.7	48.3	58.1				
6	3.4	5.3	7.6	10.6	14.3	18.7	23.9	30.0	37.1	45.2	54.3				
7	3.2	5.0	7.2	10.1	13.5	17.7	22.6	28.4	35.1	42.8	51.4				
8	3.1	4.7	6.9	9.6	12.9	16.9	21.6	27.1	33.5	40.8	49.1	58.4			
9	2.9	4.5	6.6	9.2	12.4	16.2	20.8	26.1	32.2	39.2	47.2	56.1			
10	2.8	4.4	6.4	8.9	11.9	15.6	20.0	25.2	31.1	37.8	45.5	54.2			
11	2.7	4.2	6.2	8.6	11.6	15.2	19.4	24.4	30.1	36.7	44.1	52.5			
12	2.7	4.1	6.0	8.4	11.2	14.7	18.9	23.7	29.3	35.7	42.9	51.1	60.2		
13	2.6	4.0	5.8	8.1	11.0	14.4	18.4	23.1	28.5	34.8	41.8	49.8	58.7		
14	2.5	3.9	5.7	7.9	10.7	14.0	18.0	22.6	27.9	34.0	40.9	48.6	57.3		
15	2.5	3.8	5.6	7.8	10.5	13.7	17.6	22.1	27.3	33.2	40.0	47.6	56.1		
16	2.4	3.7	5.5	7.6	10.3	13.5	17.2	21.6	26.8	32.6	39.2	46.7	55.0		
17	2.4	3.7	5.4	7.5	10.1	13.2	16.9	21.3	26.3	32.0	38.5	45.8	54.0		
18	2.3	3.6	5.3	7.3	9.9	13.0	16.6	20.9	25.8	31.5	37.9	45.1	53.1		
19	2.3	3.6	5.2	7.2	9.7	12.8	16.4	20.6	25.4	31.0	37.3	44.3	52.3		
20	2.3	3.5	5.1	7.1	9.6	12.6	16.1	20.2	25.0	30.5	36.7	43.7	51.5	60.2	
21	2.2	3.4	5.0	7.0	9.5	12.4	15.9	20.0	24.7	30.1	36.2	43.1	50.8	59.3	
22	2.2	3.4	5.0	6.9	9.3	12.3	15.7	19.7	24.4	29.7	35.8	42.6	50.2	58.7	
23	2.2	3.4	4.9	6.9	9.3	12.1	15.6	19.5	24.2	29.4	35.4	42.2	49.7	58.1	
24	2.2	3.3	4.9	6.8	9.2	12.0	15.4	19.4	23.9	29.2	35.1	41.8	49.3	57.6	
25	2.1	3.3	4.8	6.7	9.1	11.9	15.3	19.2	23.7	28.9	34.8	41.4	48.8	57.1	

Temporary Sheet Piling Design Example: Retained Height H = 7.5 ft.

Assume Embedment Depth, D, for First Iteration

Use the retained height as the initial embedment depth.
D = 7.5 ft.

Determine the Soil Type

The boring shows clay soil with varying unconfined compressive strengths in the embedment zone. These are cohesive soils.

Calculate Q_{uavg}

	Q_u (tsf)	Layer Thickness (ft.)
Layer 1	0.5	1.0
Layer 2	0.6	4.5
Layer 3	0.8	2.0

For the full 7.5 ft. embedment,

$$Q_{uavg} = \frac{0.5\text{ tsf} \times 1.0\text{ ft.} + 0.6\text{ tsf} \times 4.5\text{ ft.} + 0.8\text{ tsf} \times 2.0\text{ ft.}}{1.0\text{ ft.} + 4.5\text{ ft.} + 2.0\text{ ft.}} = 0.64\text{ tsf}$$

For the upper 3.75 ft. of embedment,

$$Q_{uavg} = \frac{0.5\text{ tsf} \times 1.0\text{ ft.} + 0.6\text{ tsf} \times 2.75\text{ ft.}}{1.0\text{ ft.} + 2.75\text{ ft.}} = 0.57\text{ tsf}$$

$\therefore$ 0.57 tsf controls.

Determine D_{req} From the Chart

Using a 7.5 ft. retained height, Qu = 0.57 tsf and interpolating from the chart,

D_{req} = 9.0 ft.

D_{req} is not within 1 ft. of the assumed embedment depth of 7.5 ft. Use 9.0 ft. as the new assumed embedment depth and reiterate the process above. This embedment zone has a combination of cohesive and granular soils. As such, the cohesive soils will be converted to granular soils and the granular soils chart used.

Calculate N_{avg}

$N = Q_u \times 10$

	Q_u (tsf)	N (blows/ft.)	Layer Thickness (ft.)
Layer 1	0.5	5	1.0
Layer 2	0.6	6	4.5
Layer 3	0.8	8	2.5
Layer 4		20	1.0

For the full embedment of 9.0 ft.,

$$N = \frac{5 \times 1.0 \text{ ft.} + 6 \times 4.5 \text{ ft.} + 8 \times 2.5 \text{ ft.} + 20 \times 1.0 \text{ ft.}}{1.0 \text{ ft.} + 4.5 \text{ ft.} + 2.5 \text{ ft.} + 1.0 \text{ ft.}} = 8.0$$

For the upper 4.5 ft. of embedment,

$$N = \frac{5 \times 1.0 \text{ ft.} + 6 \times 3.5 \text{ ft.}}{1.0 \text{ ft.} + 3.5 \text{ ft.}} = 5.8$$

$\therefore$ 5.8 controls.

Determine D_{req}

Using a 7.5 ft. retained height, N = 5.8 and interpolating from the chart,

D_{req} = 14.8 ft.

Again, D_{req} is not within 1 ft. of the assumed embedment depth of 9.0 ft. Use 14.8 ft. as the new assumed embedment depth and reiterate the process above. This embedment zone has a combination of cohesive and granular soils. As such, the granular charts will be used.

Calculate N_{avg}

	Q_u (tsf)	N (blows/ft.)	Layer Thickness (ft.)
Layer 1	0.5	5	1.0
Layer 2	0.6	6	4.5
Layer 3	0.8	8	2.5
Layer 4		20	2.5
Layer 5		25	1.5
Layer 6		30	2.8

For the full embedment of 14.8 ft.,

$$N = \frac{5 \times 1.0\text{ ft.} + 6 \times 4.5\text{ ft.} + 8 \times 2.5\text{ ft.} + 20 \times 2.5\text{ ft.} + 25 \times 1.5\text{ ft.} + 30 \times 2.8\text{ ft.}}{1.0\text{ ft.} + 4.5\text{ ft.} + 2.5\text{ ft.} + 2.5\text{ ft.} + 1.5\text{ ft.} + 2.8\text{ ft.}} = 15.1$$

For the upper 7.4 ft. of embedment,

$$N = \frac{5 \times 1.0\text{ ft.} + 6 \times 4.5\text{ ft.} + 8 \times 1.9\text{ ft.}}{1.0\text{ ft.} + 4.5\text{ ft.} + 1.9\text{ ft.}} = 6.4$$

$\therefore$ 6.4 controls.

Determine D_{req}

Using a 7.5 ft. retained height, N = 6.4 and interpolating from the chart,

D_{req} = 14.4 ft.

D_{req} is within 1 ft. of the assumed embedment depth of 14.8 ft. $\therefore$ no further embedment depth iterations are required.

Determine the Required Section Modulus

Determine the average N in the upper third (4.9 ft.) of the embedment depth (14.8 ft.),

$$N = \frac{5 \times 1.0 \text{ ft.} + 6 \times 3.9 \text{ ft.}}{1.0 \text{ ft.} + 3.9 \text{ ft.}} = 5.8$$

For a 7.5 ft. retained height, N = 5.8 and interpolating from the chart,

S_{req} = 9.3 in^3/ft.