The rise and fall of Lake Okahumpka

why the elevation keeps changing

Dan Kane December, 2024

I became very interested in the lake in December, 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.

After the Dec 16-17, 2024 Storm

Since then we have had a few significant storms. Hurricanes Debby, Helene and Milton brought significant rainfall to the region.

Oct 12, 2024 Kathy Simon Sterlace

Hurricane Debby was a slow-moving and erratic Category 1 hurricane that caused widespread flooding during August 4-5, 2024.

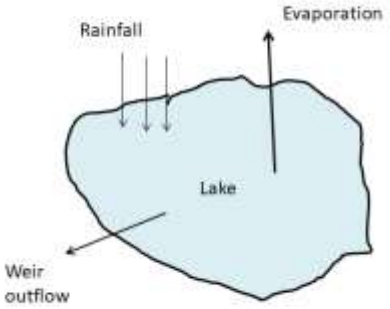
Hurricane Helene passed westward bringing winds and only about an inch of rain during September 26-27, 2024.

Hurricane Milton, preceded by days of rain, land fell at Category 3 and brought strong winds and very heavy rain (7”-8”locally, more not far away) during October 9-10, 2024, and never seen before lake elevations. So much flooding occurred that the Gazebo area had to be closed.

Oct 12, 2024 Carol Ann Hoesch

Both Debby and Milton upset the lake’s normal water budget and resulted in so much water that the lower marsh, south of the electric company easement berm, overwhelmed part or all of the berm, reversed the weir flow, and flooded its water into the lake to significantly raise the elevation. Milton’s flooding was the more significant. Debby overwhelmed a lower portion of the berm and reversed the weir flow. Milton raised the level well above the entire berm-road. This is further explained in the Discussion later herein.

Lake Okahumpka water Budget



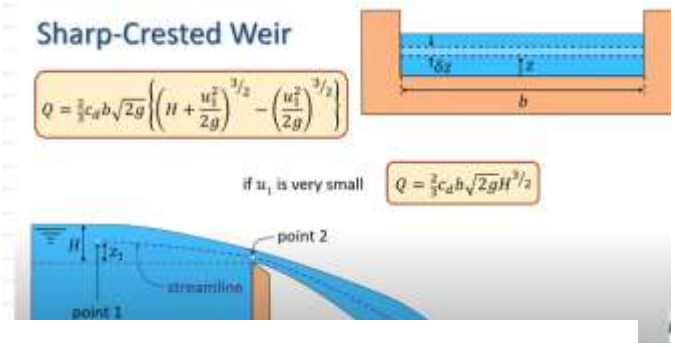
Direct rainfall to the Lake, the canals and the CCC drainage into each is the major contributors to rise in Lake Okahumpka levels. Very small streams on the Northwest edge of the Lake and near the County Park are minor contributors for raising lake elevation (Ref. 2). The ground-water component is small 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

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. It collects rainfall data and electronically sends results to SWFWMD. A cumulative daily total is reported via the SWFWMD website.

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.
The weirs have been in service now for over 20 years. At various times boards are inserted onto the weirs to raise the level for lake elevation control.

We have no record of stop board operations prior to November 2021, at which time the solar powered electronic reporting 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.

Photo: Dec 20, 2023 Richard Burr

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:

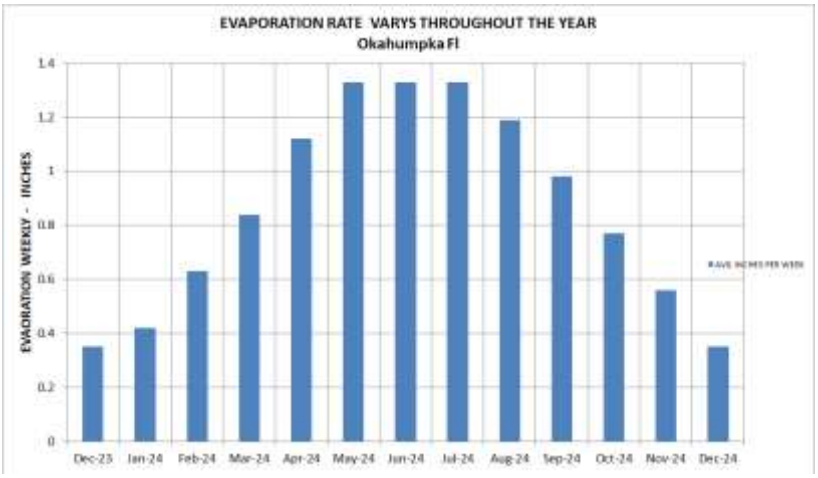
$$E_0 = \frac{700\,T_m/(100-A)+15(T-T_d)}{(80-T)}\ (\text{mm day}^{-1})$$

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.

Evaporation calculations for the past year are shown to the right.These are weekly rates of evporation for each month. There is signifcant variation during the year. Summer has high evaporation rate, winter is much less. Averages are given, but any month can also have large variation depending on weather conditions.



4) Lake Okahumpka Elevation Model (Excel)

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 at least through 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 to validate the model 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 canoes was used as a substitute.
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 (of each weir) were removed immediately after the December 16-17, 2023 storm, and only larger ones reinstalled in January- February 2024, only to be soon removed. Weir elevation is shown on Figure 1. Also shown on Figure 1 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 1 along with the data from the staff gauge and the simulated data from the immersed sign near the canoes. The values during the hurricane periods are from the electronic hourly gauge at the weirs, as the weir and general lake levels were then the same due to the massive flooding. Note the departure of the weir site readings as the water receded after Milton (Nov 2024).

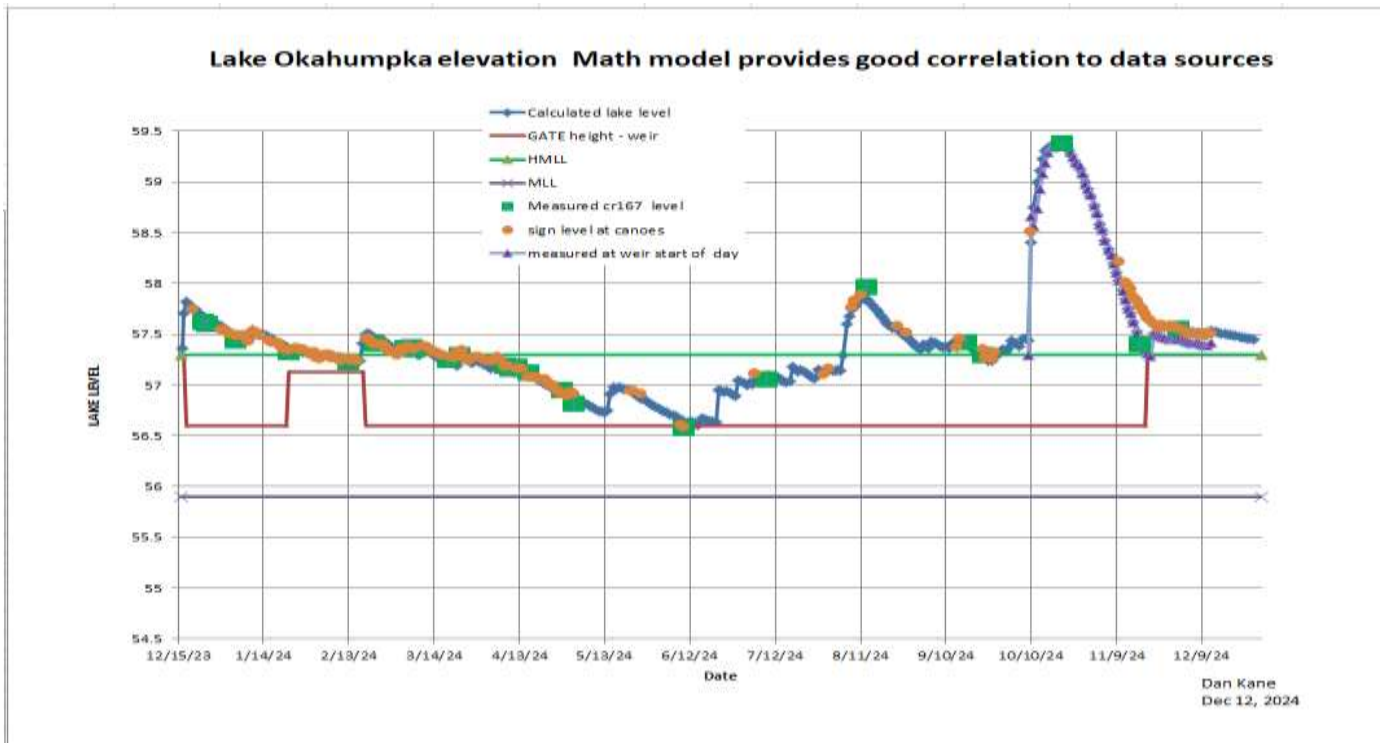


Figure 1

5) Historic Lake Okahumpka Elevations

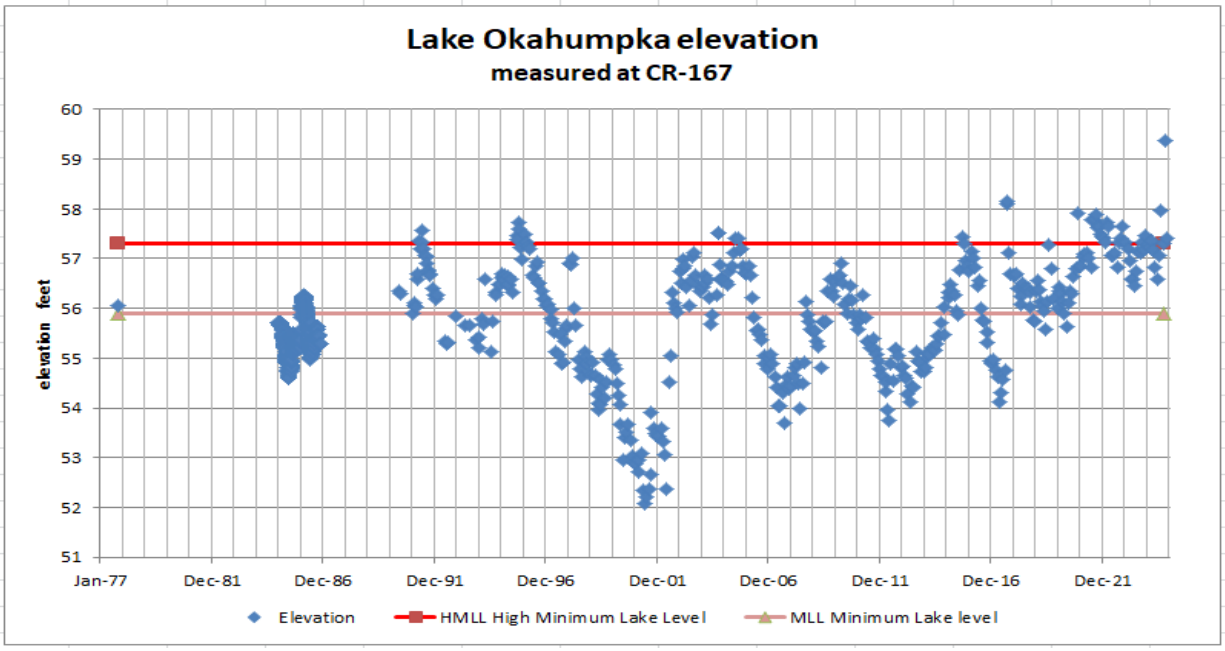


Figure 2

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 weir structures 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, as mentioned above, a calibration relating lake level (at CR-167) to bolt holes in an immersed sign post near the canoes are being used as a substitute to provide more information.

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 2 shows the CR167 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, see documentation below.

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 image, and Reference 4 and 5.

Other years had low elevations. Beverly Stevens remembers practically dry conditions of Chitty Chatty Creek at the bridge during 2007. Can anyone else 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 then stirred quite a ruckus. Certainly it would have been difficult to navigate the canals at these levels.

The data gives us a means of estimating the depth of water in the canals. The image 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.

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 2) ? 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.

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 Richard 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 long term (period of record) lake levels are within the levels proposed in Ref 2. These proposed (2006) levels are HMLL (High Minimum Lake Level)-statistical P10 for which 10% of the values are higher, and MLL (Minimum Lake Level) statistical P50 for which 50% of the data falls below. These guidelines and the period of record elevation data are shown in Figures 1&2 above.

The weir vicinity gauge and gate height are being monitored closely. No stop boards were installed since mid-April, 2024 and the weirs were flowing at maximum capability to promote some storage in the lake. This condition was maintained through hurricanes Debby, Helene, and Milton. As the water receded after Hurricane Milton, all the boards were installed to keep level high in anticipation of a long season of little rain. This is consistent with SWFWMD policy, which is printed at the end of this report. 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 future understanding and control of the lake's levels as significantly more actual lake elevation data will be available. The weirs are considered small, and it takes a long time to lower the lake. As water level further lowers, approaching the weir setting level, weir flow eventually stops and the lake loses water primarily through evaporation. This can happen fairly soon after the boards are installed, and can also eventually occur when the weir is lowered.

This report does not define what CCC wants the Lake levels to be. Setting the Weir stop boards is entirely the responsibility of SWFWMD who manage levels for over 80 lakes in the district. Each lake is different and we might know more special details about Lake Okahumpka. We have concerns of our own of the lake.

High water level – We started this study over the concern that the high water levels of the last few years was the cause of damaged trees. It is probably so, however, giving some perspective, the damage observed a year or so was slight when compared to the damage from Hurricane Milton. Future storms could easily do more damage. We also want to have reasonable levels for recreation in the Gazebo Park.

Drought – There must be a high enough end of rain season level such that the lake and our canals have enough water after long period of no-rain. Our canals go dry at 54” elevation and navigation becomes rather impossible as levels drop toward 55’ elevation.

After Hurricane Debby, SWFWMD responded to questions about the surprising level of water and the resulting high Lake Okahumpka water levels and the overwhelming of the weir and parts of the berm-road. The bulk of their response is now on our website and is reference 7 below. The measurements and explanations were very helpful, showing the source of all the water leading to our lake region. That provided an understanding when the next and larger storm (Hurricane Milton) arrived.

The berm-road is not level. There are depressions before reaching the weir site. Portions of the road are more than a foot lower. When heavy rains come and a large quantity of water approaches the lake from Chitty Chatty and the higher water containing lands around us and, possibly, reversed flow from Hogeye Sink (read Ref 1), the water flows to the lake by crossing the road in the low regions, and by reversing the weir flow direction. This was first noticed after Hurricane Debby. This and more happened during and after Hurricane Milton, which caused the entire region to have levels higher than the entire berm. The below chart (Figure 3) has a scale-less sketch of the road's depression. The small triangles show where measurements of road elevation were available. Only the deepest road depression and the road at the weir elevations were able to be calculated. The orange box indicates the variation of the weir control levels with and without the stop gap boards. Maximum lake elevations at the weir for both storms (Debby and Milton) are also shown on the chart. It can be seen how Debby was able to flood the lake via the low spots, and how Milton overwhelmed the entire berm.

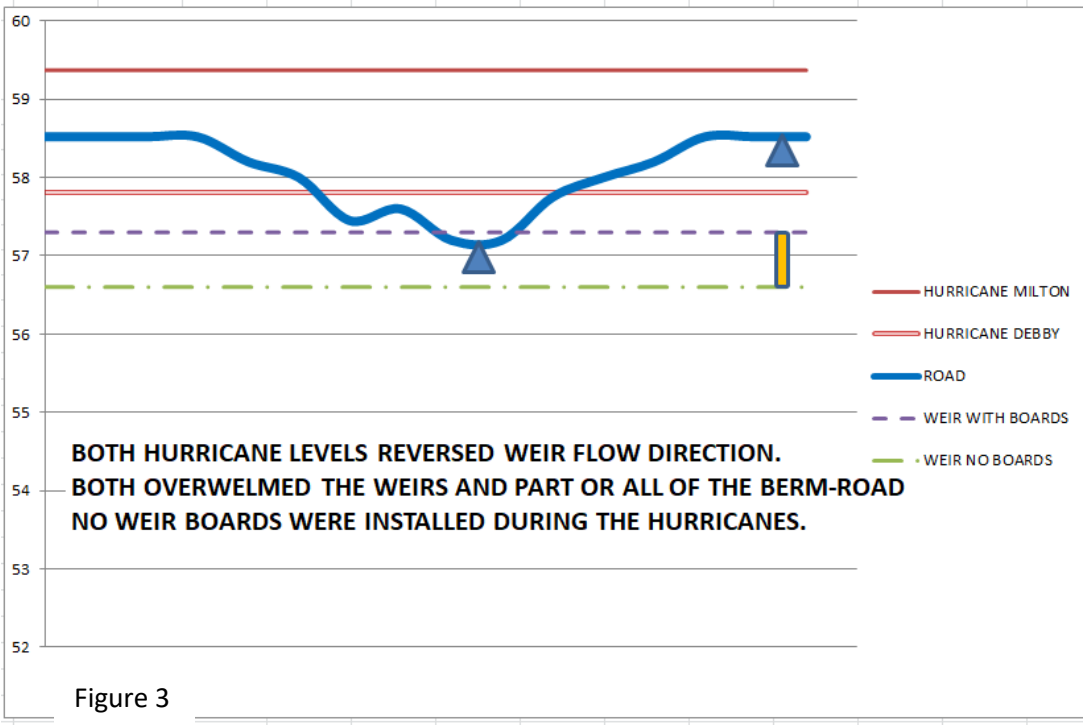
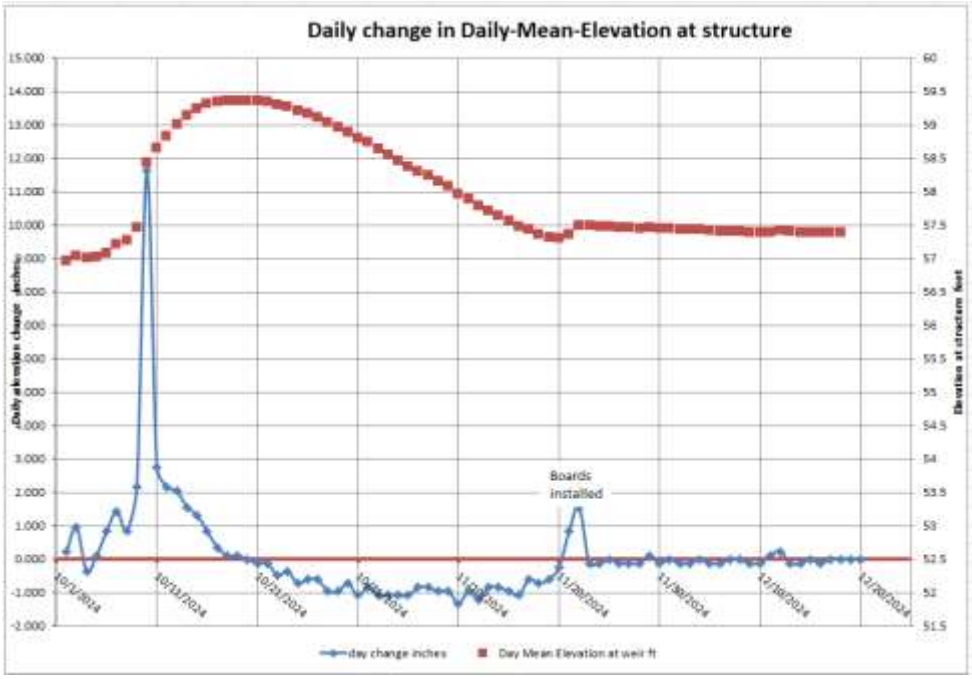


Figure 3

During both storms it was seen how the lake elevation immediately reflected the increase in level due to the rain, and then as water moved from Chitty Chatty and possibly from the Hogeye Sink towards the lake, the level continued, for many days, to climb until cresting. This secondary rise, during Milton, was as large as the immediate rainfall and accumulation continued for over a week before cresting.

Note how rapidly the Lake level dropped after Milton. Hogeye Sink is the only means of draining water from the entire region. It has enormous potential depending on the backpressure of the surficial aquifer. After Milton our lake was dropping at the rapid rate of approximately 1 inch per day for about 3 weeks, until the local weir level approached the elevation of the lower regions of the berm-road. Then the rate of dropping elevation slowed to only about 0.1 inch per day. Very soon after this, SWFWMD placed the boards on the weir to hold level in anticipation of a following dry season. The last chart shows the day by day reduction in lake level after Hurricane Milton. Lake elevation is also shown on the chart.

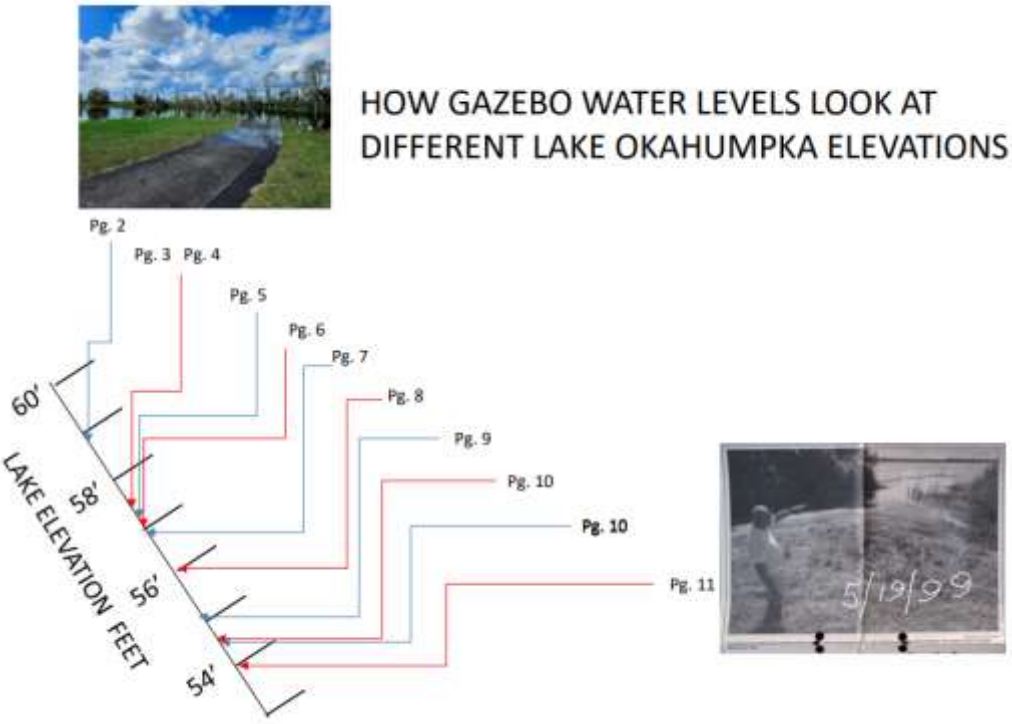


Although the depression of the berm-road allowed more flooding into the lake, it did serve as a relief valve after Milton. Acting as a bypass supplement to the weirs until the retreating lake level approached the road depression elevation. If the depression were filled in, Debby may not have raised the lake so high, but Milton's Lake Okahumpka flooding would no different as it had levels higher than all the berm. However, without that bypass, the lake would have taken 'forever' to drop from Milton's levels due to evaporation and the small weir outflow alone. So the depression is like a two edged sword.

It might be considered, if this is even practical, that a series of culverts were to be placed across the road, the culverts would need Tideflex Valves to prevent storm water flow from the lower marsh to enter the lake, acting like a check valve. This would require enough culverts to provide sufficient flow area to reduce the lake elevation, and the culverts would have to be placed high enough to prevent the lake from draining lower than the HMLL elevation.

At the very least, some fill should be placed to replaced the berm-road depressions. This cross flow has potential to erode the berm which could lead to loss of control of lake level. It is very difficult during wet times to walk to the weirs and is difficult for the SWFWMD truck to reach them for their operations. Reinforcement and build up of the berm edges may be helpful as well.

Reference 8 contains photos taken over the years showing how the Gazebo area looks when Lake Okahumpka is at different elevations. The photos are of different sites at the Gazebo - it was not anticipated that this study would be done. No single location is available for the whole story. Resident photos are welcome. The time period is from 1999 to post Milton (October 2024), and lake levels were from 54' to almost 59'. The latest one is post Milton is before the crest, which had measured level of 59.38'.



How the board operations at the weir are managed by SWFWMD

Hi Dan,

There are many factors that go into deciding when to replace the boards. Below is the information I put in the email back on March 14th for how we operate the water control structure.

- The stop logs out of the structure all summer.
- Adding stop logs – Lake Level, Climate, Weather Forecast, and limitations of the structure all play a role in making the decision to add the stop logs back. I have been making this decision for all of our 84 water control structures since 2016 and it can be a difficult decision to make. Weather forecasting accuracy is getting better every year and really helps with decision. The hardest part is we never know when a drought will start and sometime those can last for many years. When a drought occurs, everyone on the lake wants to know the last time we made an operation.

In general, the stop logs are removed during the summer, replaced in September, and then they may be removed / added during the dry season depending on lake level, rainfall, and predicted weather.

I put in that email that we normally replace the boards in September but due to extremely wet conditions this fall we delayed that operation until November. Below are a few points as to why the boards were replaced.

- Very little rain has fallen since Milton and the short-term forecast calls for no rain.
- Climate forecast for this winter calls for a 80% chance of below average rainfall. The U.S. Drought index has "drought development likely" for our area. This is most likely caused by La Nina. You can see the forecasts at: https://www.cpc.ncep.noaa.gov/
- Allow the lake to naturally fluctuate during the dry season. We try to allow lakes to naturally change by Mother Nature as much as possible during this time of the year. It is best for the health of a lake and we never know when a drought will start.
- There should still be some water flowing over the boards even with them installed so we can't hold this level anyway as it will slowly go down from evaporation and loss of water through the structure.

I am aware of the high-water concerns but all signs point to a possible drought starting this winter so I made the decision to conserve as much water as possible while we can.

Hope this helps understand how we manage lake levels.

Patrick

Patrick Casey

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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

7) Lake Okahumpka High Water Investigation by SWFWMD post Hurricane Debby
https://www.continentalcountryclub.com/images/Resident-portal/geographics/Okahumpka_HighWaterInvestigation_20240815_3.pdf

8) How the Gazebo area looks at different Lake Okahumpka elevations
https://www.continentalcountryclub.com/images/Resident-portal/geographics/WHAT_LAKE_LEVEL_LOOKS_LIKE.pdf