Heat Capacity – Can't Take the Heat?

Name _____ Date _____ Hour _____

Why does coffee take so long to cool down? Why is ocean water sometimes the warmest when the average daily air temperature starts to drop? How can buoys help us explore these questions?

Imagine it's the beginning of fall. School has been in session for a few weeks and the temperature is beginning to cool as autumn quickly approaches. At dinner one night, your parents surprise you with a trip to the beach for the weekend. Normally, if it were summer, this would be great news – hot sun and the refreshing ocean water! Unfortunately, the beach is not located in one of those areas that stay warm year-round. So how much fun will this weekend be if you cannot swim in the ocean?

The weekend finally arrives and you find yourself standing inches from the breaking waves. The air temperature is cool, but you're at the beach, so you must brave the coldest of water temperatures to get your money's worth out of the trip. Finally, you take a deep breath, grit your teeth and run full speed into the water expecting it to feel like the Arctic the instant it touches your skin.

Once submerged, you come up for air and are ready to run out just as fast as you ran in. But wait! You soon realize that the water is not cold at all, but instead, actually warmer than the air around you. As you continue to swim, you wonder how this is even possible. How could the water actually be warmer than the air after it's been cool out the past few days? The difference has everything to do with the heat capacities of the two substances.

The water was warmer than the air, despite the recent lower temperatures because of the water's much higher heat capacity than air; and because of its higher heat capacity, it takes longer for water to gain and lose heat (cool), than it dies for air. In both cases, either heating or cooling, there will be a lag between the air and the water temperatures. Because of this, you may find chilly water temperatures in early summer, even though the air temperature has been in the 80's and 90's for weeks.

The heat capacity of water has tremendous effects on the climate of the surrounding area. Because the water buffers the air temperature, the range of air temperature near water bodies is often smaller than the air temperature range further from the large bodies of water. On a greater scale, because the ocean occupies over 70% of the Earth's surface, it **buffers the atmospheric temperature providing a livable climate.**

In addition to keeping the Earth's atmospheric temperature in check, water's high heat capacity has numerous practical applications for humans. We use water to prevent engines from overheating in cars, boats, and power plants. This is also why water is used in fire fighting; it absorbs the heat of the material it comes in contact with, dissipates the heat as it changes from liquid to gas, and actually lowers the temperature of the fire. At the same time, the water increases the heat capacity of the material, making it harder for the fire to burn the material.

You often come in contact with materials that have different heat capacities. Perhaps you have walked home from the beach on a hot, sunny day without wearing shoes. The sand is scorching, so you quickly walk to the street, which you find is also hot, so you move to the sidewalk, which may be only slightly cooler, so you end up on the grass, which is the coolest. These materials each have very different **heat capacities**. Although they are all subject to the same sun exposure, they all store the thermal energy at different rates and thus radiate different temperatures to your bare feet.

The heat capacity of a material is very carefully considered in the **construction of houses and other buildings**. The ability of a material to collect and tolerate heat and then effectively dissipate it is critical to ensuring the durability and safety of a structure, and the comfort of its inhabitants.

Data Activity

- Using the information learned above, you will now explore air and water temperature data from four monitoring stations in Virginia along an inland-to-offshore gradient.

- Two of the stations are **NOAA National Climate Data Center** monitoring stations. These are located in Amelia and Petersburg, VA and you will use only air temperature data from these stations.

- The other two stations are ocean observing system buoys; one is located in the James River, VA and is a part of the **Chesapeake Bay Interpretive Buoy System**, which is a part of the NOAA Chesapeake Bay Office.

- The second buoy is a **NOAA National Data Buoy Center** entity. From these two buoys, you will use both air and water temperatures.

A. General Analysis

1. This packet contains a **Student Data Worksheet** and **Figures 1-3**.
2. Using the scale in **Figure 1** (map of the four monitoring stations) and a ruler, measure the distance between each station and Virginia Beach, VA. Enter the distance (in miles) into column 4 in Table 1. The first one has been done for you.
3. In column 5, convert the distance measured from miles to kilometers using the following conversion:

   1 mile = 1.609 kilometers

4. In column 6, indicate the direction the station is in relation to Virginia Beach, VA (N, S, E, W, etc.). The first one has been done for you.
5. In column 7, record the maximum and minimum temperatures for each parameter. The first one has been done for you.
6. In column 9, calculate the 2008 temperature range for each parameter. To calculate, subtract the minimum temperature from the maximum temperature.

B. Graphing and Graph Analysis – As a class

Using **Figure 2**, a blank graph, graph the temperature range data (Table 1, columns 7 and 8) by hand and then discuss trends as a class or in small groups.

C. Additional Analysis

Answer the following questions after viewing **Figure 3**, air and water temperature from the Chesapeake Bay Interpretive Buoy System (CBIBS) buoy at Jamestown, VA from April 13-20, 2008.

1. What is the range of the air temperature during this time period?

2. What is the range of the water temperature?

D. Discussion and Application Questions

3. From Table 1 and either the graph students created (Figure 2) or the completed graph (Figure 2a), what is the trend in air temperatures moving from west to east?

4. From Table 1, Figure 2/Figure 2a and Figure 3, what is the trend in air temperature range versus water temperature range?

5. In addition to the applications discussed in the introduction, how else can water's high heat capacity be used?

6. Discuss the implications of global climate change as it affects ocean water temperatures. How will ocean warming affect land?

7. Describe advantages and disadvantages of using buoys to record data.

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Table 1

1	2	3	4	5	6	7	8	9
Station	**Station Letter on Map**	**Parameter**	**Distance from Virginia Beach, VA (miles)**	**Distance in km** miles*1.609	**Direction, in relation to Virginia Beach (N, NE, E...)**	**2008 Maximum Temp. (˚F)**	**2008 Minimum Temp. (˚F)**	**2008 Temp. Range (˚F)**
NCDC #440188: Amelia, VA	A	Air Temp	*225*		*WNW*	100	2	
NCDC #446656: Petersburg, VA	B	Air Temp				100	12	
CBIBS Buoy: Jamestown, VA	C	Air Temp				97	18	
CBIBS Buoy: Jamestown, VA	C	Water Temp				88	40	
NDBC #44014: Offshore VA Beach, VA	D	Air Temp				83	29	
NDBC #44014: Offshore VA Beach, VA	D	Water Temp				86	47	

NCDC – NOAA National Climate Data Center – www.ncdc.noaa.gov
CBIBS – Chesapeake Bay Interpretive Buoy System – www.buoybay.org
NDBC – NOAA National Data Buoy Center – www.ndbc.noaa.gov

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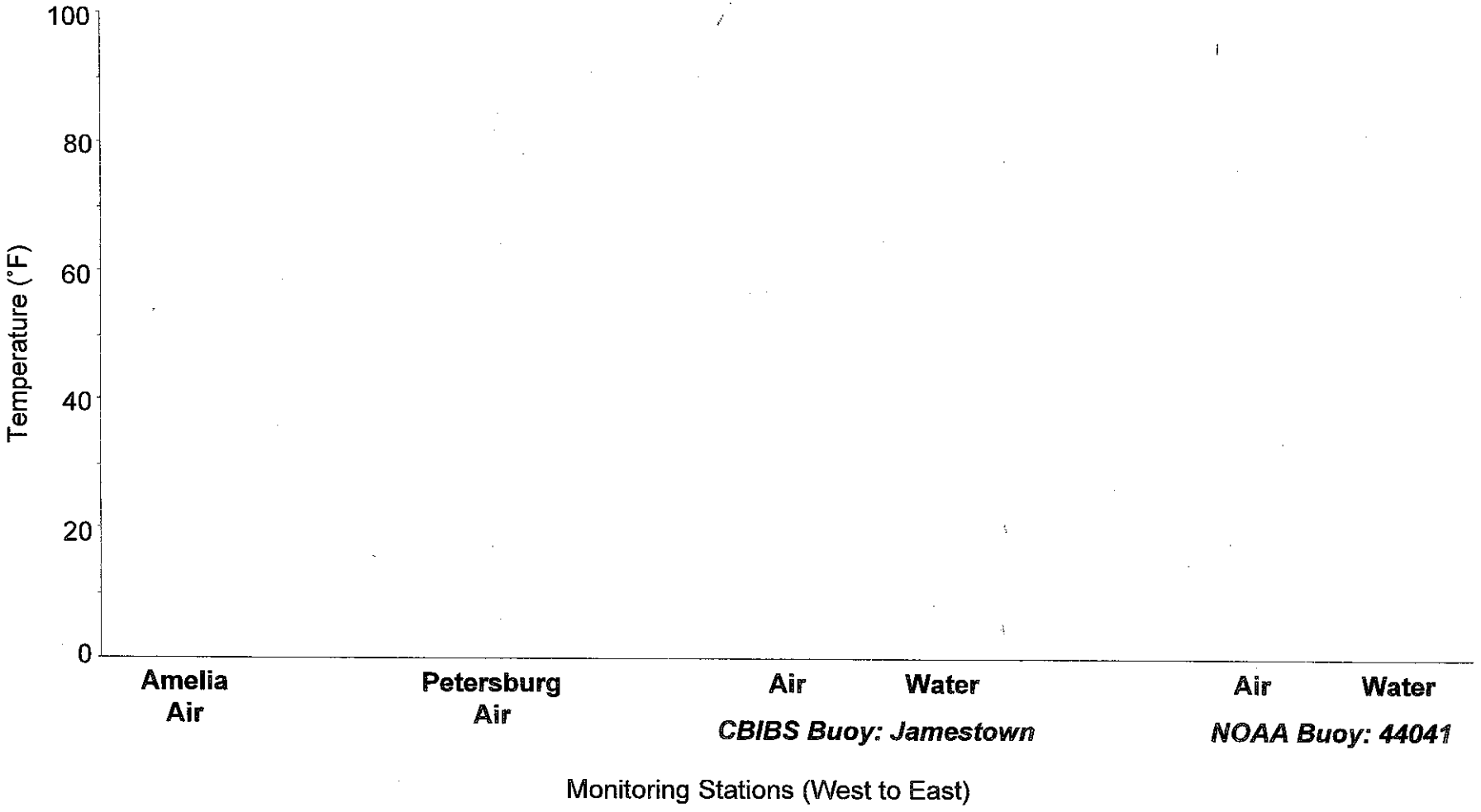
Figure 2. 2008 Temperature Range Data from Four Monitoring Stations in Southern Virginia, USA



Air and water temperature from 4 monitoring stations in Southern Virginia, USA. The Amelia and Petersburg sites are NOAA National Climate Data Center data are measured on land. The Jamestown and 44041 air data are measured over water.

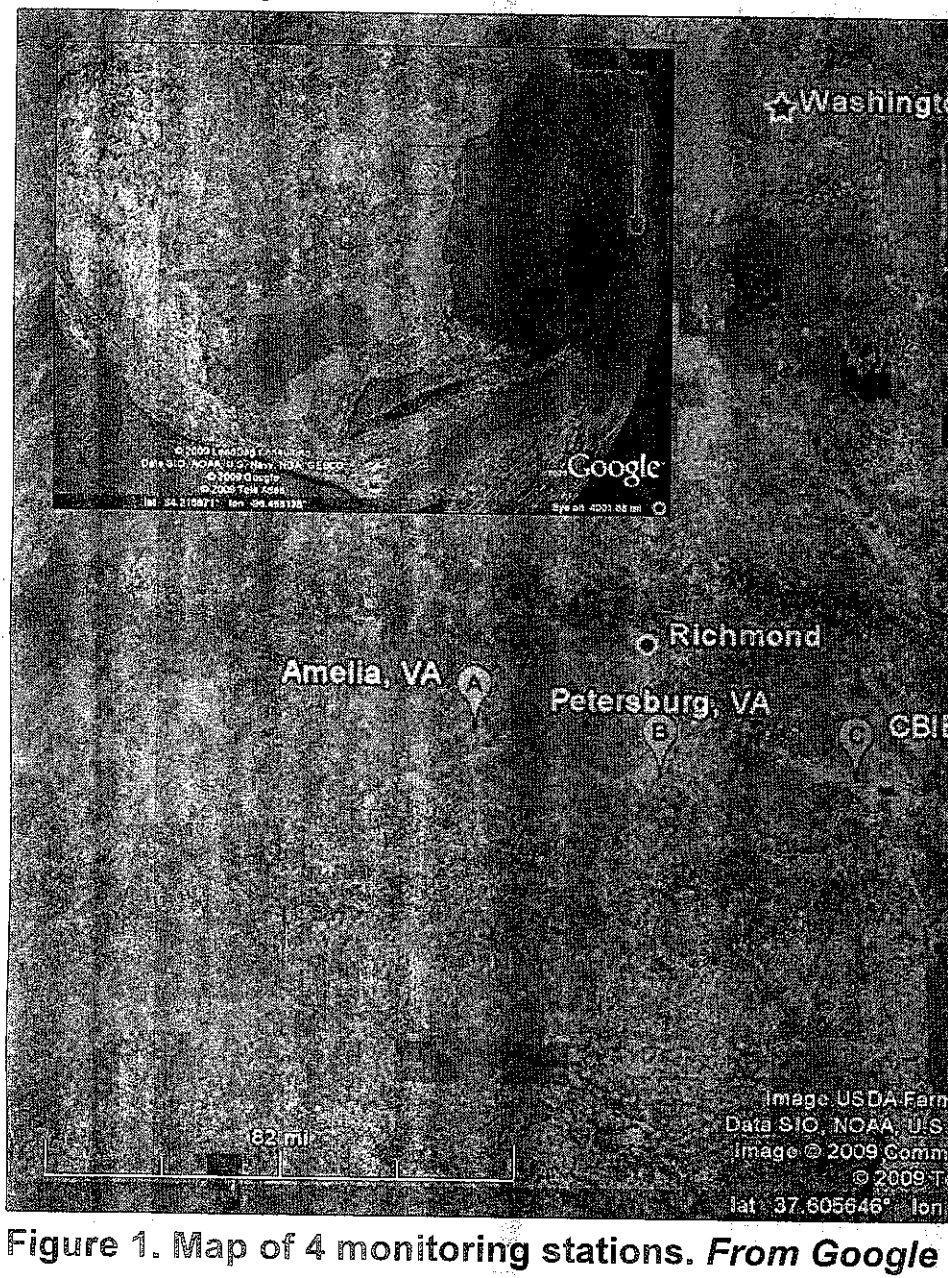
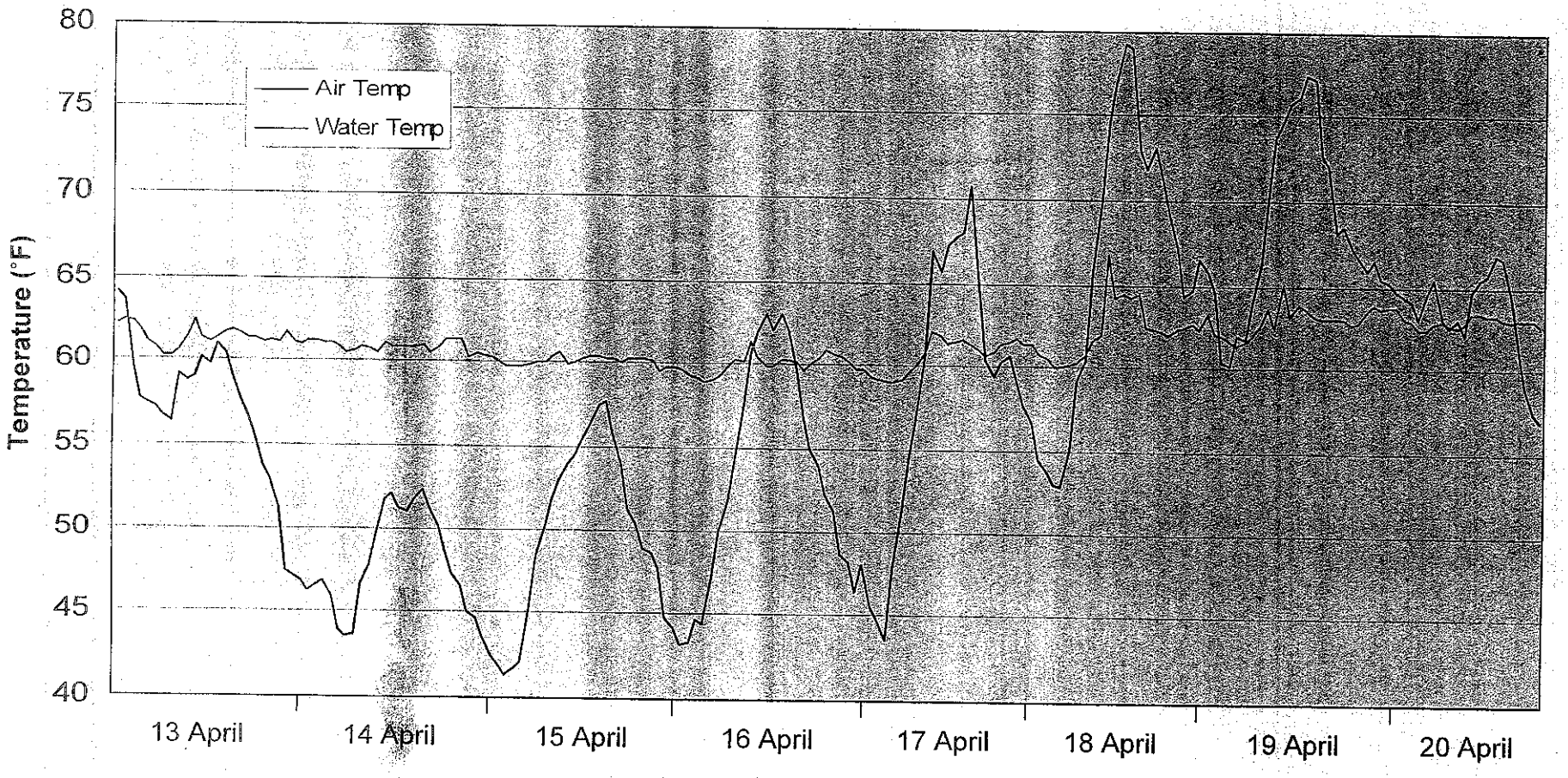


Figure 1. Map of 4 monitoring stations. *From Google*

Figure 3. Air & Water Temperature 13-20 April, 2008 from CBIBS Buoy: Jamestown



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