SE MAPS PROJECT

Nuclear Science Activity #1

(Southeastern Coastal Plain Region)

Water Transport of Waste

The SE MAPS Project is a NSF-funded project that evolved from a South Carolina model for inquiry-based classroom instructional modules proposed by South Carolina K-12 teachers participating in a series of Professional Development Courses designed to help educators better understand and appreciate the natural environment of their state. Each activity was reviewed by content specialists at Clemson University before final publication. Funding support for the 'Nuclear Science' series of activities was provided by the NEESRWM Center at Clemson University (The Center for Nuclear Environmental Engineering Sciences and Radioactive Waste Management).

Water Transport of Nuclear Waste

Steven Pruitt and John Wagner [based on an activity written by Sarah Disario, Nick Hill, and Alexandra McIntyre]

INSTRUCTIONAL FOCUS: Students will recognize how topography plays a role in the flow of groundwater and surface water. They will then use this concept to analyze the risk of nuclear pollutants such as radioactive isotopes buried at the Savannah River Site, in the South Carolina Coastal Plain, of traveling through the environment and threatening freshwater resources.

SUGGESTED TARGET AUDIENCE: high school earth/environmental studies classes

PRIMARY CORRELATION TO S.C. ACADEMIC SCIENCE STANDARDS (2014):

EARTH SCIENCE - EARTH's HYDROSPHERE

Standard H.E.6A.2 Obtain and communicate information to explain how location, movement, and energy transfers are involved in making water available for use on Earth's surface (including lakes, surface-water drainage basins, freshwater wetlands, and groundwater zones).

CHEMISTRY - ATOMIC STRUCTURE AND NUCLEAR PROCESSES

Standard H.C.2B.2 Develop models to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as the use of radioisotopes to date rocks and fossils).

Other Curriculum Connections [middle-school earth, environmental, and physical science]

"SC MAPS (South Carolina Maps and Aerial Photographic Systems) – Study Site #5A"

PRIOR SKILLS REQUIRED: The students should be able to read and interpret topographic maps (scale/legend/symbols). Students should also understand the basic concepts of radioactivity and nuclear fission. Also, the students should be familiar with accessing different websites and using search engines (Google™, etc.) to search for information.

LOGISTICS: The basic activity could fit within a 50-minute class, but more time is recommended, especially if supplemental materials or optional activities are used – a flat work area is needed so students can draw on large maps - work in cooperative groups. Internet access is required.

KEY VOCABULARY AND CONCEPTS:

- half-life
- nuclear waste
- remediation
- tritium

CONTENT OVERVIEW: [more detail is provided in the "Teacher Answer Key."]

1. The storage of nuclear waste will continue to be a problem throughout the foreseeable future with many of the isotopes contained in this waste having a very long half-life.
   - *Nuclear waste is composed of various radioactive materials produced as a result of nuclear fission.*
   - *Half-lives of nuclear materials range from a few seconds to billions of years.*
   - *After a sufficient number of half-lives have passed (depending on initial amount of radioactive material present) radioactivity falls below background levels and is no longer a threat to public safety.*
2. The Savannah River Site (a US Department of Energy facility) is one of only a few major national sites for long-term storage of nuclear waste. It is located in west-central South Carolina.
   - *The Savannah River Site is a 300 square mile region located in Aiken, Barnwell, and Allendale Counties along the Savannah River in the upper Coastal Plain of South Carolina. The site contains several streams.*
   - *In 1991, the primary role of the Savannah River Site shifted from manufacturing of nuclear materials to nuclear waste management and environmental restoration.*
3. Nuclear waste disposal sites need to be monitored frequently to insure that no leakage has occurred.
   - *Common hazardous materials needing disposal include tritium, various radionuclides, and trace metals.*
   - *Episodes of minor leakage have been detected at the Savannah River Site and other nuclear disposal sites.*

MATERIALS: internet access, 6 SC MAPS laminated lithographs ["Map #5A - "Savannah River Site"]; 6 'wet-erase' marker pens; 6 calculators; 6 30-inch pieces of string; 6 rulers; map of the United States.

PROCEDURES:

1. Ask students if they know what happens to nuclear waste that is generated at nuclear power plants. Discuss 'pros' and 'cons' of leaving nuclear waste stored at the power plants. Discuss 'pros' and 'cons' of transporting the nuclear waste elsewhere. Tell students that there are only three high-level nuclear waste storage/re-processing facilities in the United States (Savannah River Site, SC; Hanford, WA; Yucca Mountain, NV). Locate these sites on a map of the United States.
2. Divide students into groups and give each group a map of the Savannah River Site (SC MAPS #5A) and tell them to access the website <*http://www.srs.gov/general/about/history1.htm*>; which provides information about the history of this site. Also, briefly define and describe the radioactive isotope 'tritium' and its uses to the entire class and explain how it can contaminate both water supplies and the atmosphere. Ask students to follow the instructions on Student Work Sheet Part I to gather and record additional information about SRS, tritium operations, and problems with leaks.
3. [optional] If additional information about decay of radioisotopes is needed (including how to calculate the half-life), an excellent online lesson and example can be found at: <http://www.coolmath.com/algebra/17-exponentials-logarithms/13-radioactive-decay-decibel-levels-01.htm>.
4. Have student groups fill out answers to the questions on the Student Work Sheet Part II. Then lead a class discussion about the actual dangers and risks to people and the environment associated with leakage of Tritium-contaminated water into the groundwater and surface waters of the Savannah River Site. Compare the two lists showing reasons we should be concerned about such events and reasons we should not be concerned. Discuss what is meant by the term 'acceptable risk'.
5. [optional] Have students research the Yucca Mountain, NV project and explain why it is so controversial. Some suggested websites are listed in the 'Teacher Answer Key'.

SAMPLE CULMINATING ASSESSMENT:

- Ask the students to evaluate (high, moderate, low) the threat of pollution of the Savannah River from contaminants released from the Savannah River Site. Have students write a 100 word essay backing up their risk assessment, using examples from their classwork and other research.

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STUDENT WORK SHEET – Part I

Part I – Introduction to the 'Savannah River Site', its History, and Waste Storage Issues

A. Access the following website <*http://www.srs.gov/general/about/history1.htm*>; review the history and other information about the Savannah River Site (SRS), and examine the layout of the SRS as shown on the large-format map (SC MAPS #5A). Find as many of the locations mentioned in the website as you can on the map. From those sources, and from the class discussion, answer the following questions about the Savannah River Site (SRS).

1. In what year did construction at SRS begin? ___________________________________
2. What major river forms the western boundary of the SRS? _____________________________
3. What was the original purpose of the SRS? ____
4. What is the main purpose of the SRS today? ____
5. List three hazardous materials currently stored at SRS. _________________________________
   _______________________________ and __________________________________
6. List two other activities that are or have been associated with the SRS.
   ______________________________ and ____________________________________
7. In what year did the SRS begin producing tritium for the Atomic Energy Commission? _______
8. [optional] Search the internet for additional pictures of the Savannah River Site.

B. Access the following website <http://www.nytimes.com/1992/01/13/us/anger-lingers-after-leak-at-atomic-site.html?pagewanted=1> and read the newspaper account of the tritium leak from the 'K' Reactor at the Savannah River Site in 1992. Locate the 'K' reactor and the Savannah River on the Savannah River Site topographic map (SC MAPS #5A) and answer the following questions:

1. Trace on the map (with a wet-erase marker) the most likely path the contaminated water would take to get from the 'K' reactor site to the Savannah River.

2. Use a piece of string, a ruler, and the map scale to estimate the total distance that the contaminated water would have to travel before it reached the Savannah River?
MAP DISTANCE IN INCHES = ___________________
REAL DISTANCE IN FEET = ___________ REAL DISTANCE IN MILES = _____________

3. Assuming an average stream velocity of 0.5 ft/sec; about how long (in hours) would it take the contaminated water to reach the Savannah River from the 'K' reactor? ____________________

4. How many gallons total of radioactive water leaked out in this event? __________________

5. Knowing that the half-life of Tritium is 12.32 years, make an 'educated guess' as to how much of the Tritium in the initial spill would actually reach the Savannah River. __________________

6. Compare the number of gallons of contaminated water released (from question #4) to the total number of gallons of uncontaminated water flowing down the Savannah River (come up with your own method of estimating the flow in the Savannah River). Predict what will happen to the contaminated water when it mixes with the Savannah River water.

C. Access the following website <http://www.sott.net/article/272181-Radioactive-plume-in-South-Carolina-leaking-into-Savannah-River> and read the newspaper account of the tritium leak from the Barnwell Low-Level Radioactive Waste Disposal Facility in Barnwell County, South Carolina in 2014. Locate the 'Chem-Nuclear' site (in the town of Snelling - at middle of map on extreme right edge) on the Savannah River Site topographic map (SC MAPS #5A) and answer these questions:

1. Circle the location of the 'Chem-Nuclear' site on the map (with a wet-erase marker) and also draw a straight line westward from that site to the Benchmark 'BM 199' (near 'Gate 19B') that lies on the eastern boundary of the Savannah River Site property. Locate the un-named stream that flows from that Benchmark into Lower Three Runs Creek. That un-named stream is actually the 'Mary Branch Creek' that is referenced in the news article. Also trace the path of Lower Three Runs Creek until it reaches the Savannah River (note the path of the creek briefly disappears off the edge of the map at one point but quickly returns).

2. Use a piece of string, a ruler, and the map scale to estimate the total distance that the contaminated water would have to travel before it reached the Savannah River?
MAP DISTANCE IN INCHES = ________________
REAL DISTANCE IN FEET = ___________ REAL DISTANCE IN MILES = ____________

3. Assuming an average stream velocity of 0.5 ft/sec; about how long (in hours) would it take the contaminated water to reach the Savannah River from the Benchmark site? _________________

4. How do you think the Tritium-contaminated water got from the Chem-Nuclear burial site to the Benchmark Site (where Mary Branch Creek begins)? ___________________________________

5. Do you think that all of the contaminated water reaches Mary Branch Creek, or are there other places the Tritium might end up? Explain your answer. _________________________________
____
____

STUDENT WORK SHEET – Part II

Part II – Risk Assessment

A. Compare the relative hazards from a continuous leak of Tritium (as in the Barnwell situation) into the environment versus a one-time leak (such as occurred at Reactor 'K'). ______________________
____
____
____

B. The newspaper articles include quotes from people who are very concerned about the Tritium leaks and also from some people who think these leaks pose little to no danger to the public. Based on your reading, prepare two lists summarizing the main points made by each side.

REASONS LEAKS ARE A DANGER	REASONS LEAKS ARE NOT A DANGER
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

C. Write a definition for what you think the term 'acceptable risk' means.

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TEACHER ANSWER KEY

KEY VOCABULARY AND CONCEPTS:

- half-life = the amount of time it takes for one half of a mass of radioactive material to decay
- nuclear waste = any discarded material that is radioactive
- remediation = the clean-up of contaminated sites or other procedure to make dangerous waste safe
- tritium = a radioactive isotope of Hydrogen in which the nucleus has one proton and two neutrons

PROCEDURES:

1. Ask students if they know what happens to nuclear waste generated at nuclear power plants.

At most nuclear power plants, nuclear waste is stored on site until it can be transported to a long-term storage facility. However, capacity is limited at Hanford WA and Savannah River Site SC, and construction of the Yucca Mountain NV site has been delayed; therefore most waste stays at the site at which it was produced.

Leaving waste at the original site is good because it minimizes the chance that the general public would come in contact with radioactive materials. However, safe storage space is limited at most of these sites.

Transporting nuclear waste over long distances increases the possibility of public exposure, especially if there was an accident involving a train or truck carrying these materials. Such transport would require careful planning.

The three sites mentioned are shown on this map.

H = Hanford, WA - near City of Richland
S = Savannah River Site, SC - near City of Aiken
Y = Yucca Mountain, NV - near City of Las Vegas

2. Use map of Savannah River Site and websites to gather and record information about the nuclear site and also the production and storage of tritium. Use Student Work Sheet Part I.

Many of the answers to the questions on the Work Sheet about the history of the Savannah River Site can be found on the SRS 'historical' website <http://www.srs.gov/general/about/history1.htm>. Be sure to explain to students the current uses of the SRS facilities [waste management and environmental restoration] as this fact is not covered by the website. Tritium is a radioactive isotope of Hydrogen that has one proton and two neutrons in its nucleus. [Normal Hydrogen is not radioactive and has one proton and no neutrons.] Tritium was produced at the Savannah River Site in special 'heavy-water reactors' as a by-product of nuclear reactions. Pure tritium is a gas at normal atmospheric conditions, but reacts very quickly with oxygen to form radioactive water that if released into the environment can contaminate both ground water and surface water used for drinking. The half-life of Tritium is 12.32 years. For more information about Tritium and its uses, access the following websites: <http://www.srs.gov/general/programs/dp/index.htm> and <http://www.epa.gov/rpdweb00/radionuclides/tritium.html>.

A. *Students will use information from the SRS history website, the maps provided, and your class discussion to answer the following questions:*

1. In what year did construction at SRS begin? *1951.*
2. What major river forms the western boundary of the SRS? *Savannah River*

3. What was the original purpose of the SRS? *The original purpose of the site was to produce basic materials (Tritium, Plutonium-239) needed for the production of nuclear weapons in support of national defense.*

4. What is the main purpose of the SRS today? *Waste management and environmental restoration.*

5. List three hazardous materials currently stored at SRS. *Answers may vary, but might include: Tritium, Plutonium, Curium, Californium, and Uranium.*

6. List two other activities that are or have been associated with the SRS. *Answers may vary, but might include: Production of Deuterium (heavy water); receiving site for spent nuclear fuel from other reactors; production of isotopes for heat source for space exploration; designated as National Environmental Research Park; archeological program established onsite; waste processing facilities; effluent treatment program; saltstone operations; consolidated incineration facility; workforce transition and community assistance program; cold war historic preservation program; MOX fuel fabrication facility; Plutonium immobilization facility; salt waste processing facility; generating electricity from Uranium; Center for Hydrogen research.*

7. In what year did the SRS begin producing tritium for the Atomic Energy Commission? *1955*

8. [optional] Search the internet for additional pictures of the Savannah River Site. *Many options are available.*

B. *Students will use information found in the New York Times newspaper article to help answer these questions:*

1. Trace on the map (with a wet-erase marker) the most likely path the contaminated water would take to get from the 'K' reactor site to the Savannah River. *Contaminated water would run into Indian Grave Branch, then into Pen Branch Creek, and end up in the swampy floodplain of the Savannah River.*

2. Use a piece of string, a ruler, and the map scale to estimate the total distance (in both feet and miles) that the contaminated water would have to travel before it reached the Savannah River? *Note that answers given are approximations due to uncertainty of spill location and water path through floodplain.*
MAP DISTANCE IN INCHES *~10 inches on map*
REAL DISTANCE IN FEET ~ *40,000 ft [map scale is "1 inch = 4,000 feet" and map distance is ~10 inches]*
REAL DISTANCE IN MILES ~ *7.5 miles [40,000 ft divided by 5,280 feet per mile]*

3. Assuming an average stream velocity of 0.5 ft/sec; about how long (in hours) would it take the contaminated water to reach the Savannah River from the 'K' reactor? *~ 22.5 hours [40,000 ft divided by .5 ft/sec = 80,000 seconds; divided by 60 seconds per minute = 1333.3 minutes, divided by 60 minutes per hour]*

4. How many gallons total of radioactive water leaked out in this event? *Website says 150 gallons*

5. Knowing that the half-life of Tritium is 12.32 years, make an 'educated guess' as to how much of the Tritium in the initial spill would actually reach the Savannah River. *Because the Tritium would reach the river in less than one day, and the half-life of this isotope is about 12 years, very little of the original radioactive material would have decayed in that short a time. The math required to generate an exact answer is not simple, but you could reference the 'half-life activity' described in Procedure 3 (optional) on Page 2 of the Lesson Summary if you wanted to arrive at a specific number. The exact answer should be close to 149.97 gallons.*

6. Compare the number of gallons of contaminated water released (from question #4) to the total number of gallons of uncontaminated water flowing down the Savannah River (come up with your own method of estimating the flow in the Savannah River). Predict what will happen to the contaminated water when it mixes with the Savannah River water. *There are several ways to calculate the velocity of a stream or river. One simple equation is "Total Discharge = Cross-sectional Area x Velocity", but students don't have to use an equation, they just need to realize that a river carrying way over 100 times more water than the small creeks will be moving a whole lot faster. When you consider the amount of water carried by a river over 100 feet wide and more than 10 feet deep, adding 150 gallons of contaminated water will not have much of an impact. The contaminant will diffuse through the river water and become highly diluted. The intent is for students to brainstorm their own ideas and visualize the dilution (exact numbers are difficult to determine).*

C. *Students will use information found in the Atlanta Progressive News article to help answer these questions:*

1. Circle the location of the 'Chem-Nuclear' site on the map (with a wet-erase marker) and also draw a straight line westward from that site to the Benchmark 'BM 199' (near 'Gate 19B') that lies on the eastern boundary of the Savannah River Site property. Locate the un-named stream that flows from that Benchmark into Lower Three Runs Creek. That un-named stream is actually the 'Mary Branch Creek' that is referenced in the news article. Also trace the path of Lower Three Runs Creek until it reaches the Savannah River (note the path of the creek briefly disappears off the edge of the map at one point but quickly returns).

2. Use a piece of string, a ruler, and the map scale to estimate the total distance (in both feet and miles) that the contaminated water would have to travel before it reached the Savannah River? *Note that answers given are approximations due to uncertainty of stream path running off map for short distance.*

MAP DISTANCE IN INCHES *~ 25.5 inches*

REAL DISTANCE IN FEET ~ *102,000 ft [map scale is "1 inch = 4,000 ft" and map distance is 25.5 in]*

REAL DISTANCE IN MILES ~ *19.3 miles [102,000 feet divided by 5,280 feet per mile]*

3. Assuming an average stream velocity of 0.5 ft/sec; about how long (in hours) would it take the contaminated water to reach the Savannah River from the Benchmark site? *~ 56.6 hours [102,000 ft divided by .5 ft/sec = 204,000 sec; divided by 60 sec per minute = 3400 minutes, divided by 60 minutes per hour]*

4. How do you think the Tritium-contaminated water got from the Chem-Nuclear burial site to the Benchmark Site (where Mary Branch Creek begins)? *Because the waste was buried, the leakage was underground and contaminated the ground water supply. The ground water then seeped into Mary Branch Creek.*

5. Do you think that all of the contaminated water reaches Mary Branch Creek, or are there other places the Tritium might end up? Explain your answer. *Answers may vary, but some contamination might be captured by minerals in the soil, and trees and other vegetation that obtain groundwater through their roots might also capture a significant amount of the contaminated water.*

3. [optional] If additional information about decay of radioisotopes is needed (including how to calculate the half-life), an excellent online lesson and example can be found at: <http://www.coolmath.com/algebra/17-exponentials-logarithms/13-radioactive-decay-decibel-levels-01.htm>. *Although this site uses exponents and logarithms, if students have a reasonably advanced calculator, they should be able to do the calculations (even without completely understanding the math concepts).*

4. Have student groups fill out answers to the questions on the Student Work Sheet Part II. Then lead a class discussion about the actual dangers and risks to people and the environment associated with leakage of Tritium-contaminated water into the groundwater and surface waters of the Savannah River Site. Compare the two lists showing reasons we should be concerned about such events and reasons we should not be concerned. Discuss what is meant by the term 'acceptable risk'.

Answers will vary. What follows are some typical answers to these questions. Other answers are possible.

A. Compare the relative hazards from a continuous leak of Tritium (as in the Barnwell situation) into the environment versus a one-time leak (such as occurred at Reactor 'K'). *A one-time leak will create problems for only a short period of time. The contaminant will be carried through the stream system and eventually reach the ocean, where the radioactive atoms will gradually decay until their radiation level becomes so low that it is masked by prevailing background radiation levels. This pollution has a temporary effect on people and businesses who use the river water, but after a certain amount of time, normal activities can resume. A continuous leak will contribute contaminants to the water supply over a much longer period of time. The contaminant is never completely 'flushed out' of the water supply because new material is always being added. Contaminated water supplies must be closed to the public for extended periods of time.*

B. The newspaper articles include quotes from people who are very concerned about the Tritium leaks and also from some people who think these leaks pose little to no danger to the public. Based on your reading, prepare two lists summarizing the main points made by each side. *Answers may vary.*

Issues causing concern:	*Issues indicating concern is not needed:*
- all radiation is harmful; there is no safe level	*- pollutant is diluted in water below harmful levels*
- leaks are sometimes hard to detect until it's too late	*- leaks so small that total radiation exposure is small*
- safety standards are based on yearly averages	*- SRS is restricted area, so general public not harmed*
- other contaminants will eventually leak out also	*- SRS monitors streams and groundwater frequently*
- no way exists to clean up contaminated water	*- leaks happen very infrequently so are low-risk*

C. Write a definition for what you think the term 'acceptable risk' means. *Answers may vary, especially because different people will have different ideas about how much (and what type) risk is acceptable. Everyone is exposed to some risk every day, from crossing a busy street to contracting a disease from an infected person they come in contact with. One working definition might be "the amount of risk people are willing to take in order to maintain their desired standard of living". Other definitions are possible.*

5. [optional] Have students research the Yucca Mountain, NV project and explain why it is so controversial. Some suggested websites are listed in the 'Teacher Answer Key'. following websites will be helpful:

Eureka County, NV – Nuclear Waste Office <http://www.yuccamountain.org>.
The Washington Post - <http://www.washingtonpost.com/opinions/leaving-yucca-mountain/2015/02/08/101fccac-a8cd-11e4-a7c2-03d37af98440_story.html>.
The New York Times - <http://www.nytimes.com/2014/10/17/us/calls-to-use-a-proposed-nuclear-site-now-deemed-safe.html?_r=0>.
United States Nuclear Regulatory Commission - <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/yucca-license-review.html>.

Summarize the findings of the research through a class discussion. Have different groups report their findings and express whether they think the project should continue or be canceled. Link that answer to how much risk each group is willing to accept to get the economic and environmental benefits of a long-term waste storage facility.

<u>SAMPLE CULMINATING ASSESSMENT</u>:

- Ask the students to evaluate (high, moderate, low) the threat of pollution of the Savannah River from radioactive contaminants released from the Savannah River Site. Have students write a 100-word essay backing up their risk assessment, using examples from their classwork and other research.

Depending on one's personal level of risk tolerance, a student could choose 'high', 'moderate', or 'low' as the correct answer. The important part of the question is to have the student justify their opinion. A sample 100-word essay (for a student selecting 'high' risk) is included below:

Based on the data that we gathered and observed, the risk of pollution in the Savannah River by leaking tanks at the Savannah River Site (SRS) is high. The leaking of the radioactive isotopes into the groundwater is concerning because this water flows into creeks, which are tributaries of the Savannah River. Many radioactive isotopes have long half-lives and are dangerous to all living things and can cause genetic mutations, as well as other unintended consequences. If enough of the radioactive isotopes leak into the river it could cause major impacts to all of the organisms that depend on the river, including humans.

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Websites Used – Transport of Nuclear Waste Activity

[note that some websites may be blocked by school or district policies]

1. **General Information on Savannah River Site and Tritium Production**
   <http://www.srs.gov/general/about/history1.htm>
   - gives a concise outline of the history of events that have taken place at the Site
   <http://www.srs.gov/general/programs/dp/index.htm>
   - describes various defense programs (including tritium production) active at the Site
   <http://www.epa.gov/rpdweb00/radionuclides/tritium.html>
   - gives background information about tritium and tritium production

2. **Newspaper Articles Documenting Tritium Leaks at or near Savannah River Site**
   <http://www.nytimes.com/1992/01/13/us/anger-lingers-after-leak-at-atomic-site.html?pagewanted=1>
   - describes leak at 'K' Reactor Site in December 1991.
   <http://www.sott.net/article/272181-Radioactive-plume-in-South-Carolina-leaking-into-Savannah-River>
   - describes leak from Chem-Nuclear Barnwell Dump Site in January 2014

3. **Explanation of How Half-Life is Calculated, with Several Examples**
   <http://www.coolmath.com/algebra/17-exponentials-logarithms/13-radioactive-decay-decibel-levels-01.htm>
   - provides a formula for performing calculations involving radioactive decay.

4. **Websites Dealing With Yucca Mountain Waste Storage Site Issues**
   <http://www.yuccamountain.org>
   - Eureka County Nevada – Nuclear Waste Office
   <http://www.washingtonpost.com/opinions/leaving-yucca-mountain/2015/02/08/101fccac-a8cd-11e4-a7c2-03d37af98440_story.html>
   - Washington Post News Article
   <http://www.nytimes.com/2014/10/17/us/calls-to-use-a-proposed-nuclear-site-now-deemed-safe.html?_r=0>
   - New York Times News Article
   <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/yucca-license-review.html>
   - United States Nuclear Regulatory Commission