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Unit Overview

Subject: Water, Water Pollution, and Human Health
Grade Level: AP Environmental Science

The Design Down Process for this unit/topic/text:

This unit was constructed to occur about mid-way through the school year, after many weeks of classroom expectations and habits of mind have been established for our course. Students in this course have regular outside reading/homework, in class writing and lab experiences and an interactive notebook. Our daily routine consists of lecture (content delivery) through a Data of the Day lens (a modified Frayer model) that uses data to focus and expand instructional opportunities and scientific discourse through case study and data literacy). Students are also working on various thinking and questioning models, developing Community Action Projects (CAPS) and now an inquiry project around the question **What is Good Water?** When creating daily activities and experiences for the students I am constantly asking myself, "How does this knowledge help my students understand their modern world and the cost/benefits of Environmental decision making, the decision makers, and the societies that they represent?"

Essential Question: **What is Good Water?**

Timeline – 6 Week Unit including:
(3 assessments (quizzes – standards based, example of one with student work included) 4 assessments (lab/writing – standards based examples of 2 labs with student work included), 1 culminating project (students work in teams, have two deliverables each) inquiry development template and examples of student work included, 1 assessment of notebook class/homework, self/teacher evaluation tool included.

Data of the Day Sets: Global Chemical Production; LD-50 Graphs; Watersheds, Ocean Currents, Where is the World's Water (water distribution globally), Global Water Use (green, blue and grey water clarification using Hoekstra's data), Projected Ocean Acidification, Farm size/number Data (USDA, 2012) – focus on Hog Farming (in relationship to Berry's writing *What are People For?* And *Waste*); Biological Magnification (in relation to Rachel Carson's *Silent Spring*), Clean Water Act and Clean Water Rule

Scientists/Research Teams/People/ Writers referenced and utilized within this unit:
A.J. Hoekstra (Direct/Virtual Water use specialist team from Europe); Rachel Caron (*Silent Spring*) ; selected writing, by John Muir (Sierra Club); photo gallery of Teddy Roosevelt (National Antiquities Act of 1906 – land conservation movement in American West); Wangari Maathai (Green Belts Movement from Kenya); Annie Leonard (*The Story of Stuff*, *The Story of Cosmetics*); Elizabeth Kolbert (*The Sixth Extinction*); Wendell Barry (*What are People For?), Your Water Footprint* by Steven Leahy, The Clean Water Act

of 1972 and Clean Water Rule of 2016 (US Environmental Protection Agency), United Nations Sustainable Development Goals, *Idaho's Sewer System*, High Country News, *California Drinking Water Crisis*, High Country News, *The Estimated Social Cost of CO2*, National Academies Press 2017, *155 things to know for the AP Environmental Science Test*, Little via Albert.io.

Laws/Government Agencies/International involvement to understand:
Environmental Protection Agency (EPA), Clean Water Act of 1972; Clean Water Rules of 2016; Regulation vs. Economic Gain; United Nations – Food and Agriculture Organization, World Health Organization; World Bank (finances global infrastructure projects), Paris Climate Treaty 2016.

EQ: What is Good Water?
Unit: Water, Water Pollution and Human Health
Chapters 17, 9 and 14 (Environmental Science for AP), Ch 5, 6, 7 of *The Sixth Extinction* by Elizabeth Kolbert
Grading System Used: Standards Based Grading, 4/3/2/1/0 Proficiency Scale in use

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<td colspan="2">Content / Curriculum Learning Goals:
On Earth water is abundant, but useable fresh water is scarce. All organisms rely on water. The biotic and abiotic exchanges within our world's water systems are incredibly dynamic. Mankind's primary water use is agriculture, so water conservation and waste are deeply connected to feeding the world and sustainable food production. However, our manufactured goods also carry a water footprint that must be conceptualized, and our water systems and ecosystems are particularly vulnerable to pollution. Clean water and sanitation are instrumental in preventing disease and the rise out of poverty. Human beings also produce a great many chemicals that are released into our water ways, often with limited research about their long term effects in the huge open system of the biosphere. Water inequities occur world-wide between classes in society, and clean water is often a commodity that can be fraught with corruption. Clean and plentiful water is a symbol of environmental justice in every country on Earth. Changes in the state of matter between our liquid and frozen and atmospheric water are also instrumental for understanding sea level rise, coastline degradation, intrusion into aquifers, changing extreme weather patterns, and many ecosystem imbalances in fresh and saltwater systems. Water availability and quality can be considered a limiting resource for all organisms, including humans.</td>
<td>UN Sustainable Development Goals –
Where does this learning fit?
Directly related to water and toxicity
Goal 3: Good Health and Well-Being
Goal 6: Clean Water and Sanitation
Goal 9: Industry, Infrastructure and Innovation
Goal 14: Life Below Water
More Indirect: cross cutting goals
Goal 1: No Poverty
Goal 2: End Hunger
Goal 10: Reduced Inequalities
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Production and Consumption
Goal 13: Climate Action
Goal 15: Life On Land</td>
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<td>Modality / Literacy Skill Development
• Writing and speaking with focus questions around common readings (Socratic Seminar and class discussions)
• Quick writes around questions of water, water use, water conservation and water footprints.
• Creating a research question around service learning</td>
<td>Best Practices (Instructional Design) Research Based High Yield Strategies
☐ Similarities and Differences
☐ Summarizing and Note Taking
☐ Reinforcing Effort by Procedural Recognition
☐ Homework and Practice</td>
<td>State Standards (and College Board), and HS Engineering Standards
☐ HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs</td>
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project (CAPS – Community Action Project).

Peer Feedback and Self Assessment
Writing and cultural analysis regarding inspiring scientists and literary connections
Cooperating on a Water Team to support background research and individual success.
Creating an inquiry question and diving deep with research around a water inequity or system imbalance.
Creating a presentation regarding that inquiry
Composing a “System and Purpose” Poster
Thinking & communicating through a system imbalance with a solutions mindset

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☐ Nonlinguistic Representation
☐ Cooperative Learning
☐ Setting Objectives and Procedural Feedback
☐ Generating and Testing Hypotheses
☐ Cues, Questions and Advanced Organizers
Qualities of Engaged Student Work:
☐ Personal Response
☐ Emotional/Intellectual Safety
☐ Sense of Audience
☐ Learning with Others
☐ Choice (meaningful options)
☐ Novelty and Variety
☐ Frontloaded for Success on culminating tasks
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and wants.
☐ HS – ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
☐ HS – ETS1-3 Evaluate a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.
☐ HS – ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between the systems relevant to the problem.

College Board charges AP Environmental Science Teachers to teach:
Land and Water Use (10-15%)
Pollution (25-30%)
Global Change (10-15%)
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Vocabulary to know
<u>Leaching:</u> removal of dissolved materials from soil by water moving downwards
<u>Soil Conservation Methods:</u> conservation tillage, crop rotation, contour plowing, organic fertilizers.
<u>Soil Salinization:</u> in arid regions, water evaporates leaving salts behind. (ex: Fertile Cresent in southwestern US)
<u>Conservation:</u> allowing the use of resources in a responsible manner.
<u>Preservation:</u> setting aside areas and protecting them from human activities.
<u>Water Logging:</u> water completely saturates soil and starves plant roots of oxygen, rots roots.
<u>Hydrologic Cycle Components:</u> evaporation, transpiration, runoff, condensation, perception and infiltration.
<u>Watershed:</u> all of the land that drains into a body of water.
<u>Aquifer:</u> underground layers of porous rock allow water to move slowly.
<u>Cone of Depression:</u> lowering of the water table around a pumping well.
<u>Salt Water Intrusion:</u> near the coast, overpumping of groundwater causes saltwater to move into the aquifer.
<u>ENSO:</u> El Nino Southern Oscillation: See-Sawing of air pressure over the South Pacific.
<u>During an El Nino year:</u> trade winds weaken and warm water sloshed back towards South America. Diminished fisheries off South America, drought in western Pacific, increased precipitation in southwestern North America, fewer Atlantic hurricanes.
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Science Practices – where will we focus this unit:
☐ SP1: Asking Question
☐ SP2 Develop and Use Models
☐ SP3: Plan and Carry Out Investigations
☐ SP4: Analyze and Interpret Data
☐ SP5: Use Math and Computational Thinking
☐ SP6: Construct Explanations
☐ SP7: Engage in Argument from Evidence
☐ SP8: Obtain, Evaluate and Communicate Information from a variety of sources
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Effects of El Nino: Upwelling decreases disrupting food chains; Northern US has mild winters and Sothwest US has increased rainfall, less Atlantic Hurricanes. La Nina: "Normal" year, easterly trade winds and ocean current pool warm water in the western Pacific, allowing upwelling of nutrient rich water off the West Coast of South America. Composition of Water on Earth: 97.5% Seawater; 2.5% freshwater Ways to conserve water: Agriculture: drip/trickle irrigation; Industry: recycling; Home: use gray water, repair leaks, low flow fixtures, different types of yard (zeroscape not planting Kentucky Blue grass), time of day watering… Gray Water: Any wastewater from a house EXCEPT TOILIET WATER; (dish water, shower water…) this water can be used for irrigation water… Aquaculture: farming aquatic species, commonly salmon, shrimp, tilapia, oysters. Point Source: source from specific location such as pipe or smokestack Non-point Source: (Area/Dispersed Source): source spread over an area such as agricultural/feedlot runoff, urban runoff, and traffic runoff. Primary Sewage Treatment: first step of sewage treatment; eliminates most particulate material from raw sewage using grates, screens, and gravity (settling). Secondary Sewage Treatment: second step of sewage treatment; bacteria breakdown organic waste; aeration accelerates the process. BOD: (Biological Oxygen Demand), amount of dissolved oxygen needed by aerobic decomposers to break down organic materials. Eutrophication: rapid algal growth (algal bloom) caused by an excess of nitrogen and phosphorous, blocks sunlight, causing the death/decomposition of aquatic plants, decreasing dissolved oxygen (DO), suffocating fish. The rapid growth is caused by an excess nitrates $(NO_3)^{-1}$, and phosphates $(PO_4)^{3-}$ in water. Hypoxia: water with very low dissolved oxygen levels, the end result is eutrophication. The BOD rises as aerobic decomposers breakdown the plants , the dissolved oxygen (DO) drops and the water cannot support life. Fecal coliform (Enterrococus bacteria): Coccus (round shaped bacteria); indicator of sewage contamination (Happens over the summer at Chatfield or Cherry Creek Reservoir once in a while.) Chlorine: Good: disinfection of water; Bad: forms trihalomethanes (this group of compounds are byproducts of chlorination and are known carcinogens)	Some selected Idaho Core Standards that seem to be cornerstones in the course, and how they will be assessed this unit: SLST.11-12.1 (effective collaboration) SLST.11-12.2 (integrate multiple media) SLST.11-12.5 (strategic use of digital media) RST.11-12.1 (cite specific textual evidence) RST.11-12.8 (evaluate hypotheses and data analysis) RST.11-12.9 (synthesize information from a range of sources) WST.11-12.2 (write informative/explanatory text including technical processes) WST.11-12.5 (develop and strengthen with drafts and feedback) WST.11-12.8 (gather relevant info from multiple authoritative print and digital sources)
People/laws/history/Acts to know/reference material A.J. Hoekstra (Direct/Virtual Water use specialist team from Europe); Rachel Caron (*Silent Spring*) ; selected writing, by John Muir (Sierra Club); photo gallery of Teddy Roosevelt (National Antiquities Act of 1906 – land conservation movement in American West); Wangari Maathai (Green Belts Movement from Kenya); Annie Leonard (*The Story of Stuff*, *The Story of Cosmetics*); Elizabeth Kolbert (*The Sixth Extinction*); Wendell Barry (*What are People For?), Your Water Footprint* by Steven Leahy,The Clean Water Act of 1972 and Clean Water Rule of 2016 (US Environmental Protection Agency), United Nations Sustainable Development Goals, *Idaho's Sewer System*, High Country News, *California Drinking Water Crisis*, High Country News, *The Estimated Social Cost of CO2*, National Academies Press 2017, *155 things to know for the AP Environmental Science Test*, Little via Albert.io, Environmental Protection Agency (EPA), Clean Water Act of 1972; Clean Water Rules of 2016; Regulation vs. Economic Gain; United Nations – Food and Agriculture Organization, World Health Organization; World Bank (finances global infrastructure projects), Paris Climate Treaty 2016.	**Cross Cutting Concepts- Where we will focus this unit.** ☐ CC1: Patterns ☐ CC2: Cause and Effect ☐ CC3: Scale, Proportion and Quantity ☐ CC4: Systems and System Models ☐ CC5: Energy and Matter ☐ CC6: Structure and Function ☐ CC7: Stability and Change

Difficult concepts and skills that will take discreet teaching, learning and practice, some of which we work on all year (*enduring understandings).	**Concepts students should be able to familiarize themselves with successfully from the text**
• Research Skills, Data analysis • Ecosystem Services of the land and water systems • Negative Externalities and Unintended Consequences • Systems Analysis (Open vs. Closed, Inputs vs. Outputs) • Positive Feedback Loops (Constructive or Destructive) • LD-50 experiments and Toxicity Curves • Calculating the safe human mg/kg using LD-50 data or curves • Biological Risk vs. Chemical Risk vs. Cultural/Behavioral Risk vs. Physical Risk • Cost / Benefit Analysis • The abundance of freshwater vs. salt water • Blue Green Grey Water analysis • Direct and Virtual Water Footprints • Aquifers: structure and function; drawdown, refill (confined/unconfined) groundwater pollution, saltwater intrusion and cone of depression • Water treatment, water as a commodity • Ocean currents: lateral and depths, along with tilt of earth, El Nino, La Nina, and Coriolis effect → driving atmospheric patterns • Watershed and Runoff (Basins) • Points Source and Non-Point Source Pollution • pH – as a mathematical/logarithmic calculation and the concept of Ocean Acidification and relationship to CO_2 level increase globally.	✓ Major historical and emerging infectious diseases. ✓ Relationship of disease to water (water borne illness) ✓ 5 major types of toxic chemicals: carcinogens, teratogens, allergens, neurotoxins, and endocrine disruptors. ✓ Dose response studies and retrospective studies. ✓ Chemical concentration ✓ Bioaccumulation (biological magnification principles) ✓ Precautionary principle vs. "innocent until proven guilty" principle for chemical use and approval (or restriction). ✓ Water cycle and hydrologic "zones" ✓ Water management: levees, dams, canals, irrigation, distribution and conservation technologies. ✓ Industrial, agricultural and household water use. ✓ Water as a commodity, water rights. ✓ Human wastewater as a health problem/risk ✓ Sewage treatment technologies ✓ Heavy metal and chemical water pollution ✓ Oil spills (coming back to that again during energy with another set of labs) ✓ Nonchemical pollutants such as thermal, trash, noise and sediment ✓ Water pollution legislation

Reflection: Notes on specifics that the instructor noticed definitely take more than one crack to learn, or those that indicate too many assumptions about background knowledge were made:

Stage 1: Desired Results **(What will I be formally assessing? What are the enduring understandings and rich performance tasks throughout the unit?)**	**Essential Question:** **WHAT IS GOOD WATER?**

Major Unit Goals and Enduring Understandings:
***Formation of Water Teams, established research toward a Point of Inquiry (individual, with support of Water Team).**

Content Flow:
Investigation 1: Human Health and Toxicity
Major content threads of human health and the main types of environmental risk: Physical Hazards, Chemical Hazards, Biological Hazards, and Cultural Hazards.

- ✓ **Our entrance into this thinking is by having the students keep a 24 hour log and investigate the cosmetic products they use.**
- ✓ **We then must get a handle on how toxicity it measured and how LD-50 experiments are set up.**
- ✓ **We must practice calculations (using estimation) of LD-50 and mg/kg calculations based on LD-50 graphs.**
- ✓ **We must understand the "precautionary principle" of toxicology research vs. the "innocent until proven guilty" mentality of many chemical producers and unknowing consumers.**

Tools and Documents in the Investigation 1 Folder:
***Unit Planning Template Included in e-folder**
***Toxicity LD-50 graph quiz and practice included in e-folder**
***Simple 24 hour cosmetics tracker was used as an anticipatory set (along with Annie Leonard's *The Story of Cosmetics*).**
Investigation 2: Where is the World's Water?

- ✓ **We looked at water distribution data which is generally given as percents within percents… such as "0.9% of 3% of the world's water is found in the atmosphere" This data does not communicate well, so we made a model. Modeling lab and accompanying student work is attached.**
- ✓ **Socratic Seminar regarding chapters 5, 6, 7 of *The Sixth Extinction* by Elizabeth Kolbert. Students wrote their own focus questions and we had resident fact-checkers that recorded the "minutes" of the conversations. To fully understand this reading we had to delve deeper into the issue of pH and Ocean Acidification in relationship to CO_2 levels in the atmosphere.**

Tools and Documents in the Investigation 2 Folder:
***Water Team Formation (using shared google tool with students – sample attached)**
***Where is the World's Water modeling lab samples included**
***Socratic Seminar student work samples included**

Investigation 3: How do we use water?

- ✓ **Some key learning goals of this work is for students to understand how our modern scientists are studying global water use, how water is used directly and indirectly (sometimes known as virtual water use) in our manufactured goods and our foods, and how water can be best conserved.**
- ✓ **We utilized several water footprint calculator tools (online) and some infographics (samples included) from *Your Water Footprint* by Steven Leahy.**
- ✓ **To assess this standard I had students (on an instrument that looks like a quiz) where my students had to design a consumer label for a food or manufactured item that would communicate water footprint (and many of them included other sustainability information that consumers may want to know such as country of origin, carbon footprint, miles, and worker treatment.: Sample student work included. They also had to make proposals for water conservation installation in a new school project. They utilized Boise High's water use data and projected conservation technologies for a hypothetical new school design, including toilet improvements, types of faucets and sinks, HVAC possibilities, irrigation upgrades, grey water catchment ponds, and educational benefits. This item looks like a quiz, but it is more of a performance task than a typical quiz. (also student work attached).**

Tools and Documents in Investigation 3 Folder:
***Water Footprint Calculator Labs and Inquiry Included**

Investigation 4: How do we abuse water? (Why did we need an EPA, why do we still need an EPA? How does the Clean Water Act serve us in the United States?)

- ✓ **This is our ultimate culminating project on the water team. They have two deliverables and are divided up into water teams representing water pollution and conservation issues from all over the world. To do this I had to:**
- ✓ **Have them form water teams based on interest**
- ✓ **Create shared files of background information useful to the whole team (sample included).**
- ✓ **Develop a research question. (development tool and student work included)**
- ✓ **Know how to use the peer reviewed data bases.**
- ✓ **Create a presentation about their inquiry**
- ✓ **Create/compose a "Systems and Purpose Poster" (student sample work and project checklist included)**

Tools and Documents in Investigation 4 Folder:
***Inquiry question generator included**
***Presentation and Poster guidelines included**
Research team "huddle" tracker created for use toward end of the unit (also was able to give timely coaching feedback with the "huddle")
***Dice Game for peer review "hotseat": with Systems and Purpose poster.**

***Students work samples included in "student work folder"**

Subquestions/Guiding Questions:
How do we know something is safe *enough*?
What is a negative externality?
What is an unintended consequence?
What is environmental justice?
To what extent is life on land changing the world's water ecosystems?
Where is the world's water?
How do we use water directly?
How do we indirectly use water?
How do we abuse water? (pollution)
Is water a human right?
Who owns water? Who should be able to sell it, why do we need to buy it?

Misconceptions:
Because the water cycle is continual, it seems we could never run out. How do we begin to understand that water may not always be where and when society needs it?

Service Learning:

We had two formal service learning opportunities within this unit.

CAPS project (Community Action Project) – Service to Community (with a focus on individual action playing a role in environmental sustainability).

What is Good Water Project – Service to World – a deep understanding of this entanglement of human civilization and adequate and safe water resources, as well as the impressive power of changing hydrologic relationships (such as sea ice melt or sea level rise or extreme weather events).

Stage 2: Learning Activities: How will I help my students learn, keeping in mind: Curricular Coherence, Motivation/continuing impulse to learn, and planned practice/expertise in threshold knowledge

Stage 3 Assessment of Learning Strategies: **(guiding questions: How will students present and share what they have learned? How will they use precise expectations/procedural feedback to evaluate their work? How will assessment tools be matched to the goals/situation and learning (as well as AP expectations)? How will learning be applied during the unit? How will it connect to the next unit?** **How will students cultivate transfer, imaging, preparing for how they use what they have learned now and in the future?**
Student Self Assessments (practices in use regularly in class) ***Self assessment of reading/classwork in Interactive Notebook** ***Self-assessment of success/celebrations/roadblocks on CAPS project** ***Self assessment (time management tool) used in "huddle"**
Student Peer Assessment (practices in use regularly in class) ***Small group sharing and Peer Feedback given** ***Poster coaching (structured) so that students give this coaching to each other – photo in presentation** *** water team formation allows for frequent and simple grouping/regrouping for multiple self/small group/ whole group interactions each and every day.**
Instructor Assessment Philosophy ***Both labs and "quiz" items are necessary – but the giving of constructive procedural feedback is essential.** ***Learning is valued most; grades are assigned by creating learning opportunities and students producing evidence of learning.** ***Science mistakes or misconceptions must be uncovered and re-examined** ***Proficiency scales are in use, I have eliminated points from our system. This has created fantastic creativity and opportunity, and makes me rethink much of the "what are my students doing today" piece of my practice.** ***The students are the experts of their own thoughts and the true discoverers of their own inquiry path. I am their facilitator (I call it being a 'science waitress'** ***To be successful, intentional modeling of behaviors, skills, and classroom processes must be in place. These have been built now for months and are fluid. This is part of the work of an inquiry-based classroom.**