GALVESTON BAY FOUNDATION

SCIENCE OF GALVESTON BAY

2019 Edition

The following curriculum is meant to supplement 5-12th grade classes with local lessons relating to Galveston Bay. All lessons are TEKS aligned and can be adapted for specific learning groups as needed.

Topic	Lessons	Grade Level
Geology & Geography of Galveston Bay	1. Galveston Bay Regional Mapping	5-12
	2. Watershed Topography	6-12
	3. Galveston Bay Bathymetric Map	6-12
Water Quality	4. Water Monitoring in the Field	5-12
	5. Investigating the Galveston Bay Action Network	5-12
Local Wetlands	6. An Introduction to Galveston Bay Wetlands	5-12
	7. ABC's of Wetlands	5-12
	8. Researching Bay Organisms	5-12
Future of Galveston Bay	9. Examining Galveston Bay with GIS Maps	6-12
	10. Engineering Shorelines	5-12
	11. Grade the Bay: Public Service Announcement	5-12

Regional Mapping

Time: 2-3 class periods

Materials: (per student/group)
- Map of Galveston Bay (handout)
- Pencil
- Marker
- Colored pencils
- Internet access

Texas Essential Knowledge and Skills (TEKS):
Social Studies:
Grade 5:6AB, 7ABCD, 13B, 24C, 25DE
Grade 6: 3ABC, 4BCDE, 5AB, 6AC, 7AB, 21BCDF, 22ABC
Grade 7:8A, 9AC, 10A, 21BCFH, 22ACD
Grade 8:10B, 29BCIJ, 30ACD

World History: 15AB, 29H, 30ABCD

Aquatic Science: 2HJ, 4AC, 9A, 12BD

References:
What Makes Galveston Bay Special. *Galveston Bay Estuary Program*. 2013. Web. 11 Sept 2014. http://www.gbep.state.tx.us/what-makes-galveston-bay-special/

Map of Houston Ecoregions. Map. *Houston Atlas of Biodiversity.* Houston: Houston Wilderness, 2010. *Houston Wilderness*. Web. 11 Sept. 2014. http://houstonwilderness.org/about-ecoregions/.

Produced by The Galveston Bay Foundation

Objectives:
Students will be able to:
- Identify and label major geographical features of Galveston Bay.
- Identify their location in relation to Galveston Bay.

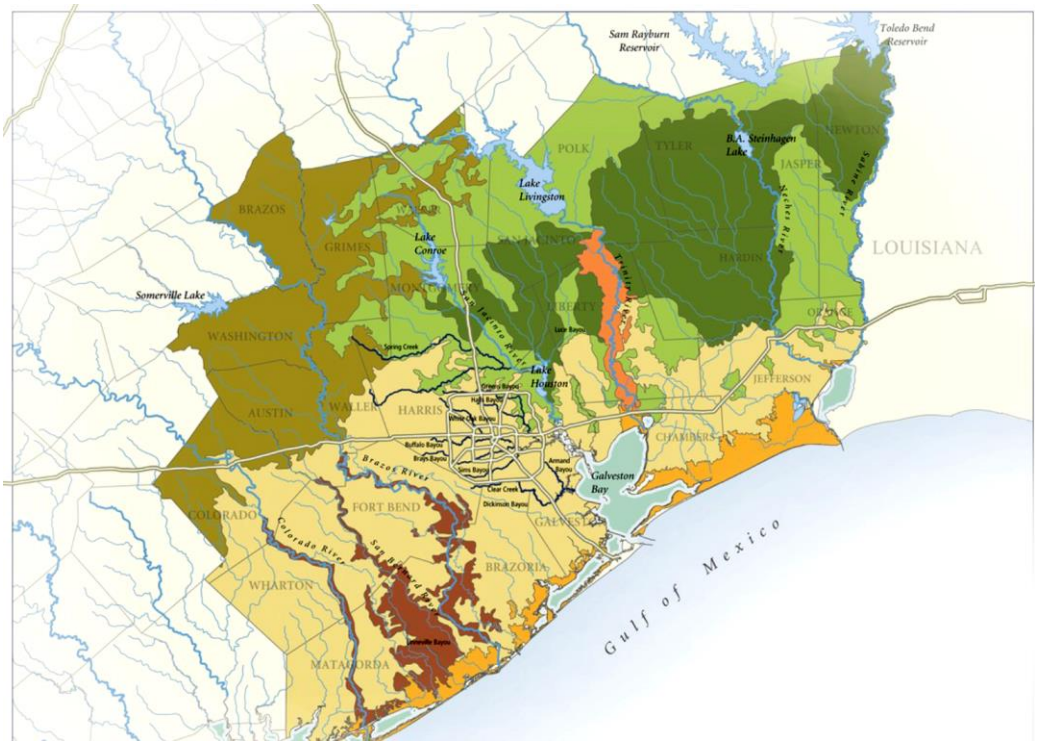
Background:

Galveston Bay covers 600 square miles of land and is surrounded by five counties: Brazoria, Chambers, Galveston, Harris, and Liberty. Approximately 4.5 million people reside in these five counties. The western side of Galveston Bay consists of urban development (housing, major cities, ports, refineries), while the eastern side remains rural.

The Galveston Bay **eco-region** is one of the most diverse areas in Texas (see Figure 1). These regions are comprised of: the Piney Woods, Trinity bottomlands, Prairie systems, Post Oak Savannah, Big Thicket, Bayous, coastal marshes, Estuary, and Gulf of Mexico. These regions are utilized in a multitude of ways including recreational opportunities, habitat for a large diversity of species, and providing a better quality of life.

Over geological time, Galveston Bay was created. The two upper bays, Galveston and Trinity, were formed approximately 4,500 years ago as many modern estuaries are, through the drowning of river valleys as sea levels rose after the last Ice Age. The two lower bays, East and West Bay, are coastwise lagoons that were segregated from gulf waters by the linear barrier system, which developed around 4,000 years ago as sea level reached near present levels. East Bay formed as a result of Bolivar Peninsula; West Bay formed landward of Galveston Island. Currently, however, humans are making the biggest changes in the geography of the bay.

Figure 1 Houston Ecoregions



Regional Mapping

Objective:
Students will use the internet, nautical maps, and geographical maps to label the following points of reference on the attached Galveston Bay map.

Instructions:
1. Create a Map Key and label the following 50 points on your Galveston Bay Map. Each category should be a different color (10 colors total):

a. Light Blue: Sub Bays of Galveston Bay (5):
   - Trinity Bay
   - Upper Galveston Bay
   - Lower Galveston Bay
   - East Bay
   - West Bay

b. Dark Blue: Major water bodies (7)
   - San Jacinto River
   - Trinity River
   - Buffalo Bayou
   - Lake Anahuac
   - Chocolate Bayou
   - Chocolate Bay
   - Gulf of Mexico

c. Orange: Islands (2)
   - Galveston island
   - Pelican island

d. Black: Peninsula (1)
   - Bolivar peninsula

e. Brown: Points (3)
   - Morgan's point
   - Houston point
   - Red Bluff point

f. Red: Passes (3)
   - Rollover pass
   - Galveston pass
   - San Luis pass

g. Purple: Man made (4)
   - Texas City Dike
   - Houston Ship channel (draw on)
   - Houston Port
   - Galveston Port

h. Yellow: School (1)
   - Place a star where your school is located

i. Black: Counties (5)
   - Brazoria
   - Chambers
   - Galveston
   - Harris
   - Liberty

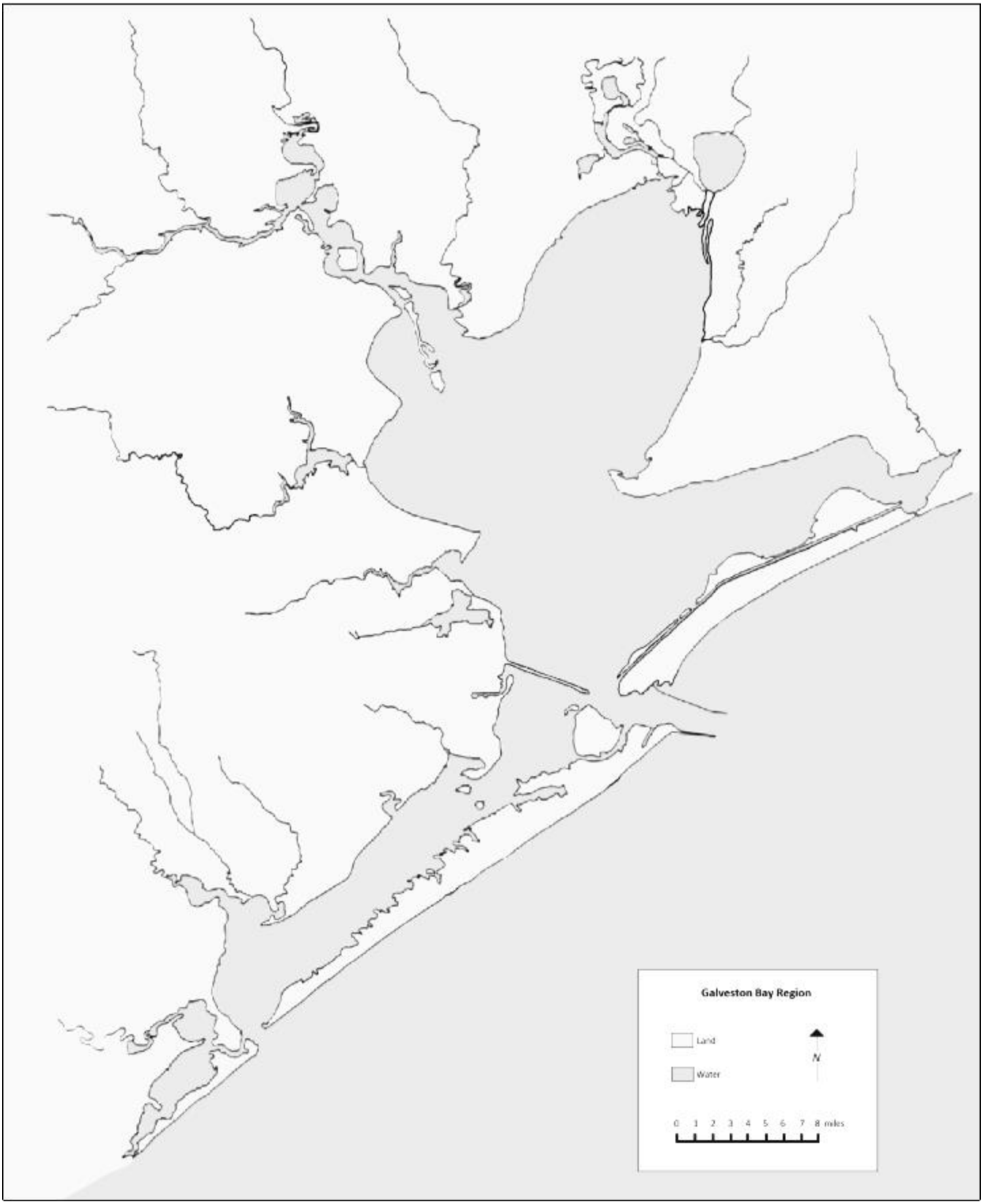
j. Green: Oyster Reefs (Draw On Map) (2):
   - Use the Oyster Appellations of Galveston Bay map to pick 2 reefs to draw. The map can be accessed at this link: http://tommys.com/wp-content/uploads/2015/05/Oyster-Map.png

There will be a total of 33 labels on your map including the star.

2. Extensions to add (use maps from www.galvbaydata.org):
   a. Tidal circulation
   b. Eco regions
   c. Urban development
   d. Shoreline development
   e. Pathogens
   f. Fishing Advisory
   g. Oyster Harvesting

Regional Mapping

Name: _____ Date:_____



Galveston Bay Watershed Topography Model

Key Words:
Topography
Watershed
Estuary
Ecosystem

Time: 1 class period

Materials:
-8.5x11 foam sheets:
- -3 black
- -3 purple
- -3 dark blue
- -3 pink
- -3 dark green
- -3 light green
- -2 yellow
- -2 orange
- -1 red
- -1/2 brown

-Galveston Bay Watershed Map Key
-Galveston Bay Watershed Model Outline
-Scissors
-gallon-sized Ziplock bags

Texas Essential Knowledge and Skills (TEKS):
Grade 6: 3B
Grade7: 3B, 8C
Grade 8: 3B, 9C
Aquatic Science: 2HJ, 4AC, 7AB, 12D
Biology: 2H, 3E, 12F
Environmental Systems: 2HK, 5B, 9E

Created by the Galveston Bay Foundation
2018

Sources:
State of Texas Elevation Map, John J. Kosovich 2008; www.galvbaygrade.org; Galveston Bay Estuary Program

Teacher Information page

Objectives:
- Students will create a 3-D model of the topography of the Galveston Bay watershed and evaluate the flow of water
- Students will evaluate how human activities along the entire watershed can affect the Bay ecosystem.
- Students will complete a quick write to convey the knowledge they learned in the lesson

Background:
The Galveston Bay **estuary** system is greatly affected by natural processes and human activities occurring in its **watershed**, the area of land from which water drains to tributary rivers, bayous, streams, and ultimately Galveston Bay itself. The important relationship between the bay waters and the surrounding landscape cannot be overstated: the estuary's physical, chemical, and biological quality is directly impacted by the quantity and quality of freshwater draining from its watershed.

The 24,000 square miles of the Galveston Bay watershed dwarfs the 600 square miles covered by the bay's open waters. It reaches as far north as the Dallas-Fort Worth area, draining to the Trinity River which, in turn, ultimately flows to Galveston Bay. Due to the large areal coverage and presence of the urbanized areas within the watershed, approximately half the population of the state of Texas lives within its boundaries and has a large potential impact on the estuary.

The "lower" Galveston Bay watershed is defined as the 4,000 square mile area draining to the Bay downstream of two major impoundments: Lake Houston on the San Jacinto River, and Lake Livingston on the Trinity River. Each stream and bayou in the lower Galveston Bay watershed has its own **sub-watershed**. We all live in a sub-watershed and affect the quality of our local water body by your daily activities. In fact, contaminated storm water runoff, or non-point source pollution, from our businesses, industries, farms, roads, parking lots, septic tanks, marinas and residential yards is the number one water quality problem facing the estuary.

Before the lesson:
1. This lesson is designed for 8 groups (A-H) where each group will receive a difference section of the Galveston Bay Watershed. Each group will receive the materials listed to the left. The colors of foam needed for each group will depend on their map (see the directions to create the model for details).
2. Decide how you want to do the lesson:
    A. Have 1 watershed model section for each group already cut out for each group to use. This will take less time and materials. OR
    B. Have each group cut their own watershed model section in class before the activity. This will take more time and materials.
3. Refer to the Table of contents on the next page to see how this document is laid out.
4. Review questions/concepts you want to discuss with the class once the watershed model is put together.

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Teacher Procedure

Table of Contents:

Page	Description
1	Teacher Information page
2	Teacher Procedure page
3	Student Procedure page
4	Procedure to make model pieces and bags
5--27	Outlines for each section (A-H)
28	Watershed Map Key
29-36	Topography Maps for each section (A-H) to give to groups

Procedure:

1. Introduce examples of topography maps to your students. Explain what the lines and colors mean. The distinctive characteristic of a topographic map is the use of contour lines to show the shape of the earth's surface.
2. Give groups materials for them to put together their models:
    a. Map outline for their section of watershed (A-H)
    b. Colored foam pieces cut out already for their section (quick reference of colors for each section is in the table below).
    c. Student procedure page
3. Students will put together their sections based on the map outline and the map key on their procedure page.
4. Once complete, have the groups come together to one table to merge their models to create a large model of the Galveston Bay watershed. This will be somewhat of a puzzle. You can reference the watershed map if needed.
5. Discuss with them what they see, what the different layers represent, and the properties and characteristics of a watershed. Have them picture rain falling in the upper watershed and what would eventually happen to the water.
6. Have students go back to their seats to write 2-3 paragraphs on their own paper explaining the Galveston Bay Watershed, its characteristics, and how human activities along the watershed can affect the health of Galveston Bay. You can have them specifically mention anything you discussed as a whole class.

Group	A	B	C	D	E	F	G	H
Color of foam	Black Purple Dark blue Pink Dark green	Black Purple Dark blue Pink Dark green	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red Brown	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red

GALVESTON BAY FOUNDATION

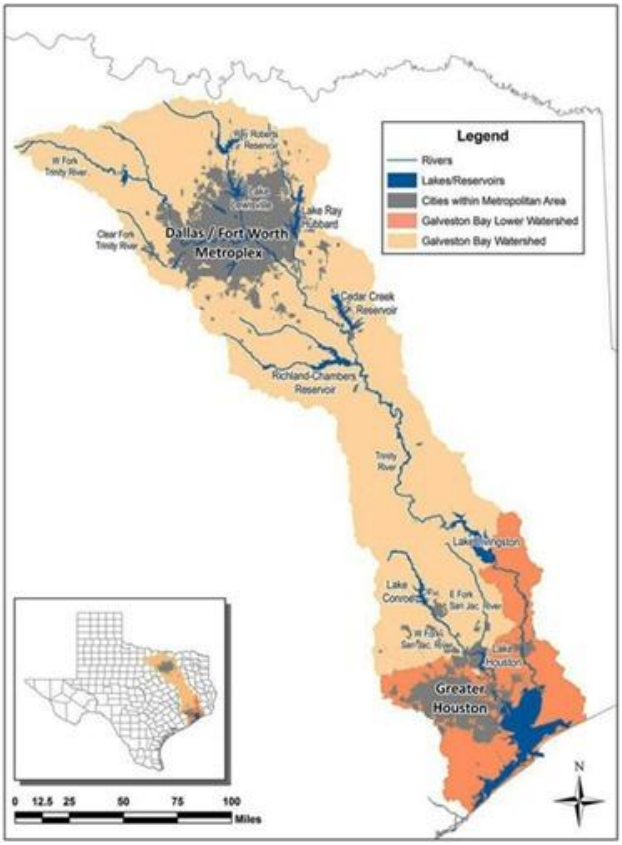
Student Procedure

Materials:

- Bag with Map outline and foam pieces for your group
- Your own notebook paper for quick write

Background:

The Galveston Bay **estuary** system is greatly affected by natural processes and human activities occurring in its **watershed**, the area of land from which water drains to tributary rivers, bayous, streams, and ultimately Galveston Bay itself. The important relationship between the bay waters and the surrounding landscape cannot be overstated: the estuary's physical, chemical, and biological quality is directly impacted by the quantity and quality of freshwater draining from its watershed.



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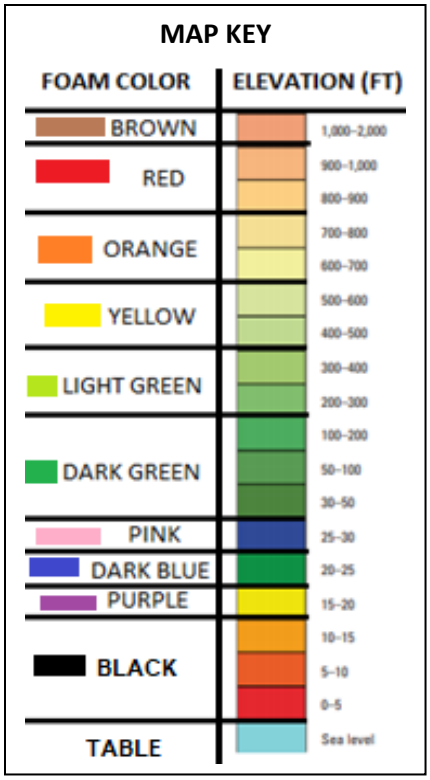


Procedure:

1. Build the topographical model of your section of the Galveston Bay Watershed using the map outline page. Refer to the Map Key to see the elevations of the watershed. ***T****he foam color does NOT match the elevation color, so double check the Map Key as you are building your section of the watershed.*
2. Once all groups are done, piece your models together to create the entire watershed as a class and discuss.

Analysis: Complete a quick write about the watershed on your own piece of paper. You must write a minimum of 3 paragraphs discussing the characteristics of a watershed, how human activities along the watershed can affect the health of Galveston Bay, things you learned during the class discussion, and any other specific points your teacher mentioned.

To Create Model Sections:

Materials:

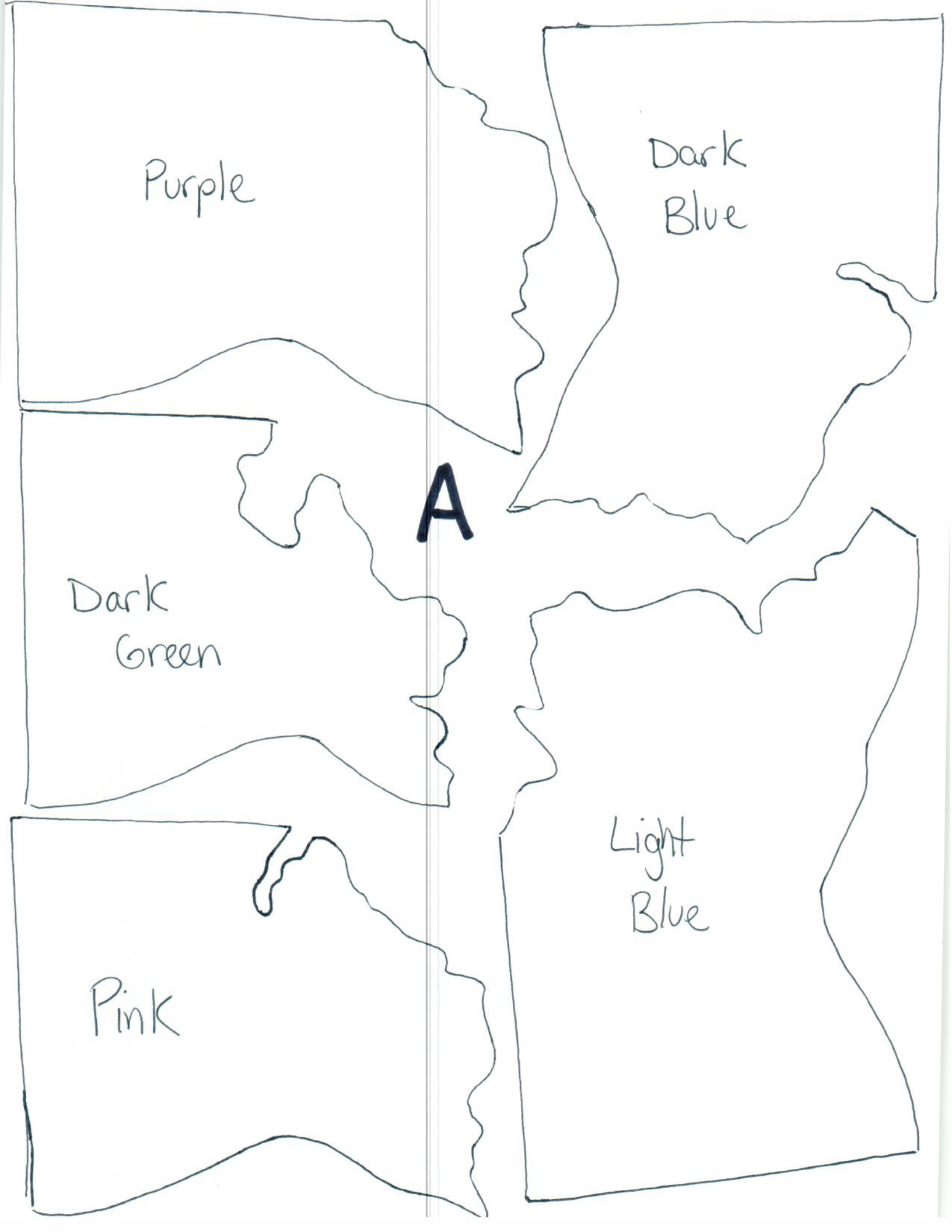
- Multiple foam sheets in the following colors:
  - Black
  - Purple
  - Dark blue
  - Pink
  - Dark green
  - Light green
  - Yellow
  - Orange
  - Red
  - Brown
- Outline sheets for sections A-H **Note: the pieces labeled "light blue" should say "black". Make sure to use black foam when cutting those pieces out.*
- Topography maps for each section (A-H)
- Scissors
- Pen
- 8 Gallon-sized Ziplock bags

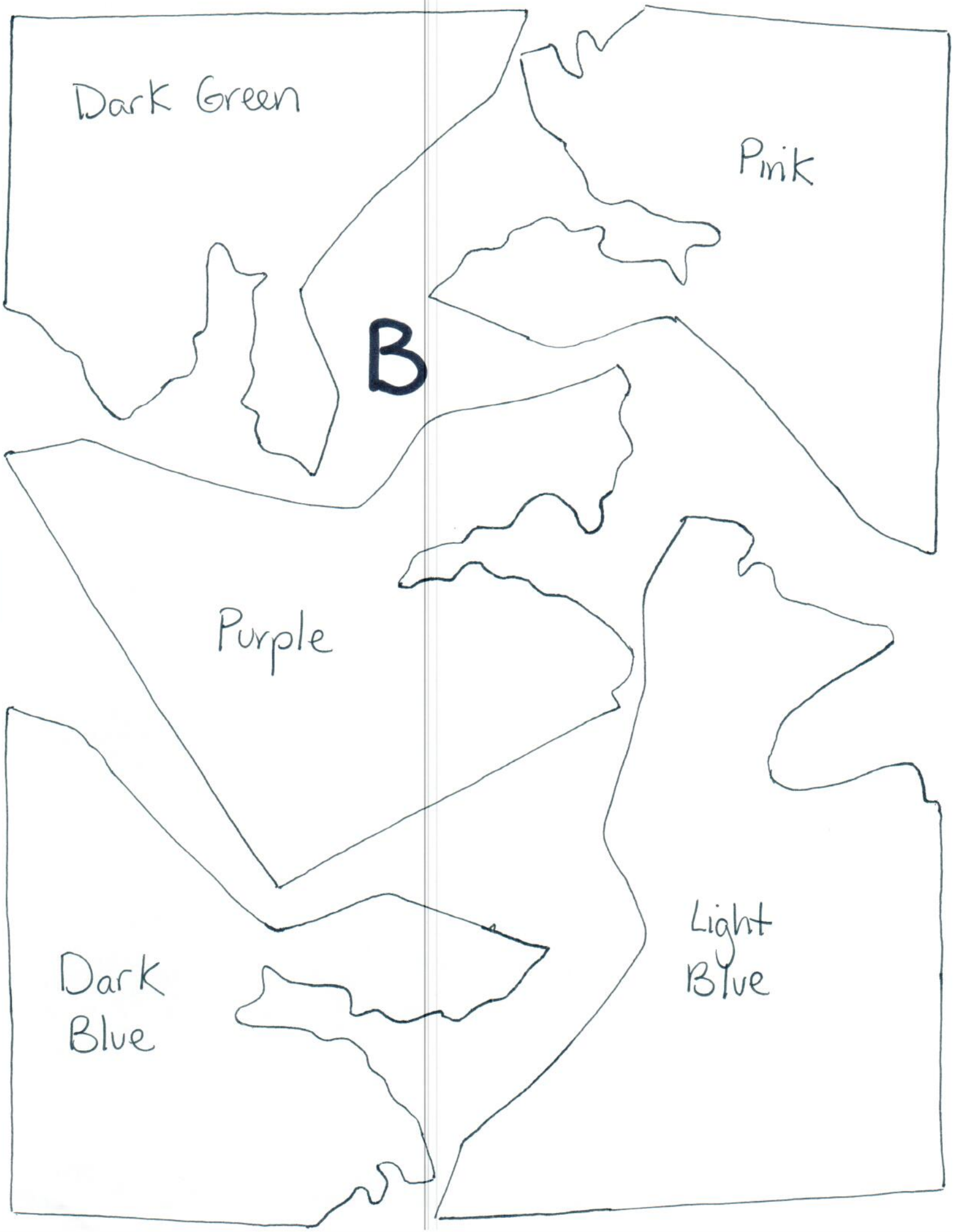
You will need the following colors for each model section listed below:

Section	A	B	C	D	E	F	G	H
Color of foam (bottom to top)	Black Purple Dark blue Pink Dark green	Black Purple Dark blue Pink Dark green	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red	Black Purple Dark blue Pink Dark green Light green Yellow Orange	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red Brown	Black Purple Dark blue Pink Dark green Light green Yellow Orange Red

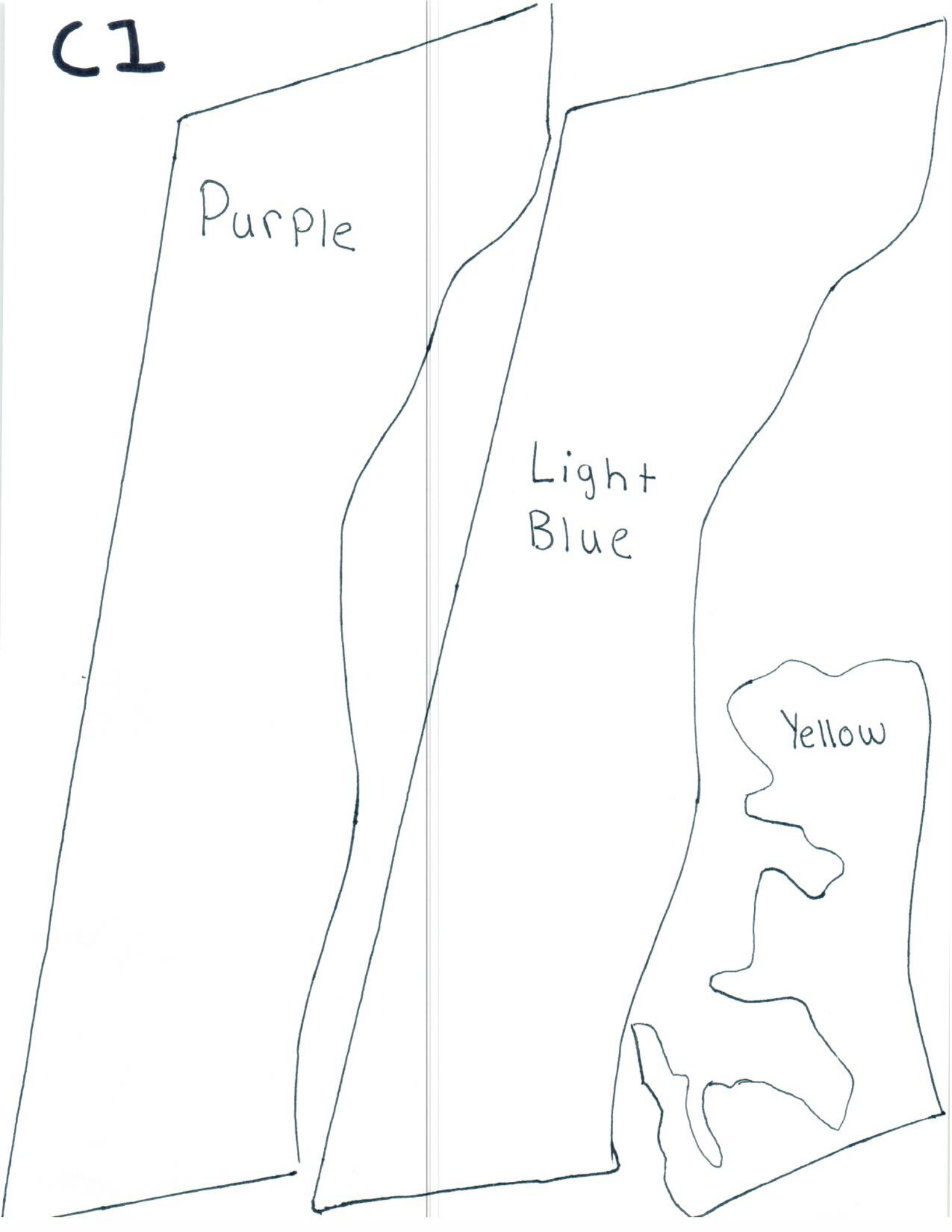
Directions:

1. Cut out the outlines for each section one at a time so they don't get mixed up.
2. Trace each outline on the correct foam color (color names are labeled on the top of each piece for your convenience. Do not flip them over as you trace & cut.) and cut it out.
3. Number the foam pieces on the BACK of each so you don't lose them. (You may want to do this prior to cutting)
4. Place fished foam pieces in a gallon Ziplock bag
5. Label the Ziplock bag with the section letter (A-H) and how many pieces are in it.
6. Place the correct watershed topography map for each section in the bag with the foam pieces.
7. Repeat #1-6 for all sections.

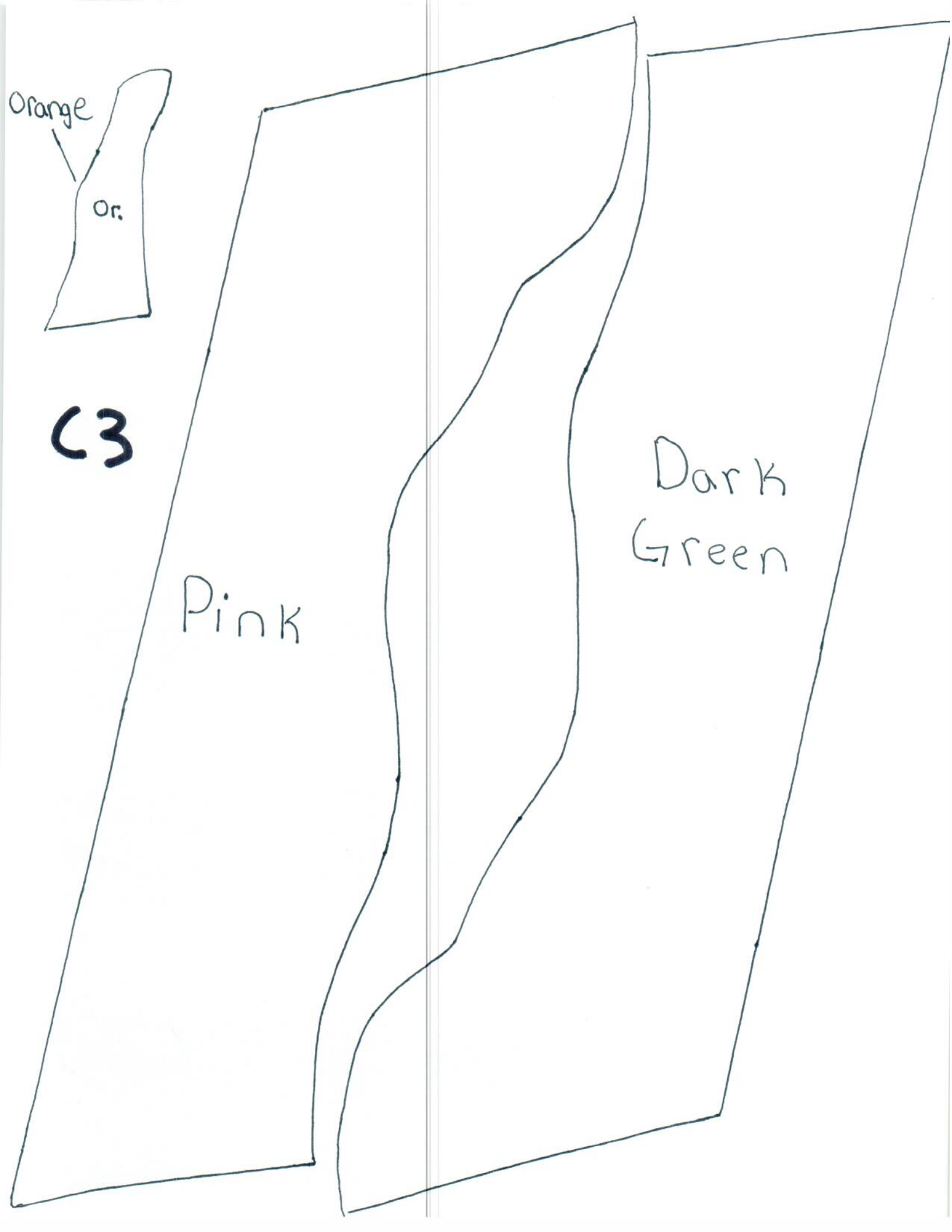

Purple
Dark Blue
A
Dark Green
Light Blue
Pink


Dark Green
Pink
B
Purple
Dark
Blue
Light
Blue

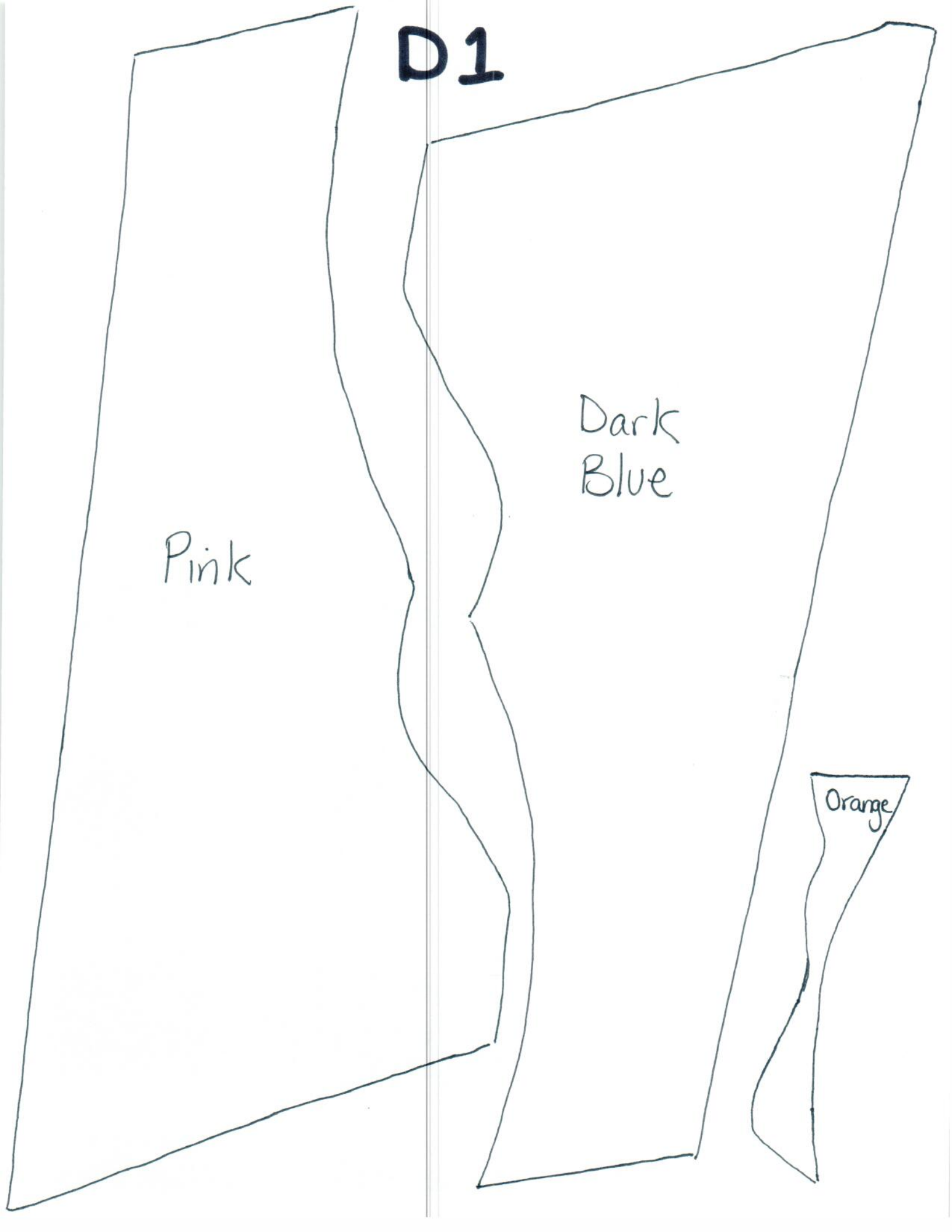
C1



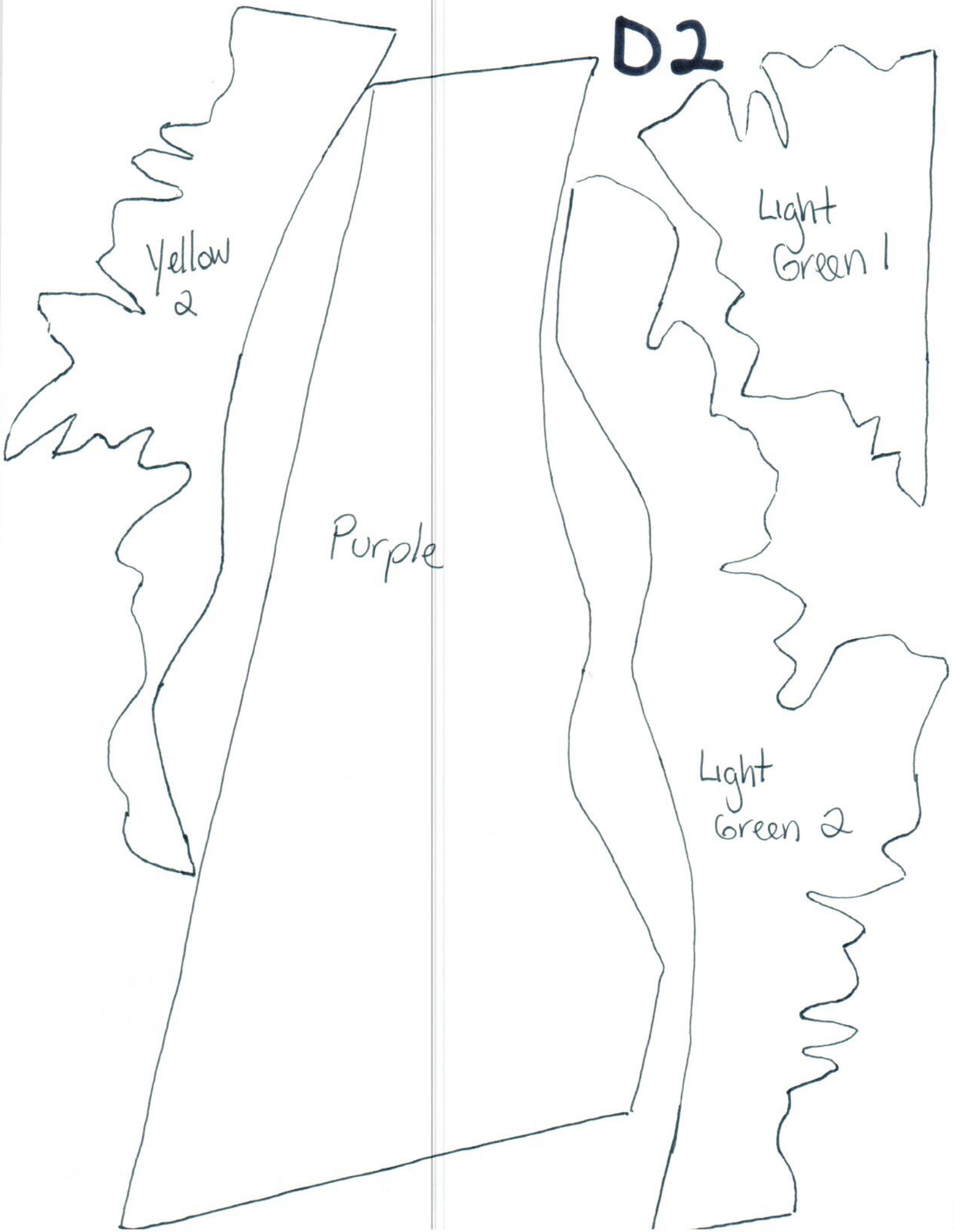
C2


Orange
Or.
C3
Pink
Dark
Green

D1

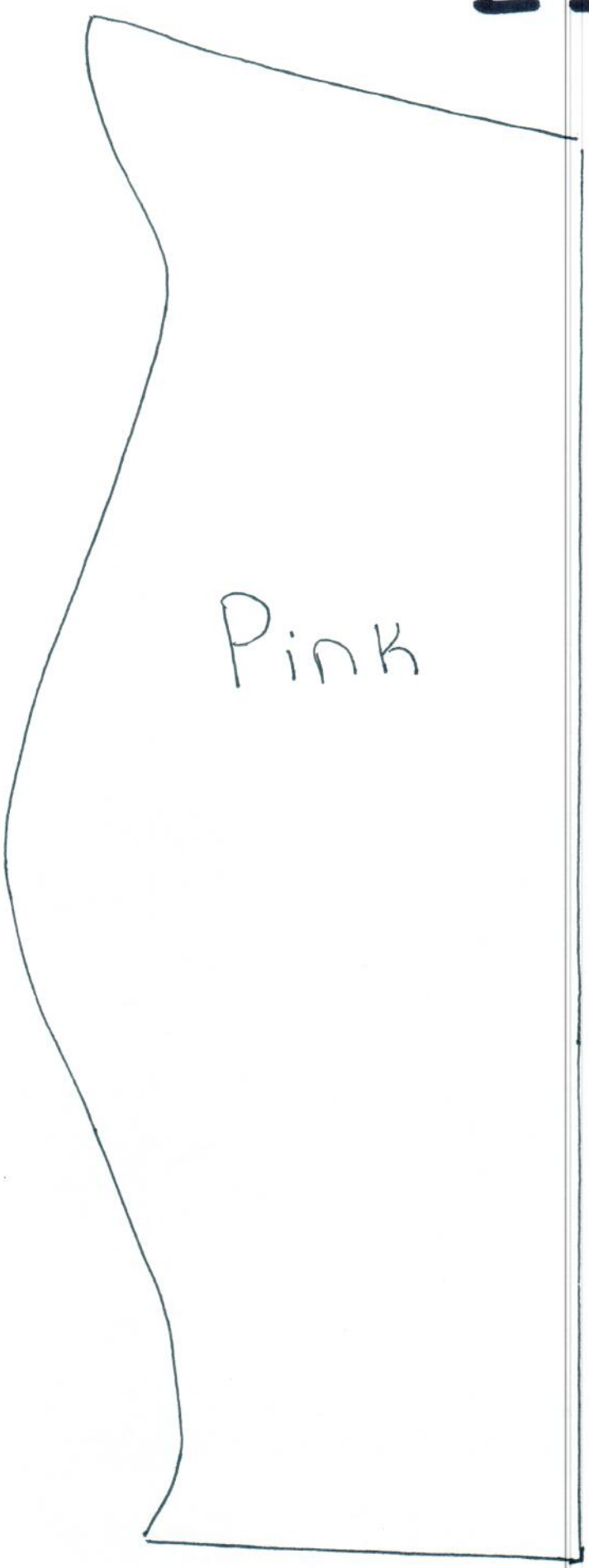


D2



D3

E1



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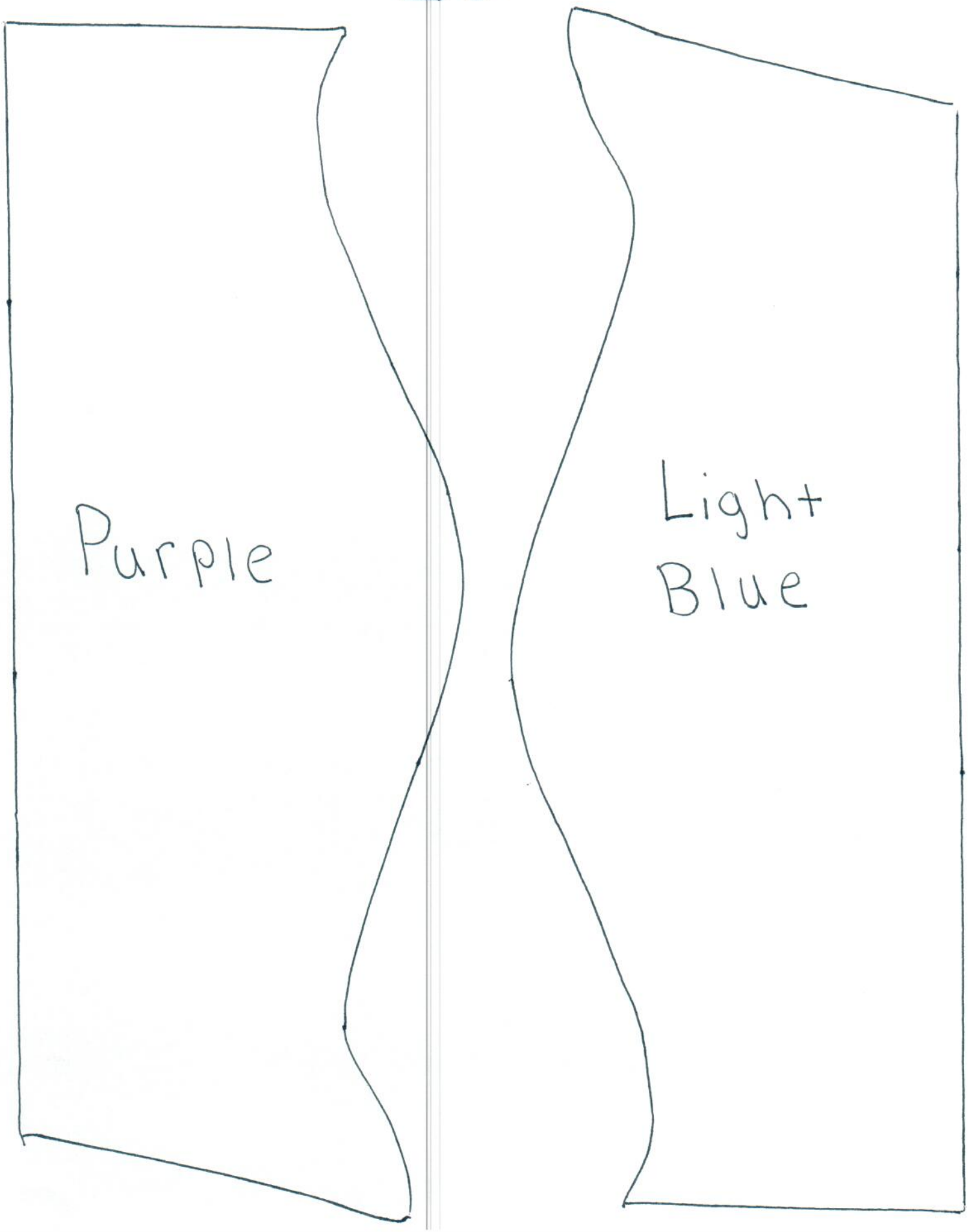
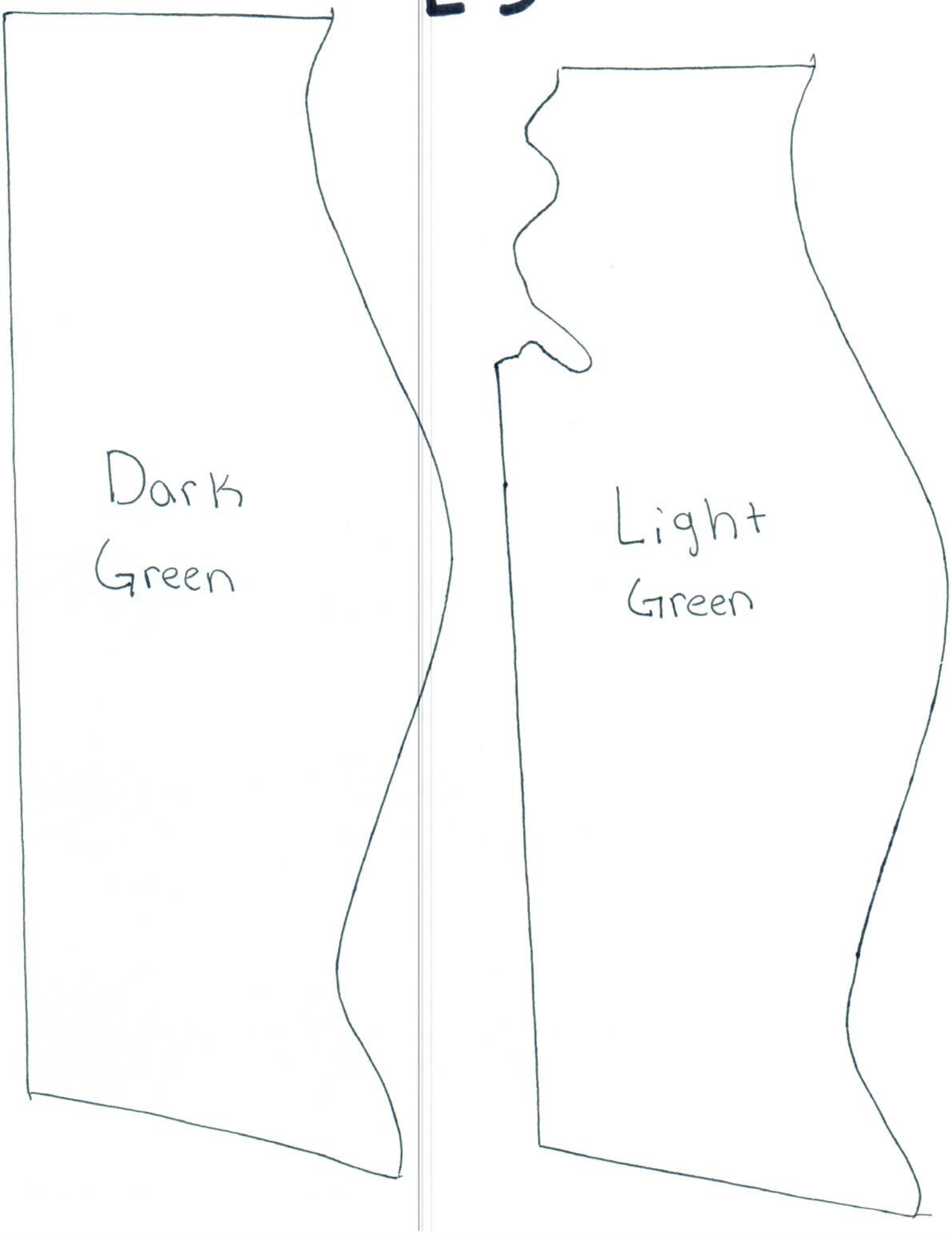
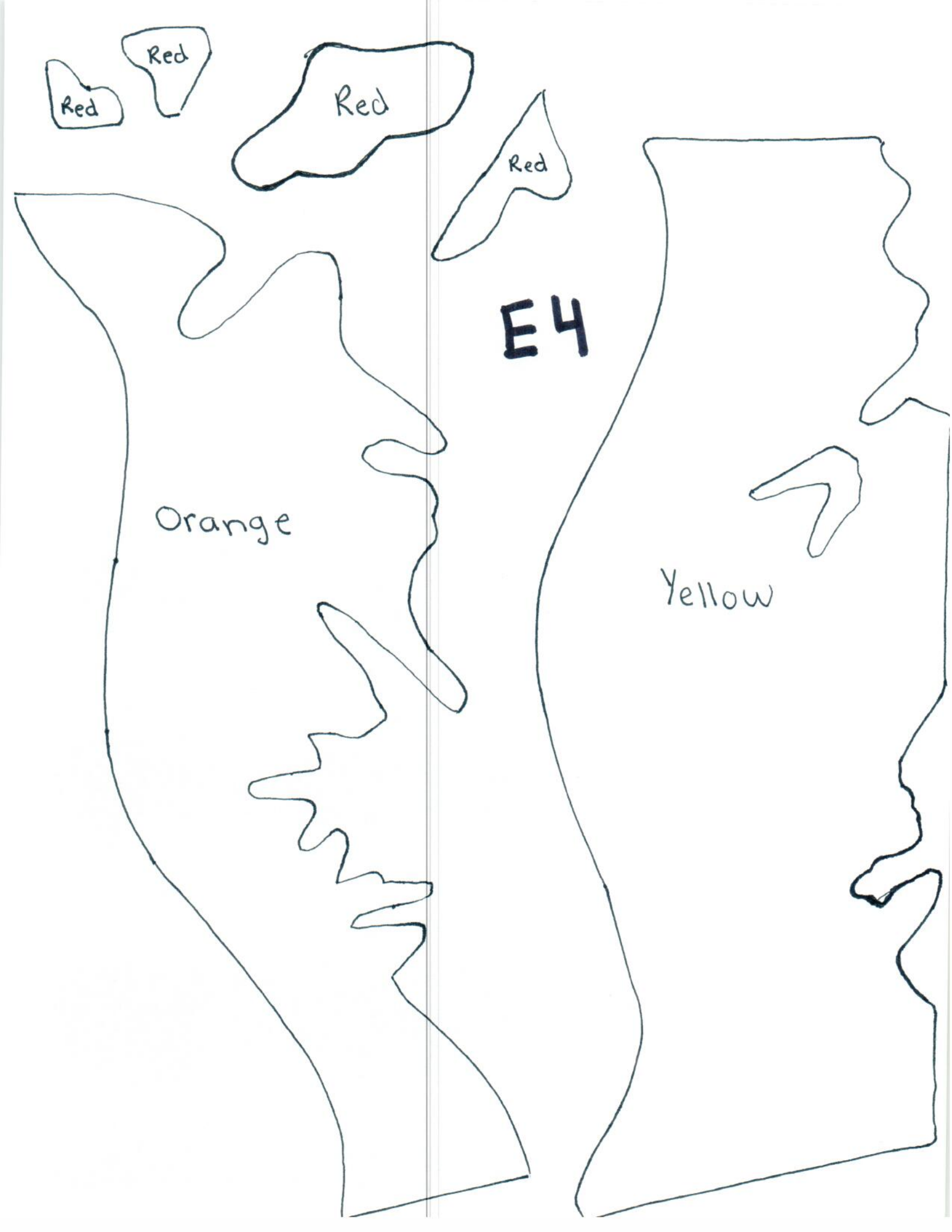
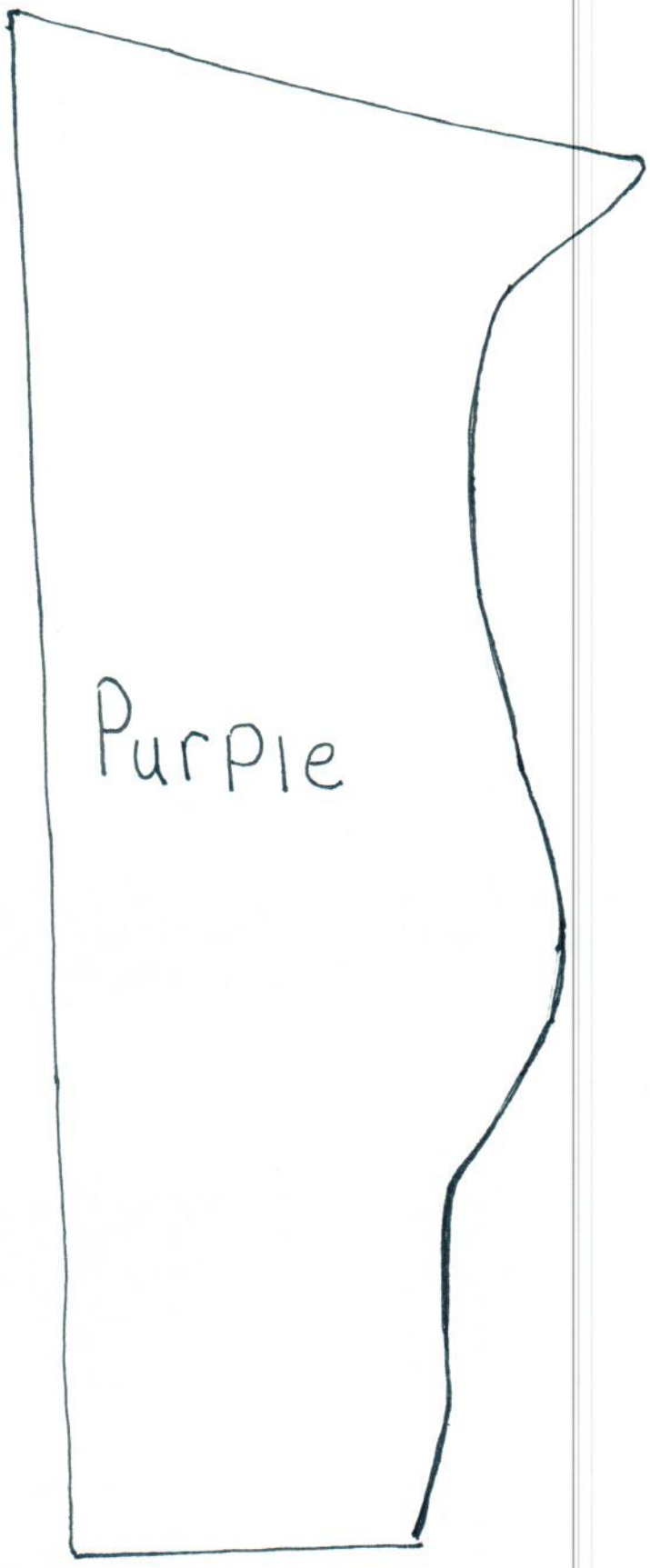


E3




Red
Red
Red
Red
E4
Orange
Yellow

F1



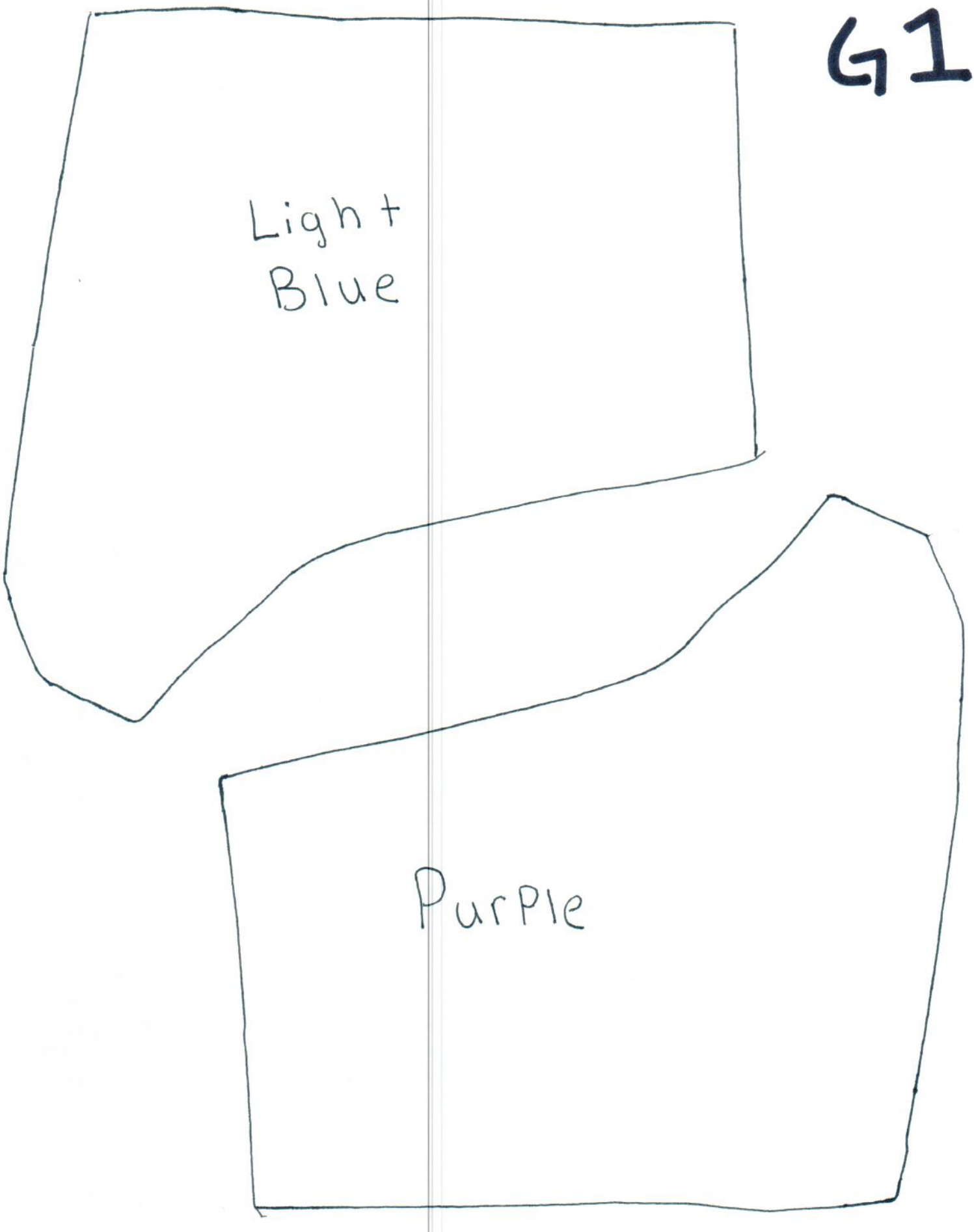
F2

F3

F4

orange — Or.

G1



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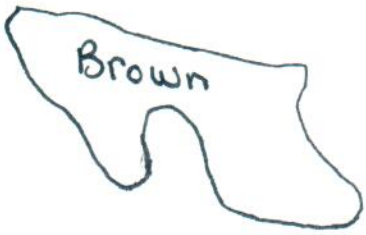

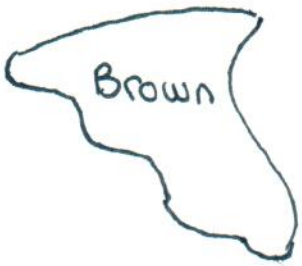

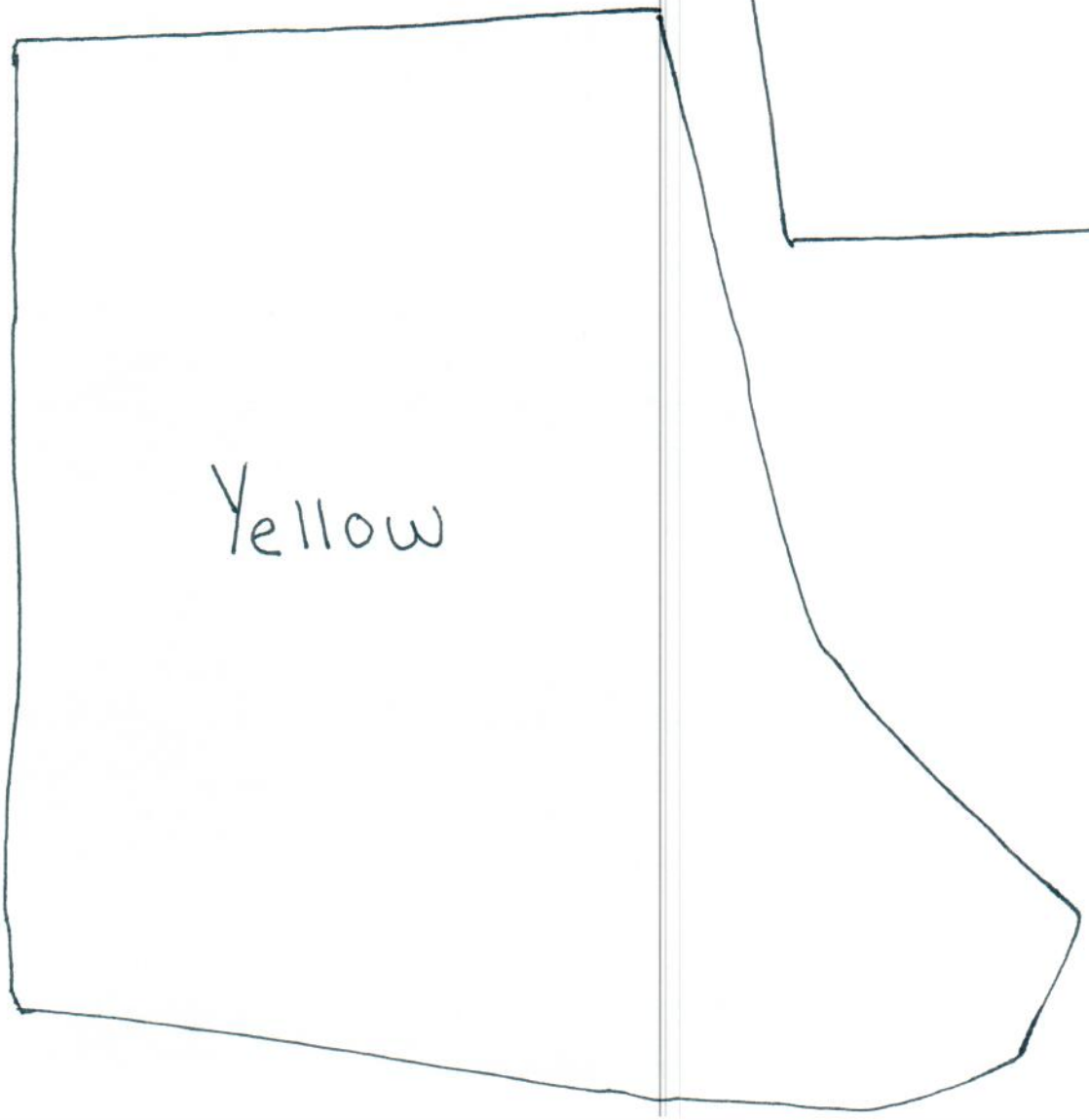

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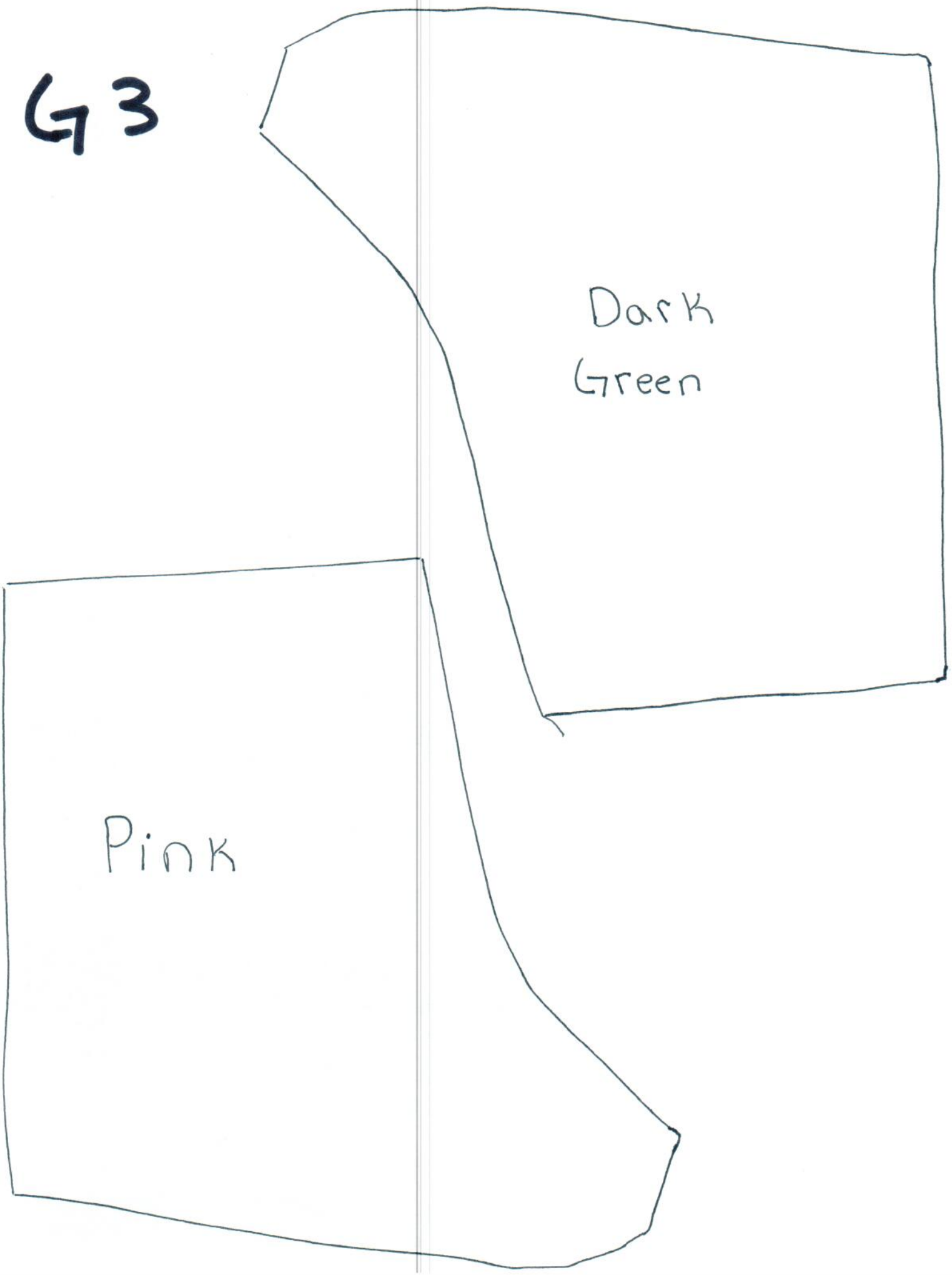

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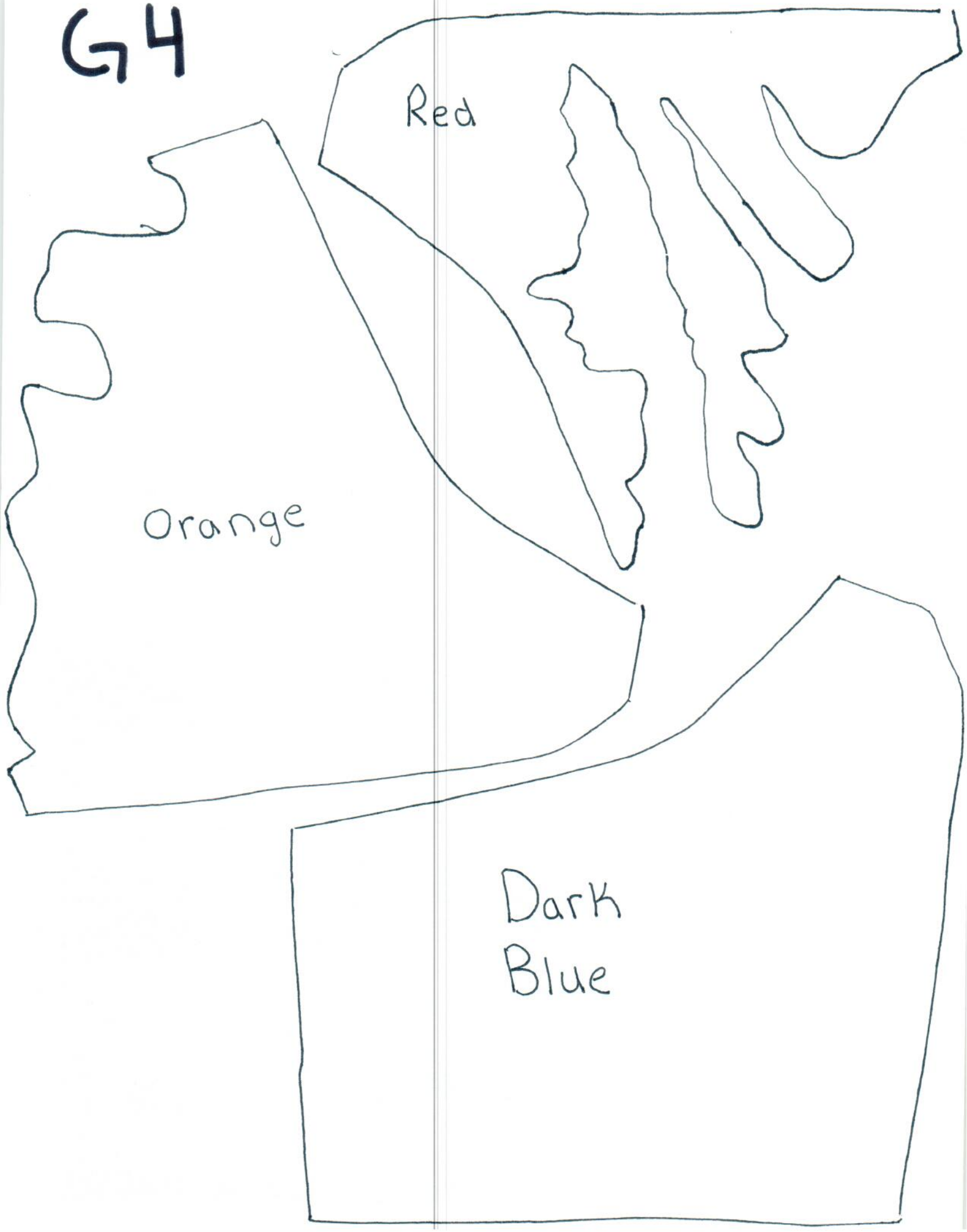
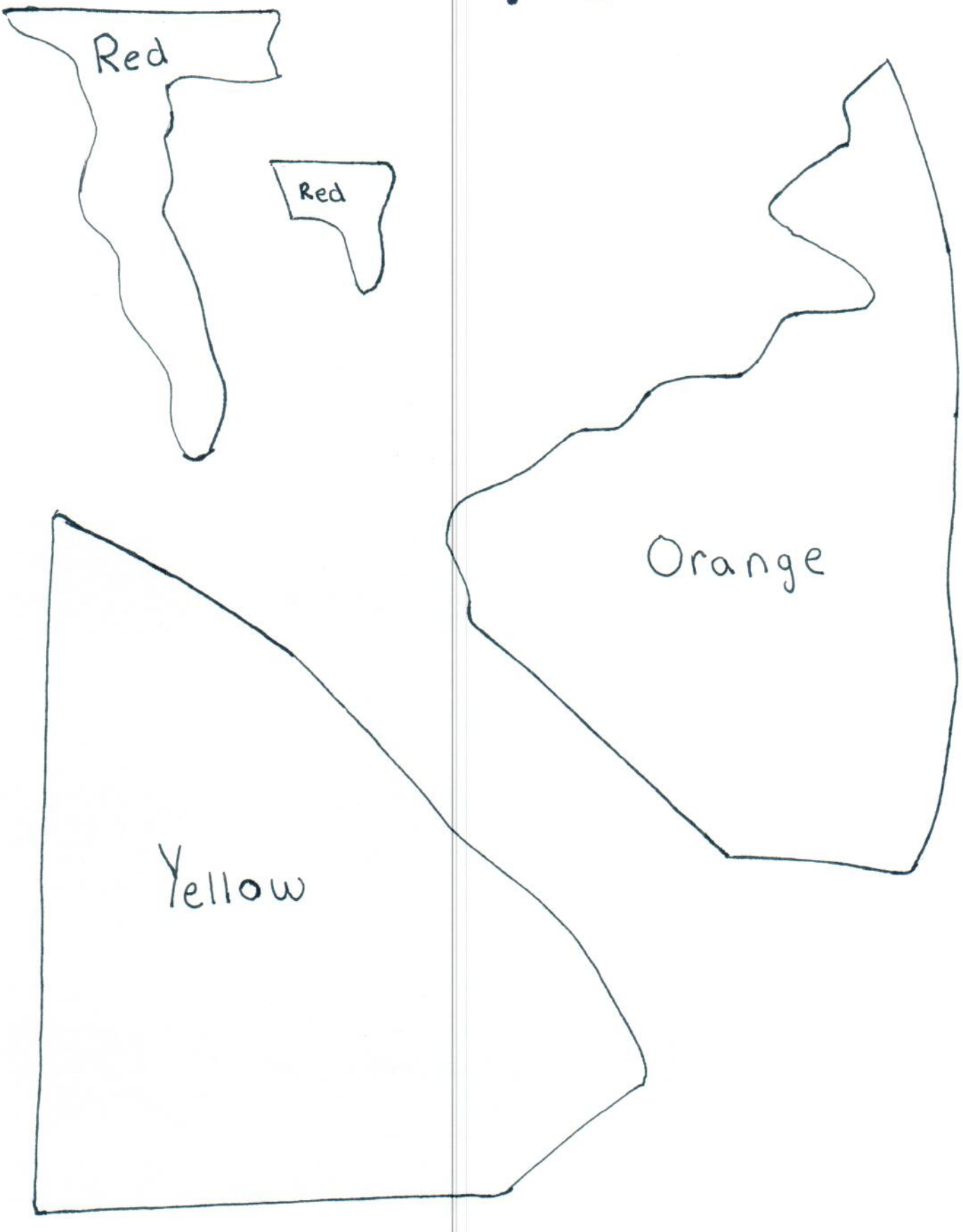
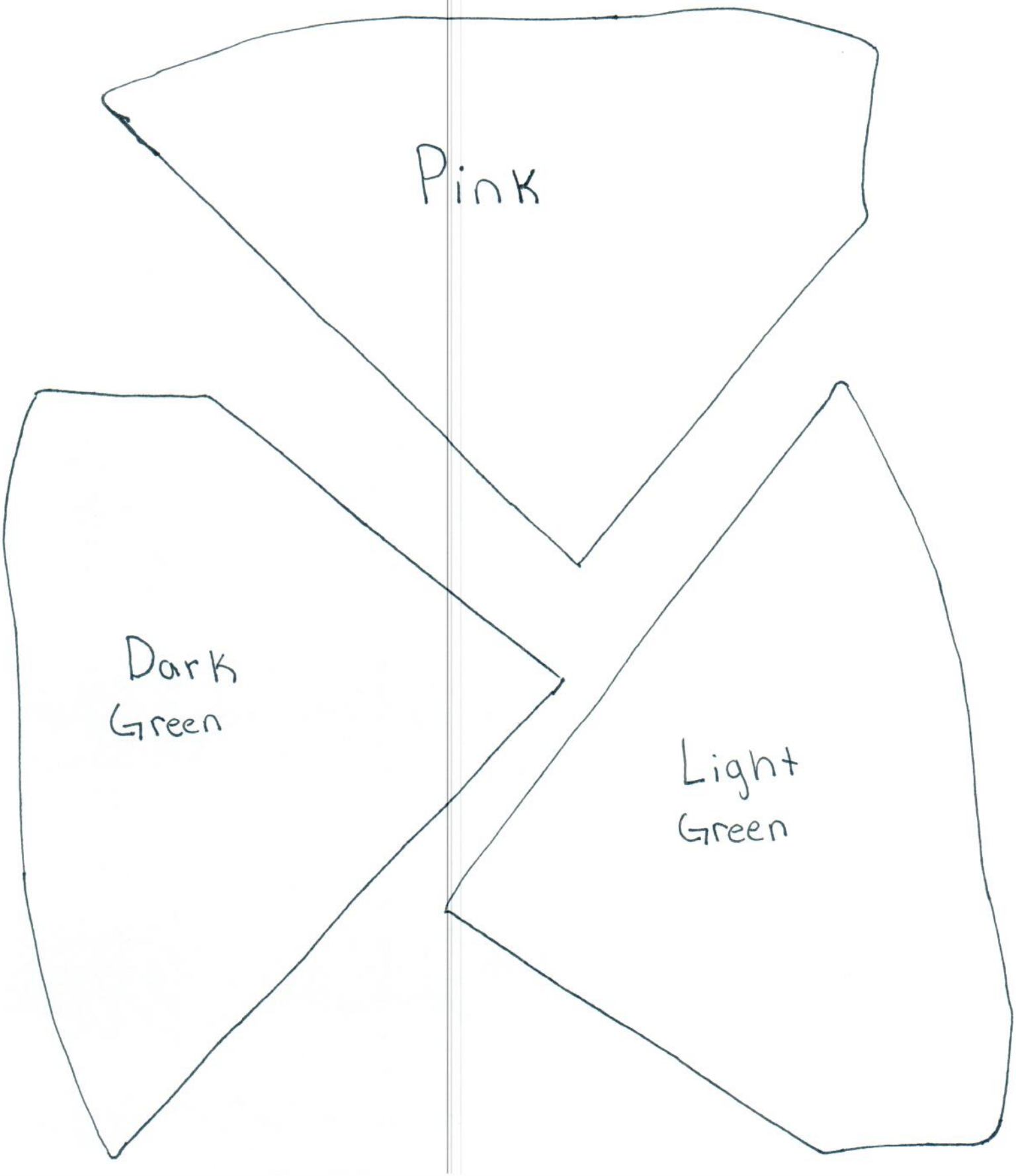


H1



H2



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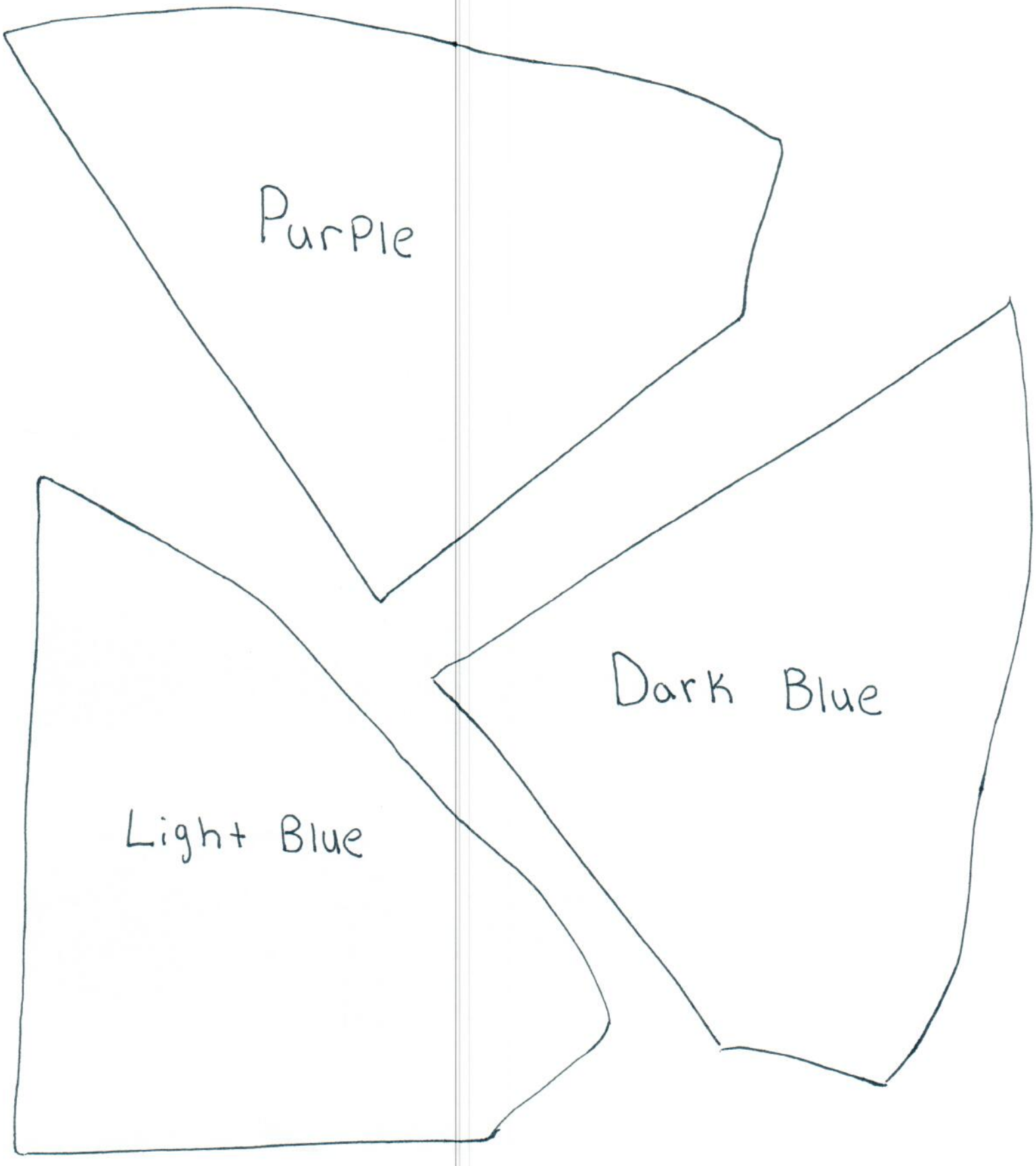
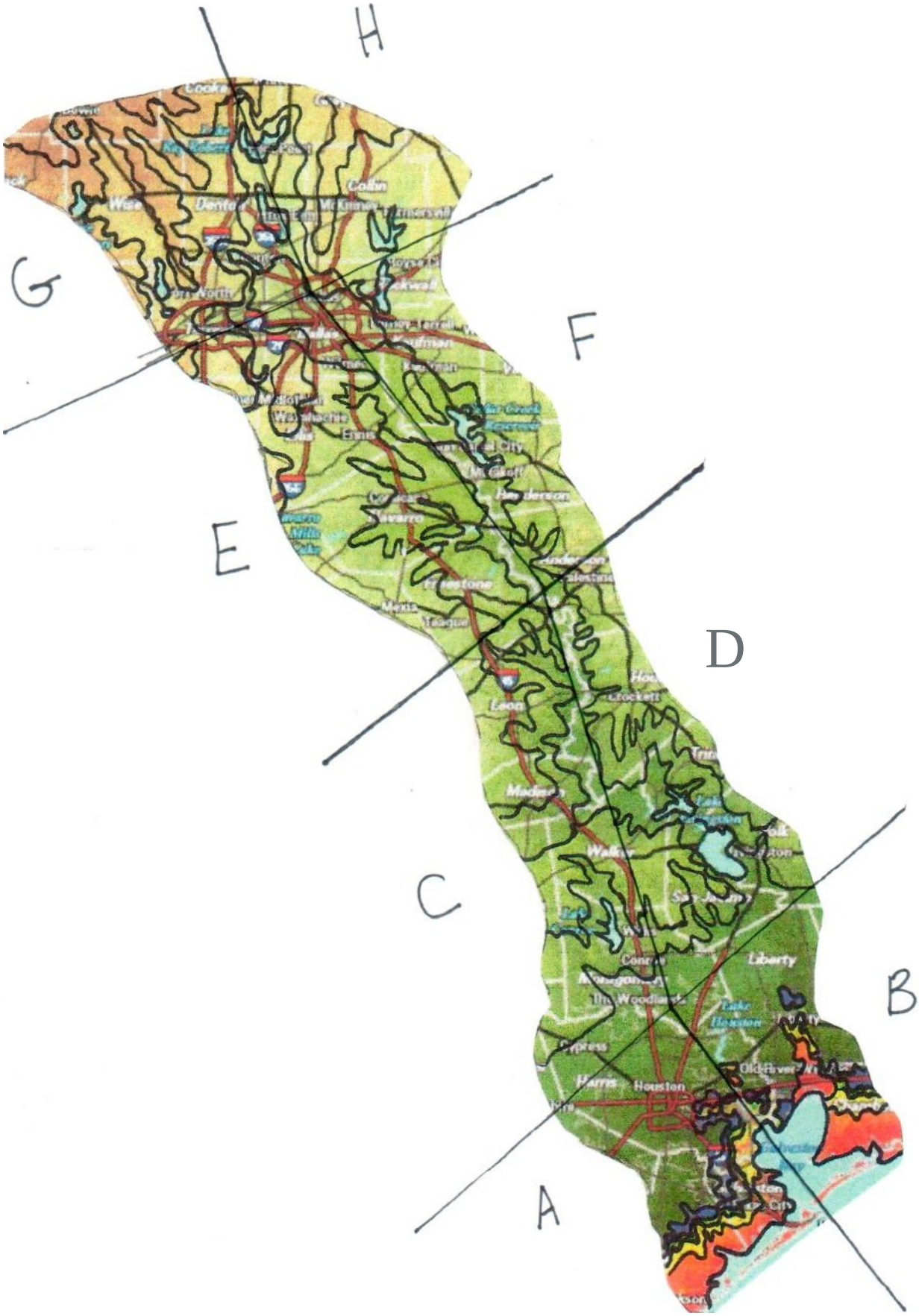
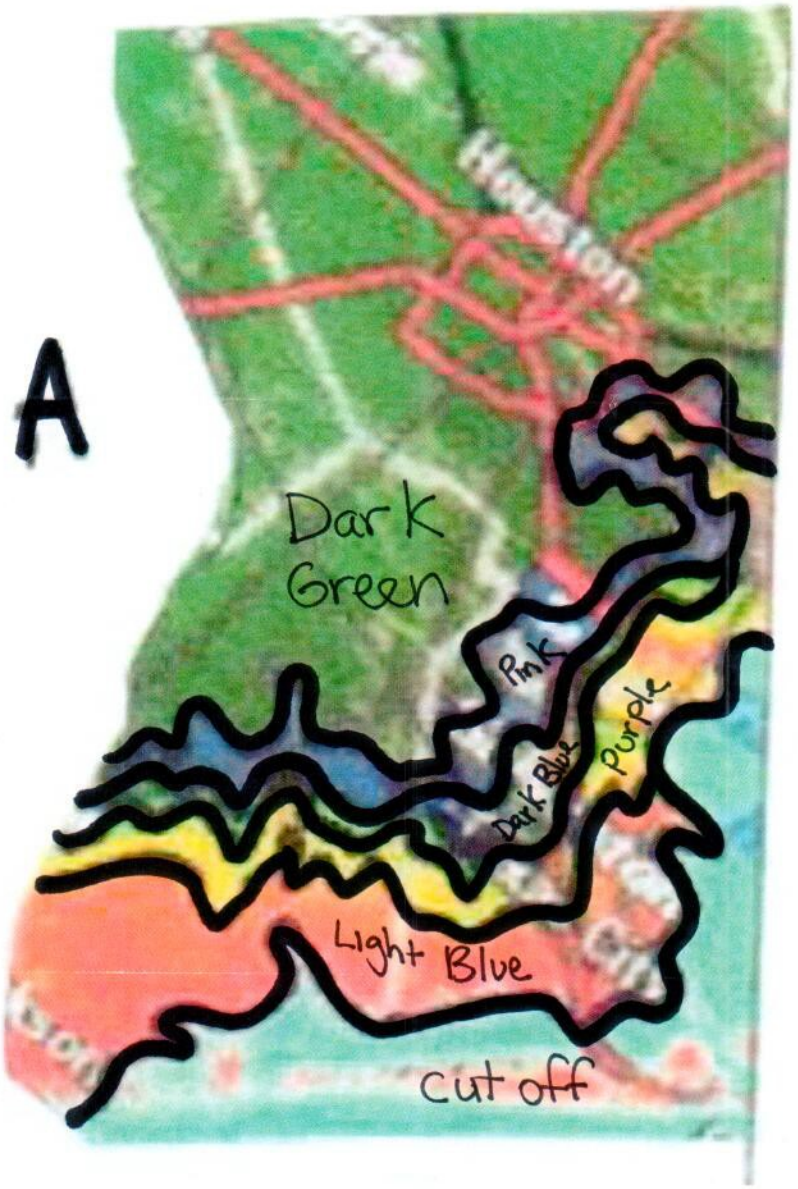


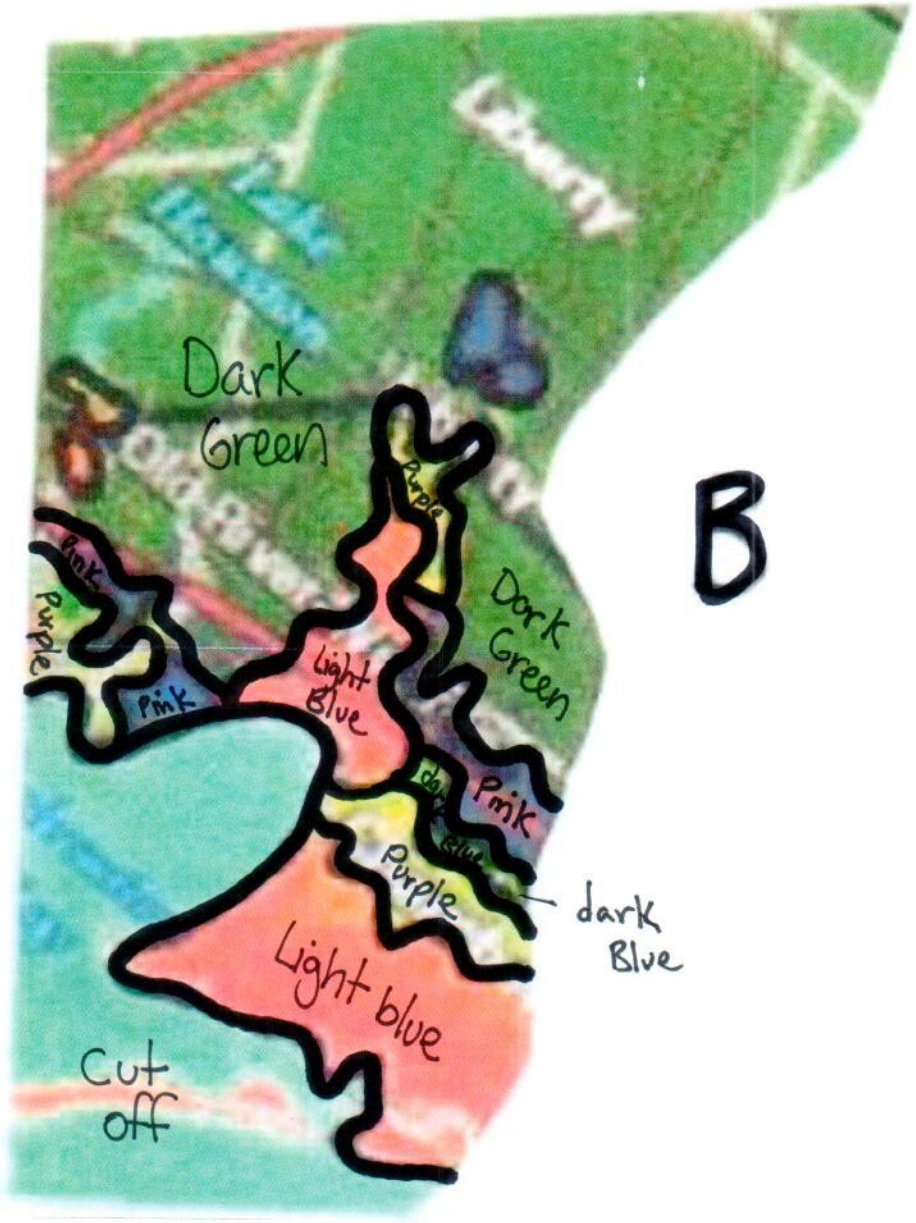
Galveston Bay Watershed Map Key



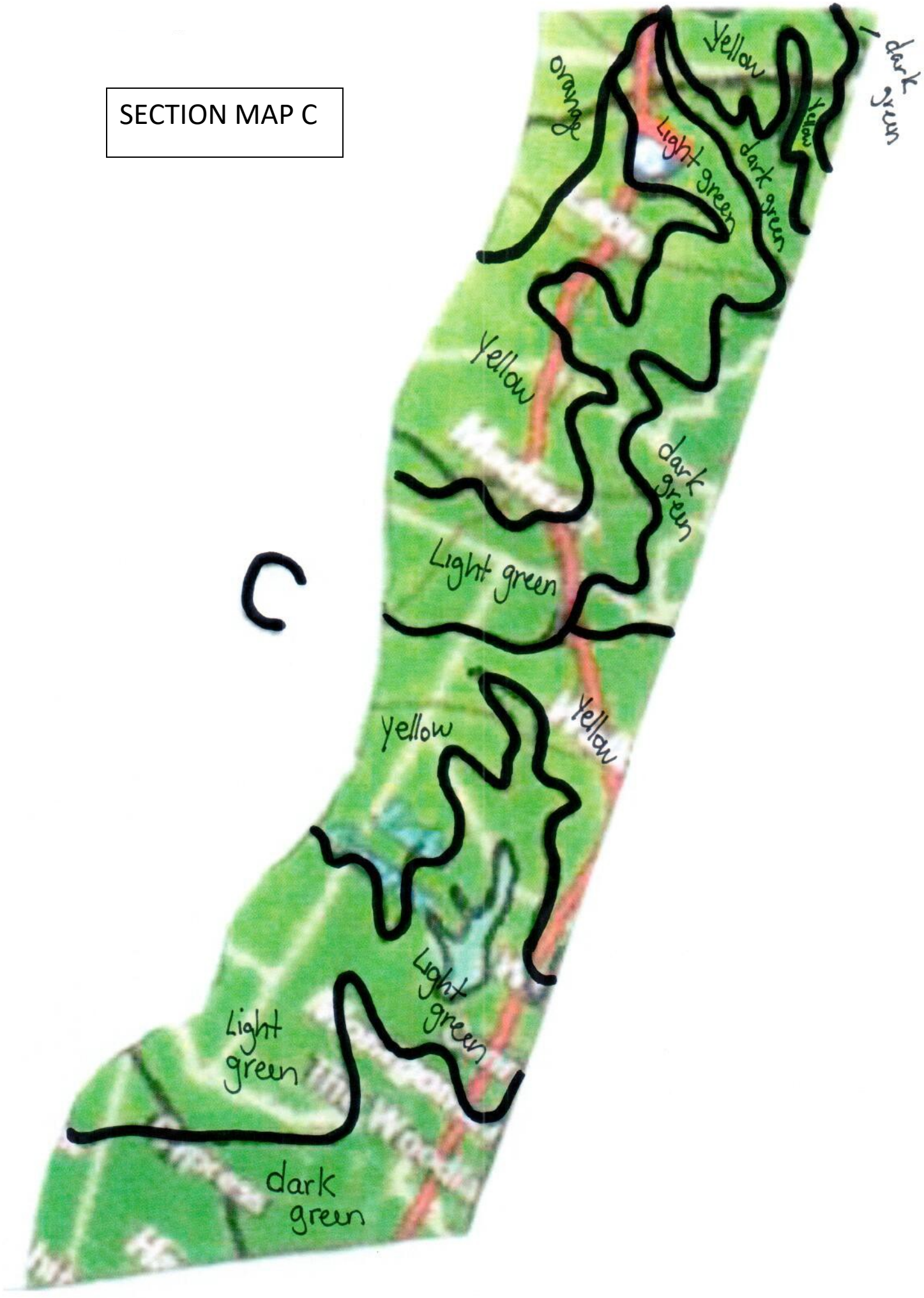
SECTION MAP A



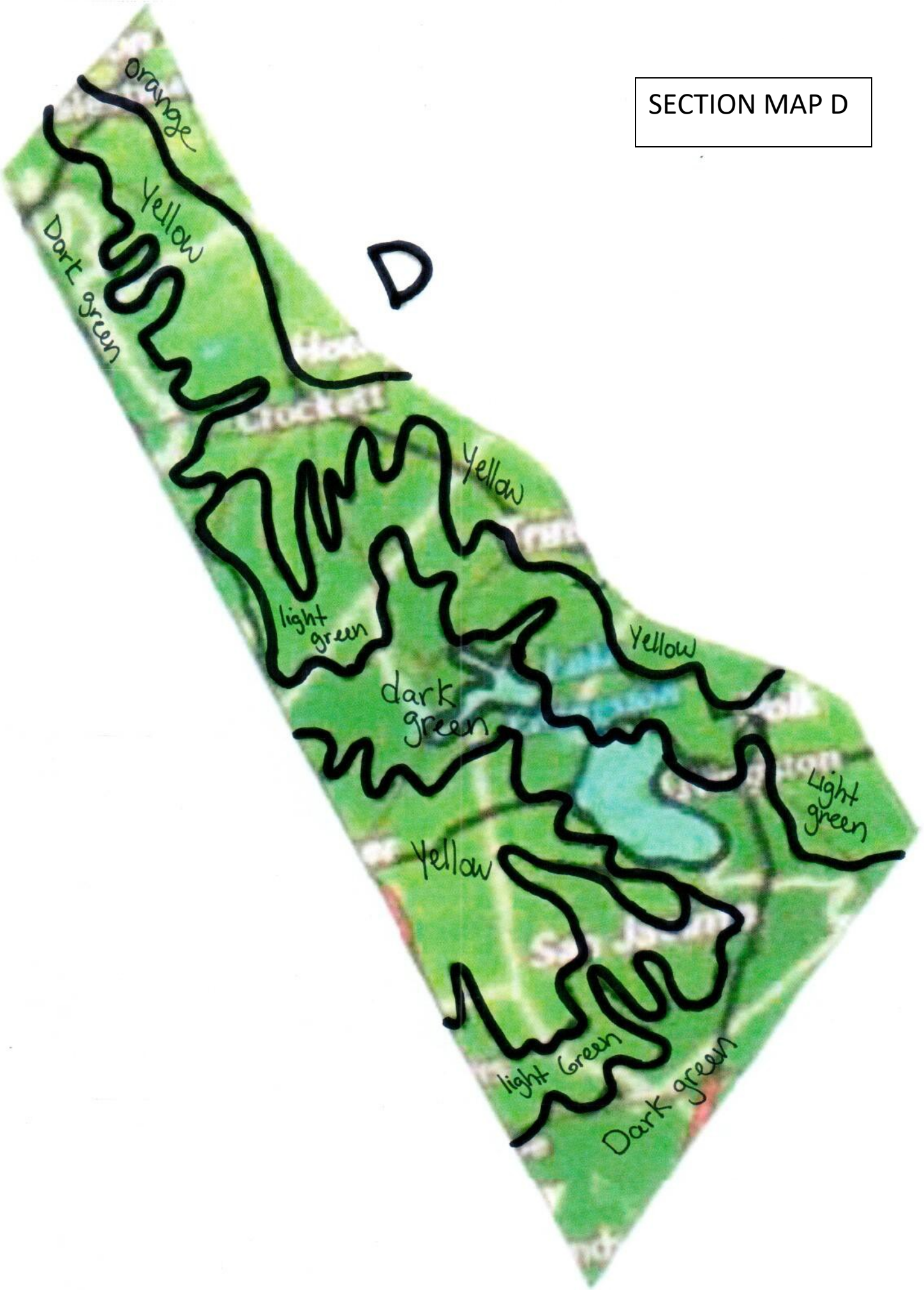
SECTION MAP B



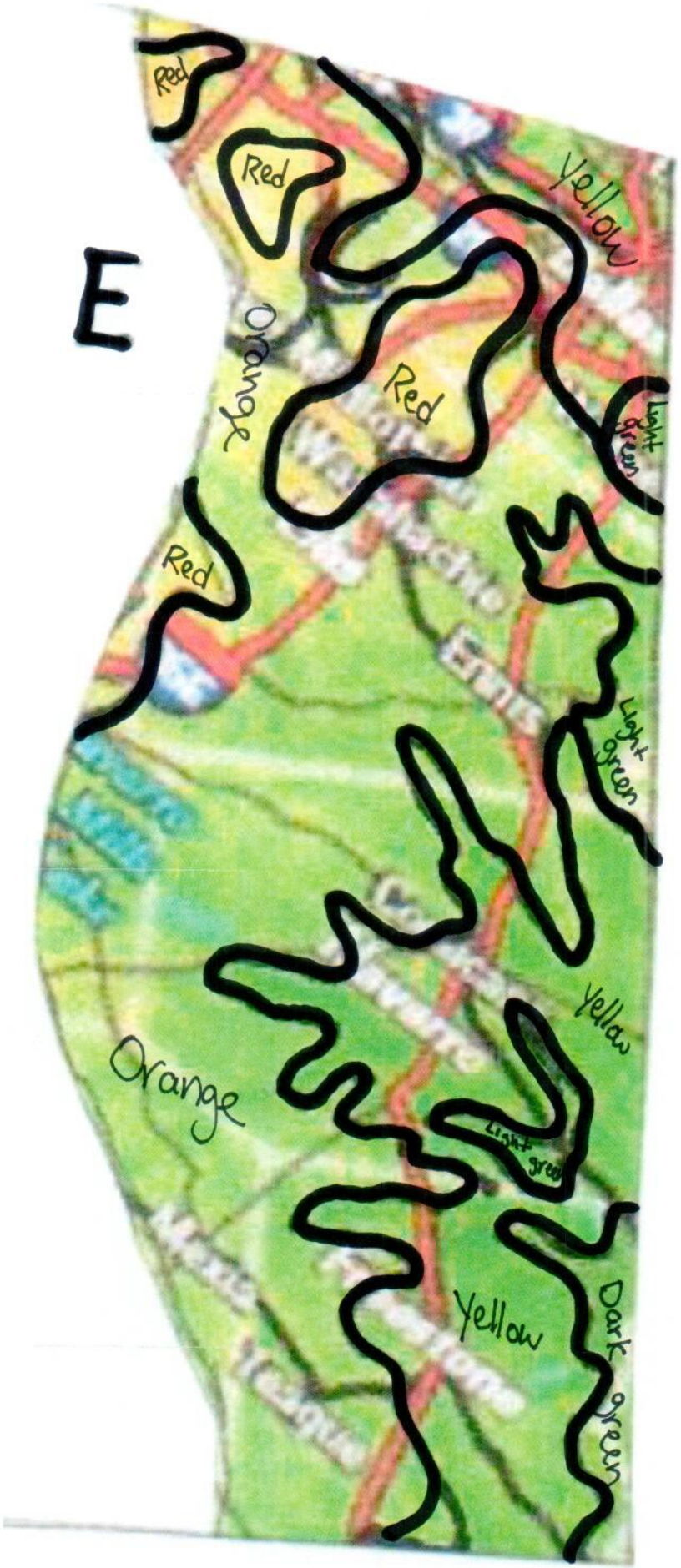
SECTION MAP C

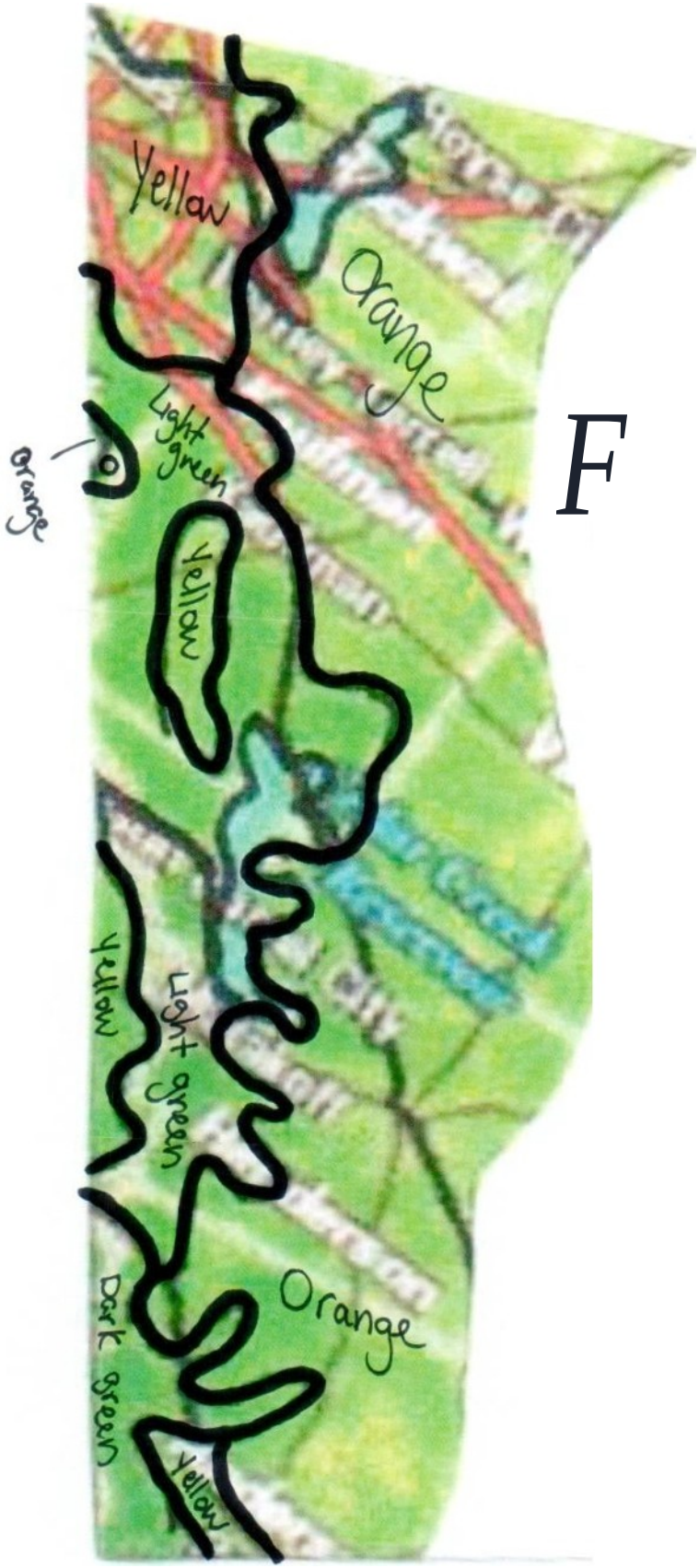


SECTION MAP D



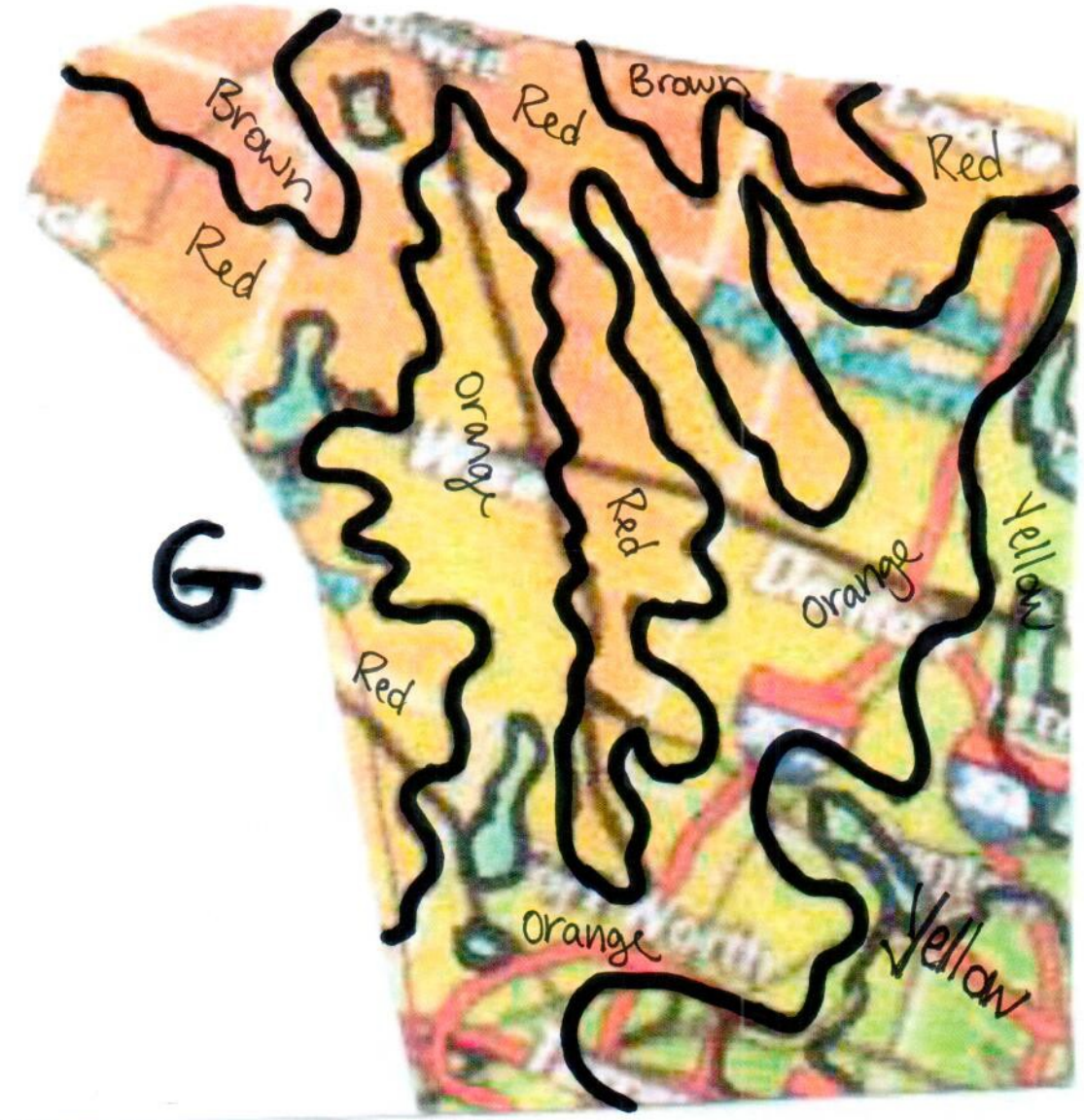
SECTION MAP E





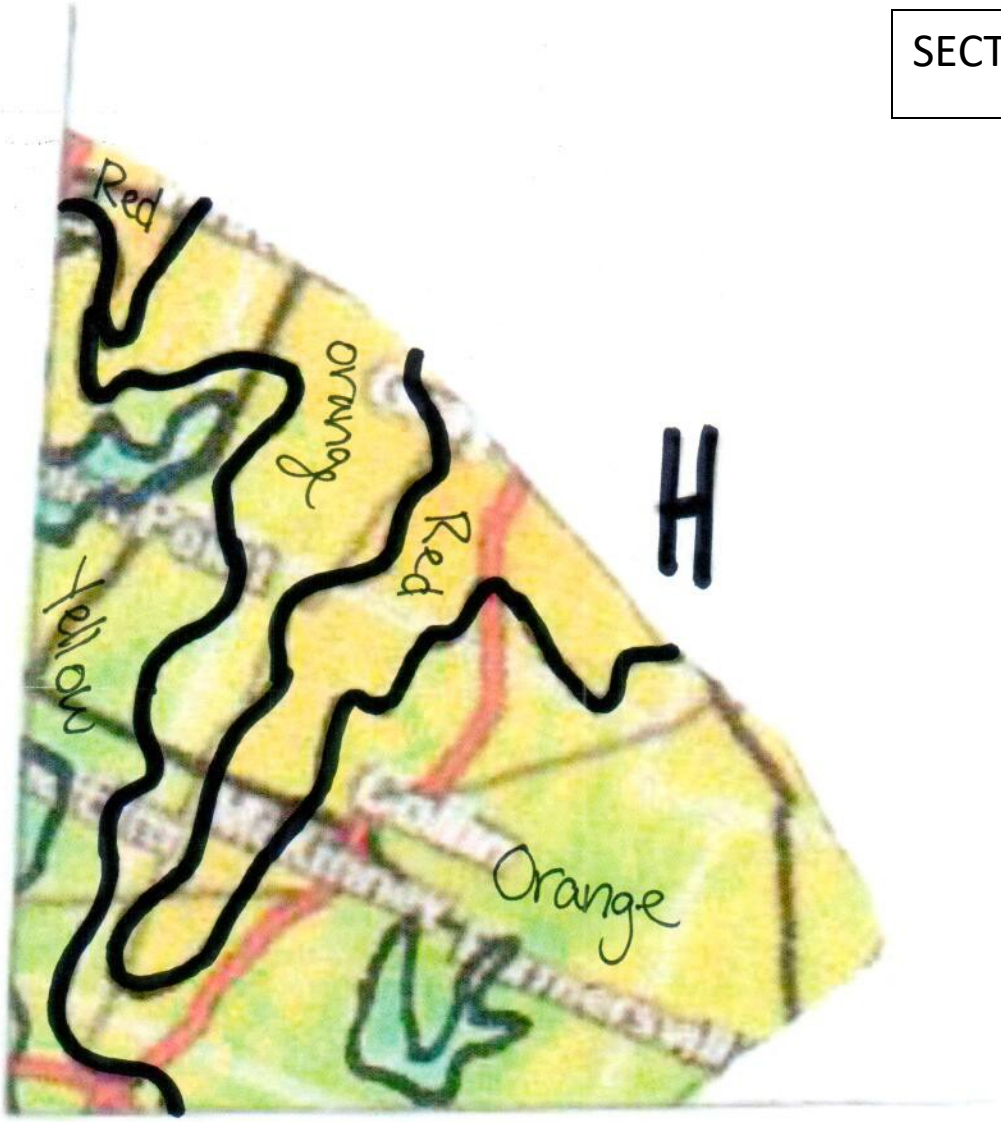
F

SECTION MAP F



SECTION MAP G

SECTION MAP H



Galveston Bay Bathymetric Map

Time: one class period

Materials:
- Worksheets
- Colored Pencils

Key Words:
Bathymetry
Topography
Circulation
Estuary
Dredged
Ecosystem
Economics

Texas Essential Knowledge and Skills:
Science:
Grade 6: 2E, 3AB, 12F
Grade7: 2E, 3AB, 8ABC
Grade 8: 2E, 3AB, 9BC, 11C
Biology: 2H, 3ADE, 12BE
Aquatic Science: 2HJ, 3AD, 4AC, 6B, 7AB, 8B, 9ABC, 11B, 12ABD
Environmental Systems: 2IK, 5AE, 8AB, 9E

Social Studies:
Grade 6: 3AB, 4BCDE, 5ABC, 6ABC, 7ABC, 21CF, 22ACD
Grade 7: 8AB, 9ABC, 10AB, 12AB, 20D, 21CH, 22ACD
Grade 8: 10BC, 11B, 12AC, 29BCHIJ, 30ACD

Sources:
Lester and Gonzalez. 2005. Briefing Paper on Galveston Bay Plan Action Items Freshwater Inflow and Bay Circulation. Houston Advanced Research Center: Galveston Bay Status and Trends Project.

Lesson developed by The Galveston Bay Foundation

Teacher Information Page

Objectives:
- Students will color a map of the depths of Galveston Bay.
- Students will understand how the bathymetry of the Bay plays a part in water circulation, the ecosystem, and economics of the region

Background:
Bathymetric maps are the measurements of the depths of water. Topographic maps of land and bathymetric maps of the ocean are created for a multitude of purposes including scientific, technical, economic, and recreational reasons. In Galveston Bay, these include ecosystem management, habitat research, modeling coastal processes (such as storm surge and contaminant dispersal), coastal spatial planning, community hazard mitigation and preparedness (hurricanes), economic/commerce planning (ship channel), and recreational vessel maneuvering.

The **circulation** of water in Galveston Bay is influenced by many factors, including freshwater inflow, salinity changes, winds, and tides. Circulation is a major force affecting the distribution of sediments, oyster reefs, wetlands, and other features of the bay. Circulation patterns are also altered by built structures such as the Texas City Dike (limits flows into West Bay) and dredged channels such as the Houston Ship Channel (acts as a conduit for seawater from the Gulf through the middle of Galveston Bay).

The Galveston Bay **Estuary** is a mix of saltwater from the Gulf of Mexico and freshwater from rain, large rivers, and local bayous. Saltwater enters the Galveston Bay system mainly through the Galveston Pass and the San Luis Pass. Most of the freshwater entering the Galveston Bay system does so through two large rivers: the Trinity River (54% of freshwater inflow) and the San Jacinto River (28% of freshwater inflow). Show students the included circulation map to explain as needed.

Students should be able to see the impact of human alterations on the bay's environment. For example, the Houston Ship Channel greatly increases the intrusion of Gulf water into the Upper Bay system, which was previously limited by Red Fish Bar (an oyster reef). Disposals of **dredged** materials create barriers to flow across the bay. The Texas City Dike also influences circulation in the lower bay by preventing freshwater from the upper bay from entering West Bay

Extensions:
- Travel further out and create a Gulf of Mexico bathymetry map
- Model effects of human activity on freshwater inflows to the Bay and infer effects on the system

Galveston Bay Bathymetric Map

Background and Procedure

Objectives:

- Students will color a map of the depths of Galveston Bay.
- Students will understand how the bathymetry of the Bay plays a part in the ecosystem and economics of the region

Background:

Bathymetric maps are the measurements of the depths of water. **Topographic** maps of land and **bathymetric** maps of the ocean are created for a multitude of purposes including scientific, technical, economic, and recreational reasons. In Galveston Bay, these include ecosystem management, habitat research, modeling coastal processes (such as storm surge and contaminant dispersal), coastal spatial planning, community hazard mitigation and preparedness (hurricanes), economic/commerce planning (ship channel), and recreational vessel maneuvering.

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Procedure:

1. Use the key below to color in the bathymetric map of Galveston Bay.
2. Complete the analysis questions.

Key
4ft –light brown
5ft – dark brown
7ft – red
8ft – orange
10ft – yellow
15ft – green
25ft – light blue
35ft – dark blue
45ft – purple

Galveston Bay Bathymetric Map

Student Worksheet

Name: _____ Date: _____

GALVESTON BAY FOUNDATION

www.galvbay.org

Galveston Bay Bathymetric Map

Analysis Questions

1. What do the different colors on the bathymetric map represent?

2. What is the depth difference between East Bay and the Houston Ship Channel? (Answer will be range of numbers. Do not forget units of measurement.)

3. How does bathymetry relate to freshwater/saltwater inflows and circulation in Galveston Bay?

4. Can these depth measurements change throughout the seasons of a year? Why or why not?

5. What are 3 ways scientists or city planners could use a bathymetric map of Galveston Bay?
   a.
   b.
   c.

6. The ship channel is a manmade feature of Galveston Bay. Sediment was dredged from the bay floor to increase the depth so that ships would be able to pass from the Gulf of Mexico to the Port of Houston. Use your prior knowledge or the internet to answer the following questions:

   a. How did the creation of the ship channel impact the economics of the Houston area?

   b. What impact do you think this had on the rest of the bay?

7. How do you believe the depth differences affect aquatic organisms that live in the Bay?

Water Monitoring and Comparison Lab

Time: 1-5 class periods/days depending on how the lab is completed

Materials):

- La Motte water testing kit
- Samples of water (in field or brought into class)
- Turbidity tube or secchi disk
- Calculators
- Refractometer
- Thermometer

Key Words:
Water quality
Water quantity
Abiotic
Biotic

Texas Essential Knowledge and Skills:
Grade 5: 1AB, 2ACDEF, 3A, 4, 9A
Grade 6: 1AB, 2ABCDE, 3A, 4A
Grade 7: 1AB, 2ABCDE, 3A, 4A, 8ABC
Grade 8: 1AB, 2ABCDE, 3A, 4A, 9C, 11ABC
Aquatics: 1AB, 2EFGHIJ, 3AD, 4C, 5BC, 6A, 7BC, 9ABC, 11B, 12A
Environmental Systems: 1AB, 2EFGIJK, 3A, 9BC

Lesson developed by The Galveston Bay Foundation

Teacher Information Page

Objective:

- Students will test water quality from a variety of local water sources.
- Students will understand differences between local water bodies.

Background:

It is important to test water quality to check for potential problems, determine the survival of organisms in a body of water, and understand water quality patterns.

Parameter	What is it?	Why do we measure it?
Temperature	How hot or cold the water is.	Influences biological activity and growth
Salinity	The amount of salt in the water.	Aquatic organisms rely on specific salinity ranges to survive.
Turbidity	The cloudiness of water caused by suspended particles.	Can inhibit filter feeders, block sunlight, and bury benthic organisms. Transports nutrients and provides protection from predators.
Dissolved Oxygen	The amount of oxygen in the water	Oxygen is introduced into the water by waves and plants. Low oxygen levels are stressful to fish and can cause "dead zones" where few organisms can survive.
pH	Measures acidity on a scale from 0-14.	Determines the biological availability of nutrients and oxygen in the water. Large increases or decreases in pH can indicate a pollution event and be harmful for fish.
Nitrate	The oxidized form of dissolved nitrogen	It is the main source of nitrogen for plants. Excess levels of nitrates in water can create conditions that make it difficult for aquatic insects or fish to survive.
Phosphate	Enters the water systems naturally by dissolving out of rock but can also be added by fertilizer runoff.	Excess levels cause excessive growth of algae in water.

Prior to lesson:

1. Discuss the 8 parameters that will be tested during the investigation as described in the chart above.
1. Go over testing procedures for each parameter with students.
2. This lab investigation can be done in the field or in the classroom. If done in the field, choose up to 5 locations for students to test from, diverse bodies of water are ideal. If done in the classroom, gather samples from 5 locations, making sure to test and record water temperature at each site to share with students. Take pictures of local wildlife, weather, shoreline, etc. for their data tables.
3. Water testing supplies can be bought as a kit or separately. Specific materials needed are listed on the student procedure page.

Extension:

- Have students complete testing over a period of time at each location.
- Use digital probeware and field kits and compare differences
- Have students create graphs to visualize their data.

Water Monitoring and Comparison Lab

Student Procedure Page

Materials:

Field Lab (per lab group)

- 3-5 gallon bucket for sampling
- Thermometer (submersible)
- Refractometer
- Turbidity tube or Secchi disk
- Dissolved Oxygen test
- pH test strips
- Nitrate test
- Phosphate test
- Calculator

Classroom Lab (per lab group)

- 1/2 gallon water samples from 5 local water bodies
- Refractometer
- Turbidity tube
- Dissolved Oxygen test
- pH test strips
- Nitrate test
- Phosphate test
- Calculator

Procedure:

Field Lab

1. Collect your water sample. Be sure to rinse bucket thoroughly in water to be tested before collecting.
2. Perform and record tests on water in the sample bucket via the instructions in your water kit.
3. Test turbidity directly in water body instead of from sample bucket.
4. Perform each test three times and determine averages.
5. Answer lab analysis questions.

Classroom Lab

1. Perform and record tests on the water samples that your teacher collected via the instructions in your water kit. Temperature will not apply since the water will all be the same temperature, but if collector took temperature readings, those can be used. Turbidity can be determined if sample is large enough, but sample should be stirred or shaken if sediment has settled.
2. Perform each test three times and determine averages.
3. Answer lab analysis questions.

Water Monitoring and Comparison Lab

Student Data Sheet

Name _____ Date: _____

Location #1: _____

Sample #	Temperature (°C)	Salinity (ppt)	Turbidity (cm)	DO (ppm)	DO (% sat)	pH	Nitrate (ppm)	Phosphate (ppm)
1A								
1B								
1C								
AVERAGE								
Features and wildlife seen at site								

Location #2: _____

Sample #	Temperature (°C)	Salinity (ppt)	Turbidity (cm)	DO (ppm)	DO (% sat)	pH	Nitrate (ppm)	Phosphate (ppm)
2A								
2B								
2C								
AVERAGE								
Features and wildlife seen at site								

Location #3: _____

Sample #	Temperature (°C)	Salinity (ppt)	Turbidity (cm)	DO (ppm)	DO (% sat)	pH	Nitrate (ppm)	Phosphate (ppm)
2A								
2B								
2C								
AVERAGE								
Features and wildlife seen at site								

Location #4: _____

Sample #	Temperature (°C)	Salinity (ppt)	Turbidity (cm)	DO (ppm)	DO (% sat)	pH	Nitrate (ppm)	Phosphate (ppm)
2A								
2B								
2C								
AVERAGE								
Features and wildlife seen at site								

Location #5: _____

Sample #	Temperature (°C)	Salinity (ppt)	Turbidity (cm)	DO (ppm)	DO (% sat)	pH	Nitrate (ppm)	Phosphate (ppm)
2A								
2B								
2C								
AVERAGE								
Features and wildlife seen at site								

Water Monitoring and Comparison Lab

Lab Analysis Questions

1. What major differences did you see in water quality between the different sampling locations?

2. Why was it important to perform each test 3 times?

3. What is the correlation between temperature and dissolved oxygen?

4. Were there any differences in ABIOTIC factors between the different collection sites? If so, what were they?

5. Were there any differences in BIOTIC factors between the different collection sites? If so, what were they?

6. Why do you think these differences occur?

Hypothesize/Research:

7. If you were to see an increase in nitrates or phosphates, how might that affect organisms found in that water body?

8. If you were to see a decrease in dissolved oxygen, how might that affect organisms found in that water body?

9. If the water has high turbidity, does that mean that the water is unclean? Why or Why not?

10. If you were to see pH levels increase and become more basic over an extended amount of time, hypothesize potential causes:

Investigating the Galveston Bay Action Network

Time: 45 minutes

Materials (per student):
Student Worksheet
Computer
1 map pencil

Texas Essential Knowledge and Skills):
Grade 5: 1B, 2ACDFG, 3A, 4, 9C
Grade 6: 2ADE, 3A, 4A
Grade 7: 2ADE, 3A, 4A, 8C
Grade 8: 2ADE, 3A, 4A, 11BC
Biology:2EHJ, 3ABD, 4C, 7C, 11B, 12ABD
Aquatic Science: 2 HJ, 3ABD, 4C, 7C, 11B, 12ABD
Environmental Systems: 2EGHIK, 3ABD, 5B, 9ABDE

Sources:
Galveston Bay Action Network, Galveston Bay Foundation
www.galvbay.org/gban

Get the GBAN app:
www.galvbay.org/gbanapp

Lesson developed by The Galveston Bay Foundation

Teacher Information Page

Objectives:

- Students will be able to explain point source and non-point source pollution.
- Students will investigate the Galveston Bay Action Network interactive map and how human activities affect the health of Galveston Bay.

Background:

The Galveston Bay Action Network (GBAN) mobile app is a pollution reporting and monitoring app that will report across the four counties that touch Galveston Bay (Brazoria, Chambers, Harris, and Galveston Counties). The app is linked to all national, state, and local governmental agencies that are involved with water pollution cleanup and human health monitoring.

The reports may be filed as a guest or as a registered user. The location and type of pollution is selected on an interactive map and the municipality are selected. Once the municipality has been chosen, the pollution event is directly reported to the governmental agency responsible for responding to it. While all personal information is kept confidential, the report location, description of the pollution, and the agencies notified will be available for public viewing.

The app is designed to allow the citizens and visitors of Galveston Bay to truly be the protective eyes on the bay. Immediate reporting from citizens on pollution, whether deliberate or accidental, helps insure fast responses to the pollution issues in the bay.

In this lesson, students will choose a specific type of pollution and investigate the interactive GBAN map on the website, learning more about types of pollution around Galveston Bay and how they affect the health of the Bay.

Before the lesson:

- Make sure you have access to the website: www.galvbay.org/gban
- This activity is designed to be used AFTER students learn about point and non-point source pollution. Students should be familiar with the terms before starting.
- Decide if you are going to assign students pollution categories for questions 5 & 6 or if you are going to let students decide.

Extensions:

- *Hands-on learning:* Have students download the GBAN app (free) and conduct a mini "field-trip" or assign students homework around your area to record potential pollution events. *Make sure these are real pollution events and not staged ones since the reports go to agencies in charge of cleanup!
- *Differentiation:* Have each student choose a pollution category and create a project around it using the information in the app and outside sources.

Investigating the Galveston Bay Action Network

Student Worksheet

Name: _____ Date: _____

Materials:
Computer
1 map pencil

Background:
The Galveston Bay Action Network (GBAN) mobile app is a pollution reporting and monitoring app that will report across the four counties that touch Galveston Bay (Brazoria, Chambers, Harris, and Galveston Counties). The app is linked to all national, state, and local governmental agencies that are involved with water pollution cleanup and human health monitoring. The reports may be filed as a guest or as a registered user. The location and type of pollution is selected on an interactive map and the municipality are selected. Once the municipality has been chosen, the pollution event is directly reported to the governmental agency responsible for responding to it. While all personal information is kept confidential, the report location, description of the pollution, and the agencies notified will be available for public viewing. The app is designed to allow the citizens and visitors of Galveston Bay to truly be the protective eyes on the bay. Immediate reporting from citizens on pollution, whether deliberate or accidental, helps insure fast responses to the pollution issues in the bay.

In this lesson, you will choose a specific type of pollution and investigate the interactive GBAN map on the website, learning more about types of pollution around Galveston Bay and how they affect the health of the Bay.

Procedure:

1. Describe the difference between point (P) and non-point (NP) source pollution:

2. Go to www.galvbay.org/gban
    a. On the map, you will see various types of pollution and incidents that have possibly been caused by pollution that have been reported by citizens around the area. You can click on the categories to observe specific reports based on each category.
    b. To investigate the reported pollution on the map, chose one report in each of the categories listed below to complete Table 1:

Table 1: Pollution

Category	Incident Title	Municipality	Date	Was there a picture?	P or NP Source Pollution?
Boat Sewage					
Chemicals					
Storm Drain					
Pet Waste					

Investigating the Galveston Bay Action Network

3. Click on the "Fish Kills" category. Complete Table 2 to learn more about reported fish kills in the area.

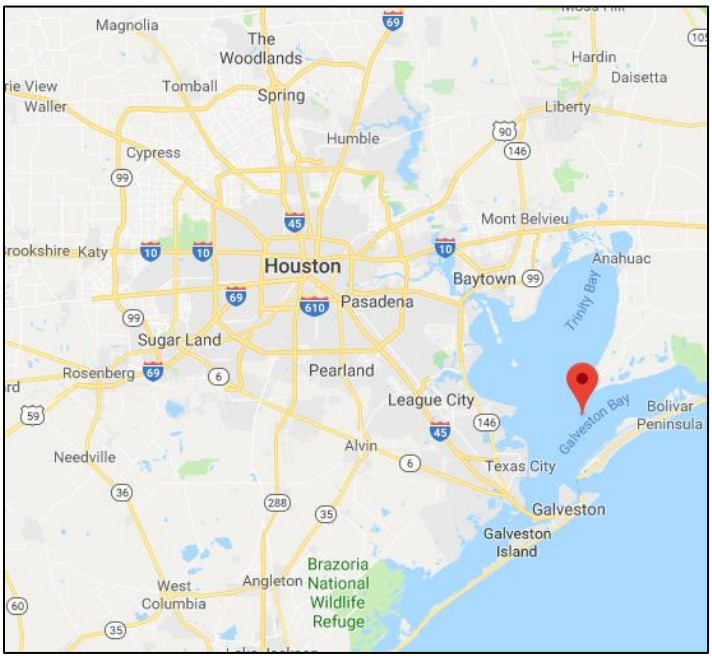
Table 2: Fish Kills

How many fish kills have been reported?	
Are all reports in the waters of Galveston Bay, or are some of them more inland?	
When was the latest report recorded?	
Where was the latest report recorded?	
What could be a cause of that fish kill?	

4. Use the "Filter" option to find any pollution reports your municipality (city). If your city has had NO reports, choose the closest city to you that has had reports. (This is a good reason for you to get the app yourself!) Answer the questions below:
   a. How many reports have been filed? _____
   b. What categories of pollution were reported? _____

5. Choose one type of pollution category with at least 7 reports (your teacher may assign this): _____
6. Plot the location of each report on the map below with your map pencil.
7. Identify a reason why this pollution category occurs in these locations on the map.

_____



Analysis Questions

1. What additional information would be useful for citizens to report in the GBAN app?

2. Name one-two things that surprised you about the types of pollution or number of reported incidents in your city.

3. Why is the GBAN app important to the health of Galveston Bay?

4. Explain how the information on the GBAN app relates to the Galveston Bay Watershed.

An Introduction to Galveston Bay and its Wetlands

Time: 1 class period

Materials (per student):
- Worksheet
- Internet

Key Words:
Spartina alterniflora
Hydrophilic
Rhizome
Aerenchyma tissue/cell
Fibrous root
Adventitious root

Texas Essential Knowledge and Skills:
Grade 5: 2DFG, 3A, 4, 7B, 9ABC, 10A
Grade 6: 2E, 3A, 4A, 12CDEF
Grade 7: 2E, 3AB, 4A, 8ABC, 11AB, 12AC, 13A, 14B
Grade 8: 2E, 3A, 4A, 11A
Biology: 2GH, 3A, 10B, 12BE
Aquatic Science: 2J, 3A, 4A, 7C, 8B, 9ABC, 10BC, 12ABCD
Environmental Systems: 2GIK, 3A, 4G, 9E

Sources:
Wetlands of Galveston Bay, *Galveston Bay Status and Trends*. 2015. Web 24 July 2015 http://galvbaydata.org/Habitat/Wetlands/tabid/846/Default.aspx

USDA, NRCS 2000. The PLANTS database. Version: 000504. National Plant Data Center, Baton Rouge, LA http://plants.usda.gov/core/profile?symbol=SPAL

www.backthebay.org

Acknowledgements:
Artwork produced by Ellen Weinheimer

Lesson developed by The Galveston Bay Foundation

Objectives:
- Students will be able to identify benefits and challenges surrounding Galveston Bay.
- Students will be able to identify *Spartina alterniflora*.
- Students will be able to identify and label major characteristics of S*partina alterniflora*.
- Students will be able to identify adaptations of *Spartina alterniflora*.

Background:
Wetlands have been declining in the Galveston Bay system since the 1990s at a rate of about 0.3 percent per year. Causes for wetland loss in this watershed include relative sea level rise; land use conversion for agricultural, urban, industrial, and transportation purposes; dredge and fill activities; and isolation projects[1].

Spartina alterniflora, or smooth cordgrass, is an inter-tidal salt and brackish water plant native to North America. It is native along the East Coast from Quebec to northern Florida and the Gulf Coast from Florida to southern Texas. It has been introduced by humans along the West Coast, specifically in Washington and California, where it is considered a non-native invasive plant species. Locally, it is the dominant marsh grass, growing in dense stands along coastlines between the high and low tide zones.

Smooth cordgrass is well adapted to marsh environments. It can tolerate high salinity levels by pushing out salt taken in with water through the small pores on its leaves. It has a strong but flexible stem that withstands the high wind and wave energy in coastal areas. Smooth cordgrass thrives in anoxic soil due to its ability to oxygenate its roots and rhizomes via aerenchyma cells within the stem. A healthy plant can reach up to 8 feet in ideal conditions, however, on the fringes of ideal conditions it may only reach 16 inches. Locally, smooth cordgrass produces seeds from June through October. Although the plant can reproduce sexually, it is more likely to successfully reproduce via asexual vegetative reproduction.

Smooth cordgrass provides vital functions within the marsh ecosystem. The extensive root systems of smooth cordgrass stands hold soil in place, preventing erosion and providing soil stability. The dense foliage provides excellent wildlife habitat, ranging from snails and fish to coastal birds. Additionally, the plants filter water, prevent flooding, and replenish groundwater. Due to its quick and hearty growth, smooth cordgrass is commonly used in its native regions as a natural method of coastal shoreline erosion control as well as in marsh restoration efforts.

Extensions:
- Students create map of smooth cordgrass range.
- Students research and report in detail how smooth cordgrass provides a specific ecosystem service such as: filtering water, providing habitat, or preventing erosion.

An Introduction to Galveston Bay and its Wetlands

Student Worksheet

Name _____ Date: _____

Part 1: Use this website to answer the following questions: www.backthebay.org.

Click "Videos" at the top and scroll down to answer the following questions:

1. Watch the "You're more connected to Galveston Bay than you think" video at the bottom. Describe one way you use Galveston Bay.

Click "About" at the top and scroll to answer the following questions:

2. What are the 3 goals for the Back the Bay campaign?
   a.
   b.
   c.

3. What is an estuary?

4. Why are estuaries an important ecosystem?

5. Name the 6 challenges that Galveston Bay is currently facing.
   a.
   b.
   c.
   d.
   e.
   f.

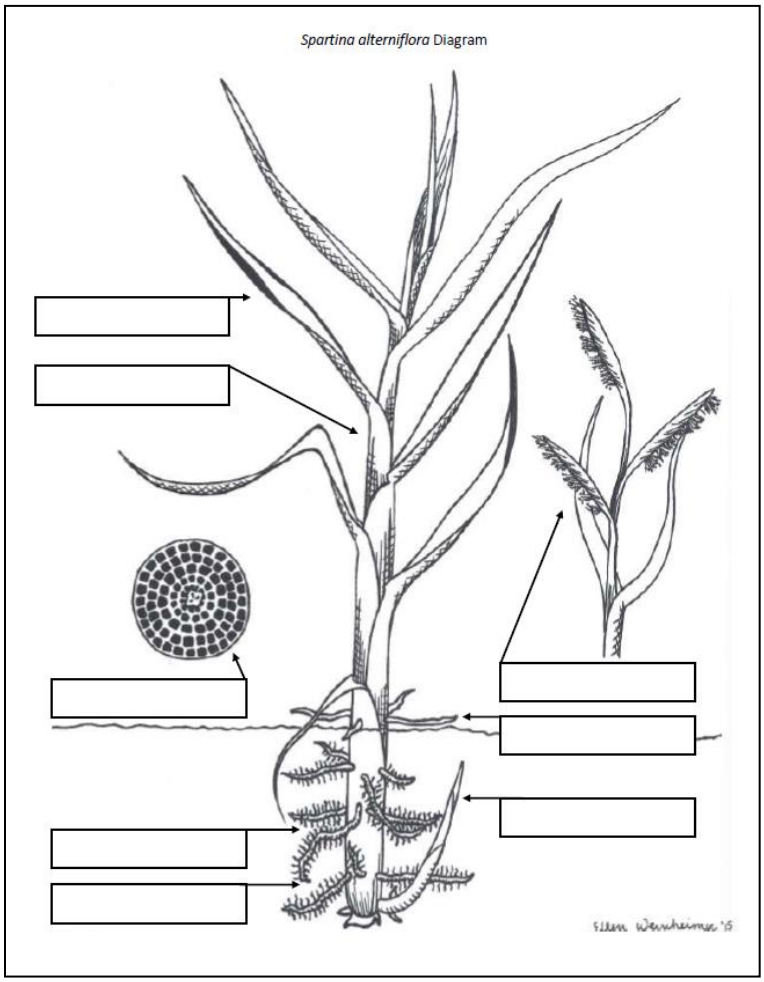
Click on "Learn more about the benefits of the Bay here" in the "About Galveston Bay" section:

6. List the 8 benefits of Galveston Bay:
   a.
   b.
   c.
   g.
   h.
   d.
   e.
   f.

An Introduction to Galveston Bay and its Wetlands

Part 2: Use the Spartina alterniflora information sheet to complete the following:

Label the picture:



Answer the following questions:

1. Where does smooth cordgrass usually grow?

2. Why does smooth cordgrass naturally form clumps or 'stands' of many stems?

3. Why is it adapted well to the wetlands in Galveston Bay?

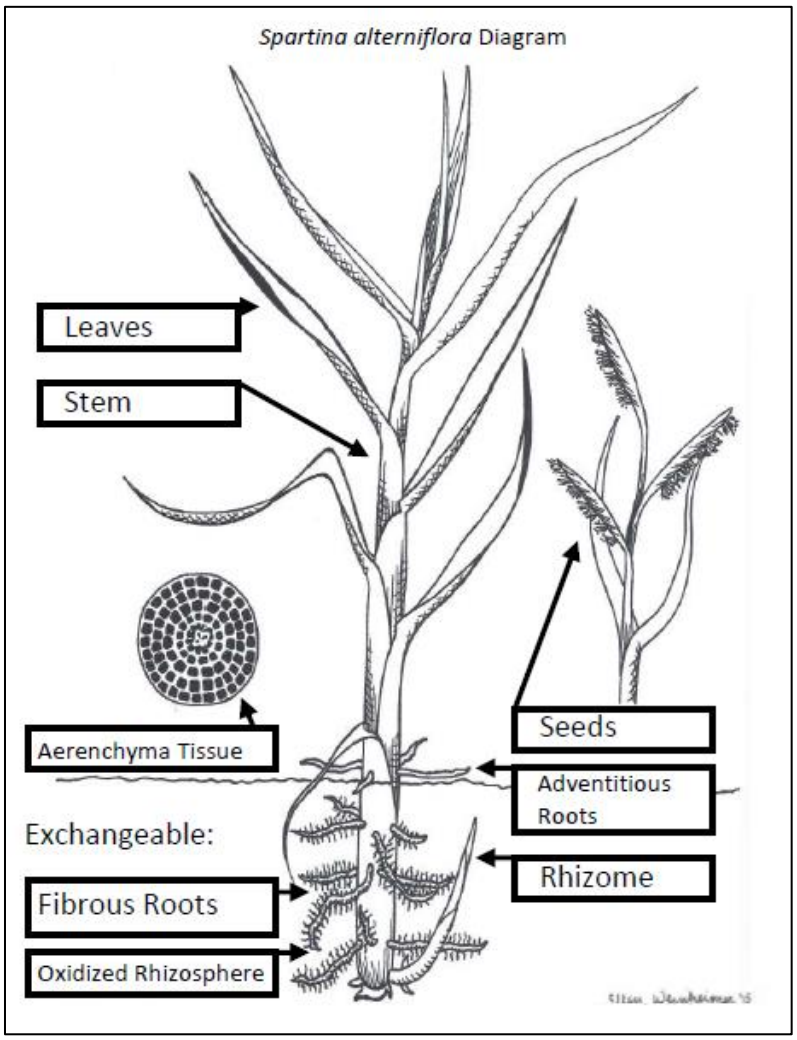
4. Would a healthy smooth cordgrass marsh be able to withstand a hurricane? Support your answer.

5. Why might smooth cordgrass be more successful reproducing by vegetative reproduction than by seed?

6. What are the 5 functions smooth cordgrass has in our coastal wetlands?
   a.
   b.
   c.
   d.
   e.

An Introduction to Galveston Bay and its Wetlands

Spartina alterniflora
Smooth Cordgrass Information



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Smooth cordgrass provides vital functions within the marsh ecosystem. The extensive, net-like root systems of smooth cordgrass holds soil in place, preventing erosion and providing shoreline stability. The dense foliage provides excellent wildlife habitat, ranging from snails and fish to coastal birds. Additionally, the plants filter water, prevent flooding, and replenish groundwater. Due to its quick and hearty growth, smooth cordgrass is commonly used in its native regions as a natural method of coastal shoreline erosion control as well as in marsh restoration efforts.

The ABC's Of Wetlands Foldable

Time: 1 class period

Materials (per student):

- 3 half sheets of printer paper to make foldable,
- ABC's of Wetlands Infographic

Texas Essential Knowledge and Skills:
Grade 5: 9ABC, 10A
Grade 6: 12E
Grade 7: 8BC, 10A
Grade 8: 11BD
Aquatic: 4.AB, 7AB, 9ABC
Environmental Systems: 4BD, 5B

Lesson Developed by The Galveston Bay Foundation

Objectives:

- Students will be able to identify the 5 main functions of wetlands.
- Students will create a foldable to illustrate the ABCDE mnemonic device of wetland functions.

Background:

A wetland ecosystem has three primary characteristics. One, it must be inundated with water at least part of the year. Two, the soils are hydric, or display characteristics of being waterlogged for most of the year. Three, the plants are hydrophilic, or specially adapted to waterlogged soils and a wet environment.

Through these characteristics, wetlands provide some very important functions for nearby ecosystems and humans. Wetlands absorb pollution, provide habitat for a great diversity of organisms, recharge groundwater, decrease flooding and prevent erosion. These functions can be summarized as the ABC's of wetland functions.

A – Absorb pollution. As runoff from agricultural fields and streets pass through wetland ecosystems, nutrient pollutants such as nitrates and phosphates settle out, and are also absorbed by the above soil roots of wetland plants. Some wetland soils can absorb heavy metal pollution from the waterways. Lastly, wetlands are a known carbon sink, absorbing carbon dioxide from the atmosphere, helping to decrease impacts from global climate change.

B – Biodiversity. Wetlands support a great diversity of plant and animal life. Many wetlands are important stops for migratory birds or important nesting grounds. Salt marshes provide crucial habitat for larval and juvenile shrimp, fish and crab.

C – Recharge groundwater. The permeable soil and waterflow through wetlands contributes to groundwater recharge.

D – Decrease flooding. Wetland soils absorb excess water. Wetland ecosystems along rivers help to contain flooding from upstream flooding events. Prairie ecosystems absorb water into the soil over large areas.

E – Prevent erosion. Wetland ecosystems capture sediment from runoff as it passes over the ecosystem into neighboring waterways. Wetland ecosystems also decrease shoreline erosion by breaking wave energy.

Extensions:

- Complete smooth cordgrass dissection and wetland soil analysis to learn about how those components of wetlands contribute to their function
- Complete the GIS of Galveston Bay activity to learn how wetlands are distributed in the Galveston Bay region, and how their functions impact the health of the bay.
- Complete economic values of wetlands and environmental history lessons to see how wetland functions have impacted the economy in the Galveston Bay Region

The ABC's Of Wetlands Foldable

Teacher Procedure:

1. Teacher preparation:
    a. To save time in class, pre-make the blank foldables for the students. Each foldable will need five blank pages for each wetland function. Paper can be cut in half lengthwise to save on supplies.
    b. Decide how to deliver information (see below)

2. Info needed on the foldable:
    a. Title
    b. ABC's
    c. Description
    d. Drawing/symbol

3. Teachers can choose from a variety of delivery methods for students to fill out their foldables. Options include:
    a. Stations: Students rotate around to 5 different stations to gather information for their foldables.
    b. Lecture: Teacher can make a power point
    c. Packet: Teacher can create a packet for students to work on by themselves
    d. Student presentation: Teacher can have students work in 5 groups to gather information for one function (1 page of the foldable). Students then present their page to their classmates, who copy the information into their foldable.

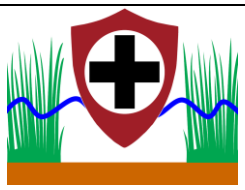
4. Extension: Teachers can have students add information to their foldables after completing all of the activities in the unit.

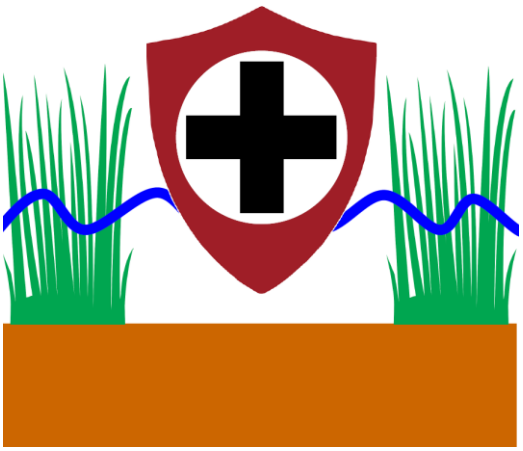
Example:

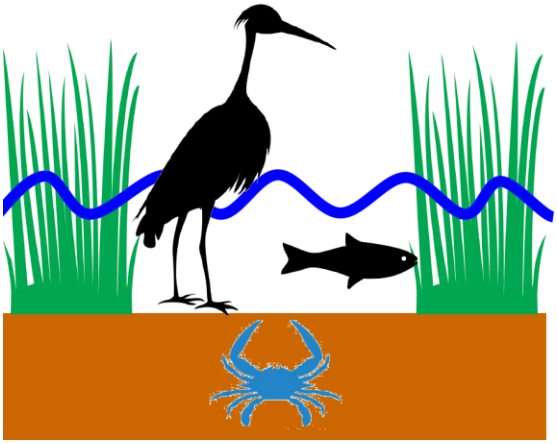
(Layout)

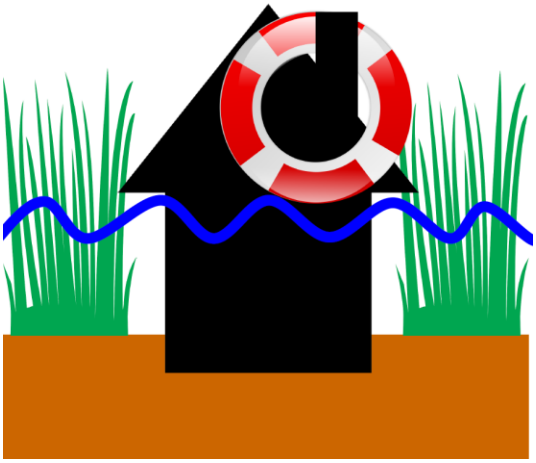
The ABC's of Wetland Functions
A – Absorb Pollution
B - Biodiversity
C- Charge Groundwater
D – Decrease Flooding
E – Erosion Prevention

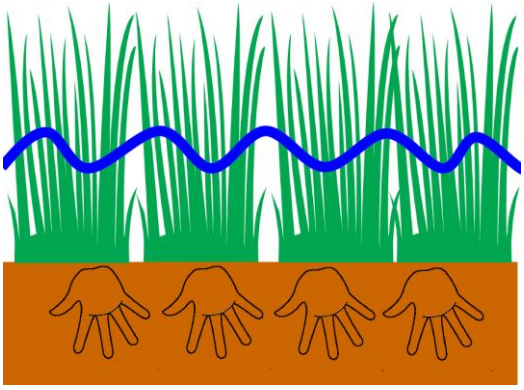
(Open flap)

Soils: Absorb heavy metals & carbon sink Plants: Decrease eutrophication Water quality & Carbon sequestration = 5.82 billion Oysters: healthier near wetlands
 A – Absorb Pollution









Researching Galveston Bay Organisms

Time: 1-2 weeks to complete project and present to class

Materials (per student):
Computer

Texas Essential Knowledge and Skills (TEKS):
Grade 5: 4, 9AB, 10A
Grade 6:4A, 12CDEF
Grade 7: 4A, 10AB, 11AB, 12A
Grade 8: 4A, 11AB
Biology: 2FH, 7E, 8ABC, 12ABCE
Aquatic Science: 2J, 9C, 10ABC, 11AB
Environmental Systems: 2GK, 4H

Citations:

Minello T.J., Caldwell P., and Rozas L.P. (2017) Fishery habitat in estuaries of the U.S. Gulf of Mexico: A Comparative Assessment of Gulf Estuarine Systems (CAGES). U.S. Dept. Commerce NOAA Tech. Memo. NMFS-SEFSC-702, 48 p.

Rooker JR, Stunz GW, Holt SA, Minello TJ (2010) Population connectivity of red drum in the northern Gulf of Mexico. Mar Ecol Prog Ser 407:187-196

Teal, JM (1962) Energy flow in the salt marsh ecosystem of Georgia, Ecology 43:614-624

Weisberg SB, Lotrich VA (1982) The importance of infrequently flooded intertidal marsh surface as a n energy source for the mummichog Fundulus heteroclitus: an experimental approach. Mar Biol 66:307-310

Lesson developed by The Galveston Bay Foundation

Teacher Information Page

Objectives:

- Students will research organisms found in Galveston Bay
- Students will learn about habitats, characteristics, adaptations, environmental stressors concerning Bay organisms.
- Students will present their findings to the class via a presentation method of their choice

Background:

Wetlands are among the most productive biological systems on the planet, and Texas coastal wetlands are highly productive biologically. They serve as nursery grounds for over 90% of the recreational and commercial fish species found in the Gulf of Mexico, and provide breeding, nesting, and feeding grounds for more than a third of all threatened and endangered animal species as well as supporting many endangered plant species, and provide permanent and seasonal habitat for a great variety of wildlife, including 66% of North America's bird species. *Spartina alterniflora* salt marshes in the USA are believed to fuel detritus-based food webs that support consumers in adjacent estuarine and marine systems (Teal 1962, Peterson et al 1980, 1986). These wetlands provide a refuge from predators for vulnerable nekton (Minello et al. 1989) and may also contribute to secondary production in food webs of adjacent aquatic habitats via direct foraging migrations (Weisberg & Lotrich 1982). Specifically, red drum, *Sciaenops ocellatus*, support a valuable sport fishery in estuarine and coastal waters of the Gulf of Mexico (Rooker et al. 2010).

Before the lesson:

- Students will need access to a computer and internet.
- Decide how you are going to assign the project
    - Will students work on it in class or at home?
    - Will students work in groups or individually?

Procedure:

1. As a class, compile a list of organisms that are found in Galveston Bay. Be sure to include a variety of species: birds, fish, invertebrates, reptiles, mammals.
2. Assign students an organism to research based on the organisms list.
3. Students will research their organism and complete their presentation project.
4. Students will relay the information they learned by presenting their organism to the class.

Extensions:

- Have students create a food web with the organisms that their class researched, filling in any blanks as needed.
- Discuss which trophic level each organism is found in.

Researching Galveston Bay Organisms

Student Project Information

Objectives:

- Students will research organisms found in Galveston Bay
- Students will learn about habitats, characteristics, adaptations, environmental stressors concerning Bay organisms.
- Students will present their findings to the class via a presentation method of their choice

Project Details:

You are to choose a Bay organism from the list, research, create a project that provides all of the information below, and present it to the class. Possible presentation methods include (but aren't limited to):

- Powerpoint
- Prezi
- Video
- Model or diorama
- Hanging mobile
- Poster

In your presentation, you must include the following:

1: HABITAT

- ✓ Geographical distribution/location as well as immediate habitat will need to be discussed (i.e. desert, etc.)
- ✓ Defining characteristics of the organism's specific habitat
- ✓ Other organisms found in their habitat
- ✓ Symbiotic or other relationships to other organisms or its environment

2: ADAPTATIONS

- ✓ Adaptations for feeding (i.e. structures or methods)
- ✓ Adaptations for survival
- ✓ Adaptations for mating/caring for young
- ✓ Adaptations for movement in the water

3: LIFE CYCLE & REPRODUCTIVE BEHAVIORS

- ✓ Migration behaviors associated with mating seasons
- ✓ Specific fertilization (internal or external) and detailed description of seasonal effect
- ✓ Summary of life cycle (i.e. time frames from infant to adulthood)
- ✓ Detailed description of after-birth care. If they do not care for their young, discuss the advantage of not caring for young for the species

4: ENVIRONMENTAL STRESSORS

- ✓ Discuss factors, either human or non-human, that affect the survival of this organism
- ✓ Provide factors that influence the survival of offspring
- ✓ Detail climate ranges and migration patterns as well as reasons for migration
- ✓ Provide a food web or chain with possible "weak links" and reasons for their weakness

5: BIBLIOGRAPHY – be sure to include every source you used!

Examining Galveston Bay with GIS Maps

Time: one class period

Materials (per group):
- 5 plastic transfer sheets per group
- 5 different colored vis--vis markers
- 5 GIS maps (included)
- White sheet of paper

Key Words:
Pathogens
Consumption
GIS
Shellfish

Texas Essential Knowledge and Skills:
Grade 6: 2E
Grade 7: 2E, 8C
Grade 8: 2E, 11C, 11D
Aquatics: 12D
Environmental: 8A, 9E

Resources:
GIS maps came from www.galvbaydata.org and produced by Houston Advanced Research Center

Lesson developed by The Galveston Bay Foundation

Teacher Information Page

Objectives:
- Students will be able to identify wetland habitat in the Galveston Bay region.
- Students will be able to spatially connect wetland habitat and ecosystem functions such as pollution control.
- Students will be able to analyze overlaid GIS maps to develop a reasoning for interactions with the environment and organisms.

Background:
Geographic Information Systems (GIS) are mostly computer systems designed to store, manipulate, and analyze data of specifically geographically referenced areas. This process helps illustrate correlations of data, which then can help describe what is happening within an environment. Currently, 4.5 million people reside in the counties around Galveston Bay. Land development to accommodate this many people has also created changes to our environment. Such changes are pathogens (infectious agents), loss of wetlands (which filter the water), and location of edible seafood.

There are many maps of Galveston Bay showing various types of recorded data. In this exercise, maps of land use and development, pathogens, and harvested oysters will be compared.

Before lesson: Use the attached Outline for Transfer Map to copy an outline of Galveston Bay onto transfer sheets (transparencies). Or have students use a permanent marker to outline Galveston Bay onto a transfer sheet at the beginning of the lesson. You will need 5 transfer sheets with the map outline for each group.

Procedure:
1. Explain what Geographical Information Science is. Discuss with students how scientists are able to collect and plot data within geographical maps. This data is then placed into GIS programs where scientist can view different data sets to interpret a larger picture of what may be happening in the environment. Relationships are easily identified in this format and thus allowing proper and sometimes immediate action to occur.
2. Give students materials. Each group should receive: 5 maps, 5 transfer sheets, 5 different colors of vis-à-vis markers, a blank white paper, and procedure page
3. Review with the students at the end to discuss what they discovered when overlaying the maps.

Extensions:
- There are many maps that can be retrieved from www.galvbaydata.org and analyzed for many different scenarios.
- Students may also choose different restoration sites around the Bay using Google Earth. By using the time lapse button students can look at a specific site and see what it once looked like, the cause of erosion, restoration work, and then the final product of a completely restored area.

Examining Galveston Bay with GIS Maps

Student Instruction Page Date: _____

Group members: _____

Objectives:

- Students will be able to identify wetland habitat in the Galveston Bay region.
- Students will be able to spatially connect wetland habitat and ecosystem functions such as pollution control.
- Students will be able to analyze overlaid GIS maps to develop a reasoning for interactions with the environment and organisms.

Background:

Geographic Information Systems (GIS) are mostly computer systems designed to store, manipulate, and analyze data of specifically geographically referenced areas. This process helps illustrate correlations of data, which then can help describe what is happening within an environment. Currently, 4.5 million people reside in the counties around Galveston Bay. Land development to accommodate this many people has also created changes to our environment. Such changes are pathogens (infectious agents), loss of wetlands (which filter the water), and location of edible seafood.

There are many maps of Galveston Bay showing various types of recorded data. In this exercise, maps of land use, shoreline development, pathogens, seafood consumption, and harvested oysters will be compared.

Materials:

- 5 maps: Pathogens, Land Use, Shellfish Harvesting, Shoreline Development, Seafood Consumption
- 5 transfer sheets
- 5 different colors of vis-à-vis markers
- Blank white sheet of paper

Procedure:

1. Split the maps up evenly between group members. Decide who is doing each map. Each group member should have at least 1 map, 1 transfer sheet, and 1 vis-à-vis marker.
2. Look at the following chart to find information about your designated map and the directions to follow.
3. Once each map is complete, overlay the maps on top of each other and the white sheet of paper (it will make it easier to see).
4. Answer the analysis questions as a group.

Examining Galveston Bay with GIS Maps

Map Directions:

Map	1: Pathogens	2: Land Use	3: Shellfish Harvesting	4: Shoreline Development	5: Seafood Consumption
Description	This map shows the sites that where water was tested for pathogens.	This map shows the areas of land and how they are used around Galveston Bay.	This map shows the Shellfish (oyster) harvesting areas and their restrictions.	This map shows the shoreline around the Bay that are developed and undeveloped.	This map shows the areas where it is unadvisable to eat specific seafood caught.
Step 1	Label the top of your transfer sheet "Pathogens"	Label the top of your transfer sheet "Land Use"	Label the top of your transfer sheet "Shellfish Harvesting"	Label the top of your transfer sheet "Shoreline Development"	Label the top of your transfer sheet "Seafood Consumption"
Step 2	Line up the transfer sheet with the data map so the Galveston Bay outline matches	Line up the transfer sheet with the data map so the Galveston Bay outline matches	Line up the transfer sheet with the data map so the Galveston Bay outline matches	Line up the transfer sheet with the data map so the Galveston Bay outline matches	Line up the transfer sheet with the data map so the Galveston Bay outline matches
Step 3	Using ONE color of marker, mark the areas where **10-25% and >25% of samples exceeded screening levels of pathogens** (see map key!)	Using ONE color of marker, outline the areas of **Medium** and **High Intensity Development.** (see map key!)	Using ONE color of marker, outline the areas of **Approved shellfish harvesting.** (see map key!)	Using ONE color of marker, outline the areas of **Developed shoreline.** (see map key!)	Using ONE color of marker, outline the areas of **Unapproved Seafood Consumption**. (see map key!)

Analysis Questions Looking at your overlaid transparencies, answer the following questions:

1. Describe the relationship between land use and pathogens.

2. Describe the relationship between pathogens and harvesting shellfish (oysters).

3. Describe the relationship between seafood consumption, pathogens, and developed shoreline.

4. What other GIS maps would be useful in determining the health and uses of Galveston Bay?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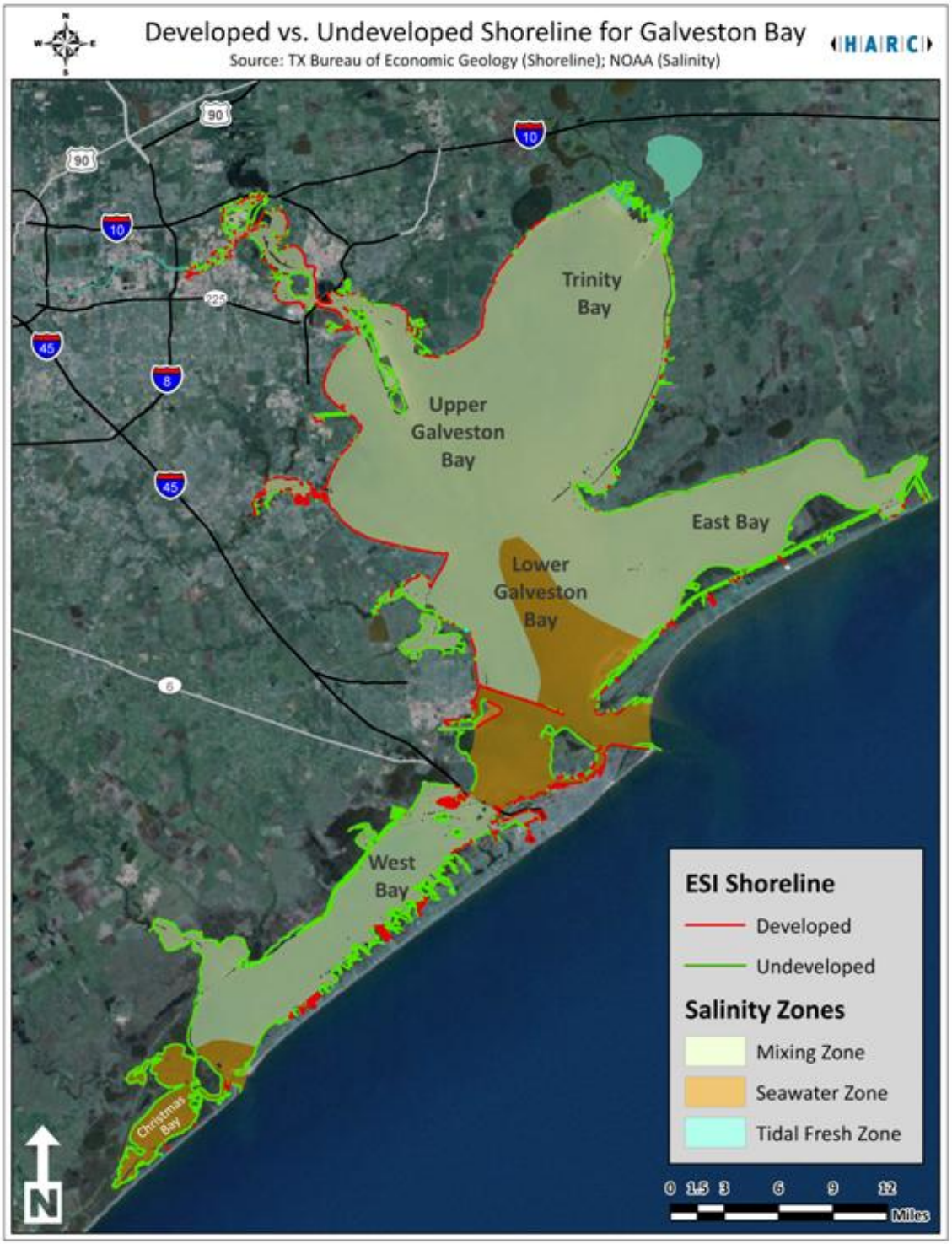
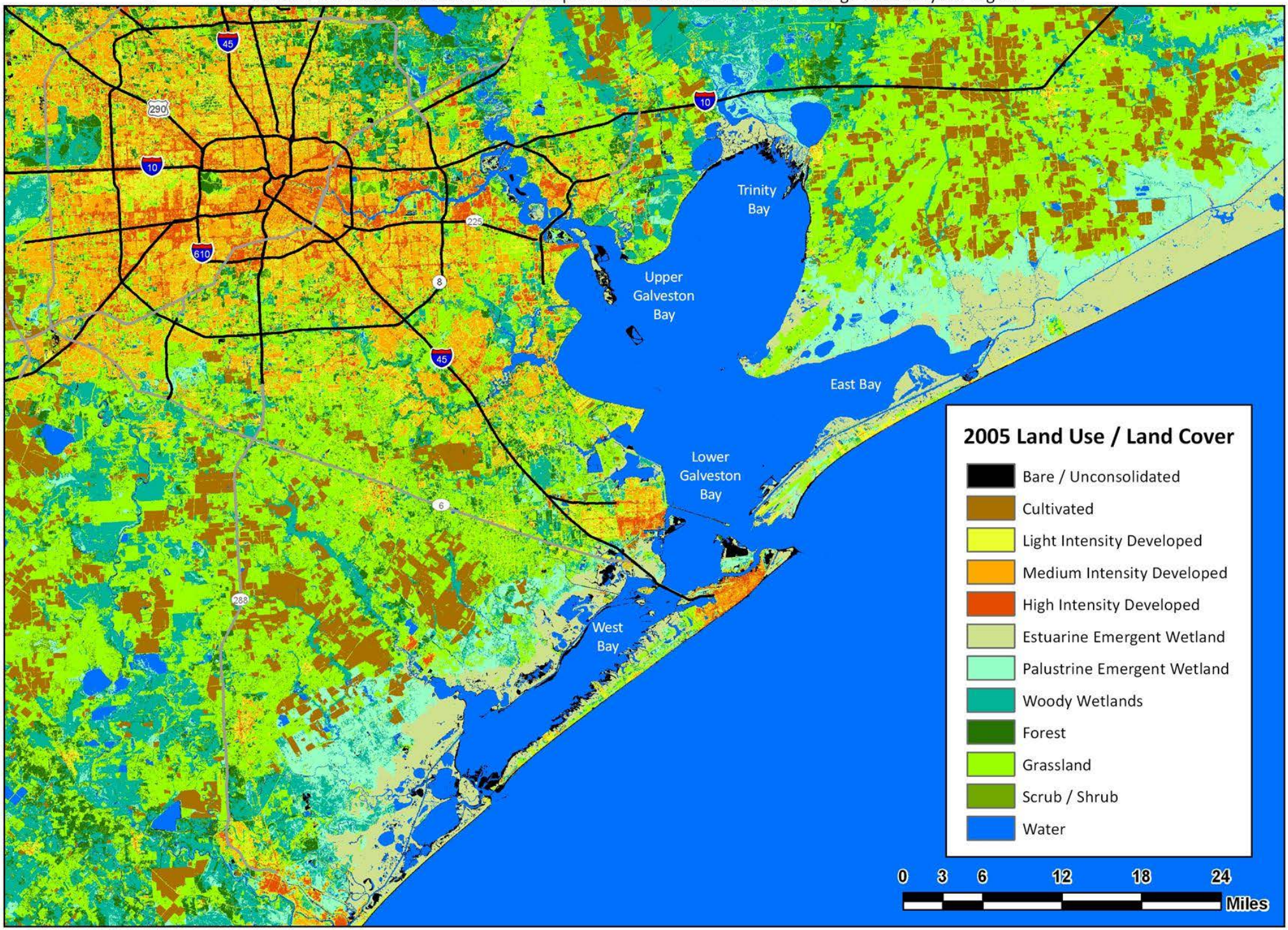
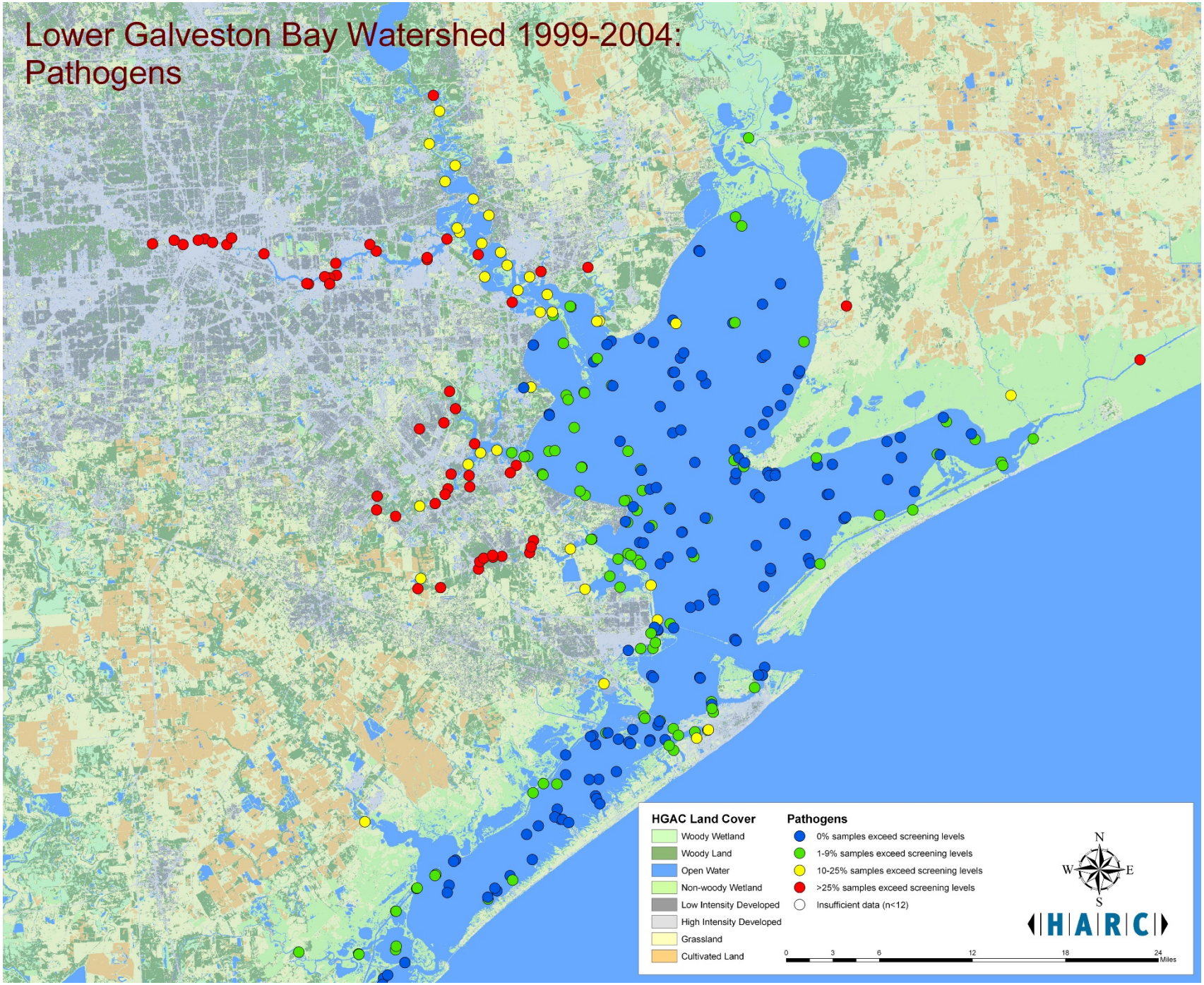

Developed vs. Undeveloped Shoreline for Galveston Bay
Source: TX Bureau of Economic Geology (Shoreline); NOAA (Salinity)
HARC
Trinity Bay
Upper Galveston Bay
East Bay
Lower Galveston Bay
West Bay
Christmas Bay
ESI Shoreline
Developed
Undeveloped
Salinity Zones
Mixing Zone
Seawater Zone
Tidal Fresh Zone
0 1.5 3 6 9 12
Miles
N

2005 Land Use/Land Cover for Galveston Bay

Source: The National Oceanic and Atmospheric Administration's Coastal Change and Analysis Program

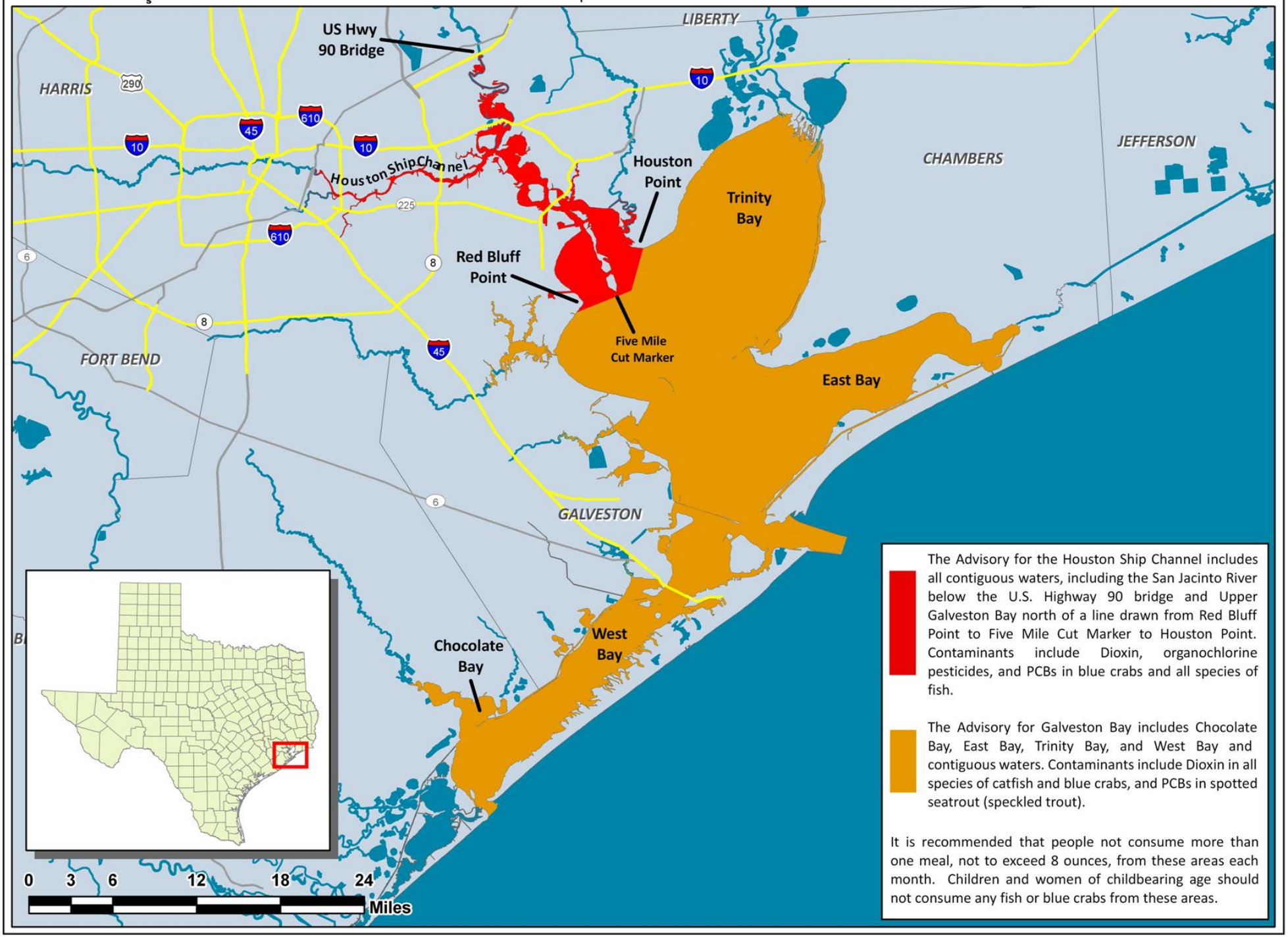
HARC




Lower Galveston Bay Watershed 1999-2004:
Pathogens
HGAC Land Cover
Woody Wetland
Woody Land
Open Water
Non-woody Wetland
Low Intensity Developed
High Intensity Developed
Grassland
Cultivated Land
Pathogens
0% samples exceed screening levels
1-9% samples exceed screening levels
10-25% samples exceed screening levels
>25% samples exceed screening levels
Insufficient data (n<12)
N
W
E
S
HARC
0
3
6
12
18
24
Miles

Seafood Consumption Advisories for Galveston Bay

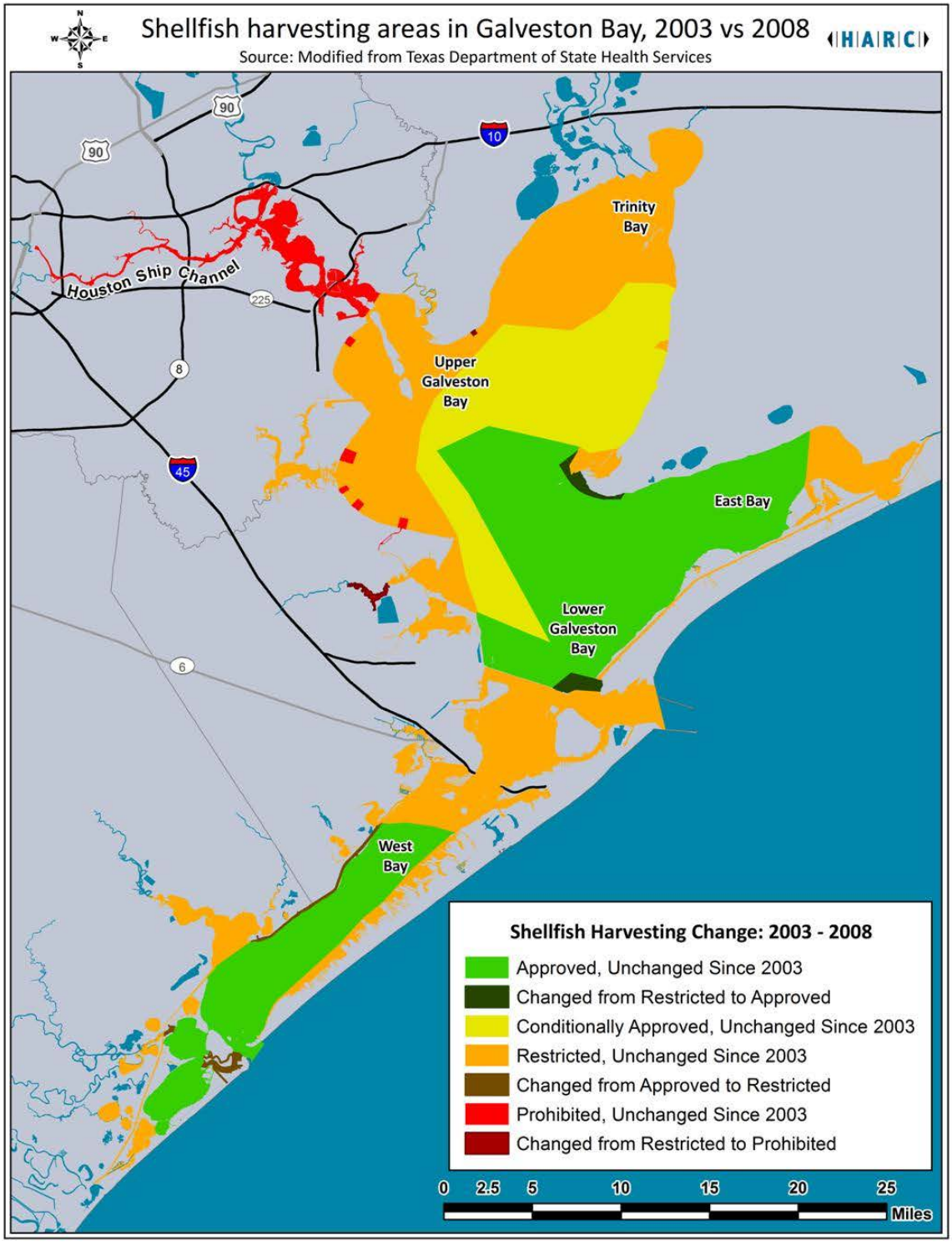
Source: Texas Department of State Health Services



The Advisory for the Houston Ship Channel includes all contiguous waters, including the San Jacinto River below the U.S. Highway 90 bridge and Upper Galveston Bay north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. Contaminants include Dioxin, organochlorine pesticides, and PCBs in blue crabs and all species of fish.

The Advisory for Galveston Bay includes Chocolate Bay, East Bay, Trinity Bay, and West Bay and contiguous waters. Contaminants include Dioxin in all species of catfish and blue crabs, and PCBs in spotted seatrout (speckled trout).

It is recommended that people not consume more than one meal, not to exceed 8 ounces, from these areas each month. Children and women of childbearing age should not consume any fish or blue crabs from these areas.


Shellfish harvesting areas in Galveston Bay, 2003 vs 2008
Source: Modified from Texas Department of State Health Services
HARC
90
90
10
225
8
45
6
Houston Ship Channel
Trinity Bay
Upper Galveston Bay
East Bay
Lower Galveston Bay
West Bay
Shellfish Harvesting Change: 2003 - 2008
Approved, Unchanged Since 2003
Changed from Restricted to Approved
Conditionally Approved, Unchanged Since 2003
Restricted, Unchanged Since 2003
Changed from Approved to Restricted
Prohibited, Unchanged Since 2003
Changed from Restricted to Prohibited
0 2.5 5 10 15 20 25
Miles

Engineering Shorelines

Time: 1 45-minute class period

Materials:
- Student worksheets
- 4 Clear plastic tubs
- Sand
- Marsh: Plastic grass glued into modeling clay (length of the width of your tub)
- Oyster reef: Oyster shells placed into a line of pantyhose (length of the width of your tub)
- Water & water pitcher
- Thin plastic cutting boards for bulkhead and wave makers
- Per group:
  - 2 expo markers
  - Thin plastic wave maker
  - 2 colored pencils

Texas Essential Knowledge and Skills:
Grade 5: 1AB, 2ABCDFG, 3C, 4, 5C, 7B, 9C
Grade 6: 1AB, 2ABCDE, 3AD, 4AB
Grade 7: 1AB, 2ABCDE, 3AD, 4AB, 8ABC
Grade 8: 1AB, 2ABCDE, 3BD, 4AB, 11C
Biology: 1AB, 2BEFGH, 3DEF, 12E
Aquatic Science: 1AB, 2BEFGHJ, 3DE, 4A, 6B, 8B, 12ABCD
Environmental Systems: 1AB, 2BEFGHIK, 3DE, 5A, 6E, 8A, 9E

This activity is modified from the North Carolina Federation's "Shifting Shorelines Activity". *www.nccoast.org*

Lesson adapted by The Galveston Bay Foundation

Teacher Information Page

Objectives:
- Identify what a living shoreline is compared to a bulkhead
- Compare different methods of erosion control
- List three types of shoreline protection methods
- Describe which protection method creates more habitat for animals and coastal resiliency.

Background:
This laboratory investigation is an inquiry lab where students will learn about living shorelines, erosion control methods, and coastal resiliency. It is considered a good introductory lab before discussing the importance of wetlands and oyster reefs. Do not feel the need to explain the importance of both prior to the lab. Allow students to come to the conclusions themselves. Below is background information for you to learn more about each concept before teaching it. Once the lab investigation is complete, you can go into depth about each concept.

Living Shorelines (a combination of oyster reef and marsh grass) are designed to allow natural coastal processes to take place by allowing the movement of organics in and out of the marsh; absorbing wave energy from wind, boats, and storm events; and filtering pollutants from runoff. In addition, they create and/or maintain vital habitat for economically and ecologically important fish and shellfish, and they provide nesting and foraging areas for resident and migratory birds. They can be built in front of bulkheads or armoring providing additional protection to existing structures while restoring shoreline habitat. Living Shorelines help protect landowner investments while enhancing the ecological value of the property. They are often less expensive than traditional bulkheads.

Coastal Resiliency is defined by NOAA as the ability of a community to "bounce back" after hazardous events such as hurricanes, coastal storms, and flooding – rather than simply reacting to impacts. As sea level rises plants can grow and adapt to it causing the coast to be resilient for future generation. Instead of having to fix a bulkhead, fill in sand, see more erosion every few years we can build a shoreline that can bounce back and recover in the future on its own. According to NASA, sea level is projected to rise about 1 foot in 40 years.

Review the following materials for more information on living shorelines:

Coastal Review Online article about living shorelines vs. bulkheads:
http://www.coastalreview.org/2016/02/12896/

Living Shorelines: A Natural Approach To Erosion Control (written by GBF)
https://galvbay.org/wp-content/uploads/2014/03/LS_alternative.pdf

Engineering Shorelines

Teacher Information Continued

Lab set -up:

1. Create your 4 different shorelines:
    a. Bulkhead:
        i. Pour sand on one end of the tub, filling it approximately 4 inches high.
        ii. Cut a plastic strip to the width and height of the bin to create the bulkhead. Place it against the sand and attach it to the tub walls with clay
        iii. Pour water 2 inches high on the open side of tub
    b. Sand only:
        i. Pour sand on one end of the tub, filling it approximately 4 inches high.
        ii. Pour water 2 inches high on the open side of tub
    c. Marsh:
        i. Pour sand on one end of the tub, filling it approximately 4 inches high.
        ii. Place the marsh strip against the sand. Ensure that it fits snugly against the walls of the tub.
        iii. Pour water 2 inches high on the open side of tub
    d. Living Shoreline:
        i. Pour sand on one end of the tub, filling it approximately 4 inches high.
        ii. Place the marsh strip against the sand. Ensure that it fits snugly against the walls of the tub.
        iii. Place the oyster reef 2 inches away from the marsh strip in the open section of the tub.
        iv. Pour water 2 inches high on the open side of tub
2. Set up your classroom into 4 stations. Each station will need the following:
    a. 1 shoreline
    b. A “wave maker” (cut piece of thin plastic cutting board or other waterproof material the width of the tub.
    c. 2 thin expo markers or vis-à-vis markers
    d. 2 colored pencils, preferably the same colors as the markers
    e. Procedure page (you may want to laminate so it doesn’t get wet)

Lab Procedure

1. Ensure that students all know what erosion means.
2. Show students actual pictures of each type of shoreline protection method and have them hypothesize which one they think will help stop erosion the best. They will write their hypothesis on their data sheet.(5 minutes)
3. Students will stay at each station for 5 minutes each, rotating as a class, to complete the instructions on their procedure page. Depending on age and ability level, you may want to have all groups proceed as a class under your instruction. Or you may want them to read the procedure and complete it themselves. (20 minutes)
4. Once rotations are complete, discuss with them which one worked the best. Was their hypothesis correct?
5. Explain coastal resiliency and ask the class what might happen to the area in 10-30 years (sea level rise, increased storms, etc.). (5 minutes)
6. Add 1-2 inches of water to each tub to represent sea level rise, and have each group perform one last test to determine which shoreline shows the greatest coastal resiliency. (5 minutes)
7. Discuss their findings.
8. Have students complete the critical thinking questions. (10 minutes)

Engineering Shorelines

Student Procedure for Each Shoreline

1. On the side of your bin, trace the line of the sand using a marker. This is the ***initial shoreline***.

2. Draw your initial shoreline in the correct box in the table below using a colored pencil. Pretend the box is the side of the bin and draw it's profile using the entire box. Draw ONLY your initial shoreline that you traced. Do not draw the water or any other features. ***(See Example)***

3. Label your line "I".

4. Make 20 waves with the wave maker, making sure to not splash water out of the bin.

5. On the side of your bin, trace the new line of sand using a different colored marker. This is the ***final shoreline.***

6. Label your line "F".

7. Draw your final shoreline in the same box that you drew your initial shoreline using a different colored pencil.

8. Record your observations. What happened to the shoreline? How does the water look?

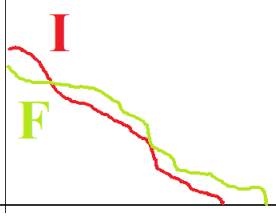
9. Wipe off the marker off of the bin and smooth out your shoreline for the next group.

10. Repeat steps 1-9 for each shoreline.

11. Discuss coastal resiliency with your teacher.

12. Complete steps 1-9 with your current shoreline pretending that 10-30 years has taken place***. Make sure to write in which shoreline you are modeling in the table.***

Example:

Shoreline	Drawing	Observations
Sand Only		

Engineering Shorelines

Student Data Sheet

Name: _____ Date:_____

Objectives:

- Identify what a living shoreline is compared to a bulkhead
- Compare different methods of erosion control
- List three types of shoreline protection methods
- Describe which protection method creates more habitat for animals and coastal resiliency.

Hypothesis:

Shoreline Protection Table:

Shoreline	Drawing	Observations
Sand Only		
Bulkhead		
Marsh		
Living Shoreline		
_____ **Shoreline After 10-30 years**		

Engineering Shorelines

Critical Thinking Questions:

1. Which shoreline lost the most amount of sand during the wave experiment? Why?

2. Which shoreline kept the most sand during the experiment? Why?

3. Which shoreline was determined to show the most coastal resiliency?

4. If a hurricane hits the Houston-Galveston area this year, what do you think will occur with each of the following shorelines? Describe in detail what each would look like.

    a. Only Sand:

    b. Bulkhead:

    c. Living Shoreline with plants:

    d. Living Shoreline with plants and oyster reef:

5. Engineers work with biologists to create living shorelines specific to an area's needs. Name 3 factors they have to think about when designing a shoreline protection method.

    a.

    b.

    c.

Grade the Bay: Public Service Announcement

Time: 2-3 class periods

Texas Essential Knowledge and Skills:
Grade 5: 1B, 2ADFG, 3AC, 4, 9AC
Grade 6: 2AE, 3A, 4A
Grade 7: 2AE, 3A, 4A, 8C
Grade 8: 2AE, 3A, 4A, 11ABC
Biology: 2GH, 3ABCD, 12E
Aquatic: 2GH, 3ABCD, 12E
Environmental: 2GHIK, 3ABCDE, 4GH, 5BF, 9ABDEG

Materials:
- Computers with internet access
- Poster board
- Markers/colored pencils
- Video camera and associated equipment if making videos

Extensions:
- Hang posters around school, have school news show videos
- Gallery walk: have students complete a gallery walk to learn more about all categories, with them taking notes as they go

Lesson developed by The Galveston Bay Foundation

Name: _____ **Date:** _____

Objectives:
- Students will research and analyze the Galveston Bay Report Card.
- Students will create a public service announcement about a specific category in the report card.

Background:
The Galveston Bay Report Card is a citizen-driven, scientific analysis of the health of Galveston Bay. Implemented by the Galveston Bay Foundation and the Houston Advanced Research Center, the report card's goal is to engage community members in meaningful discussions about Bay health topics. The report card is also designed to inspire people to take actions that protect and preserve the Bay and is updated annually.

Procedure:
1. Go to www.galvbaygrade.org to answer the following questions:
    a. What overall grade does the bay currently have? ____
    b. Why do we "grade the bay"?
2. What Can **YOU** Do to improve the overall health of the Bay?
3. Research about your chosen category for the Report Card:
    _____
4. Create a poster or short video as a public service announcement (PSA). Be creative with your presentation! Include the following:
    a. Name of category
    b. Grade it received
    c. Indicators that were looked at to determine the grade
    d. Concerns regarding the category and indicators
    e. How can we help to increase that grade in the future?
    f. Relevant pictures/tables/graphs (a minimum of 2 graphs and 2 photos with descriptions)
5. Answer the Conclusion Questions on the back.
6. Turn this paper in with your project.

Grade the Bay: Public Service Announcement

Conclusion Questions:

1. Were you surprised by the grade that your category received? Explain.

2. How important do you think it is to spread the word about the grade of Galveston Bay? Why?

3. What can you do at your own home to help influence the grade of the Bay?

Challenge:

Make a Straight "A" Bay!

Can you make a pledge to do *one* thing to **help** the **Bay**? Once you have decided, share your pledge of action with the link to the Galveston Bay Report Card on social media with the tags #galvbaygrade19 #LoveOurBay