**Title: Solving Water Problems through Integrated Science**

**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):** 9-10

**Prerequisite(s):** Elementary Algebra

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**Course Overview:**

This course is designed to allow students to explore key Earth Science and Life Science concepts as they pertain to the water industry and is the first course of a three-course integrated science sequence designed to align with the Next Generation Science Standards. For deeper understanding of scientific concepts and how those concepts apply in the careers within the water industry, students will have the opportunity to assume the role of several individuals employed in water-related careers, each with a role in trying to solve the water problems faced by the fictional city of Wateropolis. All assignments will prepare students to complete the capstone project: a portfolio of all materials and a plan to improve the sustainability of Wateropolis.

*For the purposes of teachers implementing this course, the following specifications of Solving Water Problems are useful to know and understand:* The fictional city Wateropolis is located in Southern California, on an alluvial fan approximately 150 miles inland and 1000 feet above sea level. The city is bordered by a mountain range on one side that rises 8,000 feet and has the typical seasonal changes that occur with mountain ranges at this elevation. The mountains are heavily used for recreation including hiking and fishing the streams and creeks. These waterways play an important role in the watershed and water supply for Wateropolis. One small creek converges with a larger river in the center of the town and continues through the town, through a southern wetlands, and eventually empties into the ocean. The residents of Wateropolis number approximately 75,000. Many of these residents are active in local government and are particularly concerned about the water supply including the possibility of running out of water or flooding.

**Course Content:**

## Unit 1 - Wateropolis, the History of Water in Our Town

To better understand their new home, students will explore the concept that water is important to all living things, study the origins of the components of water from the formation of the universe, pollutants and the laws of motion as it relates to the water supply. Through this work, students learn about the different kinds of work undertaken in the water industry, which requires many different types of employees to deliver water to residents and businesses. Assignments allow the student to explore tasks and work related to different careers within the water industry, such as water quality technicians, laboratory specialists and engineers. This work then allows students to explore at an introductory level the fundamental processes required to plan water supply demand, transport water within a city and ensure safe drinking water for the final project of developing a new plan to create a more sustainable water supply for Wateropolis.

### Unit 1 - Assignments

#### From the Ground on Down

Students work in small groups to complete models of an aquifer to demonstrate the connections between surface and groundwater in a residential neighborhood. Students will address the orogeny of the local mountains and explain some sources for the recharge and discharge of groundwater, and describe the relationship between soil grain size and water flow rate. Students will also identify the liquid passing rate including porosity, permeability, capillarity and rate of change. After completion of the lab, students will answer questions on their lab report describing where groundwater comes from (precipitation: snow, sleet, rain) and what would happen to a neighborhood in terms of the effects on vegetation and water quality if a well were drilled near a stream or pond and enough water pumped to lower the water table (some water from a stream or lake would be removed by the pump through the well. If enough water were removed, the stream or pond might go dry). Students will repeat lab procedures, this time using soil taken from various locations in their community.
http://www.wef.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2534

#### How Much Water?

Per person water use statistics, known as Gallons Per Capita Per Day (GPCD) are a measurement tool used by politicians, water managers, conservation specialists and other personnel at every level of the water industry. GPCD documents how much water each person uses for all needs including personal needs, cooking, laundry and outdoor use. This number also quantifies water supply and allows industry professionals to plan both near-term and long-range issues. For the final project, students will need to assess projected water use for Wateropolis. To begin the process of assessing future water demand, students will perform a lab exploring how much water they and their other family members currently use by conducting a water audit at their home. Audit forms are available on the internet. After the audit is completed, in teams of 4, students will document their home water use and their own water provider's GPCD in a computer spreadsheet program such as Excel. Students can then project the water demand for

each of the next 20 years by applying an annual growth percentage. Water use statistics (GPCD) are readily available on the State Water Resources Control Board website for every water purveyor in California. That website is www.swrcb.ca.gov. After exploring why using less water is important, students will compare the water usage of their own city to other nearby cities of similar size and will examine how their city's water use impacts their city and their neighbors in a multi paged essay. This information will become part of the portfolio and used in the final project to plan water supply for Wateropolis.

### What's in my Water?

The emphasis of this lab is the effect of treatment on water quality. Like water operators and laboratory workers across California, students will perform experiments to discover and identify common additives and pollutants such as chlorine, lead and nitrates in water. Students will use commercially available test kits that can identify these chemicals. Once a pollutant is identified, students will research the possible sources of the pollutants by correlating the water testing data to what around their own area could be causing the pollutants in the water. Students are given the acceptable levels in drinking water as well as documented methods to reduce pollutants. Students will document their findings in a lab report. This lab is critical to assist students in completion of their final project to develop a portfolio of all materials and a plan to improve the sustainability of Wateropolis.

### The Mechanics of Water Flow

All municipal water systems utilize gravity to distribute water through a system. Students will become familiar with gravity, different water storage options -- tank vs reservoir vs ground recharge -- and with the mechanics of water flow by observing how changes in pipe diameter or conduit height of water source and pressure affect the flow rate in a flow simulation model. Students will diagram how the changes in elevation affect flow rate by plotting a graph on graph paper or graphing programs such as Excel. From the graph, using the line of best fit, students can predict flow rate and pressure from any particular elevation. Students will document their findings in a lab report. This information will be useful for upcoming assignments that pertain to water flow, distribution systems and the development of a more sustainable plan. The online flow rate model is located at: https://phet.colorado.edu/en/simulation/legacy/fluid-pressure-and-flow

### Moving California's Water

In this investigation, students will be working in groups, to understand that water must be distributed from its source to residences and businesses at a safe flow rate and pressure. Students will research and/or interview a city planner or engineer to learn the components in a water system. Further, they will obtain information from text about the California Water Projects. Students will use topographical maps to explore California's hydrologic regions and regional water transfers. They will then evaluate how the California Water Project services the needs of all Californians. They will use the information obtained in this assignment to inform the Moving Water lab in Unit two.

## Unit 2 - What Do We Really Know About Water?

Students will analyze natural water sources, the cause and energy related to floods and debris flows, and sediment erosion and depositional environments as they affect the fictional town of Wateropolis. Students will also learn about the roles of civil engineers and FEMA risk analysts as they relate to the water industry -- determining sites for water storage based on analysis of possible sites and assessing the risk of flooding to Wateropolis. Students will also explore industry standards of Stormwater Design Best Management Practices. Through thinking through the problems of water shortages and flooding, students will be prepared to devise a sustainable water plan for town of Wateropolis in the final unit.

## Unit 2 - Assignments

### Moving Water

Students will create a blueprint (drawing) for approval by the city engineer (instructor) of a water distribution system model before building the design. Building supplies may include pvc pipes, joints, straws, or other materials that can be utilized for the system. From this activity students should see the connection between height and gravity instead of using electric power to move water, and should explain the connection in their lab report and/or presentation to the city engineer. Combining this information with the knowledge gained from the previous lab assignment, students should be well equipped to address concerns that could arise in building a dam in unit three.

### Vaporized

The residents of Wateropolis are still not completely convinced that their water supply is adequate and are demanding reservoirs in case of an emergency. They will calculate the rate of evaporation of these new bodies of water by modeling evaporation rates in the lab and using this data to draw a conclusion. They will take into account the changing seasons and temperature. As if they were a civil engineer, students use planning skills to choose a site for the proposed reservoir or storage tanks and have a class discussion about the concerns of building an open reservoir systems. Then students will utilize their GPCD as well as evaporation rates organized geographically to select reservoir site near Wateropolis. They will submit a 3D prototype or drawing of a reservoir system that can supply the increased water demand.

### Washed Away

A neighboring town to the fictional town of Wateropolis was recently destroyed by flooding and debris flows and so now residents are anxious about that possibility as well. Building on their analysis of potential sites for water storage in the previous assignment, students will work as a FEMA risk analyst to assess the risk of flooding to Wateropolis. They will work in small groups to obtain information about Stormwater Design Best Practices and create a "Poster Session" presentation for their classmates.

*Note:* Some of these labs can be done on a computer using the free Google Earth Program or other GIS software useful in designing a water system or solving flood

problems. ESRI ArcGIS software is also a possibility. ESRI offers some basic services for free or a free trial can be accessed at this website: http://www.esri.com/software/arcgis

## Unit 3 - Water and Ecosystems

Based on their work in previous units, students now have knowledge of the natural progression of water from an ice cap to Wateropolis. In this unit, students will explore the correlation between human water consumption, including recreational purposes and the ecological impact on different species and their habitats. Leading up to the final project, students will study the effects of municipal and recreational projects on the ecosystem and natural resources of a given area by acting as field techs, habitat restoration specialists and resource conservationists. Students will apply their knowledge of limiting factors of an ecosystem as they pertain to water storage and water use in a given municipality. Students will also examine the importance of a rich biodiversity within an ecosystem and its preservation when undertaking projects associated with water in a given area. The unit culminates in a paper and presentation. The presentation of research will be on the effects of various building projects on the local ecosystem and propose a way for Wateropolis to incorporate both recreation and water storage projects into future city plans while preserving the ecology of the area.

## Unit 3 - Assignments

### Ecosystem Biodiversity

Limiting factors affecting biodiversity of ecosystems.The residents of Wateropolis were in need of more water for an expanding golf course. The stream used to run away from the golf course and was re-routed to accommodate for the expansion. This re-routing of the stream has constricted the water flow of the original stream to 2/3rds its original flow impacting the fish population on the stream. When recreational and industrial areas coexist, their water use impacts one another as well as the local natural environment. In order to apply this knowledge, students will work in groups of 2-3 as field technicians to examine the effects of low water flow downstream on the native fish population. To simulate the changing water flow of the stream students will conduct a lab using dissolved oxygen probes. Students will increase the temperature of the water over time. They will record in a chart, over time, the temperatures and test for the amounts of dissolved oxygen. Students will obtain information about the minimum dissolved oxygen requirements for various organisms. Students will then analyze the data from their charts and explain the correlation of lowered water levels increasing temperatures, which decreases oxygen levels in the water (which makes oxygen the limiting factor) for the fish population. The fish, in turn will have a lowered carrying capacity. While constructing a lab report, students will also apply their knowledge of ecological and environmental repercussions of human impacts on the biodiversity of an aquatic ecosystem.

This will also be applied in the multimedia project in assignment 3.

1. Restoration Proposal: Mitigation for golf course expansion. Since the residents of Wateropolis wanted a bigger golf course, which is damaging to the attached

riparian area, the developer has agreed to mitigate the damage by restoring the local wetland with endangered (plant, bird, fish or insect) species.

***Optional:* In order to provide further background, teachers may want to find a case study that might apply to their local area for students to read. The Department of Fish and Game has called students in as habitat restoration specialists. Students will research the given species to understand its niche and place in the aquatic ecosystem. After completing this research, students will use the research to form the basis of a report that provides information on the species, its niche within the wetland, its food source and its migration season and pattern, if applicable. Student reports will also include a proposal for restoring the wetland to optimal habitat for chosen species.

2. Policy Recommendation Project: Our town needs a new plan! The water source in Wateropolis is starting to run low due to the building of recreational sites for an increasing population. In order to support the new population with water while still maintaining old and new recreational sites, students will work as resource conservationists and create a policy recommendation for local legislators. In this project students will work in groups of 2-3 to create a policy recommendation that would allow both ecological conservation along with recreational uses, like the golf course, to coexist. The presentation must include the following: The scope of the problem (issue), sustainable/renewable/conservation solution and rationale that would protect the water source in the area. Presentation will be done in Keynote, PowerPoint, Google Presentation, or Prezi. This assignment prepares students to complete the portion of their final project in which they must use their understanding of impacts that municipal projects have on the surrounding ecosystems in order to design a city that produces and uses water in the most sustainable way.

## Unit 4

The growing population of Wateropolis has increased water demand. In response to the increased water demand, the City Council has requested staff investigate the possibility of a new dam for water conservation and flood control. Students will work as geologists and environmental biologists to determine whether a suitable location is available for a dam. Students will conduct an experiment examining various types of rocks and material that might be found in the damned area in order to determine if a dam is feasible. This will include an analysis of the rock and minerals and the liquid passing rate of water in different soil mediums. Students will also explore the possible ecological effects of a dam including the effects on native fish, birds and amphibians. Students will then apply that knowledge in an action report on the pros and cons of building a dam.

## Unit 4 - Assignments

### Assignment-multimedia project

Students will watch *Damnation*, a movie about the environmental devastation that dams can cause. Working as environmental biologists for The Department of Fish and Game, students will research the ecosystem or individual species that could be harmed by creating a dam by examining a native species in a river or stream near their own home. They will then choose an existing dam and obtain information about: location, history, pros, cons, ecological impacts and current uses. Based on the information gathered students will then create a "visitor guide" pamphlet about the dam. After this preliminary work, students work in groups of 2-3 to prepare a multimedia presentation for the mayor of their city (or other relevant official) that details the pros and cons of dams as it relates to water conservation.

**Final Project: Wateropolis 2.0**
After much debate, many residents and leaders in Wateropolis rejected the idea of building a dam to meet the city's growing needs due to the environmental impact of such a project. Instead, city leaders and water system managers have been called upon to develop a water plan that will meet the growing city's needs but protect the environment as much as possible. Using knowledge from throughout the course, the student will design a new water distribution system focused on supply, conservation and sustainability. They will address residential use, wetlands, agriculture and landscaping. Students will work in groups or individually to address these 4 unit issues.

1. Water needs of the community
2. Natural sources for water
3. Ecological impacts for recreational areas/conservation efforts
4. Human impacts

This project could be done as a physical 3D model design of a town with a presentation providing justification for design choices, written proposal how to make their town more sustainable or a written essay about their new fictional town addressing these concepts.

*Optional:* Projects can be presented to the water board with new sustainable plans of their own local town.

**Texts:**

**District approved Earth Science textbook.**
**District approved Life Science or Biology textbook.**