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HYDRAULIC LOADING RATES

The commonly accepted formula for calculating particle capture is the Hydraulic Loading Rate (H_{LR}). It is expressed as the ratio of flow, in cubic feet per second, divided the surface area of a wet basin or vault in square feet. This is expressed as:

$$H_{LR} = \frac{Q}{L\,W}$$

The units will be ft. / sec. This calculation is often questioned because it does not include any information on the volume of the basin, the depth of the basin, or the detention time for a given storm. Detention time is also expressed as Hydraulic Retention Time, or H_{RT}.

If a basin has a given length (L), width (W), and depth (D) which equals its volume (V_o), and a particle has a certain settling velocity V_p, we can define certain formulas to describe events in the basin.

The detention time (H_{RT}) equals the volume of the basin in cubic feet divided by the flow rate into the basin, in cubic feet per second:

$$H_{RT} = \frac{LWD}{Q}$$

The time for a particle to settle to the bottom of the basin (t_p) equals the depth of the basin (D) divided by the settling velocity of the particle V_p:

$$t_p = \frac{D}{V_p}$$

If we want a basin to be just large enough to settle out a particle with the velocity of V_p, then we would set the H_{RT} (detention time) equal to the settling time t_p for that particle. Setting the equations equal gives:

$$\frac{LWD}{Q} = \frac{D}{V_p}$$

Dividing by D gives:

$$\underline{LW} = \underline{1}$$

$Q \quad V_p$

or

$$Vp = \frac{Q}{LW}$$

This shows that the Hydraulic Loading Rate (H_{LR}) is simply equal to the particles settling velocity, and that a greater surface (LW) will allow capture of particles with smaller settling velocities, as the denominator increases with the surface size of the basin.

This is easiest to see with two basins of identical volume with a Q of 5 cfs. Consider a basin that is 10 feet L, 5 feet W, and 10 feet D where LWD = 500 cubic feet. The detention time (H_{RT}) is obviously 100 seconds. To find a particle settling rate that will work for this basin, we need to find a particle that will fall 10 feet in 100 seconds. That rate is 0.1 feet per second. Because we know that the Hydraulic Loading Rate (H_{LR}) is expressed as being equal to the settling rate of a target particle, we can test that assumption, by calculating the H_{LR} as Q/LW, or as 5 / 50, which gives us the same answer as the particle setline velocity calculated above, or 0.1 ft./sec.

Consider a second basin that is 10 feet L, 10 feet W, and 5 feet D, where LWD = 500. The detention time (H_{RT}) is obviously 100 seconds. To find a particle settling rate that will work for this basin, we need to find a particle that will fall 5 feet in 100 seconds. That rate is 0.05 feet per second. Because we know that the Hydraulic Loading Rate (H_{LR}) is expressed as being equal to the settling rate of a target particle, we can test that assumption, by calculating the H_{LR} as Q/LW, or as 5 / 100, which gives us the same answer as the particle settling velocity calculated above, or 0.05 ft./sec.

These two basins are exactly the same volume and have exactly the same detention time. They vary only in surface area, which is a function of their variable depth. The calculations clearly show that, given an equal basin volume, and equal detention time, a basin with greater surface area will capture smaller particles. This is a direct relationship where increasing surface area will increase particle capture rates.

It also shows that two basins of equal volumes and equal detention times can give very different capture rates. Therefore, it is not the detention time, or the volume of the basin that dictates the capture rate, it is the surface area.