White Lake Rainfall and Lake Levels

At White Lake, lake levels vary primarily due to rainfall--both the total amount, and how it is distributed over the course of a year—so keeping records of both is important.

White Lake: Monthly Rainfall (in inches)

Monthly Rainfall (inches) for White Lake 2012-2021

Month	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	Monthly Average for Region
January	8.25	4.5	2.75	4.20	7.0	3.0	2.5	2.0	1.75	2.75	3.81
February	9.2	6.7	2.25	2.00	1.5	10.7	5.5	1.5	2.5	4.0	3.44
March	2.7	3.7	3.25	3.95	3.7	1.55	4.15	ND	1.0	7.0	3.91
April	1.75	5.1	7.25	6.75	6.75	6.75	4.55	ND	1.75	2.25	3.12
May	3.0	12.25	1.20	7.70	2.7	4.5	4.20	ND	2.25	9.25	3.67
June	7.9	7.15	5.25	10.00	4.5	3.65	8.70	3.0	17.0	2.0	4.70
July	7.5	6.85	6.00	4.75	6.75	3.75	3.0	4.65	11.25	8.6	5.75
August	6.5	7.55	5.35	6.25	5.6	4.12	9.4	9.75	8.25	9.75	5.95
September	3.2	5.95	5.00	29.45	5.2	15.0	4.7	7.0	1.0	5.0	5.29
October	0.6	3.35	3.60	2.25	2.95	14.25	9.75	1.7	1.75	2.25	3.38
November	0.4	7.5	4.90	4.25	1.0	0.50	7.25	4.15	0	2.25	3.16
December	3.4	4.25	6.00	7.5	5.45	5.1	6.5	3.7	5.75	4.25	3.14
Total	**54.4**	**74.85**	**52.80**	**89.05**	**53.1**	**72.87**	**70.20**		**54.25**	**59.35**	**49.32**
% of Lake Volume	**71**	**97**	**69**	**116**	**69**	**95**	**91**		**70**	**77**	**64**

(Volume of Total Rainfall on Lake Surface/Total Lake Volume) x 100 Gives an Estimate of Volume of Rainfall as % of Lake Volume

White Lake: Annual Lake Elevations, High and Low

2019 High (January 25): 64.6 Ft NAVD 88

2020 High (June 16): 65.2 Ft NAVD 88

2021 High (February 19): 65.3 Ft NAVD 88

2019 Low (July 9): 63.5 Ft NAVD 88

2020 Low (January 1): 64.3 Ft NAVD 88

2021 Low (November 29): 63.9 Ft NAVD 88

2019 Lake Level Variation (High to Low): 12.7 Inches
2020 Lake Level Variation (High to Low): 10.3 Inches
2021 Lake Level Variation (High to Low): 16.8 Inches

Variation (Highest-Lowest) Over the Three-Year Period 2019-2021: 21.1 Inches

The mean (average) high water level for the three-period 2019-2021 is 65 feet above sea level (NAVD 88 datum). In 2019, lake levels did not reach 65 feet, while 2020 and 2021 levels exceeded 65 feet for brief periods (including after Hurricane Florence in 2018, although no measurements were made at that time).

Legislation Does Not Mandate Lake Level, But Depth of Ditches Connecting to the Lake

A hydrological study was conducted by the State Hydrographic Engineer C.R. Edgerton in 1968, because of concerns about ditching and clearing activities along the western side of White Lake. A large, deep ditch was being proposed to facilitate development, and Edgerton concluded that seepage into this ditch could reduce lake level by 1 foot over the course of a year (his report is attached). In addition, he concluded that no openings should be allowed under U.S. 701 below the elevation of 66.0 feet, mean sea level (NGVD 29). He sent a copy of his report to the U.S. Geological Survey for review, and the district chief in the Raleigh office responded in July 1969: "our present knowledge suggests that White Lake is supplied by precipitation on the lake and by ground water flow from the adjoining area…drainage of any area adjacent to the lake will first stop ground-water inflow to the lake from that area and second permit water to drain from the lake into the drainage channels", so in his opinion any project designed to drain areas should be carefully considered (his letter is attached).

The North Carolina Legislature ratified H.B. 406, titled "AN ACT TO PREVENT THE DIGGING OF DITCHES BELOW A CERTAIN LEVEL IN BLADEN COUNTY", in 1971. Section 1 of that bill states: "It shall be unlawful for any person, firm or corporation to dig any ditch under any portions of U.S. Highway No. 701, N.C. Highway No. 53 and S.R. 1515 which surround that body of water in Bladen County known as White Lake below 66 feet above sea level". A second House Bill (994) was ratified in 1973, titled "AN ACT TO AMEND CHAPTER 570 OF THE SESSION LAWS OF 1971 SO AS TO ALLOW THE TOWN OF WHITE LAKE TO DIG DITCHES BELOW A CERTAIN LEVEL IN BLADEN COUNTY". This bill goes on to state that the Town of White Lake can obtain a written permit from the State Highway Commission for digging associated with the "installation, repair and maintenance of its water and sewer mains and lines" (copies of these bills are attached).

Nothing in the language of either bill establishes or mandates a lake level of 66 feet (NGVD 29) above sea level—the intention was to prevent ditching actions which could have a detrimental effect on lake levels.

Connecting Elevation Measurements to Lake Levels

The Town asked Walker Surveying Company to survey the elevation of the Turtle Cove spillway in December of 2017; at this time the lake elevation was 64.5 feet above mean sea level, NAVD 88 (a newer datum that is one foot lower than the old NGVD 29 datum [the elevation would have been 65.5 using the NGVD 29 datum] and at that time, sandbags were in place along the base of the invert to block water flow below a level that was roughly equivalent to 65 feet (NAVD 88). Personnel from NC DWR recommended removal of the sandbags, and that was done in April of 2018. A second survey of lake elevation was done by Walker Surveying in January of 2020 and the reading was again 64.5 feet (NAVD 88); these two surveys represent the only documented measurements of lake elevation that have been found in a search of records kept by the Town (the Walker memo from 1/17/20 is attached to this document).

Figure LL 1. Lake elevation gauge installed by Walker Surveying Company at Turtle Cove. Elevations are given in the NAVD 88 Vertical Datum. Photo taken January 16, 2020.

An easily accessible lake level gauge was installed in late 2018 on the Goldston's Motel Pier (eastern side of the lake, not far from Town Hall, installed by UNC-Chapel Hill personnel with www.locss.org), so it has been possible to collect regular lake level measurements since then. Town staff is currently collecting both lake level and rainfall information.

Figure LL 2. Lake level gauge installed by the Lake Observations by Citizen Scientists and Satellites program at the University of North Carolina-Chapel Hill, located at Goldston's Motel Pier (1608 White Lake Drive). Photo taken January 16, 2020.

Lake Level Monitoring Results--2019

Lake level variability in 2019 was consistent with the historical pattern of winter highs and summer lows, and total variation high to low was 12", which is also consistent with what has been measured in the past.

Elevation Above Sea Level in Feet (NAVD 88)	Goldston's Motel Pier Gauge
66.00	3.40
65.90	3.30
65.80	3.20
65.70	3.10
65.60	3.00
65.50	2.90
65.40	2.80
65.30	2.70
65.20	2.60
65.10	2.50
65.00	2.40
64.90	2.30
64.80	2.20
64.70	2.10
64.60	2.00
64.50	1.90
64.40	1.80
64.30	1.70
64.20	1.60
64.10	1.50
64.00	1.40
63.90	1.30
63.80	1.20
63.70	1.10
63.60	1.00
63.50	0.90
63.40	0.80
63.30	0.70
63.20	0.60
63.10	0.50
63.00	0.40
62.90	0.30
62.80	0.20
62.70	0.10
62.60	
62.50	

Figure LL 3. Lake elevation gauge readings at Turtle Cove compared to lake level gauge readings at Goldston's Motel Pier. Table developed by Steve Bunn, Lake Stewardship Officer.

Because of the relationships with rainfall and temperatures, lake levels are generally higher in winter and lower in summer. The variability that we see in weather is due to the ENSO—El Niño Southern Oscillation—and increasingly, by the influences of climate change. Rainfall patterns are changing, with more big rains and more severe droughts.

Rainfall in the first five months of 2020 totaled 32.25 inches, and lake levels responded accordingly (increasing 8 inches from the start of January). Highest lake levels were seen on June 1 (65.15 feet elevation NAVD 88) resulting in a 6.6-inch difference from 2019 highs. The difference between May 2019 (with 1.2 inches of rain for the month, and 100+ degree heat for several days, causing the lake level to drop 5 inches for the month) and May 2020, with 12.25 inches of rain and an increase of 5 inches in lake levels, indicates what a difference weather can make.

Lake Level Monitoring Results—2020

Because of high rainfall in 2020, particularly in the month of May, lake levels exhibited the inverse trend from 2019: the highest lake level, 65.2 ft, was measured on June 16. This was 10.3 inches above the lake level on January 1, 2020 (64.34 ft.). A relatively high lake level was maintained through the summer, with the level on September 30, 64.6 ft., a full 9 inches above the 2019 level on that date.

Lake Level Monitoring Results—2021

High rainfall was measured in the first two months of the year, including two rains of 3+" in February. As a result, the highest lake level for the year (65.3 feet elevation) was found in February. Also of note was a May 14 hailstorm:

The last quarter of the year had below normal rainfall, with October and November combined totaling one inch of rain; the lowest lake level, 63.9 ft., was found on November 29. The lake level range for 2021 (16.8") was higher than what was seen in the previous two years.

End of year lake levels for the past five years (2017-2021), compared with total rainfall for the year:

12/17/17	64.5	Elevation measurement by surveyor 53.1" rainfall for year
12/31/18	64.7 ft	89.1" rainfall for year (Hurricane Florence in September)
12/31/19	64.3 ft	52.8" rainfall for year
12/31/20	64.9 ft	74.9" rainfall for year
12/31/21	64.1 ft	54.4" rainfall for year

Historical Lake Level Variations

Lake level variation in 1965 was 14.5", in 1966 was 10", and in 1967 was 10", while Frey [1949] noted a variation of 14" over the time he was working at the lake. This variability means that lake depths also vary by the same magnitude, so that the summer maximum depths can be up to a foot less than winter depths: for example, the range was 9.5 to 8.5 feet maximum lake depth in 2019. Average lake depths vary around 6.5 to 7.5 feet, which means that fully half of the lake is at or below this depth.

Turtle Cove Outlet

Surface water outflow from the lake at Turtle Cove is variable, and is highest when lake levels are highest, but it is a very small outlet relative to the volume of water in the lake. For example, a flow rate of 250 gallons/minute (360,000 gallons/day) was measured in February and March 2017 (NCDEQ 2018), which is equivalent to a discharge of 0.0163 % of the lake volume per day, but flow from the lake ceased in June of that year. This pattern has also been seen in 2018 and 2019 (even after Hurricane Florence added substantial amounts of water to the lake in September 2018). The outlet was relocated and reconfigured from its original natural location during the development of the Turtle Cove neighborhood.

In December 2017, Walker Surveying Company provided the elevations of the six corrugated metal pipes at Turtle Cove: the inverts ranged from 63.39 to 63.55 feet (NAVD 88). Elevations were also made in the outlet channel; the mid-channel elevation at a point close to the lake shore was 64.44 feet (NAVD 88), which was very near the lake elevation of 64.5 feet at the time. Outlet channel elevations gradually decline as the distance from the lakeshore increases (see attached survey), which would be of benefit in high water conditions. Placing sandbags at the inverts would impede flow under high water conditions and have no impact on lake levels at other times.

State Parks personnel worked with the Town in late 2019 to establish a plan for adding sandbags at the Turtle Cove shoreline as the lake levels started to increase with increased

rainfall; the large amount of rain in 2020 raised the lake level to over 65 feet (NAVD 88), so that the sandbag dam has at times required maintenance and repair.

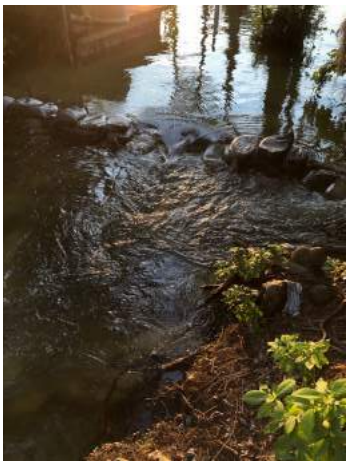


Figure LL 2. Sandbags at the Turtle Cove outlet for the lake. Photo taken on June 23, 2020, when lake level was slightly over 65 feet (NAVD 88).

Conclusions and Recommendations

1. Continuing monitoring and recordkeeping are critical to understanding what is "normal" for White Lake. There have been long periods in which no records have been kept of lake level variability or rainfall levels. Annual lake level variations of 12" (which was observed in 2019) seem to be typical, and the pattern of summer lows, winter highs is common for many lakes, including the other Bay Lakes.

2. Obtain a proposal for an outlet structure at Turtle Cove that could take the place of sandbags. If an easement to the lakeshore property is not obtained, this structure would have to be situated in the lake, which would necessitate an extended design and permitting process, and a more formal management agreement would be needed between the Town and State Parks. The Turtle Cove outlet does not regulate lake level, but it can serve a critical function during flood conditions.

Attachments:

Attachment 1. White Lake Hydrology Study, September 1968, by C.R. Edgerton

Attachment 2. Comment Letter on White Lake hydrology from U.S. Geological Survey, July 1969

Attachment 3. Memo from State Highway Commission, with copies of NC House Bill 406, Chapter 570, 1971, and NC House Bill 994, Chapter 252, 1973.

Attachment 4. Memo from Walker Surveying Company with lake elevations, January 2020.

Attachment 5. Walker Surveying Company Survey of Turtle Cove outlet, December 2017. Of note is the slope of the outlet—it is 64.4 ft elevation at the lake shore, which is where the sandbags are presently placed.

Attachment 1. White Lake Hydrology Study, September 1968, by C.R.Edgerton

WHITE LAKE STUDY
BACKGROUND INFORMATION

White Lake is a natural lake fed by springs located in a natural depression which has been theorized as being caused by a meteorite bombardment of the earth, several millenniums ago. The lake has been used for recreational purposes for many years. Most of the property surrounding the lake is occupied by private cottages, with only a few public beaches. Development in the area was inhibited prior to 1961, due to lack of water and sewer facilities. However, since that time water and sewer systems have been installed and development has become more rapid. By about 1962 or 1963, the area shown on the attached map within the town limits of White Lake was fairly well developed. However, the edge of the west of the lake had not been developed, due to the fact that it was very swampy and not adaptable to development without large expenditures of money. In approximately the year 1963, Mr. Tilden Walker acquired this property and began developing by building a road as shown on the map. The road originally was built with no openings installed for drainage purposes. In the year 1964, which was the wettest year in North Carolina of record since the Weather Bureau has been keeping records in this State, the lake became overfull and was damaging docks on the old side of the lake, and also getting up out of the lake bank and under cottages and houses. The residents of White Lake felt that surely the Tilden Walker road was blocking the outlet of the lake causing this unusual rise. There is little doubt that they were partially correct in this summation. On October 5th, at the direction of the then Governor of North Carolina, the State Highway Commission cut two dragline ditches through the Walker fill at the locations shown, and Mr. Walker, under the direction of the State Parks Service, installed seven 29"x18" C. M. pipe arches, at each of these locations.

During this same period of high water in the lake, Mr. Fred Keith, who owns property north of the Walker property, approached the Highway Commission for permission to install a pipe under U.S. 701. This permission was at first denied, but then after further study and consideration, it was decided to allow the installation provided the controlling elevation of the invert be set by the State Parks Service. Mr. Tom Ellis advised Mr. Keith that if left with his Department's jurisdiction, the elevation would be 66.0. Mr. Keith therein decided that the installation of the pipe would be of no benefit, and the matter was dropped.

Recently with the help of the Highway Commission, Mr. Tilden Walker has dug an outlet ditch below U.S. 701 and a head ditch above U.S. 701. The installation of a 24" concrete pipe was begun at an elevation of 56.8±, mean sea level. When residents of White Lake discovered that this work was being done they immediately protested, fearing that the digging of a ditch this deep may affect the surface of the lake. On September 17th, this office was contacted about this matter, and I went to White Lake and advised that work on Highway right of way should cease until the matter was given further study and settled. It was agreed with the delegation representing the people of White Lake, which consisted of the Mayor and several Councilmen, and also the Chairman of the County Commissioners and two Commissioners, that a study would be made to see if the cutting of the ditch might have a detrimental effect on the water elevation in White Lake.

STUDY AND CONCLUSIONS

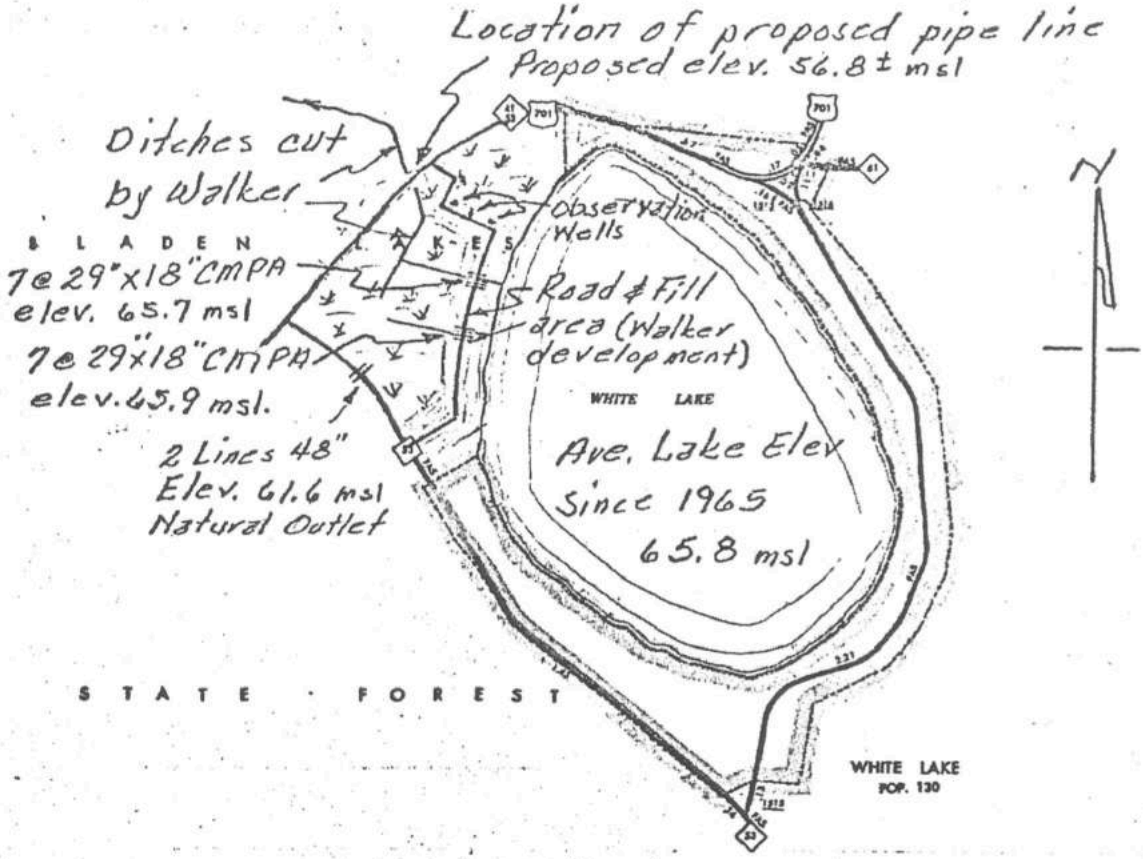
In order to make a study of the possible effects of the proposed ditch, records were obtained on the surface elevations of White Lake since October 1964, through August 20, 1968. Also, rainfall records for the rain gage at Elizabethtown Lock No. 2, which is 4½ miles from White Lake, were obtained for use in the study. Average temperatures for the same period were also obtained for the station at Lock No. 2. From this information, the mean monthly evaporation from White Lake was calculated and a chart prepared showing the lake elevation and the net rainfall evaporation. These two are shown on the attached chart and show the close correlation between the surface elevation and the evaporation rainfall. Calculations were made on the outflow through the fourteen 29x18" C. M. pipe arches and it was found that for the month of February, 1965, which had the highest outflow for any month during this period, that the amount only amounted to slightly over two-tenths of an inch on White Lake. From this it can be seen that the outflow is of no significance in the study. It is also concluded that these pipes serve only as a psychological factor that should another year occur as wet as 1964, the lake will again rise well above its normal elevation. It was also concluded from the comparision of the different factors involved that the balance of water in White Lake is very delicate. It is felt that anything done to upset this balance, in either direction, would be detrimental to the recreational facilities provided by the lake, and catastrophic to the owners of the property on the old side of the lake, who depend on the influx of vacationers during the season to provide their income.

In determining whether or not seepage would flow into the ditch three observation wells were dug at the locations shown on the attached map. It was found that within less than a 24 hour period water rose in these wells to within six inches of lake surface elevation. They were not observed for a longer period of time, however, it is felt that had they been left open, water would have eventually reached very closely the elevation of the water in the lake. It was also observed that the water in the ditch dug by Mr. Walker on the upper side of U.S. 701, rose 1.1' between September 17th and 24th. During this period absolutely no rainfall had fallen. It is, therefore, concluded that there is seepage to this ditch from the lake. It is felt that the seepage under the road would be retarded for some period of time, but due to the manner in which this fill was put in, that is - the trees were knocked down with bulldozers and covered with sand clay, that the seepage through this area would increase over a period of time and could actually increase to the point that the lake would be lowered several feet. As an example, it has been calculated that even 1½ cubic feet a second seepage to this ditch could over a year's time cause the average surface of the lake to fall one foot. This, of course, depending on rainfall and temperatures, but for the average year the above would hold true.

It is, therefore, concluded that no openings should be allowed under U.S. 701 below the elevation of 66.0, mean sea level.

Supporting data for the above conclusions is available in the Hydrographic Engineer's office of the State Highway Commission.

Submitted by C. R. Edgerton, State Hydrographic Engineer.



Bladen County
White Lake
Drainage Study
CRE 9-68

Attachment 2. Comment Letter on White Lake hydrology from U.S. Geological Survey, July 1969

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

P. O. Box 2857
Raleigh, North Carolina 27602

July 2, 1969

Mr. C. R. Edgerton
Hydrographic Engineer
N. C. State Highway Commission
Highway Building
Raleigh, North Carolina 27601

Dear Charlie:

In compliance with your request I have read the report prepared by J. N. Pease Associates entitled "A Study of White Lake, N. C., Hydrography." Your copy is returned herewith.

As you know and as is pointed out in the enclosed report, relatively little is known about the hydrology of White Lake and the other "Carolina Bay" lakes of Bladen County. Therefore, I believe any project designed to drain areas adjacent to White Lake should be carefully considered before it is undertaken.

Our present knowledge suggests that White Lake is supplied by precipitation on the lake and by ground water flow from the adjoining area. The changes in lake level and the outflow from the lake through the present surface channel respond to variations in precipitation and ground-water inflow. Thus, drainage of any area adjacent to the lake will first stop ground-water inflow to the lake from that area and second permit water to drain from the lake into the drainage channels. I do not believe the ultimate effect of these two factors on the level of the lake can be determined from the data available at this time.

I hope the above comments are useful to you and if I can be of further help, please let me know.

Very truly yours,

Ralph C. Heath

Ralph C. Heath
District Chief

Enclosure

RCH:rr

Attachment 3. Memo from State Highway Commission, with copies of NC House Bill 406, Chapter 570, 1971, and NC House Bill 994, Chapter 252, 1973.

STATE OF NORTH CAROLINA

STATE HIGHWAY COMMISSION

May 16, 1973

MEMORANDUM TO: Messrs. C. R. Edgerton and N. S. Day

FROM: Don Overman

SUBJECT: Ratified House Bill 994 - An Act To Allow The Town of White Lake to Dig Ditches Below a Certain Level

Attached for your information and guidance is a copy of Ratified House Bill 994 - 1973 Session of the General Assembly and Ratified House Bill 406 - 1971 Session, pertaining to digging ditches below a certain level in the vicinity of White Lake.

Basically, the Ratified House Bill 994 excludes the Town of White Lake for the purpose of installing, repairing and maintaining its water and sewer mains and lines, provided the Town has obtained a permit from the State Highway Commission in accordance with G. S. 136-93.

HJ:ph

Attachments

GENERAL ASSEMBLY OF NORTH CAROLINA
1973 SESSION
RATIFIED BILL

CHAPTER 252

HOUSE BILL 994

AN ACT TO AMEND CHAPTER 570 OF THE SESSION LAWS OF 1971 SO AS TO ALLOW THE TOWN OF WHITE LAKE TO DIG DITCHES BELOW A CERTAIN LEVEL IN BLADEN COUNTY.

The General Assembly of North Carolina enacts:

Section 1. Chapter 570, Session Laws of 1971, is hereby amended by deleting the period and adding a comma at the end of Section 1 and by adding the following: except for the Town of White Lake, after first having obtained a written permit from the State Highway Commission or its duly authorized officers, as provided in G.S. 136-93, in the installation, repair and maintenance of its water and sewer mains and lines.

Sec. 2. This act shall become effective upon ratification.

In the General Assembly read three times and ratified, this the 23rd day of April, 1973.

JAMES B. HUNT, JR.

James B. Hunt, Jr.
President of the Senate

JAMES E. RAMSEY

James E. Ramsey
Speaker of the House of Representatives

GENERAL ASSEMBLY OF NORTH CAROLINA
1971 SESSION
RATIFIED BILL

CHAPTER 570

HOUSE BILL 406

AN ACT TO PREVENT THE DIGGING OF DITCHES BELOW A CERTAIN LEVEL IN BLADEN COUNTY.

The General Assembly of North Carolina do enact:

Section 1. It shall be unlawful for any person, firm or corporation to dig any ditch under any portions of U. S. Highway No. 701, N. C. Highway No. 53 and S. R. 1515 which surround that body of water in Bladen County known as White Lake below 66 feet above sea level.

Sec. 2. If any person shall violate the provisions of this act he shall be guilty of a misdemeanor and may be fined or imprisoned in the discretion of the Court.

Sec. 3. All laws and clauses of laws in conflict with this act are hereby repealed.

Sec. 4. This act shall become effective upon ratification.

In the General Assembly read three times and ratified, this the 16th day of June, 1971.

H. P. TAYLOR, JR.

H. P. Taylor, Jr.
President of the Senate

PHILIP P. GODWIN

Philip P. Godwin
Speaker of the House of Representatives

Attachment 4. Memo from Walker Surveying Company with lake elevations, January 2020.

205 Cypress St. (P.O. Box 125)
Elizabethtown, N.C. 28337
TEL: (910) 862-2047
CELL: (910) 840 0147
lwalker@solesandwalker.com

WALKER SURVEYING COMPANY

January 17, 2020

Town Hall
Town of White Lake, N.C. 28337

RE: **ELEVATION GAUGE**

Ladies and Gentlemen;

Please consider this a MEMORANDUM of Survey Work performed in conjunction with herewith submitted Drawing entitled Spot Elevations For TOWN OF WHITE LAKE "SPILLWAY" dated December 18, 2017, and Revised January 16, 2020, to provide additional Elevations and Gauge Installation Information. Field Survey Data for both the Original and Revised Survey Dates, and subsequent Data Reduction, and Field Staking for Setting the Furnished Water Elevation Gauge, were all performed by Jason S. Walker, NC PLS No. L-5147. Referenced Vertical Datum used on both Survey Dates was NAVD 88. A comparison of this Datum with the Older Datum NGVD 29, which has been used for many Utility Projects at White Lake over the years, is that the Elevation Number for the Newer Datum (NAVD 88) is Approximately 1.0 Foot LOWER than the Elevations Number for the Older (NGVD 29) Datum. The observed Top of Lake Water Elevations on Both Survey Dates were both the same (64.50 Feet – NAVD 88).

The Survey Work for setting the referenced Water Elevation Gauge was performed in accordance with the Standards of Practice for Land Surveying in the State of North Carolina.

Thank you for the opportunity to provide this service; and we will be glad to address any questions or comments.

Sincerely,

Lloyd R. Walker, P.L.S.
Walker Surveying Company

NORTH CAROLINA PROFESSIONAL SEAL L-1333 LAND SURVEYOR LLOYD R. WALKER

Attachment 5. Memo from Walker Surveying Company with lake elevation, outlet channel elevations and invert elevations, January 2020.