

GROUND-WATER MOVEMENT IN THE VICINITY OF  
FRESH POND AT NACS HEAD AND KILL DEVIL HILLS  
DARE COUNTY, NORTH CAROLINA

By

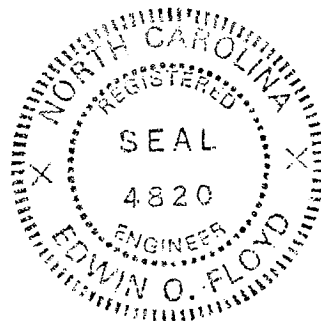
Edwin O. Floyd, P. E.

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MOORE, GARDNER & ASSOCIATES, INC.

CONSULTING ENGINEERS

CARY, NORTH CAROLINA



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Introduction

The source of fresh water from the municipal water supply system at Nags Head and Kill Devil Hills is the 27-acre lake situated about half way between the ocean and the sound and bisected by the boundary of the two towns.

In order to protect the quality of the water in the lake, the construction of septic tanks and other possible sources of pollution has been prohibited within 1500 feet of the edge of the lake. Recent increases in land values and developmental pressures have made it advisable to reexamine the 1500-foot restrictive zone to determine, by actual field measurements, the minimum distance from the lake that construction of septic tanks may be safely permitted.

The Dare County Department of Health requested the firm of Moore, Gardner & Associates, Inc., to make an investigation of the ground-water conditions at Fresh Pond for the purpose of determining the minimum distance from the pond that septic tank effluent could be safely discharged.

The investigation began during the late summer of 1978 with the construction of 17 observation wells. The wells were drilled to depths of 10 to 12 feet, and all were finished in the upper part of the water table aquifer. Mean sea level elevations at each well were determined by field surveys. Periodic measurements of water levels in the wells and some existing wells were made to determine the elevation of the water table in the vicinity of the lake.

Figure 1 shows the location of the observation wells and the elevations of the water table surface as it appeared on October 23, 1978 when it was at or very near the lowest water levels of the year. Table 1 shows the elevation of the water table at each observation well and the dates on which the measurements were made. Figure 2 shows the elevation of the water table as it appeared on February 22, 1979 when it was at or very near the highest level of the year.

### Hydrology

The source of fresh water on barrier islands of North Carolina is precipitation. Of the 45 inches average annual precipitation in the area, about 25% actually seeps into the zone of saturation and becomes ground water. The ground water moves laterally in response to gravity towards points of discharge such as the ocean, sound, lakes or pumping wells.

Well No.	M.P. Elev.	Elevations of Water Table and Date of Measurement					
		9-28-78	10-23-78	12-7-78	12-13-78	2-6-79	2-22-79
1	13.07	6.14	5.81	-	6.03	-	7.47
2	13.19	6.45	5.89	-	6.22	-	7.68
3	25.02	Plugged	- Unused	-	-	-	-
4	14.69	6.28	5.05	-	5.88	-	7.48
5	-	Plugged	- Unused	-	-	-	-
6	14.31	5.16	4.49	-	4.92	-	6.21
7	14.80	4.86	3.82	-	3.97	-	5.98
8	13.88	5.40	4.27	-	5.14	-	6.58
9	12.52	5.52	4.38	-	5.40	-	6.87
10	13.09	2.47	3.24	3.34	3.59	5.63	5.44
11	13.27	4.96	4.32	5.27	6.60	6.81	5.90
12	12.47	5.82	6.20	5.42	5.47	8.01	6.91
13	14.05	4.30	3.75	-	4.1	-	5.77
14	13.35	6.35	5.76	6.10	6.15	-	7.60
15	13.96	7.66	7.10	-	7.3	-	9.14
16	12.99	2.07	2.99	3.49	3.6	-	5.43
17	13.15	5.21	4.69	5.00	5.2	-	6.59
18	14.35	7.44	5.69	6.49	6.74	-	7.11
19	21.97	5.70	5.29	5.02	5.1	-	7.1 est.
20	14.21	2.38	1.94	-	2.2	-	4.59
0-2	17.78	-	-	-	4.16	-	1.75
Small pond	-	6.60	-	-	6.82	-	-
Lake	-	-	1.21	-	-	3.80	4.04

Table 1 - Elevations of the water table in the vicinity of Fresh Pond.

When water is withdrawn from a well, the water level in the well is lowered, and water then flows towards the well from all directions. The gradient on the water table surface increases towards the well with continued withdrawal, and the water table in the vicinity of the well assumes the shape of an inverted cone with its apex centered at the well. The cone is referred to as the "cone of depression". Water is withdrawn from Fresh Pond by pumping and evaporation, and it functions somewhat as a large-diameter well, forming a large cone of depression around it. Within this cone of depression, ground water flows toward the lake.

In figure 1, the shape of the cone of depression around the lake is illustrated as it appeared on October 23, 1978. The edge of the cone is shown as a ground-water divide, and water outside the divide flows away from the lake toward the sound or ocean.

Figure 3 shows two profiles of the water table taken along Fresh Pond Road in Kill Devil Hills. These profiles illustrate the changes in the water table as they occurred from October 23, 1978 to February 22, 1979. Note that the position of the water-table divide remained relatively stationary during the change from the seasonal low water level to the seasonal high water level. This is less movement than was anticipated at the beginning of the study, and it indicates that the area of influence around the lake

remains relatively constant throughout the year.

When the County water system becomes operational, pumping from the lake by Nags Head and Kill Devil Hills will be discontinued, and the lake will become a standby source of water supply for the two towns. At some time following the cessation of pumping, the lake surface will return to its natural level, and the only discharge from the lake will be through evaporation. However, evaporation can amount to 30 to 40 inches of water per year from the lake. From the profiles shown in figure 3, it is estimated that during the summer months pumping from the lake imposed from 2 to 3 feet of drawdown on its surface in addition to that imposed by natural losses through evaporation. The additional drawdown imposed by pumping from the lake produced the necessary loss of head to induce additional flow of water from the aquifer into the lake. Due to the water storage and transmittal properties of the aquifer, sufficient ground-water flow to balance the pumpage could be obtained from storage within the cone of depression (see figure 1.) without causing significant changes in its horizontal dimensions. As such, it is expected that when the lake surface returns to its natural level, the cone of depression will become shallower in shape but will not significantly change its diameter.

If the boundary of the restrictive zone is changed to coincide with the edge of the cone of depression around the

lake during the dry season, then there can be no natural flow of polluted ground water toward the lake from outside the cone of depression during any season of the year.

However, because of the hydrologic character of the water-table aquifer in the vicinity of the lake, the slope of the water table is small. The limits of the cone of depression extend far enough from the lake that the time of travel of the ground water becomes a factor that should be considered because many types of bacteria cannot survive more than 90 days in the soil.

Studies of the reaction of septic tank effluent in the soil reported by J. W. Patterson et al<sup>1)</sup> indicate the survival time of fecal bacteria in the soil has been observed to be as long as two years for E. coli, 3 months for coliform bacteria and 41 days for Salmonella typhosa. Inasmuch as the computed velocity of ground-water movement within 500 feet of Fresh Pond, assuming 25% porosity of the soil, is on the order of 1.25 feet per day, it appears possible that E. coli bacteria could survive long enough to travel about 900 feet. However, most types of bacteria would not survive a journey of 200 feet. Most natural lakes

1) Patterson, J. W. et al, (1971) Septic Tanks and the Environment, State of Illinois Institute for Environmental Quality.

contain coliform bacteria, as well as other types normally associated with sewage, that are brought to the lakes by waterfowl and other visiting wildlife. Disinfection is a normal part of water treatment when the source is a surface reservoir. Therefore, the problem with septic tank effluent near a water supply reservoir is not in keeping out all the bacteria but rather in controlling the concentration of the septic tank effluent that enters the surface water body. The concentrations of the effluent must be kept below levels that will upset the biotic balance and stimulate the growth of algae in the water. This can be accomplished through dilution with natural ground water and filtration through the sands of the aquifer. Of course, the volume of effluent must be balanced against the potential for natural dilution and filtration.

This relates directly to the North Carolina Administrative Code, Title 15, Subchapter 2H, Section .0404-4 that states, "Treated wastewater may be disposed of in subsurface disposal facilities, which are to be located at least 500 feet from any impounded public surface water supply...". Also in N. C. Administrative Code, Title 10, Subchapter 10D, Section .1312a, it states, "No septic tank system shall be approved for a residence, place of business, or place of public assembly except on a lot containing at least 40,000 square feet of area suitable for septic tank