Monthly Manager Moments – Article #20

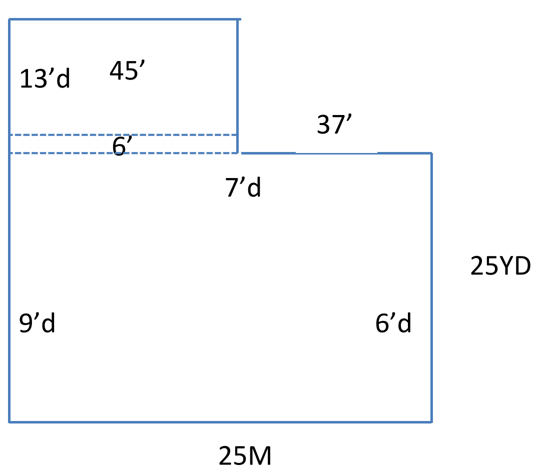
Pool Math #1: The 5th in our series on how pools work

Introduction – Pool Math, what? Surely, there isn't math involved in operating a pool! In fact, there is quite a bit of it. Aside from the spreadsheets that pool managers must do for budgeting, keeping track of payroll, etc. - pool operators must understand the geometry and algebra needed to keep their pools running smoothly. There are really two basic math areas that operators must know: how to calculate the capacity and flow rates required for their pools, and how to calculate chemical dosages to achieve the desired pristine and balanced water. This article will cover the first area: capacity and flow rates.

Capacity – Some might say that this term is synonymous with volume. For the pool operator, the two are distinctly different. Volume is measured in cubic units, whereas capacity is in gallons. Since nearly all pools have slopes, the volume and capacity calculations can be somewhat involved. The more complex the slope pattern of the pool, the more involved the calculation. For example, the EWU Pool has a very unique and complex slope pattern, making the calculation of volume & capacity very long indeed. I've done the capacity calculation of this pool twice. When I did the calculation the second time, I took careful measurements, then made a scale drawing of the pool. After that I divided the pool into 16 subsections of various geometric shapes, with varying depths. This method follows the principle for capacity calculation: divide the pool into individual geometric shapes, calculate the capacity of each, and add them all together (see the drawing that I made of this pool on the last page.) For a rectangular pool, it's a snap. For a water park with a free-form lazy river, zero depth beach, wave pool, spas with benches inside, etc. it can be a real project! Here are two examples:

Pool #1 – An L shaped pool, with a diving tank. This pool is 10 lanes wide and 25M long. The depth is 6' to 9' at the other end. The diving tank is 45' square, 13' deep and the bottom is sloped to the 13' depth on the open side. The slope is 6' from the edge to the bottom (horizontal distance). The other walls are vertical with no slope. Note: standard lane width is 7.5'; so we'll assume that this pool is 75' wide and 82' long (25M).

This pool should be divided into three sections: The main lap pool, which is 82' X 75' and slopes from 6'-9'; which we'll call P_1. The next section is the sloped area of the diving tank, which is 6' X 45' and slopes from 8' to 13'; and which we'll call P_2. The third section is the main section of the diving tank, which is 39' X 45' and 13' deep. We'll call that section P_3.



Now we'll calculate each section. P_1: 75' X 82' = 6150 ft^2. This is the surface area. To get the volume, we need the average depth: $\frac{6' + 9'}{2}$ = 7.5'. The volume is the surface area X the depth = 6150 ft^2 X 7.5' = 46,125 ft^3. Volume is in cubic units. A cubic foot of water holds 7.48 gallons, so we must convert the units to gallons. $\frac{46125\ \cancel{ft^3}}{1} \times \frac{7.48\ gal}{1\ \cancel{ft^3}}$ = 345,015 gallons in section P_1.

P_2: 6' X 45' X $\left(\frac{8' + 13'}{2}\right)$ = 2835 ft^3 X 7.48 gal/ft^3 = 21,206 gallons in section P_2.

P_3: 45' X 39' X 13'deep = 22,815 X 7.48 gal/ft^3 = 170,656 gallons in section P_3.

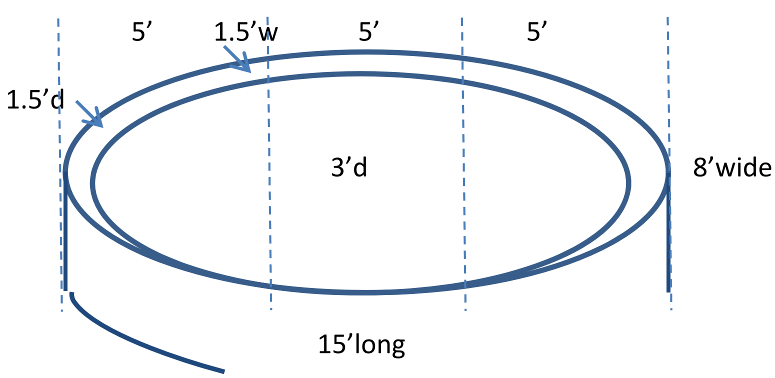
Add them together: 345,015 + 21,206 + 170,656 = 536,877 gallons. That's a big pool. The water in this pool is heavy!! - 536,877 gallons X 8.333 pounds per gallon = 4,473,796 pounds!

Now, for the flow rate – In Washington State, as in many states, a pool such as this must maintain a minimum turnover of 6 hours, or 4X per 24 hours. If you recall from a previous article, a turnover (TO) is the time required for the entire capacity of the pool to go through the pump room. In order to figure out how much flow is required, we use a conversion to get the required units of gallons per minute:

$$\frac{536{,}877\ gal}{1\ \cancel{TO}} \times \frac{1\ \cancel{TO}}{6\ \cancel{HR}} \times \frac{1\ \cancel{HR}}{60\ Min} = 1491 \text{ gallons per minute required}$$

It is this flow rate that determines the size of the pump, pipes, filters, heater, feed systems, etc. So, it is clearly VERY important. It all starts with an accurate capacity calculation. If you're not into fun math problems, buy yourself a water meter, attach it to the fill line, and just fill the pool! You'll have the capacity down to the nearest gallon!

Example #2 – Let's say we have a spa that's in the shape of an oval, it's 8' wide and 15' long from tip to tip. Spas all have benches that are underwater, and usually they're about 18" wide and high and from the surface to the top of the bench. First, we want to draw a picture of the spa.



Next, we want to divide it into logical geometric sections: P_1 – upper oval; P_2 – inner/lower oval. The upper oval is only 1.5' deep and the entire surface area of the spa. The formula for the area of a circle is πr^2, however, this is not truly a circle. If we further divide the top section into three subsections, we can make our calculation more accurate by designating the center a rectangle, and the ends a circle.

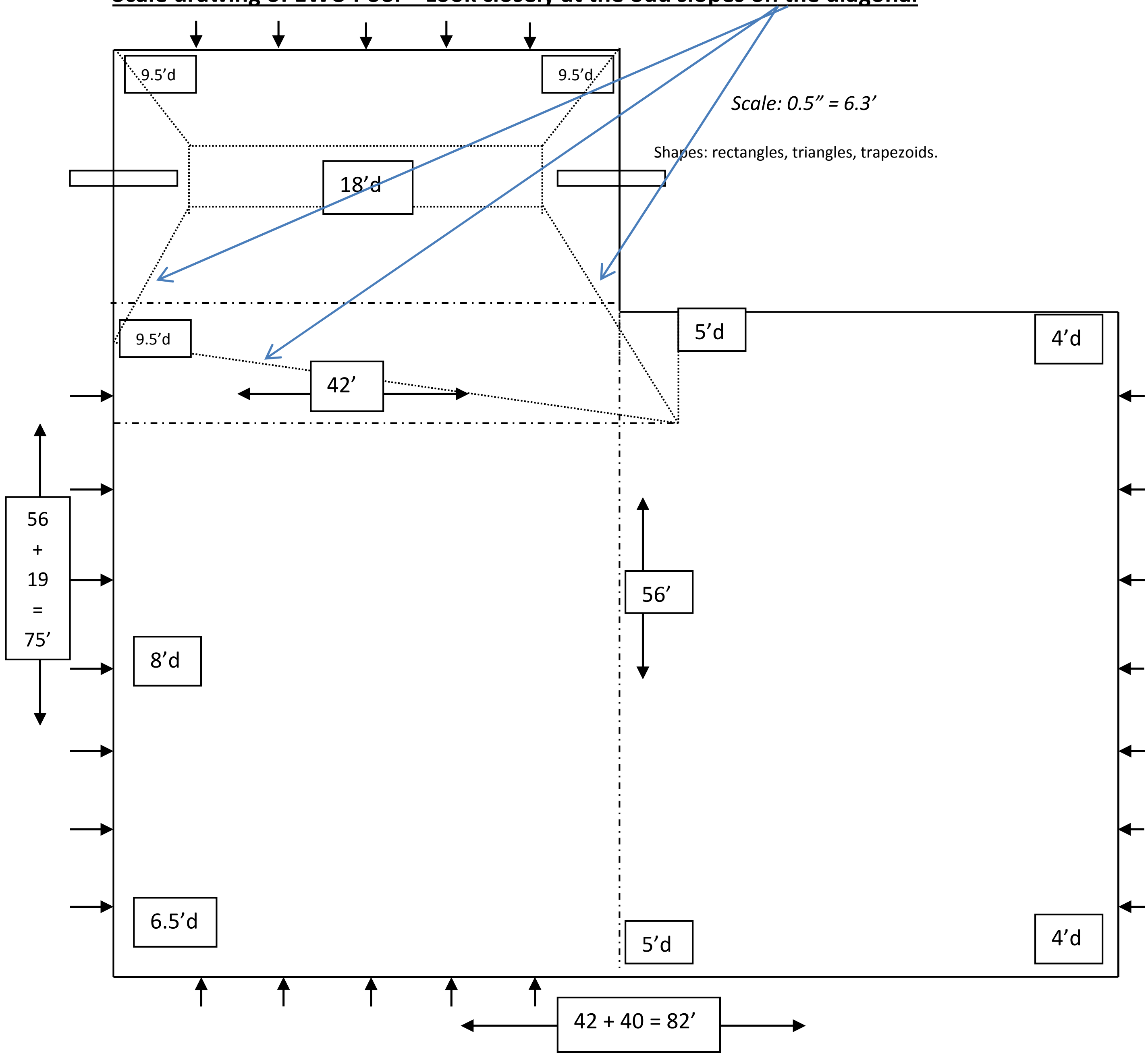
When doing capacity calculations of odd shapes, it is often necessary to subdivide in order to approximate a standard geometric shape, such as a circle and a rectangle. The rounded edges of the rectangle can be ignored, as long as they don't represent a significant amount of the total. Generally, you need to be at least 90% accurate to use your capacity for flow rates and dosage calculations.

OK, let's do the upper oval. If we combine the two 5' ends, we have about a 10' circle. Applying the πr^2 formula to the surface: r = 5'; so 3.14 X 25 = 78.5 ft^2. Now add the center rectangle (L X W) = 8 X 5 = 40 ft^2. Total SA = 118.50 ft^2. The depth of the upper oval is 1.5', so 118.5 ft^2 X 1.5' = 177.75 ft^3.

Section P_2 is the inner oval. We have to remember to subtract the width of the bench, which is 1.5' on all sides. So, if we use the same two steps as we did in the upper oval, we'd have an oval that is 3' shorter in both directions, or 12' X 5'. We'll assume that when measured, the half-circled ends are now 3.5' instead of 5', and that the rectangle in the center is 5' X 5', and actually a square. We apply our formulas for the SA first: πr^2 = 3.14 X 3.5^2 = 38.48 ft^2 + 5^2 (25) = 63.48 ft^2. 63.48 ft^2 X 1.5'd = 95.23 ft^3.

Lastly, we add the two volumes together 177.75 ft^3 + 95.23 ft^3 = 273 ft^3 X 7.48 gal/ft^3 = 2042 gallons. Of course we could also convert to gallons in each section first, then add: 177.75 ft^3 X 7.48 = 1329.57 gallons; and 95.23 ft^3 X 7.48 = 712.32 gallons. Added: 1329.57 + 712.32 = 2042 gallons.

<u>Scale drawing of EWU Pool – Look closely at the odd slopes on the diagonal</u>



Above is the scale drawing of the EWU Pool. How many sections would you use to divide it up? Notice that only one section has a flat bottom, and that's 18' deep. Next time, we'll look at how to calculate chemical dosages.

Questions about pool math? Email me at leos@ewu.edu.

Greg Schmidt,
EWU Aquatic Center Manager
Aquatic Facility Operator Instructor