

## Determining Volume in a Small Pond with a Staff Gauge

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Determining stored water volume in stock water ponds has become a requirement for many landowners. Pursuant to SB588 the California State Water Resources Control Board (Water Board) requires the monitoring of water being diverted and put to beneficial use. Stock water ponds are part of this requirement. The water board's deadline for installation of a monitoring method has already passed, meaning if not done, this should be completed immediately. The frequency of reporting stock water pond volume depends on the size of the pond. This could change, but as of 2019 the current reporting requirements listed by the water board are:

| <b>Pond<br/>size<br/>Acre<br/>feet</b> | <b>Required<br/>Monitoring<br/>Frequency</b> |
|--|--|
| <10                                    | Monthly                                      |
| 10-49                                  | Monthly                                      |
| 50-199                                 | Weekly                                       |
| 100-999                                | Daily  |
| >1,000                                 | Hourly                                       |

[https://www.waterboards.ca.gov/waterrights/water\\_issues/programs/diversion\\_use/water\\_use.html](https://www.waterboards.ca.gov/waterrights/water_issues/programs/diversion_use/water_use.html)

Ponds over 100-acre feet require either the completion of a UC water measurement course by the land manager or measurement must be set up by a contractor, professional or engineer. Ponds under 100-acre feet require an individual with experience in measurement and monitoring. This article provides a method of determining the volume of these smaller ponds. This method is most practical for ponds between 10 and 50-acre feet, as the monitoring requirements of larger ponds will likely require some form of automation. While depth-capacity curves are less essential for < 10 acre-feet ponds, the calculator is still useful in determining the overall capacity of the ponds.

Since stock ponds aren't flat bottomed, the simplest way to monitor water volume is with a pond curve showing the total volume stored as the water level changes throughout the season. While pond curves are available for some ponds in CA, it is not uncommon for ponds constructed decades ago to have never had a staff gauge installed or a pond curve developed. If your pond is registered with the Bureau of Dam Safety, was designed by the USDA NRCS or Resources Conservation Districts (RCDs), or was surveyed during an inspection by the Water Board, a pond curve may be available. Check with those agencies to see if they can provide it.

Permittees or licensees of ponds (Water Right IDs begin with 'A') can send an email request to the CA State Water Resources Control Board (SWRCB) at [dwr-measurement@waterboards.ca.gov](mailto:dwr-measurement@waterboards.ca.gov), with the Water Right IDs of interest, to see if the Division has a depth capacity curve or survey information that the diverter can use to construct the curve for their water right. The SWRCB does

not maintain survey information for Domestic, Irrigation, or Livestock Registrations (Water Right IDs beginning with ‘D,’ ‘H,’ or ‘L,’ respectively); Stockpond Certificates (Water Right IDs beginning with ‘C’); or Riparian and Pre-1914 claims of right (Water Right IDs beginning with ‘S’).

If a pond curve can’t be found, one will need to be developed. It can be accomplished by measuring the water and corresponding surface area of the pond for at least three or four different levels between full and empty. This can be accomplished by installing a staff gauge (Figs. 1). Because of the irregularity of many reservoir bottoms, the staff gauge needs to be installed in a location that represents the average ground level of the bottom of the pond. A handheld GPS unit (or smart phone with GPS capability) can then be used to determine surface area (Fig. 2)

Figure 1. Staff Gauge



Figure 2. GPS Unit noting area



The timing for beginning this project is late summer/early fall when the pond is at its lowest elevation. Here are the steps for completing the measurement.

1. Install the staff gauge in a location that represents the average ground level of the bottom of the pond. It must be plumb to get an accurate reading. If you have an existing staff gauge that is installed at an angle the App will not work until a relationship can be made between the demarcations on the angled staff gauge and actual pond depth
2. Note the level of the water on the staff gauge.
3. With a GPS unit or smartphone app, set to “determine area” and walk around the water line (at water’s edge) of the pond to determine the surface area. **Record the surface area in square feet and corresponding depth in feet.** Table 1 shows potential sources and cost for example types of equipment.

Table 1. Selected GPS Equipment Costs

| Equipment Name          | Cost  | Platform            |
|-------------------------|-------|---------------------|
| Garmin Etrex 10         | \$110 | Standalone GPS Unit |
| GPS Fields Area Measure | Free  | ios smartphone      |
| Fields Area Measure     | Free  | android smartphone  |
| Field Navigator         | Free  | android smartphone  |

4. As the pond fills, repeat this process to establish the relationship between depth of the pond and surface area of the water. Table 2 is an example of measurements taken across four different days throughout the season.

Table 2. Example Measurements Across Four Days

| Date       | Depth (ft) | Surface Area (square ft) | Surface Area (ac) |
|------------|------------|--------------------------|-------------------|
| N/A        | 0.0        | 0                        | 0                 |
| 8/31/2018  | 1.0        | 27,940                   | 0.64              |
| 11/15/2020 | 3.5        | 230,860                  | 5.30              |
| 1/31/2019  | 5.5        | 426,888                  | 9.80              |
| 2/28/19*   | 6.0        | 495,713                  | 11.38             |

\* Pond is at capacity-overflowing

5. Go to : <https://ucanr-igis.shinyapps.io/PondCalc/> and follow the steps to generate a personalized pond curve. For full functionality, view this website using google chrome. Figure 3 is a screen shot from the App.

- a. To familiarize yourself with the app, try entering the data from this article (Table 2) and compare the outputs. It is important that after entering each depth and surface area, you confirm your entry by clicking on the “add row” button.

Figure 3. Screen shot of the Pond Volume Calculator

Click on the 'Calculate' button to show the total Acre-Feet of your pond. (Optional) To save your entered values, click on the csv or xlsx file after you have calculated your pond values.

**Step 1: Enter Raw Pond Data**

**Upload completed table**

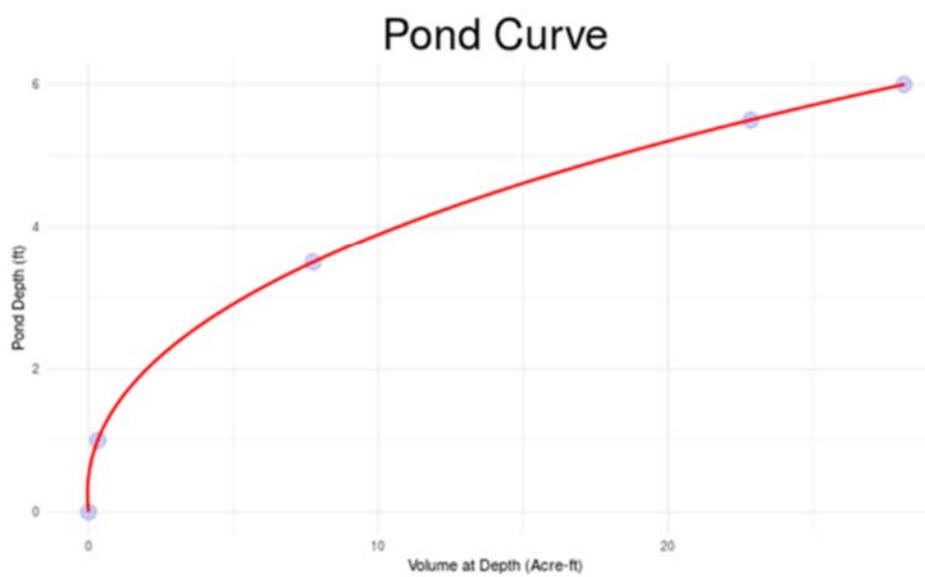
Browse... No file selected

or add manually below:

**Depth(Feet)**  **Surface Area**   Acres  
 Square Feet

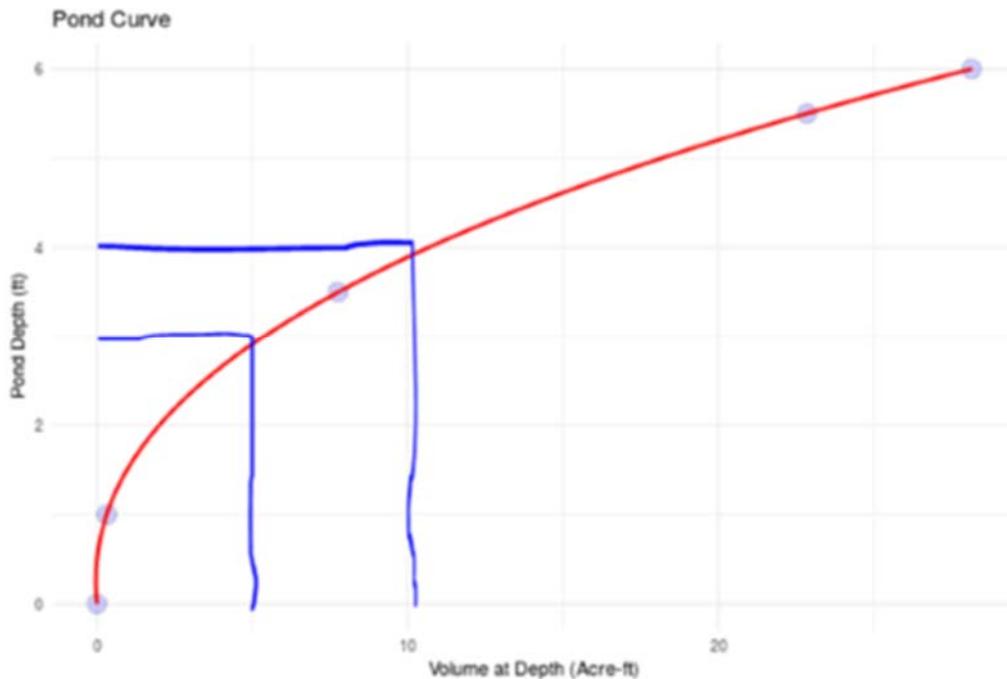
**Step 3: Current Pond Volume**

Enter current pond depth (Feet)



- b. After you have entered all your collected data (depth and corresponding surface area), a pond curve will be automatically generated (Figure 4).
- c. For incorrect values, click on the incorrect row and click “Remove selected rows”. The pond curve should adjust automatically.
- d. The pond curve is calculated using a three-factor polynomial equation and is suitable for most ponds. To improve the accuracy of the curve, increase the number of data points (pond depth and corresponding surface area).
- e. This App will not work for ponds with islands or channels cut into in the pond.

Figure 4. Pond Curve developed from depth and corresponding surface area data. Example provides relationship between pond depth and water volume (acre feet)



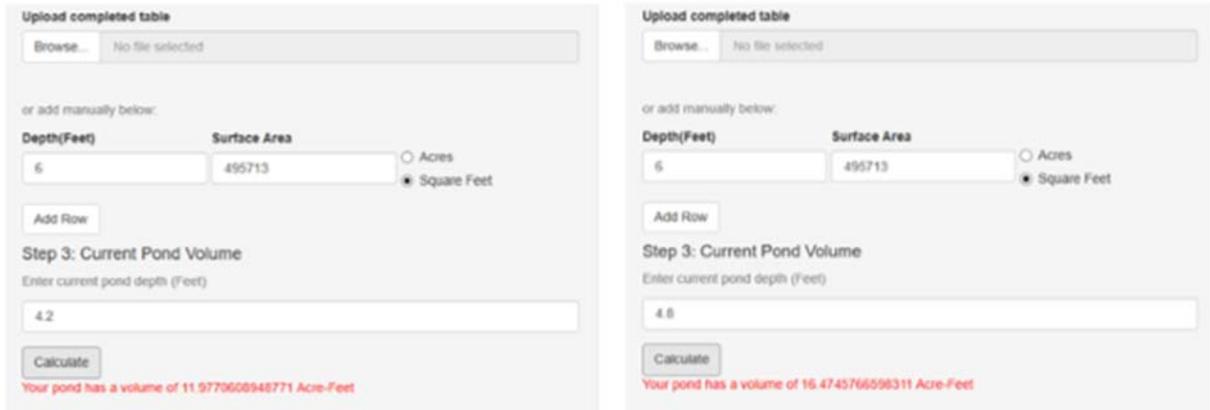
6. After a pond curve is developed (Figure 4) it can be used to track changes in total volume using staff gauge readings. If you want to know the change in volume during the month of November, you would note the staff gauge reading on November 1. In this example, the staff gauge read 3’. The corresponding volume is five acre-feet. You read the staff gauge again on November 30<sup>th</sup> and it reads 4’. The corresponding volume is ten-acre feet. The increase in volume is 5-acre feet. Table 3 outlines this change.

Table 3-Volume change data based on pond curve.

| Date Staff Gauge Read | Staff Gauge Reading | Corresponding Volume    |
|-----------------------|---------------------|-------------------------|
| November 1            | 3’                  | 5 acre feet             |
| November 30           | 4’                  | 10 acre feet            |
| Change                |                     | Increase of 5 acre feet |

Once the curve is established, the app can also be used to calculate pond volume. Step 3 in the app will let the user key in a value and “Calculate” the pond volume at that depth.

Figure 5



7. This function can also be used to determine volume change in a month. Assuming that a water level of 4.2 feet (Figure 5, Left) was collected in Jan. 1, we calculate a volume of 11.98 acre-feet. On Jan. 31, the depth moved to 4.8 feet (Figure 5, Right) to calculate a volume of 16.45 acre-feet. The increase in volume for the month is therefore 4.7 acre-feet. Table 4 summarizes this approach.

Table 4

| Date           | Depth | Acre Feet Storage (from App) |
|----------------|-------|------------------------------|
| Jan. 1         | 4.2 ‘ | 11.98                        |
| Jan. 31        | 4.8’  | 16.45                        |
| Change in Jan. |       | 4.47 (increase)              |

8. To save your inputs so that you do not have to manually enter all the individual values, select one of the export options (CSV, Excel) using the buttons above the table. This generated file can be modified and uploaded to the app as more information is collected.

Copy CSV Excel Print

| depth | area   |
|-------|--------|
| 0     | 0      |
| 1     | 27940  |
| 3.5   | 230860 |
| 5.5   | 426888 |
| 6     | 495713 |

Showing 1 to 5 of 5 entries

If there is incorrect data, remove the rows before calculating. Click once on each row containing incorrect information, then click on the 'Remove Selected Rows' button below.

Remove Selected Row(s)