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| **Title**  | **Fracking in the Sandhills** |
| **Introduction**  | Hydraulic fracturing, or “fracking,” as it is more commonly called, is one of the major issues in environmental and political news today. Recently, the issue has come to the forefront in North Carolina, as various municipalities have begun considering whether they will allow the oil companies to purchase oil rights on private and public property. This lesson seeks to provide students with the background knowledge and critical thinking skills necessary to understand and evaluate the issue to be able to take a stand in the debate. |
| **Real Science Application**  | Hydraulic fracturing, more commonly known as “fracking,” is a commercial drilling technique used to extract oil and natural gas from deep underground. While hydraulic fracturing has been around for about 65 years, modern fracking combines classic hydraulic fracturing with newer technique called horizontal drilling. Basically, a vertical well is dug into the earth until it reaches the oil or natural gas stores, then turns at a 90 degree angle and can stretch up to a mile horizontally. The well is then pumped full of high-pressure fracking fluids, the exact composition of which is an industry secret. Approximately 98% of the fracking fluid is plain water, but the remaining two percent can be any mixture of chemicals, some of which are known to be radioactive.Many drilling companies claim that the process used in fracking is harmless and that it is providing us with much-required oil and clean-burning natural gas. Many government entities support fracking because it is bringing jobs and money to struggling rural economies. Environmentalists, however, claim fracking is a huge risk to the environment and cite instances where leftover fracking fluids have infiltrated freshwater systems as proof. This lesson will provide students with the opportunity to analyze how fracking works on a small-scale model. After reading scientific literature and media accounts, students will evaluate the various arguments in the fracking debate to determine where their own opinions lie.  |
| **Curriculum Alignment**  | This section contains the curriculum alignment of each lesson in the module to the North Carolina Standard Course of Study, specifically the Common Core and Essential Standards, as well as the Next Generation Science Standards. NC Essential Standards

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| **Content Area** | **Grade Level** | **NC SCS** |
| Science | 8 | 8.P.2 Explain the environmental implications associated with the various methods of obtaining, managing, and using energy resources.* 8.P.2.1 Explain the environmental consequences of the various methods of obtaining, transforming and distributing energy.
* 8.P.2.2 Explain the implications of the depletion of renewable and nonrenewable energy resources and the importance of conservation.
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| Earth/Environmental Science | 9 | EEn.2.2 Understand how human influences impact the lithosphere. * EEn.2.2.1 Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present.
* EEn.2.2.2 Compare the various methods humans use to acquire traditional energy sources (such as peat, coal, oil, natural gas, nuclear fission, and wood)

EEn.2.4 Evaluate how humans use water. * EEn.2.4.1 Evaluate human influences on freshwater availability.
* EEn.2.4.2 Evaluate human influences on water quality in North Carolina’s river basins, wetlands and tidal environments.
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 Next Generation Science Standards

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| Standard |
| MS-ESS3-2 | Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment |

Common Core Standards Literacy Connections

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| Content Standard |
| **RST.6-8.1** - Cite specific textual evidence to support analysis of science and technical texts.**WHST.6-8.7** - Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.**WHST.6-8.8** - Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. |

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| **Learning Outcomes**  | * Students will model the movement of liquids underground through a variety of permeable and impermeable mediums.
* Students will analyze informational text to determine possible positive and negative implications of “fracking” for natural gas.
* Students will develop a plan of action to address fracking in their state, incorporating opposing viewpoints in the plan.
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| **Time Required and Location**  |

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| **Day**  | **Lesson** | **Time Required/Location** |
| 1 | “Hook” and background info | 60 minutes in classroom |
| 2 | Lab: Modeling underground movement of liquids | 60 minutes in classroom |
| 3 | Student presentation preparation | 60 minutes in classroom |
| 4 | Student presentations | 60 minutes in classroom |

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| **Materials Needed**  | Teacher List* Computer with smartboard and internet connection
* Teacher copy of handouts

Student List* Computers with internet access for all students
* Print materials (especially government resources and newspaper/magazine articles) related to fracking
* Student handouts
* 20 2-liter soda bottles (4 per group)
* Scissors
* Plastic tubing
* Modeling clay
* Sand
* Clay
* 20 250-mL beakers
* 5 graduated cylinders
* Calculators
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| **Safety**  | * Students should utilize lab safety precautions when using scissors. Always direct a sharp edge or point away from self and others.
* Students should handle breakable materials, such as glassware, with care. They should not touch broken glassware.
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| **Student Prior Knowledge**  | These activities are designed to be used as part of a lesson on alternative energy sources. Students should have a background understanding of renewable and nonrenewable resources, various alternative energy sources, and the benefits and drawbacks of each of those sources. Students should understand that the United States is still primarily dependent on fossils fuels and that various methods of obtaining fossil fuels are in use today. Students should understand that many human undertakings have major impacts on the environment and that we are stewards of our environment. |
| **Teacher Preparations**  | * Reserve the appropriate number of computers for group research
* Collect the required number of soda bottles
* Research local hydro-fracking news to share with students, including local town hall meetings or current relevant issues
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| **Activities**  | **ENGAGEMENT*** The teacher will write “Fracking Debate” on the board in advance of students entering the classroom.
* Students will be asked to write a brief statement to take a guess at what the topic of the day actually means. After they write their sentences, students will ball the papers up, and place them in the Bin of Anonymity (a clean empty trash can). The teacher will ask students to randomly draw paper balls from the bin and read them aloud to the class. This allows students to share their ideas without fear of being ridiculed.
* The teacher will show the video [Communities Divided Over Fracking](https://www.youtube.com/watch?v=oMboTKOWeAs&feature=youtu.be) from the Associate Press (2 minutes 53 seconds). While students are viewing the video, they will complete a plus/delta chart regarding the potential benefits and risks of allowing fracking to occur.
* After the video, students will discuss their findings with their table groups.

**EXPLORATION*** The teacher will introduce students to the lab activity that they will be participating in.
* The teacher will provide students with lab procedure and answer sheet.

Modeling Natural Gas Flow Through Mediums Before and After Fracking* Students will be creating models to simulate the flow of liquids through various mediums underground. The models will be created using four 2-liter soda bottles, plastic tubing with modeling clay to hold it in place, and four different mediums.
* Model A will be filled with sand only
* Model B will be filled with clay only
* Model C will be filled with a layer of clay sandwiched between two layers of sand (this models shale layers before fracking)
* Model B will be filled with a layer of clay sandwiched between two layers of sand; however there will be a distinctive gap or “crack” in the clay layer (this models shale layers after fracking has occurred)
* Students will bore a hole into the bottle and attach plastic tubing to the hole, being sure that the connection is tightly sealed with the modeling clay.

The holes in each bottle should be bored at the same height. The opening of the tubing should be placed in a small beaker. * Students will pour 500 mL water into Bottle A, and time it for 30 seconds, allowing the water to flow through the medium, through the tubing, and eventually into the beaker. This step should be repeated for each of the three remaining bottles.
* Students should measure each of the water outflow amounts for each of the bottles using a graduated cylinder.
* Students should then calculate the outflow of each model into mL per minute.

Focus Questions* Through which medium did the liquid move most freely? Which medium was most impermeable?
* How do these models explain why some people feel that fracking is necessary to assist with our energy issues?

**EXPLANATION*** Begin the Explanation stage by allowing students to share their findings from the mini-lab activity.
* Display the following questions, column-style, on the Smartboard

• What is fracking? • What are some of the positive things you have heard about the process? • What are some of the negative things you have heard about the process? • Where have you gotten your information about fracking? • Do you think that your sources of information about fracking have been credible or not and why? * The teacher should use the following questions to guide classroom discussion with the students.

1. How might fracking economically impact the country in the near and distant future? 2. How does the goal of U.S. energy independence relate to fracking? 3. How does fracking negatively impact the environment?4. To what extent should we sacrifice the environment to become energy independent? 5. To what extent should the federal government regulate hydraulic fracturing processes throughout the US?**ELABORATION*** Students will complete a problem-based learning activity in which each group member takes on a different role to approach the issue of fracking. Students will work in groups of four to research, develop ideas, and create a multimedia presentation about fracking in the Sandhills region of North Carolina.
* The four roles that students will embody will be:

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| Role | Job Description |
| Drilling Company Scientist | This person is responsible for understanding the fracking process, chemicals used, etc. Should take the position that the chemicals are not harmful to the environment.  |
| Environmental Activist | This person is responsible for understanding how fracking can impact the environment, including air quality, water quality, wildlife, etc. |
| Government Official | This person should understand laws about drilling for oil and natural gas in the Marcellus Shale region (where fracking occurs) and also what chemicals are considered safe. Also needs to know what bills are currently being debated related to fracking, specifically the issue of American energy independence and national security. This person should also consider the economic effects of allowing fracking to occur. |
| Concerned Citizen (family farmer) | This person has been offered a deal with the big drilling company to allow them to drill on their land. He/she has 20 acres of land that the drilling company would like to drill under. This person needs to be responsible for determining what information is available to the public and evaluating whether that information is credible. |

 * Students should take notes on fracking from a variety of resources (print and internet), being sure to focus on looking at the issues from the viewpoint of the role they have taken on.
* Students are directed to some specific research resources to start them in the right direction.
* Students will create a persuasive multimedia presentation that they will present at a mock “city council” meeting to try to determine what the town’s decision will be regarding fracking.
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| **Assessment**  | * Student will create a multimedia presentation (video, PowerPoint, Prezi, Glogster, etc.) that addresses each of these roles. The students need to offer some type of resolution or plan to the issues surrounding the fracking practice with the goal of making all of the stakeholders as satisfied as possible. Students should discuss any compromises between parties that would have to occur to allow this plan to be viable in the foreseeable future. The focus of the presentation should be on the Sandhills region of North Carolina.
* The presentation will be evaluated using a rubric.
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| **Critical Vocabulary**  | **Marcellus Shale:** a sedimentary rock formation named after the town of Marcellus, New York where the shale is distinctly exposed at ground surface. The shale formation is an exceptional source of natural gas.**Hydraulic Fracturing (“fracking”):** a process which forces water, sand and chemicals under high pressures into rock formations to expose and extract natural gas.**Natural Gas:** a mixture of hydrocarbons (hydrogen and carbon) which are primarily methane.**Well Pad:** a drilling site containing a drilling tower and equipment covering 2-3 acres.**Wellbore:** the hole created by drilling.**Vertical Drilling:** constructing a borehole from ground surface to more than a mile below.**Horizontal Drilling:** a well constructed perpendicular to the vertical wellbore (drilled and turned using a directional tool) which may measure more than 6,000 ft.**Seismic Surveying:** a technology used to collect data on subsurface hydrocarbon deposits (detect underground gas deposits).**TOC:**total organic carbon (helps determine amount of hydrocarbons or natural gas potential). |
| **Community Engagement**  | * Invite a member of the community that is active in the anti-fracking grassroots movement to speak. Sustainable Sandhills is one group that often cooperates with local schools.
* Have a representative from the local electrical company come to the school to discuss our current local usage of electricity and explain the percentage of that which comes from fossil fuels so that students can understand why fracking might be needed.
* Have students create a tri-fold board presentation and display them in public areas, such as your local city hall, to illustrate how fracking might impact the community.
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| **Supplemental Information**  | The following resources are excellent sources of information about fracking for both students and teachers:* [*http://exploreshale.org/*](http://exploreshale.org/)This website provides a phenomenal visual trip through the fracking process. Also provided are various pieces of text related to how fracking works and why fracking is so very controversial.
* [*http://www.dangersoffracking.com/*](http://www.dangersoffracking.com/)This animation gives students a visual explanation of how fracking can impact our groundwater. WARNING: This website is extremely biased!
* [*http://www.showusyourclips.com/a-gorgeous-animation-about-fracking-foolishness-and-the-fallacies-of-peak-oil/*](http://www.showusyourclips.com/a-gorgeous-animation-about-fracking-foolishness-and-the-fallacies-of-peak-oil/)This video is both entertaining and informative. It is another (biased) account of the way in which the oil companies provide propaganda related to the need to drill for oil in such a way.
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| **Author Info**  | Gabrielle Patrick is a Kenan Fellow from Sandy Grove Middle School in Lumber Bridge, NC. She has been teaching middle school science, seventh and eighth grade, for five years. She can be contacted at gpatrick@hcs.k12.nc.us. Hanah Ehrenreich is the Executive Director for Sustainable Sandhills. She is a vocal advocate and engaging public speaker on environmental issues in the Sandhills. She earned an MSc in Violence, Conflict, and Development Studies from the School of Oriental & African Studies (SOAS), University of London; and a BA in Government with Honors from Smith College. Hanah is committed to the progression of the Sandhills as a vibrant and forward thinking region. She has lived and worked in London, Israel, Belfast, Syracuse and Washington, DC. She can be contacted at HanahE@sustainablesandhills.org  |