<u>**Levels of Inquiry Exercise**</u>

An inquiry-based approach to lab activities can help engage students and enhance their understanding of content material. However, not all types of inquiry are equal. Here are four levels of inquiry with a brief description, plus an example from the NCSU physical geology labs.

Reference: Buck, Laura B., Stacey L. Bretz, and Marcy H. Towns. "Characterizing the Level of Inquiry in the Undergraduate Laboratory." *Journal of College Science Teaching* (2008): 52-58.

This exercise was prepared by Katherine Ryker, MEAS, NCSU, August, 2011.

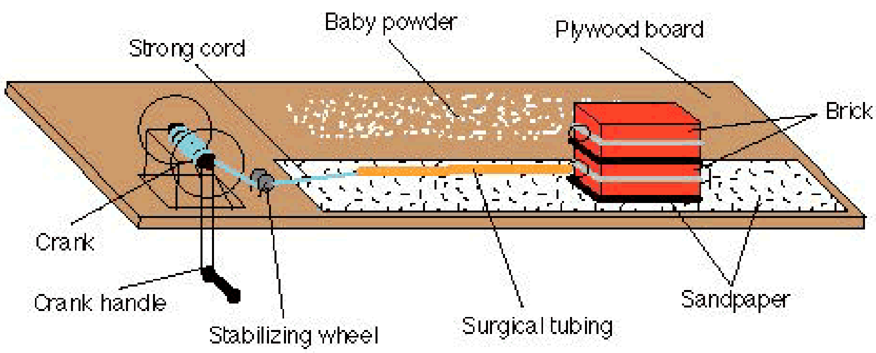
Level 1: Confirmation - The problem, procedure, analysis and correct interpretations of the data are immediately obvious from the statements and questions in the laboratory manual.

Level 2: Structured - The lab manual provides the problem, procedures, and analysis by which students discover relationships or reach conclusions not already known from the manual.

Level 3: Guided - The lab manual provides the problem and procedures, but the methods of analysis, communication, and conclusions are for the student to design.

Level 4: Open - The problem and background are provided, but the procedures/design/methodology are for the student to design, as are the analysis and conclusions.

Activity: Observing the Earthquake Machine in Operation



Earthquake Machine Activity #1

i. Arrange the apparatus to match the "starting position," shown above. Mark the position of the cord/tubing connection and the forward edge of the brick. The device is now in the starting position, before there has been any motion on the fault.

ii. Predict what will happen when we turn the crank handle. Slowly turn the crank.

iii. Watch for any "earthquakes" represented by motion of the brick. When an earthquake occurs, stop turning the crank while we record how much the brick has moved and mark its new position. Also record how far the cord/tubing connection has moved from its initial position.

iv. Continue turning the crank and recording the motions until the brick travels to the end of the sandpaper.

Earthquake Machine Questions (8 pts)

1. What was happening to the rubber tubing while you were turning the crank but there was no motion of the brick? Draw one or more diagrams to illustrate your answer. (2 pts)

2. When you were turning the crank, you were exerting energy. Energy cannot be created or destroyed. (2 pts)
   a. Between earthquakes, where do you suppose that energy was going in the model? Explain how this is analogous to the real world.
   b. During earthquakes, where do you suppose that energy was going in the model? Explain how this is analogous to the real world.

2. In nature, what are the equivalents for (4 pts):
   a. The sandpaper surface
   b. The movement of the brick
   c. The turning of the crank handle
   d. The stretching of the tubing?

Activity: Introducing Topographic Maps

1. Examine the map of the Raleigh West topographic quadrangle provided by your instructor. The fine irregular brown lines represent contours, lines that connect points of equal elevation. Each contour represents a 10 foot change in elevation. Every 5th contour is drawn with a heavier line.
   a. Use the contours to estimate the elevation of Meredith College near the center of the map.

   b. What is the difference in elevation between the surface of Lake Johnson and the main buildings of Athens Drive High School in the southeast corner of the map?

   c. Examine the northwest corner of the map and find the ridge that lies below the northern half of Ebenezer Church Road. What are the names of the two streams that are separated by the ridge?

   d. We can determine the gradient of a slope by dividing the change in elevation by the determining how much the slope changes elevation over a given horizontal distance (e.g., feet per mile). We can use the contours to determine the change in elevation and the scale on the map to determine the horizontal distance. Route 1571 drops 40 feet over a distance of about 2000 feet in the southernmost center of the map. What is that gradient in feet per mile? (1 mile = 5280 feet.)

      Gradient: ________________ feet per mile

2. Drainage basin calculation (see map on next page) (4 pts)
   a. Describe how you could estimate the approximate size of the drainage basin in square miles.

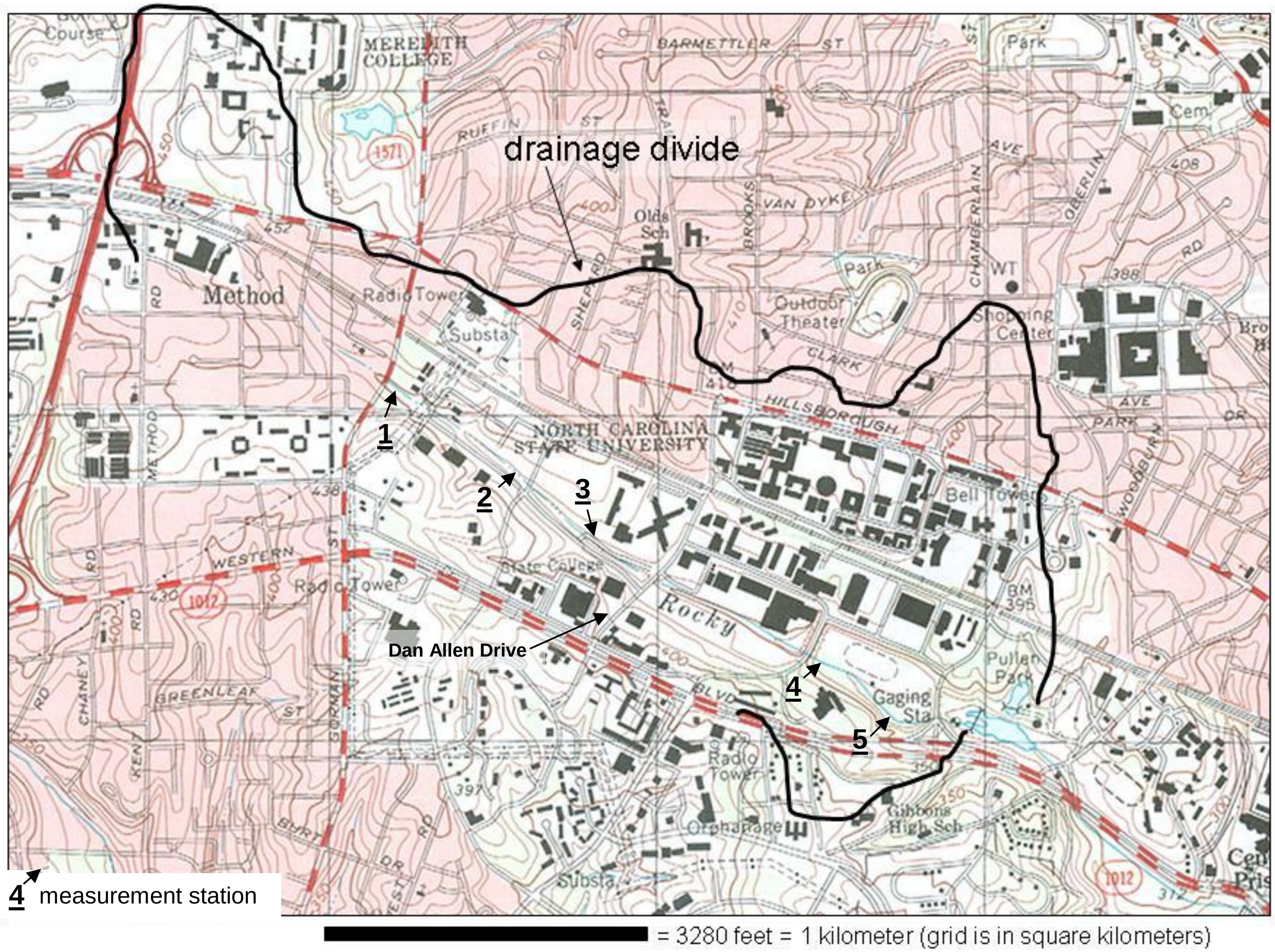
      How large is the drainage basin? ___________ square miles.

      (1 square kilometer = 0.39 square miles)

   b. Approximately what proportion of the drainage basin is covered by buildings, roads, and other man-made surfaces that prevent water from soaking into the ground? Keep in mind that there has been considerable construction since this map was created so that this is a low estimate.

   c. Look at the stream channel on the map. Describe in a few sentences how stream gradient changes along the length of the stream. (4 pts)

2. Complete the outline of the drainage divide for the southern boundary of Rocky Branch drainage basin on the enlarged topographic map of campus and the surrounding area to outline the stream's drainage basin. Hillsborough Street and Western Boulevard are clearly visible on the map. It might be useful to look outside at the land around Western Boulevard when defining the southwest boundary of the drainage basin. (4 pts)



Activity: Groundwater Consulting Case

A local college learns that the level of heating oil in one of their underground storage tanks is lower than would be expected. They do not know how long this has been the case. They perform a tightness test on the tank and lines that leave it and discover that there is a leak in the system. They need to hire an environmental consulting firm to determine the extent of the leak and how to clean it up.

Your group is the group they hire. You need to first drill wells near the tank to determine if the tank actually leaked into the groundwater. Then, if there is a leak, you will need to figure out the extent of the leak by drilling more wells. For each well, you measure the elevation of the water table. You can also send the water samples to a lab for them to test for the Total Petroleum Hydrocarbons (TPH).

TPH Value Interpretation	
less than 200 ppb	Clean
between 200 and 20,000 ppb	Contaminated
more than 20,000 ppb	Very Contaminated

The company hires you for a total budget of **$6500**.

- It will cost you $1500 to write the final report for the company.
- It costs $1000 to drill 4 wells, and this includes measuring the elevation of groundwater.
- Because you hire the driller for a day, you need to drill 4 wells at a time.
- The TPH test costs $75 for each sample, and there is no daily limit.

Once your group determines the locations of the wells you want to drill, present your drill requests to your instructor. The instructor will give you the elevation of the water table in the wells. If you want to perform the TPH test, the instructor will give you the results for your wells. The TPH test can be done at any time for the wells you drill.

After determining the extent of the leak (while staying within your budget) you need to prepare a report for the college which hired you. Your report will include a colored map showing:

- the extent of the leak (be sure to 'fill in the gaps' so your map shows where you interpret the entire leak to be, not just where you have measured it) [**5 pts**]
- arrows showing the direction of groundwater (contamination) movement [**2 pts**]
- locations of wells [**2 pts**]
- ground water contours [**2 pts**]
- table showing the data collected along with the budget (next page). [**4 pts**]

Upon completion of this exercise, return to the pre-lab and answer question 1d.

Hydrogeology consulting exercise was created by Karen Kortz, Community College of Rhode Island.

Final Report Data Table and Budget

Drilling Day 1					
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Total Cost Day 1:					

Drilling Day 2					
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Total Cost Day 2:					

Drilling Day 3					
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Total Cost Day 3:					

Drilling Day 4					
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Well location:		Water Table Level (m):		TPH Test Results:	
Total Cost Day 4:					
Final Report Cost:					
Overall Total Cost:					

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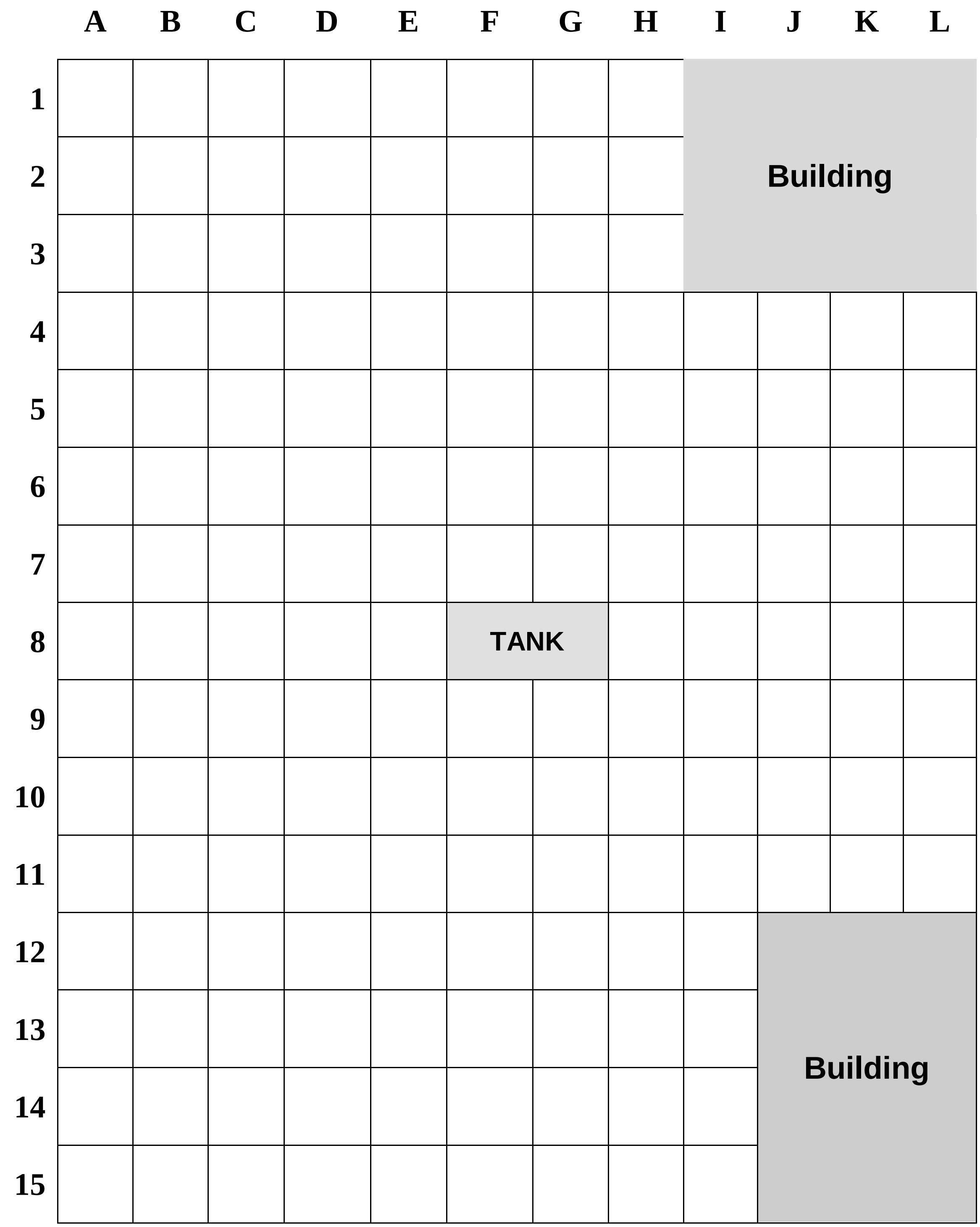
Company Name: ______________________________________

Final Report Map



Activity: Discovering Plate Boundaries – Plate Boundary Types

You will be assigned to one of four Scientific Specialty Teams. The Scientific Specialties are:

A. Seismology B. Topography C. Geochronology D. Volcanology

- Assemble in your assigned specialty team and examine your team's map and the map of the locations of the plate boundaries. What patterns do you see? Compare your answers with others in your team. Classify the plate boundaries *based on your observations of the data*.
- How many types of boundaries can you identify based solely on your teams' observations? Briefly describe your boundary types below. Restrict yourselves to a maximum of about 4 boundary types (Boundary type 1, Boundary type 2, etc.). At this point, *do not try to draw any inferences or explain the data; just observe*!
- Color your first plate boundary map to locate your group's boundary types. If the data are asymmetric at a particular boundary type, devise a way of indicating that on your plate boundary map.
- Each person should make their own map and write down descriptions of the plate boundary classifications. Maps and descriptions will be turned in at the end of the exercise.

Boundary Type 1

Boundary Type 2

Boundary Type 3

Boundary Type 4

The original Discovering Plate Boundaries exercise was developed by Dr. Dale Sawyer, Department of Geology and Geophysics, Rice University. A complete description of the exercise is available at http://terra.rice.edu/plateboundary/

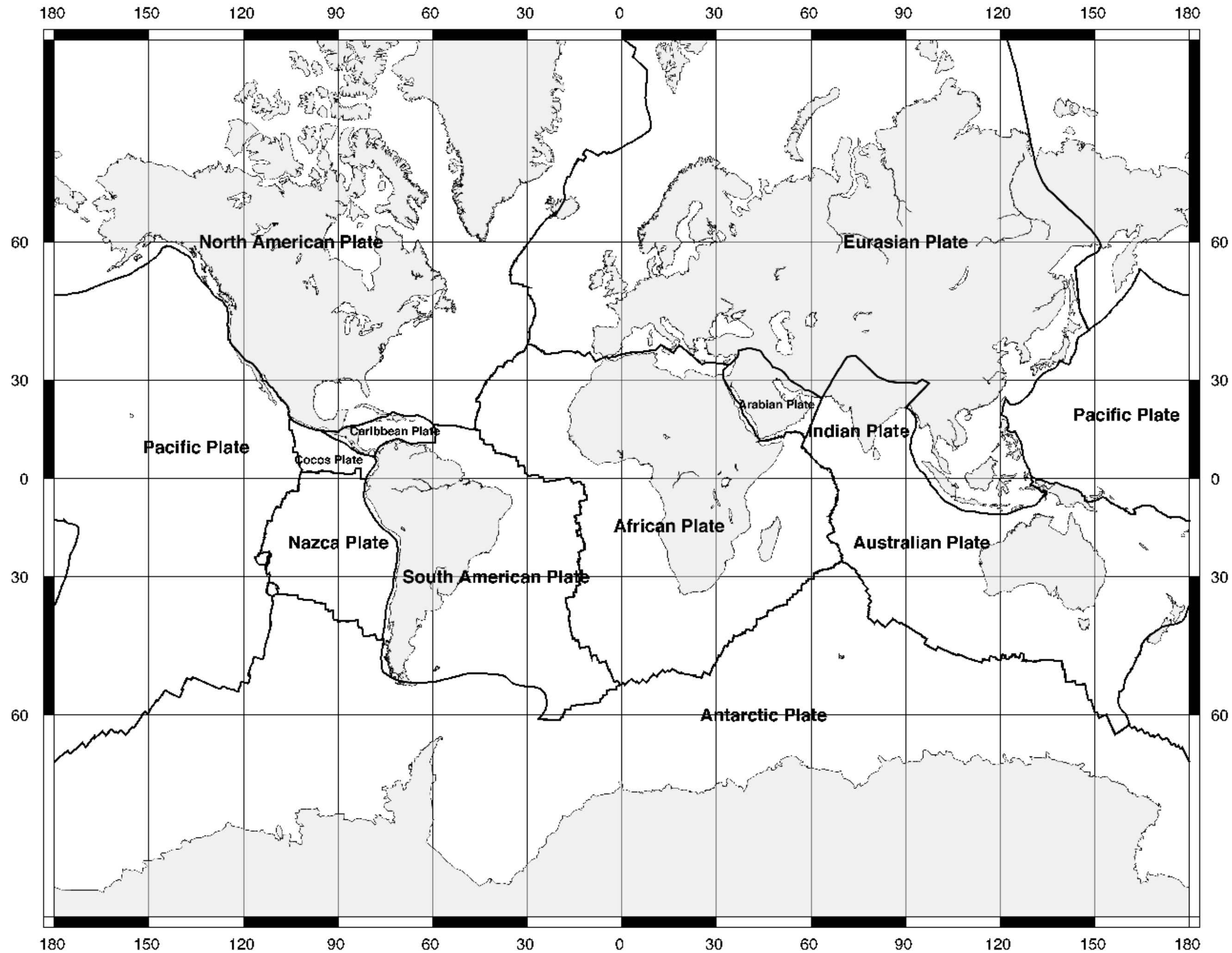


PLATE BOUNDARY MAP

This map is from Dietmar Mueller, Univ. of Sydney

This map is part of "Discovering Plate Boundaries," a classroom exercise developed by Dale S. Sawyer at Rice University (dale@rice.edu). Additional information about this exercise can be found at http://terra.rice.edu/plateboundary .