How Far Are You From The Sea? The Vertical and Horizontal Truth

Objectives

Students will be able to

- Identify and explain the causes of land loss in Louisiana
- Identify their school location from the sea both in vertical distance and horizontal distance
- Evaluate the risks of flooding in a certain area based on various indicators

photograph provided by BTNEP

Materials

- Access to the internet
- Computer that can access online videos
- Information pages on causes of land loss:
    - Sea level Rise
    - Subsidence
    - Hydrologic Change
    - Storms
    - Saltwater Intrusion
- Student Record Sheet
- Benchmark (Note: Markers in 2012 cost about $14 each with the printing http://www.berntsen.com/Go-Shopping/Surveying/Concrete-Survey-Markers/Aluminum-Concrete-Survey-Markers)

Background:

As Louisiana's coastal marshland continues to erode away from natural forces and human activities, the Gulf of Mexico will keep getting closer to our homes and communities; closer in terms of both distance and elevation.

The causes of coastal erosion include:

- **subsidence** (the sinking of marshland),
- **hydrologic changes** such as channelization (canals like the Gulf Intracoastal Waterway or GIWW),
- **saltwater intrusion**, and of course,
- **storms** washing away the shoreline.

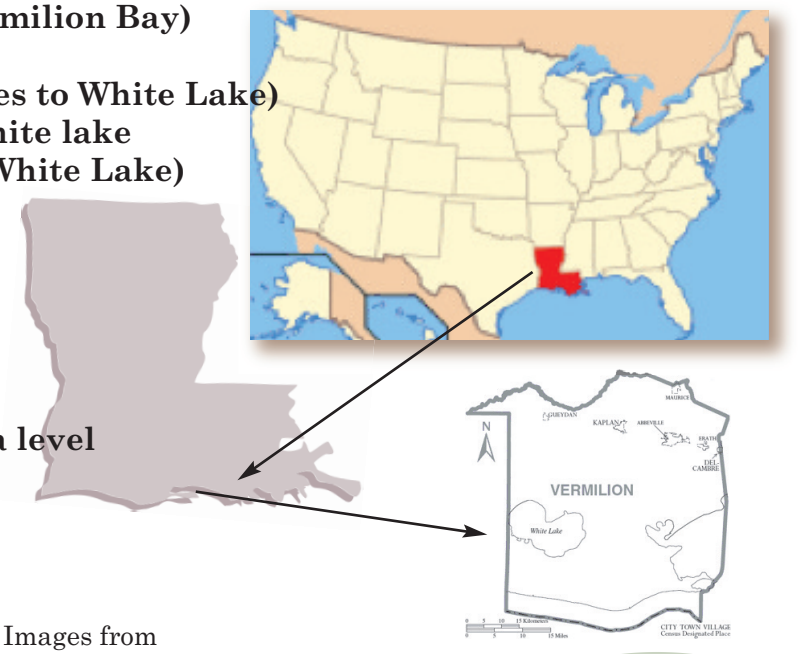
The Gulf is also getting closer in terms of elevation due to **sea level rise**. Over the last 50 years, sea level along Louisiana's coast has risen about 1.5 feet. If these trends continue, storm surges will appear stronger and reach further inland.

So, just how far away is the Gulf of Mexico? If you live along the coast of Louisiana, you may be very familiar with the idea that we don't live very far from the sea. For example, in Vermilion Parish alone, if you traveled horizontally you might find these distances to the portion of the sea called the Gulf of Mexico:

- **Abbeville: 26 miles (14 miles to Vermilion Bay)**
- **Erath: 26 miles (12 miles to Vermilion Bay)**
- **Maurice: 36 miles**
- **Indian Bayou: 37 miles (20 miles to White Lake)**
- **Kaplan: 30 miles (17 miles to White lake**
- **Gueydan: 31 miles (15 miles to White Lake)**

But have you considered how far away you are from the sea based on total feet above sea level? Let's look at those numbers in Vermilion Parish again.

- **Abbeville: 8 to 15 feet above sea level**
- **Erath: 5 to 7 feet**
- **Maurice: 18 to 20 feet**
- **Indian Bayou: 15 to 19 feet**
- **Kaplan: 10 to 14 feet**
- **Gueydan: 6 to 7 feet**



Images from
http://en.wikipedia.org/wiki/Vermilion_Parish,_Louisiana

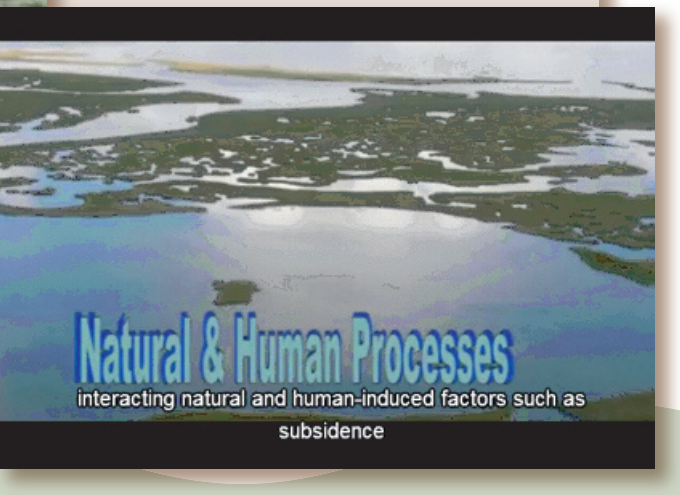
Procedure

Watch *"Sea-level Rise, Subsidence, and Wetland Loss"*
http://gallery.usgs.gov/videos/347
Sea-level Rise, Subsidence, and Wetland Loss

This video describes causes of wetland loss in the Mississippi River Delta. Rapid land subsidence due to sediment compaction and dewatering increases the rate of submergence in this deltaic system.

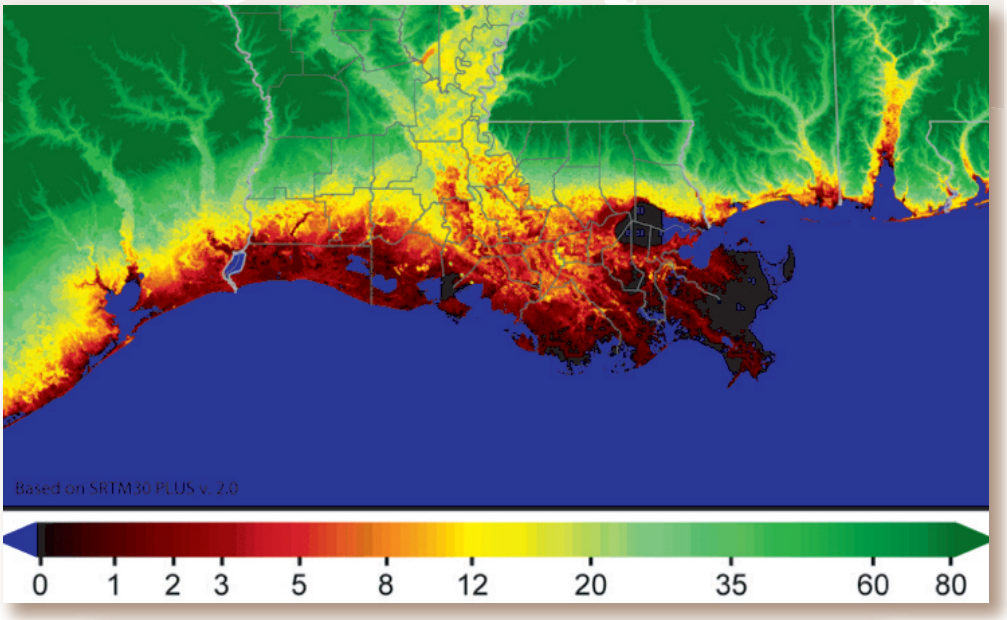
The construction of levees along the lower Mississippi River has also reduced delivery of sediments to coastal wetlands, which have been deteriorating as soil surfaces sink and wetland plants are subjected to excessive flooding. Other factors that have contributed to land loss include construction of canals and periodic hurricanes. Sea-level rise can lead to movement of saltwater inland, but coastal plants tolerate salinity through several morphological and physiological mechanisms.

The causes of wetland loss are complex and not the result of any single factor. Natural and anthropogenic factors have combined with global processes such as sea level rise to cause wetland loss in the Mississippi River Delta.



Sea Level Risks—Louisiana

Sea Level Rise



This map shows the risks associated with sea level rise.
http://ete.cet.edu/gcc/?/resourcecenter/viewResource/6

Let's start with sea level rise because it will affect all of the people on Earth who live in coastal zones.

Sea level rise is an increase in the mean level of the ocean. The National Oceanographic and Atmospheric Administration (NOAA) has been measuring mean sea level for over 150 years, with **tide stations** operating on all U.S. coasts. Sea level is the base level for measuring elevation and depth on Earth.

Because the ocean is one continuous body of water, its surface tends to seek the same level throughout the world. However, winds, currents, river discharges, and variations in gravity and temperature prevent the sea surface from being truly level.

So that the surface of the ocean can be used as a base for measuring elevations, the concept of "local mean sea level" has been developed. In the United States and its territories, local mean sea level is determined by taking hourly measurements of sea levels over a period of 19 years at various locations, and then averaging all of the measurements.

Global warming, the current period of climate change on Earth, is causing glaciers and ice sheets to melt. Melting ice sheets cause an elevation in sea level. This phenomenon is called sea level rise.

Geography

Sea Level Rise

Sea level rise threatens low-lying areas around the world. Island nations, such as Maldives and Comoros, are particularly at risk. Coastal cities, such as those along coastal Louisiana, New York City, New York, and Mumbai, India, must also prepare for higher sea levels.

photo credit: Marian Martinez

1. The earth's climates have changed in the past, are currently changing, and are expected to change in the future, primarily due to changes in the amount of light reaching places on the earth and the composition of the atmosphere. The burning of fossil fuels in the last century has increased the amount of greenhouse gases in the atmosphere, which has contributed to Earth's warming (4B/H6).

2. Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere.

Global sea level rose about 17 centimeters in the last century. Over the past decade, sea levels have risen at twice the rate of the preceding century. Currently, the rate of rise is a little more than 3 millimeters a year. There are two main factors responsible for sea level rise, and both are related to our warming climate: the melting of land-based glaciers and ice sheets, and the thermal expansion of the upper ocean caused by warming surface waters.

http://ete.cet.edu/gcc/?/resourcecenter/slideshow/6/81

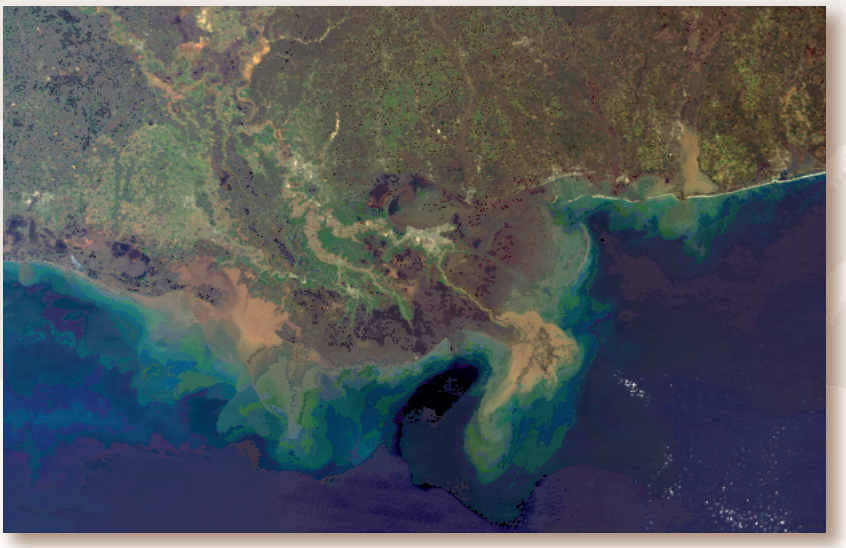
Geography

Subsidence

http://celebrating200years.noaa.gov/foundations/leveling/image8.html
This elevation benchmark shows the effect of subsidence.

The second reason Louisiana citizens need to be concerned about their "distance" to the sea is subsidence or the gradual sinking of land. Subsidence or the compaction of the sediments is influenced by a number of factors. Heavy sediment loads brought down by the Mississippi river are now being compacted. Additionally, organic material in the sediment oxidizes causing soils to eventually be compacted. Louisiana also has faults underground that can cause the land to slump. Geologically, the crustal adjustment in Louisiana may even be caused by the removal of earlier ice sheets far to north of this region. Fluid withdrawal due to hydrocarbon extraction may cause soil compaction or fault reactivation.

Hydrologic Changes

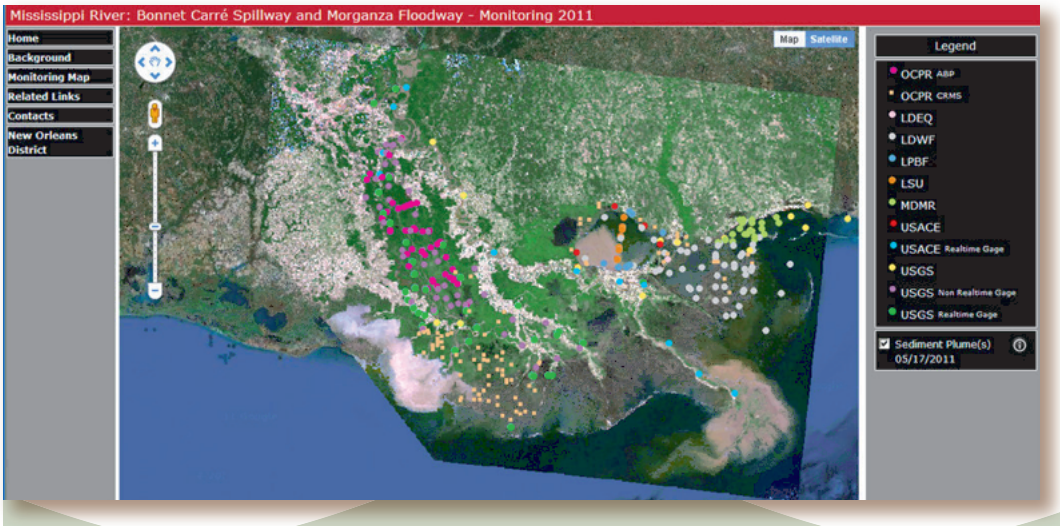


evNASA http://earthobservatory.nasa.gov/IOTD/view.php?id=1257
The Mississippi River carries roughly 550 million metric tonnes (500 million tons) of sediment into the Gulf of Mexico each year. This true-color image, acquired from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite via direct broadcast on March 5, 2001 at 10:55 AM local time, shows the murky brown water of the Mississippi mixing with the dark blue water of the Gulf two days after a rainstorm.

Hydrologic changes are defined as water flow variations that redistribute water with abrupt modifications or changes that occur faster than human or natural systems can adapt. In Louisiana, these hydrologic changes come from a variety of sources.

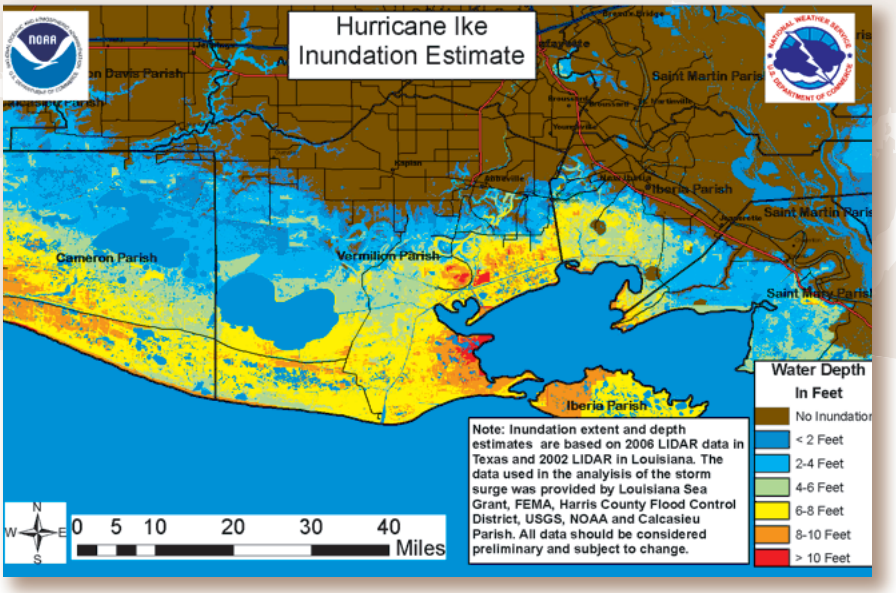
The leveeing of the Mississippi River protected citizens from flooding but now the river acts as a funnel, preventing sediment from flowing over wetland areas. The building of the Gulf Intracoastal Waterway (GIWW) provided intrastate transportation via a water canal between Texas and Florida, however over time, wake erosion has progressively widened the channel, and the spoil banks have breached allowing saltwater intrusion into previously fresh areas. Other navigation channels and oil field drilling canals also change the natural flow of water in Louisiana's coastal ecosystem.

Before human induced hydrologic alterations for flood protection, navigation channels, and drilling in the early 1900s, the natural drainage of the rivers in Louisiana provided a sheet flow across the wetlands delivering sediment. As tributaries were cleared, deepened, and somewhat straightened vital sediment and nutrients were funneled out into the Gulf of Mexico.



This map has been developed to serve as a data portal to the various monitoring activities related to the opening of the Bonnet Carré Spillway and the Morganza Floodway in 2011. Collaborating organizations that have provided their monitoring information are reflected on the map with links to their data, where available. This map only provides known monitoring information related to the 2011 opening of the Bonnet Carré Spillway and the Morganza Floodway and does not provide an exhaustive list of existing gages and other data collection points.
http://deltas.usgs.gov/spillway/BonnetCarre2011.aspx

Storms



From: Land Area Changes in Coastal Louisiana After Hurricanes Katrina and Rita by John Barras
pubs.usgs.gov/circ/1306/pdf/c1306_ch5_b.pdf

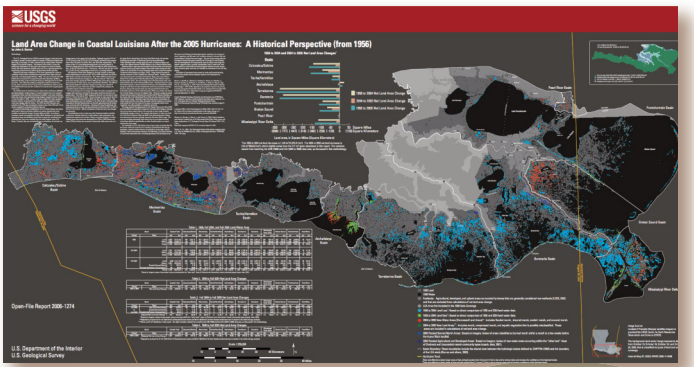
Storms such as tropical cyclones like hurricanes bring strong winds combined with low pressure, excessive rain, and storm surge that drive water onshore. Hurricanes often remind us that we live in a vulnerable location. Even severe winter storms can bring in changes in water.

"The U.S. Geological Survey's (USGS) National Wetlands Research Center analyzed land loss or change to water immediately after Hurricanes Katrina and Rita. Analysis was based on USGS Earth Resources Observation and Science (EROS) Data Center's multiple Landsat TM satellite images of coastal Louisiana acquired immediately before and after the landfalls of Katrina and Rita. A series of seven Landsat TM scenes acquired between October 16 and October 25, 2005, provided a snapshot of land-water area changes after the storms. Total water area increased by 217 mi2 (562 km2) after the hurricanes according to a comparison of the 2004 and 2005 classified imagery.

View in detail the "Land Area Change in Coastal Louisiana After the 2005 Hurricanes: A Historical Perspective" at http://pubs.usgs.gov/of/2006/1274/

The 217 mi² (562 km²) of new water area occurring after the hurricanes contains losses caused by direct removal of wetlands as well as transitory water area changes caused by remnant flooding, removal of aquatic vegetation, scouring of marsh vegetation, and water-level variation caused by normal tidal and meteorological variation between images.

Estimation of permanent losses cannot be made until several growing seasons have passed and the transitory impacts of the hurricanes are minimized."



Saltwater Intrusion

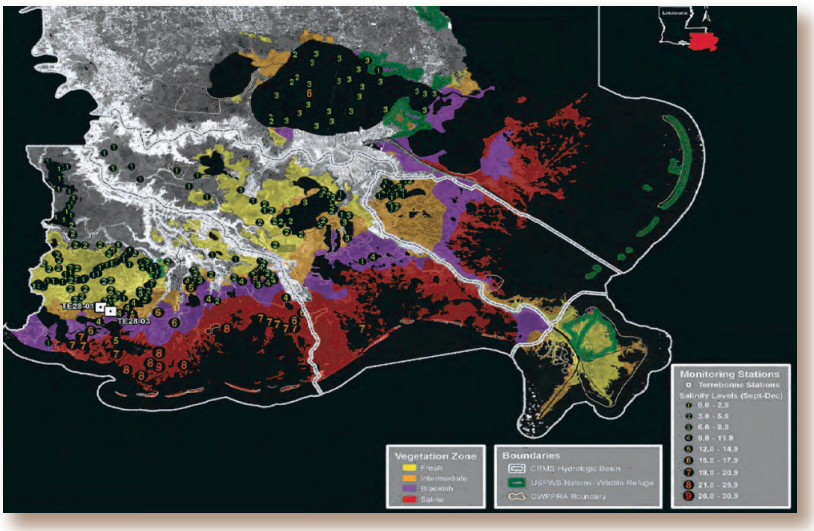
Above is an image of plants suffering from saltwater intrusion. Photo credit USGS

Plant communities along the coastline are dependent on salinity and hydrology. Often after a hurricane event or winter storm salinities in marsh areas can increase. Plant species living in these exposed areas express changes as increased salinity act as an environmental stressor. Symptoms of salt injury to plants look similar to drought conditions. Plants can wilt and growth may be stunted. Long term consequences of exposure to high salinities may include plant dieback, shifts in plants from species those less salt tolerant to those more tolerant of salt and a reduction in seed germination.

Table 1.
Typical salinity ranges found within various vegetation types in coastal Louisiana (Chabreck, 1970), and maximum discrete salinity measurements of surface waters recorded between September and December 2005.

[All salinities are reported in parts per thousand (ppt). Note that the salinity of ocean water is approximately 35 ppt]

Vegetation type	Typical salinity range	Maximum salinity measured after 2005 hurricanes
Swamp	0–0.5	8
Fresh marsh	0–3	26
Intermediate marsh	2–8	26
Brackish marsh	4–10	34
Saline marsh	8–29	30



Eastern coastal Louisiana discrete surface salinity measurements (September–December 2005) with proximity to vegetation zones (Chabreck and Linscombe, 2001) and U.S. Fish and Wildlife Service (USFWS) national wildlife refuges. Regarding boundaries, CRMS refers to Coastwide Reference Monitoring System, and CWPPRA refers to the Coastal Wetlands Planning, Protection and Restoration Act. *(pubs.usgs.gov/circ/1306/pdf/c1306_ch6_c.pdf)*

Procedure

1. Review the information sheets on SEA LEVEL RISE, SUBSIDENCE, HYDROLOIC CHANGES, STORMS AND SALINITY CHANGES with your students as a whole class or in small groups.

2. Watch "Sea-level Rise, Subsidence, and Wetland Loss" online at http://gallery.usgs.gov/videos/347. This video describes causes of wetland loss in the Mississippi River Delta area.

3. Ask students to list and describe four causes for land loss in Louisiana on the student record sheet

4. Using Google maps, have students calculate their horizontal distance to the Gulf of Mexico.

    a. Go to www.maps.google.com
    b. Click on "Get Directions"
    c. In the first box type in the address of your home or school.
    d. In the second box type in the name a town nearest to the Gulf of Mexico.
    e. And click "Get Directions"
    f. The map will show your current location, a line, and your final location.
    g. This will give you a rough estimate of your horizontal distance to the Gulf.
    h. Record that distance on your student record sheet.

5. Using LSU AgCenter data, have students calculate their vertical distance from average sea level.
    a. Click on
http://www.lsuagcenter.com/en/family_home/home/design_construction/Laws+Licenses+Permits/Getting+a+Permit/Your+Flood+Zone/flood_maps/

    b. Click on the parish you live in. It will be highlighted in red.
    c. Click GO.
    d. Type in your address in the box that says "Enter your address here." Be sure to use your house or school number, street, city, and state.

e. Click the "Locate" button.
f. On the left hand side of the map a list of information will appear. It will include your latitude, longitude, Flood Zone, and actual ground elevation number. If the number has a negative sign in front of it you are BELOW sea level.
g. Record your distance on the student record sheet.

6. Ask students to record which issues they think will most likely be a cause for flooding in their region.

7. Help students "plant" a metal marker or benchmark in the front of the school. That marker will be stamped with the current elevation of that school. Students will also be taught how to locate the elevation of other points of interest including their homes.

NOTE: The survey markers in 2012 cost about $14 each with the printing. http://www.berntsen.com/Go-Shopping/Surveying/Concrete-Survey-Markers/Aluminum-Concrete-Survey-Markers

8. Using the method above, locate the elevation of other points of interest such as:
   a. students' homes
   b. library or park or
   c. a nearby levee

Students decide where to place benchmark.

activity

Student Record Sheet

1. List and describe four causes of land loss in Louisiana.

   1.

   2.

   3.

   4.

2. Using Google maps, calculate your horizontal distance to the Gulf of Mexico.

   a. Go to www.maps.google.com
   b. Click on "Get Directions"
   c. In the first box type in the address of your home or school.
   d. In the second box type in the name a town nearest to the Gulf of Mexico.
   e. And click "Get Directions"
   f. The map will show your current location, a line, and your final location.
   g. This will give you a rough estimate of your horizontal distance to the Gulf.
   h. Record your horizontal distance to the Gulf of Mexico; _____

3. Using LSU AgCenter data calculate your vertical distance from average sea level.

   a. Click on http://www.lsuagcenter.com/en/family_home/home/design_construction/Laws+Licenses+Permits/Getting+a+Permit/Your+Flood+Zone/flood_maps/

   b. Click on the parish you live in. It will be highlighted in red.
   c. Click GO.
   d. Type in your address in the box that says "Enter your address here." Be sure to use your house or school number, street, city, and state.
   e. Click the "Locate" button.

activity

Student Record Sheet—CONT'D.

f. On the left hand side of the map, a list of information will appear. It will include your latitude, longitude, Flood Zone, and actual ground elevation number. If the number has a negative sign in front of it, you are BELOW sea level.

g. Record your elevation. _____

4. Which of the issues related to coastal land loss are most important to the area you live in and why?

5. Your class may choose to "plant" a metal marker or benchmark in the front of your school to identify the land's elevation. That marker will be stamped with the current elevation of that school.

6. Using the method above locate the elevation of other points of interest such as:

a. your homes

b. your library

c. a nearby levee

Find out about

FLOOD and WIND Hazards

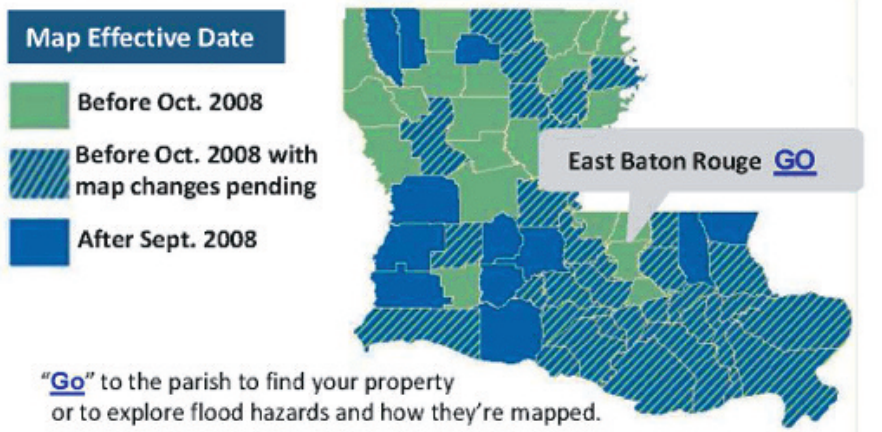
at your Louisiana location!

LSU AgCenter Research & Extension

When you're planning, building or insuring a home, it's important to know your exposure to natural hazards such as floods and high winds.

Throughout Louisiana, building to minimize flood and wind damage is a building code requirement .

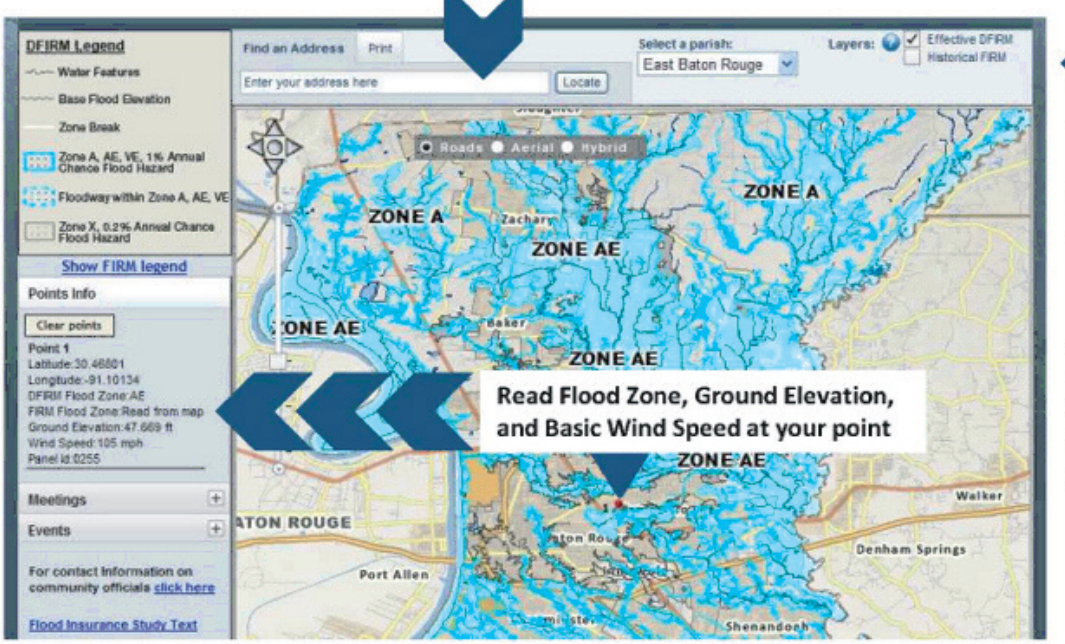
Use this online tool to study conditions at your site or to explore how flood maps are changing in your parish.



"Go" to the parish to find your property or to explore flood hazards and how they're mapped.

LSUAgCenter.com/floodmaps

Enter an address or click and zoom to find your point of interest



Read Flood Zone, Ground Elevation, and Basic Wind Speed at your point

Turn on map layers you want to view and compare.

Choose the "Hybrid" view to find your house on an aerial photograph.

Visit *LSUAgCenter.com/floodmaps* to learn why October 2008 is significant and how knowing the ground elevation helps you understand your vulnerability to floods.

Made available by the Disaster Recovery and Mitigation Unit, LSU AgCenter, with funding assistance from the Louisiana Department of Transportation and Development, Floodplain Management Office.
Contact Pat Skinner, pskinner@agcenter.lsu.edu for information and help with the site.

April, 2011

LSU AgCenter Interactive Maps

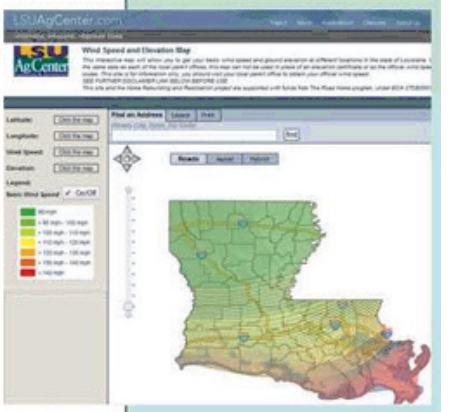
Tools help Louisiana citizens assess risk of flooding

September 2011

As the 2011 hurricane season continues, many Louisianans want to compare their area's elevation to a predicted flood crest nearby.

The LSU AgCenter has two mapping services/sites that ANYONE can use to find ground elevation at ANY spot in Louisiana. Both sites were built as part of the LSU AgCenter code enforcement and hazard resistant building education programs to aid with recovery from hurricanes Katrina and Rita.

- Both sites allow you to find a point by pan-and-click on the map or by entering a street address.
- Both sites allow you to turn on a background aerial image to locate a specific building or property.
- You can zoom in and out on either map, as well as pan the map in any direction.
- Click with the mouse on either map to place a pin and see ground elevation value (along with other information about the point).
- These sites provide images with a resolution and precision that is more accurate than the flood modeling or forecasts shown on them. The location of flood boundaries is approximate and should be used ***for estimating purposes only.***

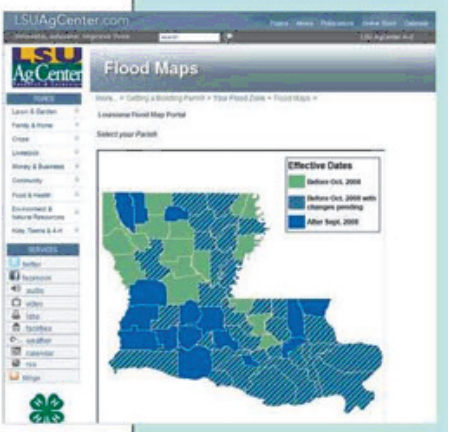


This mapping site gives Basic Wind Speed for building code purposes and shows ground elevations provided by the USGS.

Wind Speed Map System: *maps.lsuagcenter.com/windspeed_elevation*

The LSU AgCenter's wind speed and elevation interactive map does not require you to select a parish before locating the property of interest.

- Turn off the "Basic Wind Speed" layer. (The on-off toggle is just to the left, above the legend.)
- Enter an address and click on "find."
- Turn on the "Hybrid" base map to activate the aerial imagery and identify individual structures.



This mapping site presents Flood Insurance Rate Maps (FIRMs) and related products. It also shows ground elevations provided by the USGS.

Flood Map System: *www.LSUAgCenter.com/floodmaps*

The LSU AgCenter's flood maps portal displays flood insurance rate maps, which are used in the National Flood Insurance Program.

- Click on the parish of your choice and choose "Go."
- When the parish map opens, turn off the flood layers. (Uncheck the boxes in the upper right corner.)
- Enter an address and click on "Locate."
- Turn on the "Hybrid" map to activate the aerial imagery and identify individual structures. (Check "Hybrid" option that appears on map.)

LSUAgCenter.com/2011Hurricanes
Your guide to the LSU AgCenter 2011 hurricane preparation, prevention, recovery and rebuilding resources

Using the Flood Maps portal during flood threats

For any point on the map, you can see whether the area has been identified as a special flood hazard area. A special flood hazard area has a 1 percent chance per year of being inundated. Areas protected from rivers by levees are NOT in the special flood hazard area unless they flood from some other source, such as poor drainage or other rivers and streams running through the parish. For example, New Orleans is protected from the Mississippi River and Lake Pontchartrain by levees, but many areas flood due to rain that exceeds the capacity of drainage canals and pump systems. Similarly, Baton Rouge is protected from the Mississippi River by a levee but has extensive flood hazard areas associated with the Amite and Comite rivers, which run through and east of the parish.

For any point on the map, you can see the approximate ground elevation. Ground elevation is provided by the U.S. Geological Survey. If you have been told that a flood will reach a certain level AT YOUR LOCATION, and you know the ground elevation, you can estimate the flood depth. For example, if the flood will reach 55 feet mean sea level and your ground elevation (from this website) is 52 feet mean sea level, you would anticipate that the flood would be about 3 feet deep at your point—unless there is high ground between you and the river that would prevent the flood from reaching your property.
The flood level at your location is seldom the same as the reading on the nearest river gauge. Some river gauges use a different vertical reference than the USGS uses when providing ground elevations. A correction factor must be applied.

Online mapping systems have limitations. Use with caution

- The websites should not be relied upon to determine levee elevations. Narrow features such as the crown of levees are difficult to represent accurately and are only approximations. Local Office of Emergency Preparedness should have information about current local levee elevations.

- The flood elevation in the river, at the gauge, is not necessarily the elevation the water will be 100 yards or a few miles away from the gauge. The river elevations are of the water level in a very constrained environment. Local authorities will attempt to provide water surface elevation in specific locations.

- Some stream gauges need to be adjusted when comparing their readings to ground elevation. Most river gauges in southern Louisiana use the same ***vertical reference*** system that is used to provide ground elevations in our websites. Northern gauges, including those at Natchez and Vicksburg, require a conversion factor. Gauge locations and readings can be accessed at: http://www.srh.noaa.gov/lmrfc/ . For Natchez, add 17.3 feet to the gauge reading. For Vicksburg, add 46.2 feet.

Authors: Maurice Wolcott, Paco Capello and Pat Skinner

What you need to know about the flood maps on the LSU AgCenter Flood Maps portal

- These maps do NOT show historic floods. They do NOT show imminent flood threats or forecasts.
- Where an area is protected by a levee, the map shows only areas that flood WHEN THE LEVEES HOLD (do not leak, break or get overtopped).
- Most areas along the main rivers in Louisiana are protected by levees. This includes the major rivers and streams that feed them
- Lands near these rivers may be more likely to flood when the rivers inside the levees are very high, even if the levees hold. There may be seepage, leakage, a higher underground water table or sand-boils (where water finds a channel of sandy soil, travels under the levee and rises on the protected side).
- Lands near rivers and streams that drain into these major rivers may be more likely to flood for several reasons. Water will back up from the major rivers into the feeder streams. High water levels in the receiving rivers will retard the normal flow of streams into them. When rivers and streams are full, heavy rains that normally would run off quickly may accumulate, producing a flood.
- Lands shown on the maps as flood hazard areas usually are the lowest lands and the most difficult to drain. These would be the areas most likely to flood, most likely to flood first – in a slow levee failure -- and most likely to have the deepest floodwater, if the levees were fully overtopped.
- Flood maps that show hazard areas in shades of blue are NEWER and have more reliable flood risk assessments than flood maps that show flood hazard areas only in shades of gray.

follow up

Extension Activity

1. Using FloodSmart.gov view the current flood map of your area.

   a. Click on http://www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/map_update_schedule.jsp

   b. In the box, enter your zip code.

2. To check real time flood conditions visit http://water.weather.gov/ahps/

3. Encourage students to learn more about flood risks. Print the *"Flood and Wind Hazards"* and LSU AgCenter Interactive Map pages"

Bibliography

Initial lesson plan created by Mr. Mark Shirley, LA Sea Grant and LSU AgCenter, Vermilion Parish 4-H

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ww.noaa.gov/features/climate/sealevelchanges.html

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http://plant-materials.nrcs.usda.gov/technical/gulf_restoration.html
http://pubs.usgs.gov/circ/c1075/wetland.html
http://plant-materials.nrcs.usda.gov/technical/gulf_restoration.html

follow up

Assessments

Assess the students' understanding of land change and sea level rise from their answers on the student assessment sheet.

Resources

LSU AgCenter FloodSmart.com
http://www.lsuagcenter.com//en/family_home/home/design_construction/Laws+Licenses+Permits/Getting+a+Permit/Your+Flood+Zone/flood_maps/

USGS National Wetlands Research Center
http://www.nwrc.usgs.gov/

GLE's

Environmental Science
Personal Choices and Responsible Actions

21. Analyze the effect of common social, economic, technological, and political considerations on environmental policy (SE-H-C3)

22. Analyze the risk-benefit ratio for selected environmental situations (SE-H-C4)

23. Describe the relationship between public support and the enforcement of environmental policies (SE-H-C5)

Lesson Source