

# A Primary Amebic Meningoencephalitis Case Associated with Rafting on an Artificial Whitewater River

Jennifer R. Cope, MD, MPH<sup>1</sup>, Jennifer Murphy, PhD<sup>1</sup>, Amy Kahler, MS<sup>1</sup>, Daniel G. Gorbett, MD<sup>2</sup>, Brandi Taylor<sup>3</sup>, Nicole Lee, MPH<sup>4</sup>, Lisa Corbitt<sup>5</sup>, Scott Brewer, MPH, RS<sup>6</sup>, Vincent R. Hill, PhD<sup>1</sup>

1. Waterborne Disease Prevention Branch, CDC, Atlanta, GA; 2. Mt. Carmel Health System, Columbus, OH; 3. Ohio Department of Health, Columbus, OH; 4. North Carolina Department of Health and Human Services, Raleigh, NC; 5. Mecklenburg County Health Department, Charlotte, NC; 6. Franklin County Public Health, Columbus, OH

## Background

- Primary amebic meningoencephalitis (PAM) is a fulminant central nervous system infection with mortality >97%
- PAM is caused by *Naegleria fowleri*, a thermophilic free-living amoeba that thrives in warm freshwater
- PAM results when water containing the amoeba goes up the nose and gains access to the brain via the cribriform plate
- Typical exposure is swimming in warm freshwater lakes in southern-tier states during summer months



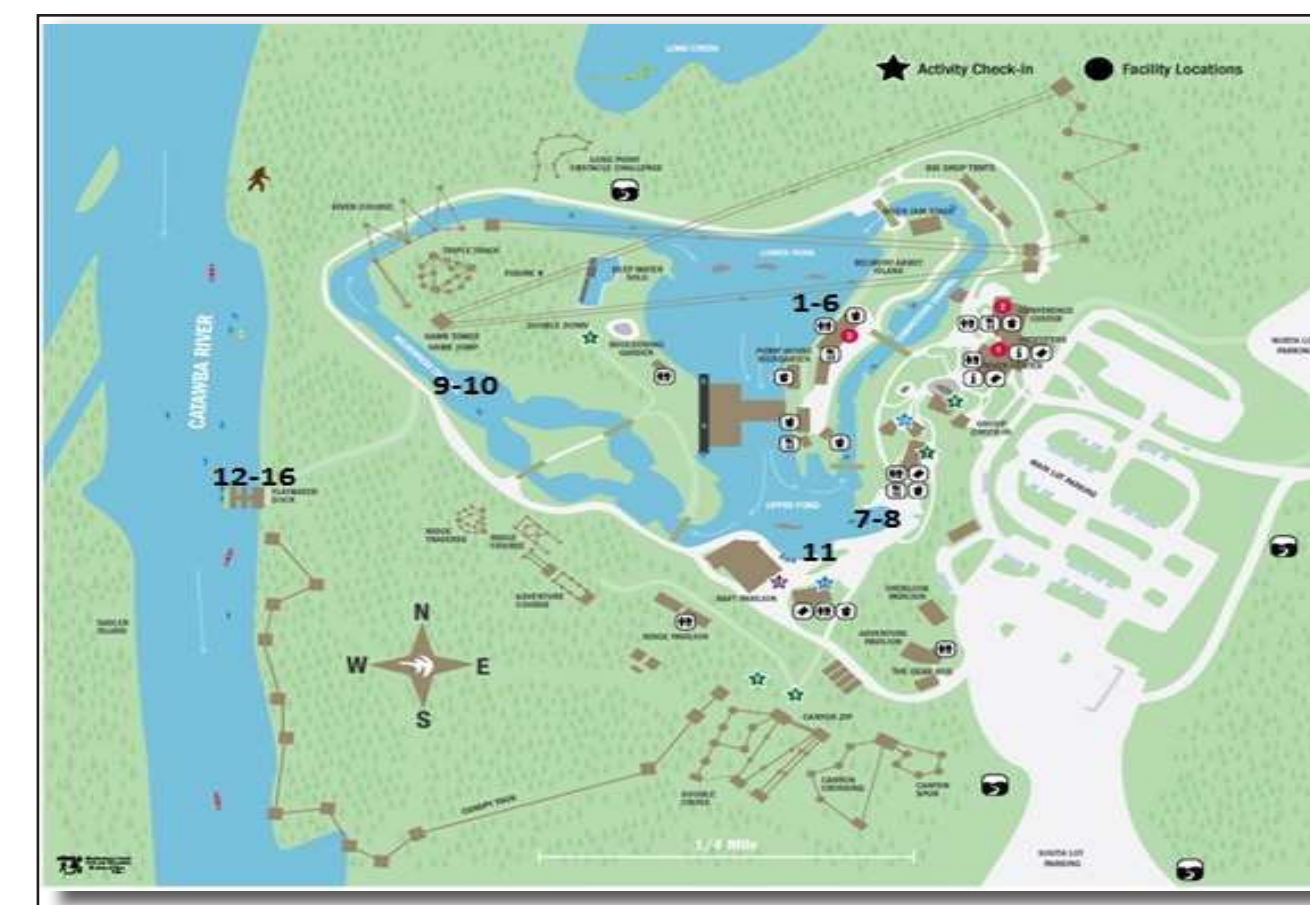
## U.S. National Whitewater Center (USNWC)

- Located in Charlotte, NC on 1100 acres along the Catawba River
- Offers kayaking and rafting in a recirculating artificial whitewater feature along with flatwater kayaking, stand-up paddleboarding, zip lines, ropes courses, and mountain biking
- Not subject to NC public swimming pool regulations



## Methods

- Site visit and meeting with USNWC staff to determine operation of whitewater channels and current water treatment practices
- Water, filter backwash, and surface swab sampling in whitewater channels and water, sediment, and surface swab sampling in nearby Catawba river
  - Measured basic water quality parameters
  - Submitted for direct *Naegleria fowleri* real-time PCR assay
  - Submitted for culture, incubated at 44°C, if trophs or cysts visible on plate within 7 days, submitted to PCR for confirmation of viable *Naegleria fowleri*



Numbers correspond to sample numbers in the tables and indicate location of sampling.



CDC laboratorian obtains 4x4 surface swab sample in the USNWC Wilderness channel



CDC laboratorian obtains a sediment sample from the Flatwater Dock area of the Catawba River



CDC laboratorian uses dead-end ultrafiltration to obtain a high-volume water sample



Water sample with organic matter collected from upper pond settling area

## Results

- Whitewater channels constructed with poured concrete, filled with ~12 million gallons of water from onsite wells and county municipal water (no river water is introduced into the system)
- Four filters of interlocking plastic disks, pore size 200 microns, total volume of water is intended to be filtered every 24 hours
- Water is directed through an ultraviolet disinfection system after filtration
- Chlorine is added as a liquid to the upper pond only when coliform counts trend upward or algal growth is visibly increased



Heavy algal growth observed on concrete wall of boat loading ramp

## Water Quality Parameters Measured at the USNWC and Catawba River, June 22, 2016

	Free chlorine residual (mg/L)	Total chlorine residual (mg/L)	Turbidity (NTU)	Water temperature (°C/°F)
USNWC Lower pond	0.05	0.15	6.7	29.6/85.3
Catawba River	N/A	N/A	4.1	28.3/83.0

NTU: Nephelometric Turbidity Units  
N/A: Not Applicable; free and total chlorine residuals are not typically measured in natural waters

## Naegleria fowleri PCR Results on Samples Taken from the Whitewater Channels

Sample Type	Direct Real-time PCR Results*	Culture Real-time PCR Results*
1. Pod 1 backwash (0.75 L)	Positive	Positive <sup>†</sup>
2. Pod 2 backwash (0.75 L)	Positive	Positive <sup>†</sup>
3. Pod 3 backwash (0.75 L)	Positive	Positive <sup>†</sup>
4. Pod 4 backwash (0.75 L)	Positive	Positive <sup>†</sup>
5. Bottom pond small volume (0.75 L)	Positive	Positive <sup>†</sup>
6. Bottom pond large volume (50 L)	Positive	Positive <sup>†</sup>
7. Top pond small volume (~0.7 L)	Positive <sup>†</sup>	Positive <sup>†</sup>
8. Top pond small volume (~0.5 L)	Positive	No data
9. Wilderness channel surface swab (4"x4")	Positive	Positive <sup>†</sup>
10. Wilderness channel plant material	Positive	Positive <sup>†</sup>
11. Boat loading ramp surface swab (4"x4")	Positive	Positive <sup>†</sup>

\*A sample was considered positive for *N. fowleri* when Ct<40  
†Ct value ≤30

## Naegleria fowleri PCR Results on Samples Taken from the Catawba River

Samples Type	Direct Real-time PCR Results*	Culture Real-time PCR Results*
12. Small volume	Negative	Negative
13. Large volume	Negative	Negative
14. Sediment	Negative	Positive <sup>†</sup>
15. Dock surface swab (below water surface) (4"x4")	Negative	Negative
16. Dock surface swab (above water surface) (4"x4")	Negative	Negative

\*A sample was considered positive for *N. fowleri* when Ct<40  
†Ct value ≤30

## Conclusions

- Based on epidemiologic investigation, most likely water exposure leading to PAM in this case-patient was falling out of the raft at the USNWC
  - Supported by environmental sampling that found all samples taken from the whitewater channels to be positive for *N. fowleri* by PCR and culture
- Conditions in the whitewater channels promoted the growth of *N. fowleri*
  - High water temperature
  - High turbidity
  - Heavy algal growth
  - Inadequate disinfection
- When it comes to regulation, USNWC falls into grey area between swimming pool and natural lake

Whitewater Center rafting closes after brain-eating amoeba found in water

Gov. McCrory calls for 'total' review of Whitewater Center oversight

CDC calls Whitewater Center filtration 'inadequate' after death of rafter

Mecklenburg commissioners approve first Whitewater Center regulations

