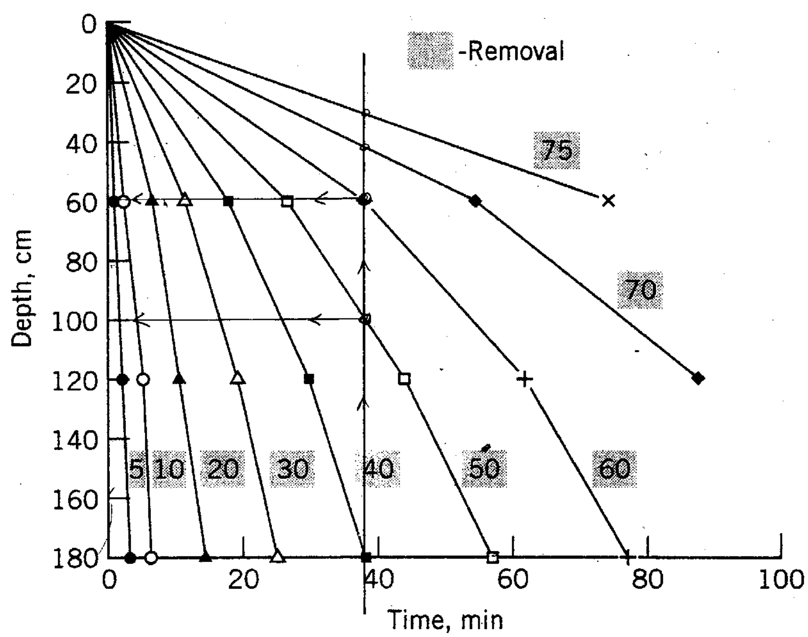
General Procedure for Sizing a Clarifier Based on Settling Column Data

1. Choose the **desired removal efficiency**. For example, suppose we want a clarifier to remove about 50% - 60% of the suspended solids.

2. Look at **isoconcentration curves** (Fig. 11.13) and from the deepest sampling point, find the shortest time that gets close to this level of removal, allowing for the fact that we will get more removal than the intersecting isoconcentration curve indicates. For this example, let's try the 40% removal level, knowing we will get more than that. Pick a time that corresponds to the end of an isoconcentration line because then you are starting with a nice round number for %-removal and it's an easy starting point for the rest of the graphical procedure. For Fig. 11.13 the 40% curve intersects at a settling time of 39 min.

   Reality Check: Is 39 min a reasonable detention time for a clarifier for our flow? For example, for Drain, OR, with approximately 100,000 gpd = 9.3 ft^3/min, 39 min requires a tank with a volume of 362 ft^3, which is a cube about 7 feet on a side. That seems quite satisfactory. If this volume had been excessive, you would need to design two or more parallel clarifiers to handle the flow, or, you could decide that you could accept a lower removal efficiency in return for a smaller clarifier.

3. At 180 cm depth, 40% of the solids were completely removed in 39 min. Therefore, 40% of the particles had a settling velocity v_o > 180 cm / 39 min = 4.6 cm/min (and 60% were smaller (slower) than that, so p_o = 0.60). But we know that the tank *as a whole* did better than 40% removal. At shallower depths we got more than 40% removal, as you can see by running a vertical line up from 39 min. We get 50% removal at d = 100 cm, 60% removal at d = 60 cm, and so on. However, these higher efficiencies are due to particles that settle at less than v_o = 4.6 cm/min, so not all of these particles reach the bottom within 39 min. Only that *fraction* of these slower particles that are close enough to the bottom add to the overall %-removal.



Isoconcentration curves.

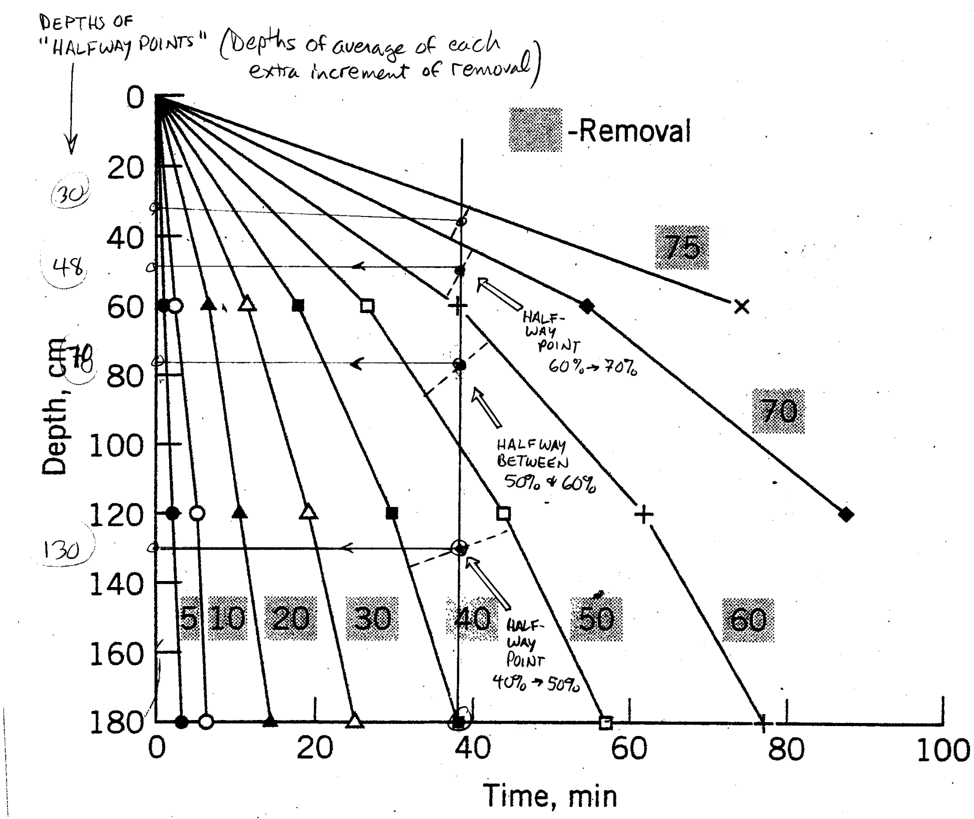
4. The fraction that *are* close enough to the bottom is easily calculated. For example, find the average depth of all the particles between 40% and 50% removal, then ratio that depth to the total depth. That ratio is the fraction of particles that experience the extra 10% removal. Repeat for each subsequent increment of removal:

R = [Baseline %-removal] + [1st-Fraction that Contributes to Next Higher %-removal] + [2nd-Fraction that Contributes to Next Higher %-removal] + [3rd-Fraction....] + etc.

R = [Baseline %-removal] + 10%[(Average depth of 1st increment)/(total depth)] + 10%[(Average depth of 2nd increment)/(total depth)] + 10% [3rd ....] + etc.

$$R = r_o + (\Delta r_1)(h_1 / H) + (\Delta r_2)(h_2 / H) + (\Delta r_3)(h_3 / H) + (\Delta r_4)(h_4 / H) + \ldots$$

In practice, this series of terms converges to a pretty steady value within three or four terms. To find the average depth for each increment, draw a vertical line up from t_d, and then between each pair of isoconcentration curves draw a line perpendicular to the isoconcentration curves; the mean depth of that increment is the intersection of the vertical line and the perpendicular. See the sketch below:



Isoconcentration curves.

For the example in the text, using the mean depth found on the curve above:

R = 40% + 10%(130/180) + 10%(78/180) + 10%(48/180) + 10%(30/180)

R = 40% + 7.2% + 4.3% + 2.7% + 0.8% = **55.0%**