Earth System Science (ESS) What is Water?

Target Grade Level
Earth Science (8th Grade)

Duration
8-9 class periods

Michigan Content Expectations

- **E1.2k** Analyze how science and society interact from a historical, political, economic, or social perspective.
- **E4.1 Hydrogeology**
- Fresh water moves over time between the atmosphere, hydrosphere (surface water, wetlands, rivers, and glaciers), and geosphere (groundwater). Water resources are both critical to and greatly impacted by humans. Changes in water systems will impact quality, quantity, and movement of water. Natural surface water processes shape the landscape everywhere and are affected by human land use decisions.
- **E4.1A** Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).
- **E4.1C** Explain how water quality in both groundwater and surface systems is impacted by land use decisions.

Learning Objectives

Students will be able to:

1. Identify numerous definitions, uses, and values of water to different global places and people.
2. Recognize and distinguish between scientific, economic, and social uses and values of water.
3. Explain how multiple understandings of water contribute to current water conflicts in specific places.
4. Name the different types of global water reservoirs (oceans, glaciers, groundwater, freshwater lakes, inland seas/saltwater lakes, atmosphere, and rivers).
5. Identify the ways global water reservoirs are measured.
6. Recognize the different quantities of water in global water reservoirs.
7. Explain how different quantities of water affect water uses.
8. Explain how water protection and conservation policies can change water – society relationships.
9. Identify and explain the mission and primary goals of the Clean Water Act (CWA) of 1972.
10. Explore different categories of water pollutants and provide examples of sources, types, and impacts.
11. Find out their local municipalities' standards and current performance on drinking water standards.
12. Explain how the CWA goals (drinkable, swimmable, and fishable) affect the water –society relationships in their local area using national, regional, and local sources of agency information.
13. Explain how multiple understandings of water can contribute to water solutions in specific places.

Unit Summary

Unit comments

First and foremost, this Unit would not have been possible without the inspiration provided by Jamie Linton, author of *What is water?: The History of a Modern Abstraction* (2010). Linton is a geographer at Queen's University in Canada. His book recognizes the modern crisis of water and seeks to identify the roots of current quantity and quality problems associated with global water. In doing so, he explores the history of way societies have interacted with, defined, used, and understood water. This Unit has been created in an effort to convey the multiple identities of water alongside current Western science understandings of water. Although science education focuses on water as a 'cycle', a 'state of matter', and as an Earth system, the reality is that water and its definition can never be fixed. Addressing the current global water crisis will take more than scientific definitions, economic calculations, and environmental regulations. As Linton states: "The state of water reflects the state of society." Focusing on healing our current water – society relationships and our common future requires exploring identities of water with identities of societies.

Purpose of teaching and learning water – society relationships

What is water? Well, it's one of those simple questions that have no obvious answer. Ask the question and it will inevitably attract an "it depends" response which I believe is the most correct, accurate answer possible. But in fact, over the course of the last two centuries, scientific knowledge, political borders, technological advances, and economic progress has attempted to mask water's complexity, its fluidity, and especially, its vulnerability. 'Water' is defined, understood, and known primarily as an entity separate from humans in multiple forums across the globe but yet, upon reflection, water – society relationships are indisputable. Water is increasingly at the core of scientific, political, economic, and social problems *and solutions* worldwide. Encouraging thinking toward *solutions* will require a holistic understanding of water from multiple places and perspectives: reflecting on the historical, contemporary, and future conceptions of water, reflecting on water – society relationships.

Water – Society relationships and Graduate research

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Comment [1]: It looks like you need to complete this section about how this unit relates to your graduate research.

For each and every environmental issue, there are a slew of complex explanations. As an environmental anthropologist, my graduate research requires understanding the natural and social sciences, and how in the real world, natural and social phenomenon can rarely be separated. My work focuses on the many connections between environmental and human health. Primarily, I am concerned with synthetic toxic chemicals and the global environmental pathways they travel to accumulate in cold regions, in waters, and especially, in marine species' and human communities. *Water*, in its many forms, transformations, and activities, facilitate the constant movement of all things, including contamination. Further, synthetic toxic chemicals' travel continues to be made possible by environmental policies that do little to directly protect human health. Instead, the adoption and proliferation of synthetic chemicals takes place as abstract economic and/or toxicological calculations apart from their materializations in environments. Once in the environment, policy makers rely on the natural sciences to calculate synthetic concentrations in soil, air, water, and even living bodies. And protecting human health becomes an indirect endeavor—policy makers rely on risk communication, teaching the public how to avoid contaminated environments and exposure.

Global and regional water processes and characteristics, plus current scientific and political activities, lead to reactive and piecemeal policies and programs which forces specific communities to absorb the burden of toxic exposure, risks, and experiences. Ameliorating the adverse physical, economic, and cultural consequences of global toxic contamination in specific places will require new ways of connecting then addressing the interrelatedness and embeddedness of environmental and social phenomenon. Water – society relationships, and the teaching of those relationships, offer a major opportunity to accomplish this. This will ultimately depend on being able to communicate these connections in ways that resonate with the water – society

relationships that are important to communities, including secondary student communities. I believe that this is how we can gain support for policies that encourage healthy water – society relationships, environmental and human health as one experience.

Throughout this unit, teaching and learning content 'thickens' the relationship between water and societies, a primary objective in environmental anthropological research. In the final lesson, I chose to incorporate my research of *water* policy problems (numeric 'quality') and risk communication (fish consumption advisories) into an understanding of *Water – Society relationships* primarily focused on the Clean Water Acts' promise of "drinkable, swimmable, and fishable national waters". Implementing water – society objectives in the U.S. has proven to be unattainable, some of the reasons I stated above: policy has attempted to address these goals indirectly. The research I am concerned with requires public outreach, education, *and* the participation of multiple perspectives of environment, including water, and facilitating understandings of those perspectives. Water science alone cannot create healthy water policies and communities; 'science' is not a sole solution. Solutions require common goals, objectives, and societal values. And finally, the importance of adding historical context to teaching, no matter the subject or topic, cannot be overstated. Simply teaching U.S. environmental policy formation and environmental quality a mere 40 years ago had quite an impact on our students. They were unaware of the quality of our nation's waterways prior to the Clean Water Act; they were unaware that it was such a short time ago; they were unaware of the Act's promise; and finally, they were challenged by our nation's inability to reach these goals. In a science class, or any teaching venue, I believe it is important to highlight that current society not only doesn't have everything figured out, but we're not even close. This highlights the importance of education and content as well as their roles in the future of our society.

Expected Prior Student Knowledge
E2.1A Explain why the Earth is essentially a closed system in terms of matter.
E2.1 Earth Systems Overview
The Earth is a system consisting of four major interacting components: geosphere (crust, mantle, and core), atmosphere (air), hydrosphere (water), and biosphere (the living part of Earth). Physical, chemical, and biological processes act within and among the four components on a wide range of time scales to continuously change Earth's crust, oceans, atmosphere, and living organisms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of geochemical cycles.
E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.
E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.
E2.4B Explain how the impact of human activities on the environment can be understood through the analysis of interactions between the four Earth systems.

Lessons Table

Title and Description	Learning Objectives	Content Expectations
Lesson 1: **What is water?** "What is water?" Lesson 1 is an introduction to a five part unit using *Earth System Science* (ESS) to widen students' scientific, historic, political, economic, and social perspectives of water. We will explore multiple definitions of water and how these multiple, differing understandings of water contribute to regional, national, and global contemporary water issues. It is designed and intended to be used with students who are proficient in ESS. This lesson will introduce the study of water in the following ways: 1) by identifying numerous definitions, uses, and values of water; 2) by recognizing and distinguishing between science, economic, and social uses and values of water; and 3) by illustrating how these multiple understandings of water contribute to contemporary water issues. They will then complete an ESS concept map assignment showing an example of a water – society relationship, which will illustrate their accomplishment of the Learning Objectives.	1, 2, 3	**E1.2k**
Lesson 2: **The 'quantity' of water** "Where is all Earth's water and why does it matter?" In Lesson 2, students will be introduced to the quantification of water and what these quantities mean to the water – society relationship. What is known about the quantity of global water can be useful to human decisions and actions. Students will explore the quantification of water in the following three ways: 1) identifying the ways global water reservoirs are measured; 3) name the different types of global water reservoirs and recognizing the different quantities of water in each; 3) and explain how different quantities of water reservoirs affect the water – society relationship using ideas of water protection and conservation. They will then complete an ESS concept map, using support materials based on water quantity and the Great Lakes, of one water – society reservoir that will illustrate their accomplishment of the Learning Objectives.	4, 5, 6, 7, 8	**E1.2k** **E4.1A**
Lesson 3: **The ValueS of WaterS** "What do you mean, 'valueS of waterS'?" The valueS of waterS is the third lesson in the *What is water?* unit where students will discover many values of waters through multiple perspectives worldwide. Students will view the 2012 documentary film *Blue Gold: World Water Wars* which will draw their attention to the complexity and severity of values of waters and the importance of water – society relationships in specific places across the globe. This lesson will focus on the valueS of waterS in the following four ways: 1) by identifying water definitions, uses, and values to different global places and people; 2) by recognizing and distinguishing between scientific, political, economic, and social uses and values of water; 3) by explaining how multiple perspectives and understandings of water contribute to current water conflicts in specific places and 4) by explaining how multiple perspectives and understandings of water can contribute to current and *future* water *solutions* in specific places. This lesson will begin with the viewing of *Blue Gold* and using the handout to take notes. They will read a geographer's assessment for the water future and finally, write a reflection based on *Blue Gold* and the reading (Jamie Linton's *Water, Problems, Hope*).	13, 1, 2, 3	**E1.2k** **E4.1** **E4.1C**

Lesson 4: **Drinkable, Swimmable, and Fishable Waters** "Would you drink, swim, and fish in this water?" In the final Lesson, students will explore water quality through the goals and mission of the Clean Water Act of 1972—*drinkable, swimmable, and fishable*, EPA's national water pollution categories, and then, by looking at their own local water quality assessments and regional fish consumption advisories. The quality of water will then be explored by the water – society relationships of drinking, swimming, and fishing. Students will learn about the quality of water in the following three ways: 1) identify and explain the mission and primary goals of the Clean Water Act of 1972; 2) explore the different categories of water pollutants and provide at least 2 examples of each; 3) and explain how the CWA goals (drinkable, swimmable, and fishable) affect the water – society relationship in their local community using information from the EPA's water pollutant categories and "How's my waterway"; regional fish consumption advisories; and local municipal drinking water standards. They will then complete a series of assignments which will aid in an essay and class presentation. Each student will conduct independent research, write a draft, participate in a peer review, and present their findings in a final essay and class presentation. (Each student will be working with and presenting on different EPA pollution categories, state fish consumption advisories parts, and local municipal/well drinking water qualities' information.) This will demonstrate their accomplishments of the Learning Objectives.	9, 10, 11, 12, 13	**E1.2k**

Materials and Equipment

- Computer and LCD projector, speakers, and classroom Internet access
- DVD player and LCD projector or TV
- Multi-colored chalk/dry erase markers
- Multi-colored pencils and/or markers
- Lessons 1-4 handouts; provide a printed copy for each student
- Computer & Internet access for students
- Lesson 2 'Global water quantities' activity materials' list

Evaluation Plan

Students will be evaluated throughout the Unit on their understanding of expanded water definitions, uses, and values: water – society relationships within Earth Science systems, features, and interactions. They will create ESS models displaying different features of these relationships and use writing to explain their meanings. Every lesson incorporates informal evaluations, no 'points' are gained; and every lesson incorporates a formal evaluation, assignments for 'points'. All evaluations are intended to draw on a variety of students' skills, allowing students to be evaluated on what they know using their skill strengths, and allowing students to strengthen other skills that may be weaker. And finally, evaluations are intended to elicit a diverse set of 'correct' answers: no two students will create exactly the same model, maps, descriptions, or writings. Holistic learning and thinking requires diverse contributions. (Scientific holistic learning and thinking requires diverse contributions in the real world.)

Informal evaluations

A primary goal of this Unit is to implement all four lessons by keeping this in mind: student-teacher implementation will be 50-50. During each lesson, students will participate through note taking, partner work, and completing parts up on the board for their fellow students. They will contribute to teaching their classmates and be evaluated on their understanding by explaining each of their contributions. Further, students will evaluate their fellow classmates work by editing, revising, and/or confirming all board contributions and participation. Some of the best teaching and learning will come from students adding to each other's work, and confirming each other's work. Also during the lesson, the teacher will implement specific check points outlined

in each lesson.

Formal evaluations
Following each lesson, students will be evaluated on incorporating each of the lessons' learning objectives into their model and writing. The repetition of drawing the model, connecting Earth systems, and describing the water – society relations as interactions is intended to solidify holistic scientific *and social* thinking through doing and seeing. In the final lesson, students will explore federal, state, and local agencies' information and use that information to describe the water – society relationships of drinking, swimming, and fishing through writing. And finally, students will provide information to their classmates in presentation form (Lesson 4). This is for two reasons: 1) The number of EPA pollution categories and regional advisories is *numerous* and I wanted students to be exposed to a variety of categories and advisories' information; there are too many for the teacher to research, teach, and explore one by one. This way, all students will explore different parts of the whole and present them to their classmates. 2) And the best way to solidify personal learning, for students and for anyone in particular, is to research, teach, and explore for others about what you know. Explaining what you know in order to convey understanding to and for an audience is solid, real, and permanent learning and understanding.

Evaluation through writing
In each evaluation, the importance of *writing* cannot be stressed enough; students will be expected to describe and discuss the understanding and significance of multiple water – society relationships through writing. Each evaluation scaffolds writing expectations. Clear and holistic writing ensures that students have gained clear and holistic thinking. The two primary goals of each writing activity draws attention to explanation, reflection, and *action*: Explain what you know, the importance of knowing, *and* what you can do. Students must describe the importance of knowing different water – society relationships in their local watersheds, as a nation, and global perspectives different from their own. Writing allowed students to reflect on the sheer complexity of water – society relationship issues, social institutions, and human uses and values. I wanted to highlight the fact that science alone cannot heal water – society relationships; healing can only come from understanding that water and society cannot be separated because they are intertwined in historical, economic, political, and social ways.

Resources

1. Linton, Jamie. 2010. What is water?: The history of a modern abstraction.
2. Earth System Science (ESS) for teachers' background knowledge: http://www.qem.org/NASA-NSFConfPresentations/%20Thurs%20130/ruzek22feb07reva.ppt.pdf
3. Earth System Science (ESS) Analysis and Model: http://www.cotf.edu/ete/ESS/ESSmain.html
4. "Our Waters: Diversions of Great Lakes Waters" ("DiversionsCWeb" PDF). Available at: http://www.glwi.freshwater.uwm.edu/ourwaters/documents/DiversionsCWeb.pdf
5. 1967 Youtube video of Cuyahoga River pollution (4:46) http://www.youtube.com/watch?v=_jxV6BbREfY
6. "Burn on, big river" by Randy Newman. Available at: http://pratie.blogspot.com/2005/03/cuyahoga-river-fire-of-1969.html
7. Clean Water Act 1972 40th anniversary article
8. EPA's "How's my waterway?" Available at: http://watersgeo.epa.gov/mywaterway/mywaterway.html
9. EPA's "Summaries of water pollution reporting categories" Available at: http://www.epa.gov/waters/ir/34PARENTATTAINSDESCRIPTIONS.pdf
10. MDCH's "2011-2012 Michigan Fish Advisory A Family Guide to Eating Michigan Fish" Available at: http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf (OR *your own regional fish advisory*)
11. Documentary - *Blue Gold: World Water Wars* (89 min)
12. Linton, Jamie. 2010. "Water, Problems, and Hope" (pdf)