Title: Integrated Science and Water Technology

Length of Course: Full Year (2 semesters; 3 trimesters; 4 quarters)

Subject Area – Discipline: Laboratory Science ("d") – Integrated Science

UC Honors designation: No

CTE Sector: Energy, Environment and Utilities

CTE Pathway: Environmental Resources

Grade Level(s): 10-12

Prerequisite(s): Solving Water Problems Through Integrated Science (UCCI)

Course Overview:

Integrated Science and Water Technology is a second-year college preparatory laboratory science course that integrates Next Generation Science Standards with the CTE Environmental Resources Pathway. Building on foundation knowledge gained in *Solving Water Problems Through Integrated Science,* the pre-requisite to this course, this course provides students with an understanding of the cyclical relationship humans have with our water supply. The course establishes a career pathway for students interested in earning a certificate or degree in Water Supply Technology, providing an opportunity for them to explore a variety of potential jobs available in the water industry. Students conduct experiments on water quality, research and raise public awareness of the effects of contaminants, observe the economic impact of moving water to the community, learn how to treat water and evaluate the impact human activity has on this natural resource.

Course Content:

Unit 1 - Finding Water

In this unit, students evaluate the impact that human activity has on our limited water resources and gain familiarity with particular work individuals might do in various jobs as they relate to finding water. Through small-group interaction they conduct research to identify areas across the globe where water is scarce, or projected to be scarce, in the future. Students identify lifestyle decisions that contribute to decreased water availability and develop real-world solutions to reverse or slow its depletion. Students will also learn of the relationship between surface water and groundwater and how this relationship affects vegetation and water quality. Lastly, students will examine the roles of the federal

and state government in managing water resources, learn about water rights and evaluate legal claims that apply to water rights.

Unit 1 - Assignments

1. Global View of the Wet Earth

In this assignment, students work in small groups to evaluate the impacts of human activities on our limited water resources by conducting research to identify major population centers and the availability of potable water to these populations. Through research, students will identify countries that are currently water-scarce and countries projected to be water-scarce in the future. Students within their groups will then identify the relationship between population centers and fresh water sources and how human activity affects water sources. Student teams will then discuss and identify some possible environmental and cultural factors leading to water scarcity and determine ways to prevent misuse, while evaluating factors such as economic impact and cultural acceptability. Groups present their ideas to the class through a poster session gallery and then develop a Public Service Announcement to educate the American public on reducing water waste.
http://water.epa.gov/learn/kids/drinkingwater/upload/The-Water-Sourcebooks-Grade-Level-9-12.pdf

2. Water is More Priceless Than Gold

In this assignment, students will be asked to outline the four different types of water rights laws in the state of California as a means to develop an understanding of California's vastly overcommitted supply of water. Students will work in groups to explore Water Rights Laws (Riparian, Appropriation, Prescriptive, Pueblo and Federal) and create outlines that summarize each one. They will then analyze the Mono Lake case study of a water-rights issues in California and create a timeline of water diversion and the environmental movement that is restoring the area. Students will complete a simulation to evaluate how to bring California's water supply and demand into balance comparing successful water supply balancing strategies. Through this, students gain experience drawing informed conclusions based upon: researching and defending claims, interpreting and analyzing information. Drawing on knowledge gained from their research, students will prepare for and engage in a formal/town hall debate with the "mayor and council" (students), leading to a decision to grant or deny water rights to a large agricultural firm interested in relocating its operation given scarce water supplies. This unit will conclude with an introduction to local water careers.
http://water.epa.gov/learn/kids/drinkingwater/upload/The-Water-Sourcebooks-Grade-Level-9-12.pdf
http://www.calrecycle.ca.gov/eei/UnitDocs/EarthScience/E9c/E9cTE.pdf

Unit 2 - Examining Water

In this unit, students move from an analysis of where water comes from to an exploration of water quality and how that quality is maintained. Students will do this, in part, through

the work of various jobs such as an *Industrial Waste Inspector* and an *Environmental Compliance Inspector*. Whenever possible, students should interview industry personnel working in those jobs as a research method or information gathering tool for completion of assignments. Students will use water quality indicators to test the quality of three different water sources using proper experimental design. Students will be able to analyze data on water quality and explore the effects of contaminants on human health and ecosystems. Using the movie Erin Brockovich as a platform, students will observe how drinking water contamination can affect human health and create a public service announcement. Students will simulate how antibiotic resistant bacteria evolve, learn the danger of how emerging contaminants enter the water supply, and write a children's book to illustrate strategies to prevent these things from happening.

Unit 2 - Assignments

1. Properties of Water

Part 1: In this activity, students will build a three dimensional water molecule, and model its bonding properties in order to understand how its polarity lends itself to being a solvent. Students will then progress through a series of labs to illustrate the properties of solubility, adhesion, cohesion, surface tension, density and capillary action in order to understand how easily water is able to adhere to other things as well as cohere to itself. Students will then investigate the solubility rate of molecules under different temperatures, and write a balanced equation for the reaction.

- http://www.ck12.org/chemistry/Structure-of-Water/lesson/Structure-of-Water/?referrer=featured_content
- http://www.myteacherpages.com/webpages/jflynt/files/Sticky%20Molecule%20Activity.pdf
- http://www.amphi.com/media/1086851/water%20properties%20lab2011.pdf
- chem.engr.utc.edu/asee/2011-vancouver/**reactions**-experiments.doc

Part 2: Students will then transfer this concept to an examination of cleanup methods used during the Exxon Valdez or BP oil spill. Students will then read about the Exxon Valdez or BP Oil Spill, how dispersants were used to clean them up and the effects of the oil and dispersant on the environment. Acting as an Industrial Waste Inspector or HAZMAT team member, students have just arrived on the scene of an oil spill. They need to write a memo to their crew detailing which dispersants they plan to use, how they will work and what impact they will have on the surrounding environment.

2. Why Laws? A Case of Contamination

For this assignment, students will read the Clean Water Act and Safe Drinking Water Act in order to understand the reason for MCL limits in our water supply. Students will also watch the movie "Erin Brockovich" about the Erin Brockovich Pacific Gas & Electric case of 2000 in order to be exposed to a real life example of environmental toxicology. After gaining an understanding of DNA and its role in human health, students will, in pairs, research chromium as a contaminant, including investigating the mutagenic properties of chromium, and create a public service announcement as the local Environmental

Health and Safety Officer for the residents of Hinkley explaining the connection between the CWA/SDWA, environmental toxicology and the potential mutagenic effects of pollutants on DNA. This assignment introduces students to the subject of toxicology explored further in assignment three.

CWA (Clean Water Act) http://www2.epa.gov/laws-regulations/history-clean-water-act
SDWA (Safe Drinking Water Act)
http://water.epa.gov/lawsregs/guidance/sdwa/basicinformation.cfm

3. Evaluating Water Quality Results

In this assignment, students will further develop their knowledge of potential water contaminants. Using a copy of current local water quality test results, students will analyze the data. From that data, they will choose two contaminants that are closest to their MCL limits and research their effects on human and ecosystem health, tracing potential sources of contamination as well. Acting as an Environmental Compliance Inspector, they will create a 3-5 minute multimedia presentation in the form of a PowerPoint or Prezi or other platform showing their research and findings regarding the specific contaminants to the local city council.
http://water.epa.gov/drink/contaminants

4. Water Quality Testing

Assuming the role of water quality technician, students are tasked with determining which water source would be best suited for filling fresh water aquariums for the local dentist office. As water quality technicians, students will test factors that impact water quality, as it pertains to sustaining the life of freshwater fish, such as pH, turbidity, dissolved oxygen, nitrates, phosphate, chloride, carbonates, hardness and total dissolved solids. Utilizing tap, bottled and pond/stream water, groups will develop hypotheses regarding which water type has higher levels of each factor. They will produce data tables and graphs in spreadsheets, analyze data comparing their data to appropriate MCL's, and draw conclusions. A final report will be prepared for the dentist regarding which water source is the best choice for her aquarium, including an explanation regarding why the chosen water is best for the fish.

5. Emerging Contaminants—What Are They and Why Do We Care?

During this assignment, students will explore genetic variation and inheritable traits in order to understand development of antibiotic resistant bacteria. Students will begin by playing a simulated game which demonstrates the importance of taking the full dose of antibiotics. Additionally, they will understand why stronger bacteria are left behind when people don't complete their medication as prescribed. Students will complete an online simulation to discover how misuse/overuse of antibiotics result in evolution of antibiotic resistance in bacteria. Students will then take on the role of a public health educator by creating a Public Service Announcement which describes the evolution of heritable resistance in bacteria, the problems associated with antibiotic resistance in human health, and the ways in which these bacteria infiltrate the water supply.
http://www.eduplace.com/science/hmsc/6/a/simulation/simcontent_6a.shtml

http://www.glencoe.com/sites/common_assets/science/virtual_labs/LS08/LS08.swf
http://learn.genetics.utah.edu/content/microbiome/resistance/
https://www.nrdc.org/health/files/dosed4pgr.pdf
http://www.flinnsci.com/store/Scripts/prodView.asp?idproduct=22028

Unit Three - Storing & Moving Water

Students now move from analyzing water quality to analyzing and solving problems related to how water is stored and transported to consumers. Through this, students will gain familiarity with water technology work done by facilities engineers, water transfer operators, combustion turbine technicians and meter technology managers. Students will illustrate the relationships among ecosystems affected by the human impact involved with water storage and movement. Using their knowledge of gravity and pressure, students will develop a model that demonstrates their understanding of how water flows from treatment plants to reservoirs and on to households. Students will demonstrate that water temperature, flow and quality has an impact on biochemical reaction rates in a water ecosystem. Students will create a final report and action plan for a community that has been negatively impacted by the construction of a dam.

Unit 3 - Assignments

1. Reservoirs: What Goes Up Must Come Down

In order for students to identify and understand the role reservoirs play in water distribution they will explore the role of pumps and gravity in municipal drinking water distribution. Students learn how clean, treated water is delivered to homes, schools and businesses using a system of underground pipes, pumps and above and below ground storage reservoirs. Cooperative learning groups will be assigned a water delivery system, i.e., treatment to underground reservoir, and will construct a flowchart poster illustrating the assigned system. Groups will use a gallery walk to observe to compare and contrast the delivery systems.

2. The Best Dam Assignment in the World (include geography; google maps)

Students will investigate the chemical, physical and thermal changes that flowing water undergoes when it is stopped by the formation of a dam. Students will work in groups to research specific case studies of various communities around the world where the construction of dams have made a significant impact on their ecosystems. The research will correlate the length of time water is stored in a reservoir to the overall deterioration of water quality. Students will also investigate the effect of seasonal temperature changes on the quality of the water and the life cycles of aquatic organisms. They will also analyze how the temperature changes, differing levels of dissolved solids, and changes in dissolved oxygen affect reaction rates and how the change in rates affects water quality and respiration and photosynthesis rates in aquatic life. If possible, students should collect and analyze water and soil samples from their communities to gather data on the above variables for contrast or comparison.

Students will combine the information from their research to arrive at a final conclusion of how the water quality in the reservoirs in the dam in their assigned community impacted

the surrounding community and develop solutions on how to return the ecosystem to balance. Students will develop a final action plan to present to their city council members.

Unit Four - Treating Water

This unit serves to introduce the principles of water treatment and the particular work associated with the water treatment field through an understanding of the behavior of water and its interactions with the treatment unit for contaminants removal. Students will use a systems-based approach to understand that all industrial and public owned systems consist of matter and will apply this knowledge to solving current and future global water issues. This unit seeks to explain the basic technological resources required to understand crucial water treatment in order to encourage students to take a critical approach to solving complex water- related issues on a local and global scale. Upon completion of the unit, students will be able to integrate the complex questions surrounding the future use and consumption of water and develop possible solutions to this global crisis.

Unit 4 - Assignments

1. Industrial versus POTW Systems Flushed-water Storybook

Students write a creative story/storyboard that follows the life of flushed water as it moves through the various stages of its life in a POTW (Publicly-Owned Treatment Water Facility) and an industrial treatment facility. Throughout the assignment, students must demonstrate a thorough understanding of a wastewater treatment plant and how it behaves differently from a water treatment plant. Students gain an understanding of how water changes as it travels into wastewater treatment facilities and ends up in a home as drinking water. Students demonstrate understanding of a solid, liquid and gas (by BOD, COD, TSS, MLSS, F/M ratio) by describing and illustrating these in their storyline as part of the disposal product. Students demonstrate water moving through all the stages of the wastewater plant, describing both physical and chemical changes. In service of this, students gather background information of how humans have impacted the water cycle by introducing industrial processes and explain how water is extracted as a residual process of the industrial process and ultimately moves through an industrial water treatment facility. Students may also include the industrial and wastewater treatment plant operator job. This exposes students to man-made systems that have been engineered to transport and purify water as they will learn more about the job opportunities in this fields. Teacher can prepare a tour to a wastewater facility: during a tour of a wastewater treatment plant, students gain firsthand knowledge of the specific roles that professionals/workers play in the treatment of industrial water. Students articulate their questions to the staff and record answers to the questions they have after their research.

2. Pros and Cons of Different Treatment Systems

Students will split into teams to research what types of filtration treatment systems exist: filtration, microfiltration, ultrafiltration, reverse osmosis, as well as disinfection processes widely used in the industry as part of a treatment system such as chlorine, chloramines,

hypochlorous solutions, ultraviolet, ozone among others. Students will use their textbooks or variety of online resources provided by the teacher to determine and analyze the basic components of a treatment plant. Students visit a treatment facility and investigate online job recrutiment sites (BCWaterJobs.com, Indeed.com, Monster.com, etc.) to learn about the requirements for and daily responsibilites of various water treatment jobs. Working in groups, students create charts that show specific job titles that correspond with certain filtration strategies. Students present their models to the class and discuss which elements are present in treatment plants in their city.

3. Primary Stage Filter Design

Students will identify the common water contaminants and materials (trash, liquid, gases) found in stormwater by creating a diorama or tactile, 3D poster showing objects frequently trapped by primary-stage filtration. To demonstrate their understanding of how traps function students will then build a physical model capable of fitting in a stormwater drain. Student will test their actual-size devices with multiple dyed liquids chosen for their various consistencies (water, molasses, cooking oil, corn syrup, etc) including plastics and cans (diapers, flowers, leaves, nuts, marbles, feathers, rubber stoppers, etc). Students will pre-screen the large items and record their observations about the effects their removal has on subsequent treatment efforts. To further understand the principles of contamination and classification of matter both chemical and physical, students will record the relative changes from the initial solution and later compare their final values. They will observe the sedimentation process of the residual in an imhoff cone, and calculate the total solids. After this experiment is done, students will filtrate the liquid part to calculate the total suspended solids. Using digital media, students will research the ecological impact and need to clean and treat the stormwater basin prior discharge into surface water. Students will prepare a report with their observations and conclusions.

4. Desalination: Ocean and Energy Factors

Students will get into groups of 3-4 and research the need for desalination, the main characteristics of the process, problems with materials in working with high levels of salt and corrosion, and energy usage. Students should also calculate how much energy is needed to distill the water as one of the drawbacks of desalination is that it takes huge amounts of energy. They should look up how much energy is needed in large scale desalination and compare that amount of energy to other methods of water treatment/purification. In other words, how much energy does it take to get a liter of clean water using different methods. Students will present their findings in class.
In addition, students will practice a simple distillation lab or a fractional distillation lab- Students will be distilling salty water and separate salt from the water/salt mixture by manipulating the difference between salt and water. Water's boiling point is 100 degree Celsius, so water will boil and turn into a gas before salt will. Measurements will be made of the chemical water condition at the beginning and end to conclude.
https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_desal/cub_desal_lesson01_activity2.xml

Students will then use their research to determine what combination of factors would make desalination an ideal method for a community to use for obtaining their water. Students will find a real world community that meets those specifications, and create a report detailing why desalination would work best for them. Students will pick one other method that they learned about this unit, and in their report show why desalination would be a better choice for their community than an alternative water treatment method. Students should consider relevant environmental factors in the region/community and conduct additional research if necessary. Students should include in their recommendation/report a description of any relevant chemical/biological processes.

5. Drinkable Water

Students research and analyze ways to remove impurities or contaminants from an aquatic sample. They will examine the effectiveness of different filtration media. Students will begin by identifying a problem (for example: what kind of material will be removed from the sample?) and hypothesize the effects this would have on population for water consumption. Students will then brainstorm solutions to this problem and identify a product that could be engineered to allow both the human use of this resource and ensure the health of the environment. The teacher will provide different materials for filtration media (per example: Sand, fabric, paper, cotton, sand, zeolite, activated carbon). Students are given a case study outlining a scenario in need of filtration. Students propose a specific filtration system, test the basic chemical and physical properties (pH, turbidity, temperature, chlorine level, odor, color, hardness, alkalinity, conductivity) of their sample to establish a baseline. Students test their systems and create a report outlining the effects and results of this filtration device. This will include failures and successes of their device and summarize all potential contaminants in their sample. Students will also justify their filtration rate with reasons outlined in their report on how it can be improved.

Unit Five - Sharing Water

Water is a finite resource. During this unit, students develop an understanding of what it means to share water in a closed system. In order to understand the importance of sharing water, students move through a series of assignments aimed at promoting an understanding of their responsibility as a user of a public resource. Students will evaluate their personal consumption of water, utilizing web-based assessments, and develop a model for low water use home. Understanding EPA/FDA regulations for water contaminants leads to evaluation of a case study regarding biomagnification of mercury in the environment and an understanding that what we put in water supplies affects food webs in all ecosystems. Students then move from a personal relationship with water to an ecosystem perspective. Why is it important to share water within an ecosystem, keeping in mind that there are both human-centric and fauna/flora-centric perspectives ? How does the development of dams affect riparian systems? From there, students will again move to a bigger picture covering how climate change and reduction of water availability affect people regionally and globally. Is privatization of a public resource valid under the Public Trust Doctrine? What are the effects of water insecurity in developing countries? In order for students to be well-rounded members of the water technology field, they must have a clear and global understanding of water issues around the world.

Unit 5 - Assignments

1. Low Flow in the Home

During this project, students will utilize a water use assessment to evaluate their home water usage on a monthly basis. They will then research home methods (grey water, low flow faucets/toilets, water catchment methods, landscape choices) for both interior and exterior water conservation. By doing so, students will learn water is a limited resource. After learning various methods, students will apply their knowledge to create a poster showing a cross-section elevation design of a single family, low water use home, in which they highlight both interior and exterior conservation methods.

2. Biomagnification in Ecosystems

Students will closely read a case study to examine FDA and EPA recommendations for tuna consumption due to biomagnification of mercury from coal-powered plants into water sources. Additionally, students will examine mercury wet deposition maps to determine where mercury content is highest in the United States and how this contaminant affects ecosystem viability. After understanding biomagnification and food chains, students extrapolate information from the case to create an oceanic food chain showing accumulation of mercury in tuna. Students research, via FDA/EPA regulations, an additional compound that biomagnifies, and create a radio/TV public service announcement educating the public about how to protect themselves from the toxin, as well as how to reduce their contribution of the toxic to the environment. In doing so, students develop an understanding of how toxins enter our ecosystem and how the public must protect itself and adjust to a changing environment.
PCBs in the Last Frontier: A Case Study on the Scientific Method or Tuna for Lunch?
http://sciencecases.lib.buffalo.edu/cs/files/mercury_in_fish.pdf

3. That Dam Effluent

In this assignment, groups of students are provided with materials to construct a scale model of a dam (and its surrounding environment) in order to study the impact that dam effluent has on a downstream ecosystem. By releasing water at different rates and intervals, students have an opportunity to assume the roles of hydrologist or riparian ecologist and quantify specific changes that take place to the landscape, such as ecosystem flooding/changes in river banks/effects on flora and fauna, as a result of large water releases. As a hydrologist, students will explore effluent effects on groundwater systems as well. For example, students consider how the amount released affects the basin/river bank's ability to absorb water and extent of sedimentation. Students use this information to make a recommendation to the water district about whether it should release small, medium, or large amounts of water. The recommendations should be backed up with observations made while operating the scale models.

4. Snowpack Trends in California

Water is a commonly held resource regulated by the Public Trust Doctrine and the California Constitution, Article 10 which states all water use must be reasonable and

beneficial. To set the stage for discussion of water as a public resource, students will participate in a "Tragedy of the Commons" lab (see below). Students will take what they learned from the lab to determine how water is shared among multiple stakeholders—how is it divided between public and private ownership? Students are asked to consider the question: As snowpack and water availability decrease due to climate change, should private companies still be permitted to draw from m the public resource to produce a product sold for profit that is not shared in the public domain? Students will gather data regarding temperature and snowpack in California over the past 50 years. They will create a spreadsheet and line graph correlating the change in temperature with the change in snowpack. Individually, students will utilize evidence from the lab, research and data to establish an opinion in writing regarding whether bottled water companies should be permitted to remove water for profit from the public domain. Does their opinion change based on times of water crisis? This activity introduces students to the issues involved in privatization of a public resource and leads into a more local discussion in activity five focusing on the California drought. http://apcentral.collegeboard.com/apc/members/repository/ap03_apes_tragedy_stu_35071.pdf

5. Disappearing Before Our Eyes

In this assignment students build models of glaciers and design an experiment to explain how the rate of retreat changes as the environment heats up and as the size of their "glacier" changes. In anticipation of building scale models of glaciers, students learn about the formation of glaciers and the environmental conditions that promote their growth and/or sustenance. In building and testing their models, students design an experiment to answer the primary question: Does a glacier melt at a quicker rate as its size decreases? If so, does one size parameter (surface area or depth) affect the retreat more drastically? Or is the rate simply a function of temperature? After conducting the experiment, students are asked to research glaciers throughout the world that they think are at-risk for disappearing in the near future. Students plot these on a shared Google Map, and the class collectively discusses any patterns that seem apparent. Students must justify, in an oral argument in front of the class, their plotted glaciers based on the data and parameters of their experiment. Finally, students will discuss how glacial melt is a significant source of water in developing countries. How does the recession of glaciers due to climate change affect water security of indigenous people in developing countries? Should foreign companies be permitted to privatize the water supply in such countries. In partners, determine all the ways loss of water by indigenous people will impact their lives. Students will then utilize a carbon footprint website to evaluate their own contribution to climate change gasses and develop a personal plan for reducing their footprint.

Final Project: Water Technology

You have inherited a large piece of valuable river waterfront property and enough money to "develop" (draw) the land, to build a luxury eco-friendly resort. Using knowledge from throughout the course, design a plan to build the resort but protect the environment as

much as possible. Students will work in groups or individually to address these 5 unit issues:

1. Legal claims that apply to the water rights
2. How the quality of the surface and groundwater is maintained
3. How the water will be transported from an underground reservoir to the resort
4. How greywater will be treated and used on the property
5. Whether any of these actions polluted or added materials to the waterway.
6. This project could be done as multiple drawings or 3D models with a presentation providing justification for design choices, and a written proposal about how their resort will address these concepts.
   Based, in part, on the Sum of the Parts activity by Project Wet.

Texts:

District approved Earth Science Textbook
District approved Life Science Textbook
District approved Environmental Science Textbook