The rise and fall of Lake Okahumpka

why the elevation keeps changing

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I became very interested in the lake in December of last year (2023) after a very heavy rain storm brought 4.7" of rain and very high winds during Dec. 16-17. The result of the storm was very high Lake Okahumpka water levels, which we all noticed at the Gazebo area. Very little grassy area remained as the canals and the pond expanded and approached the pavement loop. I wondered what were the controlling factors governing the elevation of Lake Okahumpka. See Figure 1

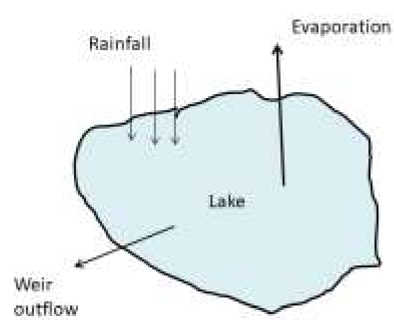
Figure 1

Measurements of Lake Okahumpka elevation

Staff gauges at a lake inlet (at CR-167) and at the weirs are visually recorded monthly, and an electronic gauge sends elevation at the weirs hourly. These give us the history of Lake Okahumpka elevation. Study of the gauges results exposed a departure between the lake gauge and the structure gauges. This is due to the restrictive nature of the upper marsh between the lake and the weirs which control the outflow rates. The local region near the weir empties faster than the lake as the marsh does not enable rapid resupply; differences of up to 5" or so result. This is the reason that SWFWMD might install an hourly reporting elevation sensor near the Gazebo. In the meantime a calibration relating lake level (at CR-167) to bolt holes in an immersed sign post near the canoes is being used as a substitute to provide more information.

Lake Okahumpka water Budget

Direct rainfall to the Lake, the canals and the CCC drainage into each is the major contributors to rise in Lake Okahumpka levels. Very small streams on the Northwest edge of the Lake and near the County Park are minor contributors for raising lake elevation (Ref. 2). The ground-water component is small also (Ref. 1). The large components of lake elevation reduction are evaporation and discharge via the twin weirs at the berm of the electric company transmission easement. As a result, the water budget can be simplified to be Rainfall minus weir-outflow-and-evaporation. Figure 2



Calculating Lake Okahumpka elevation

1) Rainfall values

Rainfall is easy, as it is directly measured. The rain gauge is located near the old wastewater treatment facility (Figure 3). It collects rainfall data and electronically sends results to SWFWMD. A cumulative daily total is reported via the SWFWMD website.

Figure 3

2) Weir outflow values

Bernoulli's principle is a key concept in fluid dynamics that relates pressure, speed and height and more. Bernoulli's principle states that, in this case, an increase in the speed of a parcel of fluid occurs simultaneously with a decrease in height. Knowing the water height above the weir lip and weir width, we can calculate the flow rates (Figure 4). At various times boards are inserted onto the weirs to raise the level for lake elevation control.

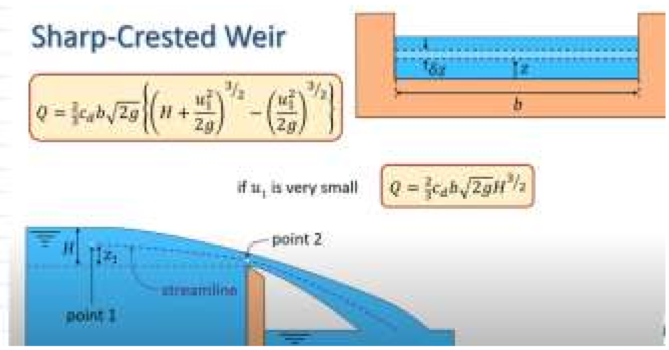


Figure 4 From Reference 6

3) Evaporation values

Evaporation from the lake is a highly variable process. The calculation of evaporation is tedious and requires looked up knowledge of daily atmospheric properties. The Florida Automated Weather Network (FAWN) was created in 1997 with a legislative appropriation for the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS). Fortunately FAWN enabled lookup of calculated evaporation using parameters measured in Okahumpka Fl.

The Penman formula for the evaporation rate from a lake is simplified to the following:

$$E_0 = \frac{700\, T_m/(100-A) + 15(T-T_d)}{(80-T)} \ (\text{mm day}^{-1})$$

where $T_m = T + 0.006h$, h is the elevation (metres), T is the mean temperature, A is the latitude (degrees) and T_d is the mean dew-point. Values given by this formula typically differ from measured values by about 0.3 mm day^{-1} for annual means, 0.5 mm day^{-1} for monthly means, 0.9 mm day^{-1} for a week and 1.7 mm day^{-1} for a day. The formula applies over a wide range of climates. Monthly mean values of the term $(T - T_d)$ can be obtained either from an empirical table or from the following empirical relationship, provided precipitation is at least 5 mm month^{-1} and $(T - T_d)$ is at least 4°C:

$$(T - T_d) = 0.0023h + 0.37\,T + 0.53\,R + 0.35\,R_{ann} - 10.9^\circ \text{C}$$

where R is the mean daily range of temperature and R_{ann} is the difference between the mean temperatures of the hottest and coldest months. Thus the evaporation rate can be estimated simply from values for the elevation, latitude and daily maximum and minimum temperatures.

4) Lake Okahumpka Excel Elevation Model

A Microsoft Excel spreadsheet was created to make day step incremental calculations of the lake elevation using the three components of rainfall, weir outflow and evaporation described above. The calculations were initiated the day prior to the December 16-17, 2023 storm, and the model was run through September, 2024. The model was created to validate understanding of the principles. Coefficients were applied to each component to provide the best mathematical fit to match the measured data.

Data from the SWFWMD gage at CR-167 was used when it was available but it is only recorded once per month. To augment this gauge's data, a sign immersed in the canal near the canoe was used as previously noted.

The model is capable of predicting the effect of various weir gate height settings, reflecting the presence of stop board placement for increasing the lake elevation. Both boards were removed immediately after the December 16-17, 2023 storm, and the larger one reinstalled in January-February 2024, only to be soon removed. Weir elevation is shown on Figure 5. Also shown on Figure 5 are the MLL (Minimum Lake Level) and HMLL (High Minimum Lake Level) target levels used by SWFWMD when making judgements as to the weir height required (Ref. 2).

The Lake elevation prediction is shown on Figure 5, just below, along with the data from the staff gauge and the simulated data from the immersed sign near the canoes. The weir portion of daily water elevation loss is shown as percentage of total loss. The remainder of elevation loss is due to evaporation, which can exceed 1" per week during summer months.

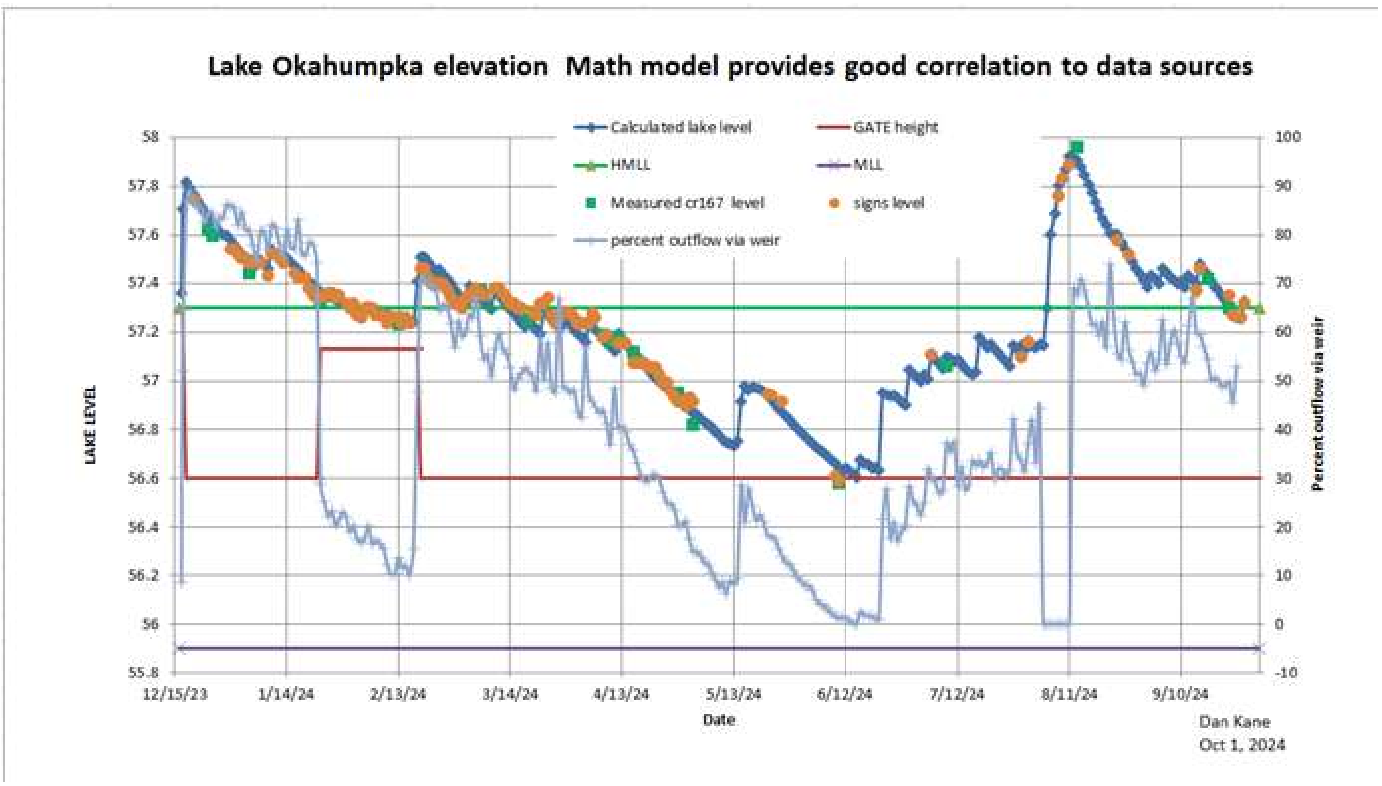


Figure 5

Historic Lake Okahumpka Elevations

Monthly readings at the staff gauge at a lake inlet off CR167 have been documented for some time. Observations prior to 1991 were scant. Figure 6 shows the results of those readings. Some years with high lake elevation had particularly long periods of heavy rain with thunderstorms almost daily, other years were high in elevation due to hurricanes. The last few years are showing tendency toward generally higher elevations. A SWFWMD scientist explained this, and this is documented below.

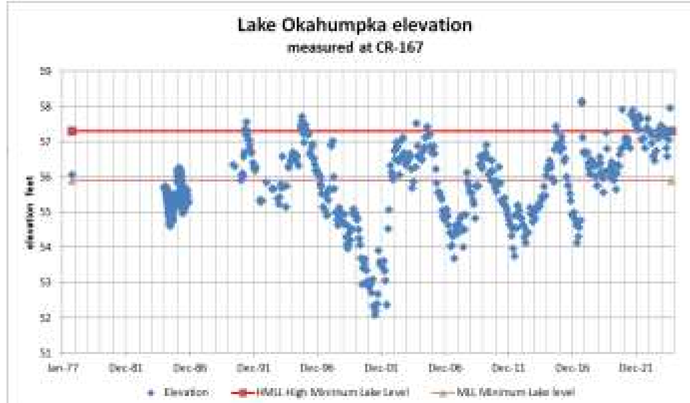


Figure 6

During drought years, the lake elevation dropped below 54’ (all herein using NAVD88, the current elevation system). Years 1998-2002 were particularly bad drought wise, note the extremely low elevations-down to 52’. This latter period elevation may have resulted in both drought and the failure and subsequent repair action of the culverts in the electric company transmission berm. The failed culverts, which connected the upper and lower marshes, were replaced by the current weir structure during this period.

Reports of and complaints about low water levels in the canals and the lake have been discovered in one of my history sweeps. In July 1994, the lake had dropped to near 55’, resulting in navigation difficulties (See Ref 3). In May 1999, the lake again was low - 54’ elevation. At this level the canal became dry in places. See Figure 7, and Reference 4 and 5.

Figure 7

Other years had low elevations. Beverly Stevens remembers practically dry conditions of Chitty Chatty Creek at the bridge during 2007. Can anyone comment about low water in the canals during 2007, 2012, and 2017? During these years the lake was as low as or lower than that of May 1999, which stirred quite a ruckus. Certainly it would have been difficult to navigate the canals at these levels.

The data gives us somewhat of a means of estimating the height of water in the canals. Figure 7 shows bare ground in some areas near the gazebo. This was when the lake elevation was 54’. The depth in that canal would be the difference between 54’ and the current elevation of the lake. From the elevation history, the canal would never be much greater than 4’ since the value of elevation of the lake hardly ever exceeds 58’. This also fits comfortably with the comments in Reference 3.

Flow capacity of the weirs

The weirs have been in service now for over 20 years. We have no record of stop boards operations prior to November 2021, at which time the solar powered electronic gauge was installed. However it is clear that the two weirs, although somewhat effective, are each only 4 feet wide and too small to be able to reduce the lake elevation at a more reasonable rate to provide additional storage capacity for future rains. The weir capability is overwhelmed by the intermittant (fortunatly) rainfall. Figure 8 shows the individual water budget daily contributions.

Photo: Dec 20, 2023 Richard Burr

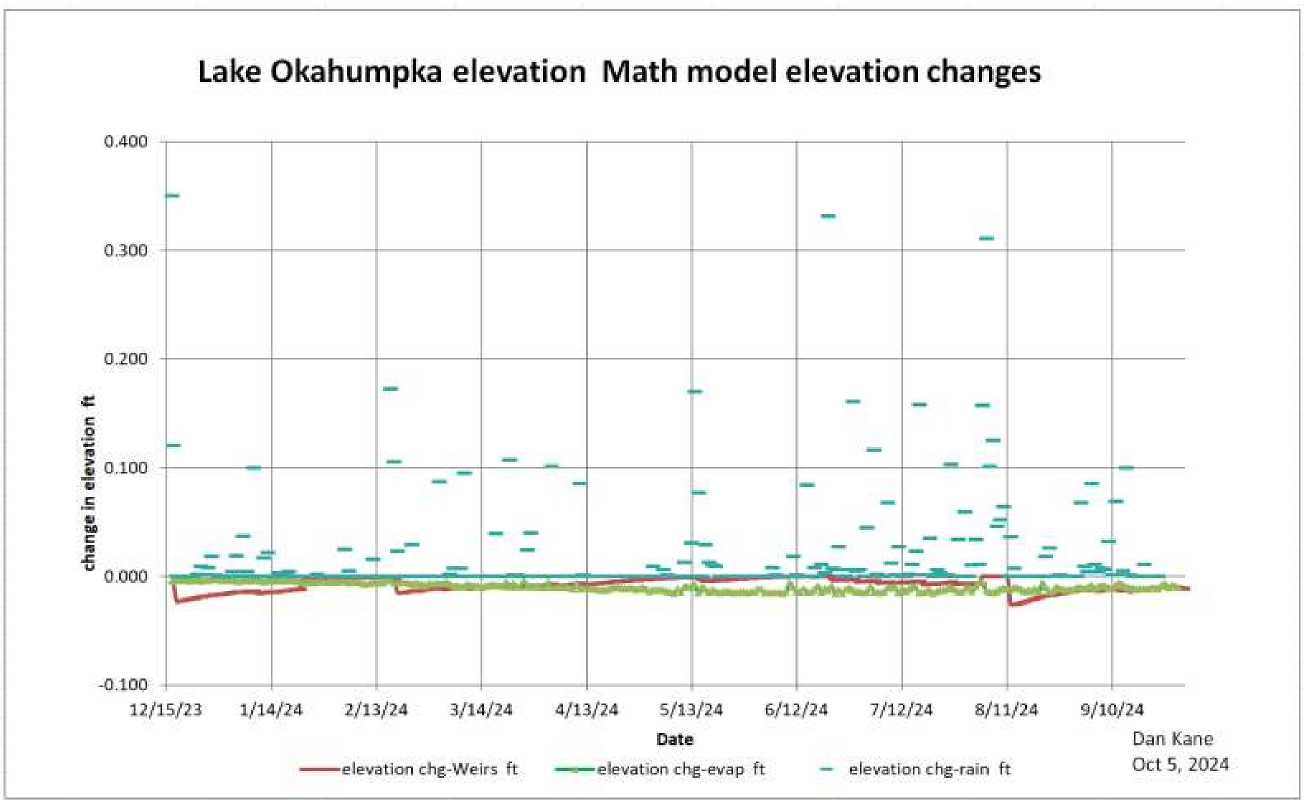


Figure 8

SWFWMD Scientist provided a relationship between rainfall and lake level

One last question needed answering: Why are the lake elevations over the last few years so much higher and less variable (see figure 6) ? We got our answer from SWFWMD.

"After looking at the relationship between rainfall and water levels on the lake, there is a strong correlation (Pearson correlation coefficient 0.78) with the previous 34-month average rainfall which you can see in the graph below. This is close to the 3-year (36 month) average which is also strongly correlated (0.77), so taking a look at the 3-year average rainfall totals does reveal that the last 3-year average (21-23) has been the highest 3-year average rainfall dating back at least since the current structure has been in place. Going back even just slightly further, the 3-year average from 2020-2022 is the 4th highest 3-year average. Just a quick look into some of the surrounding lake levels reveals a similar pattern on these lakes as well. I haven't yet taken a deep dive into that, but I will update when I do." T.J. Venning SWFWMD. Rainfall is presented as a 36 month rolling average

Figure 9

Discussion

This study was initiated after meeting with the SWFWMD scientist (T.J. Venning). He responded to Richard Burr's call about dying trees around the lake, which he thought to be caused from high lake water levels. Scientist Venning acknowledged that the lake levels have been high in recent years, and explained that (see above). The district feels that the lake levels are within the levels proposed in Ref 2. The weir vicinity gauge and gate height are being monitored closely. No stop boards are installed at the moment and the weirs are flowing at maximum capability to promote some storage in the lake. The weirs are considered small, and it takes a long time to lower the lake. It is expected that the boards will be left removed well into the next drought year. SWFWMD wants to install an hourly reporting gauge in our canal. This will provide a more accurate, and higher, value than the current gauge at the weir. This will enable better understanding and control of the lake's levels.

References – all available via CCC website's "The Lake and the Land"

1) Hydrology of the Lake Deaton and Lake Okahumpka area, Northeast Sumter County, Florida
https://www.continentalcountryclub.com/images/Resident-portal/geographics/lake_Okahumka_et_al.pdf

2) Minimum and Guidance Levels for Lake Okahumpka in Sumter County, Florida
https://www.swfwmd.state.fl.us/sites/default/files/documents-and-reports/reports/okahumpka_lake_proposed_mfls_report_sep2006.pdf

3) Letter discussing low water level in canals. 1994
https://www.continentalcountryclub.com/images/Resident-portal/geographics/lake-_Zimmer_letter_concerning_lake_canal_lake_level_july_1994.pdf

4) Letter and news article describing low lake water levels. 1999
https://www.continentalcountryclub.com/images/Resident-portal/geographics/save_lake_okahmpka_committee_sinking_level.pdf

5) Second Letter describing low lake water levels. 1999
https://www.continentalcountryclub.com/images/Resident-portal/geographics/save_lake_okahumpka_committee_nov_1999_memo.pdf

6) Source of Bernoulli equation documentation
https://www.youtube.com/watch?v=gxJWAUqGX9w