How Many People Can the Aquifer Support?

Student Tasks

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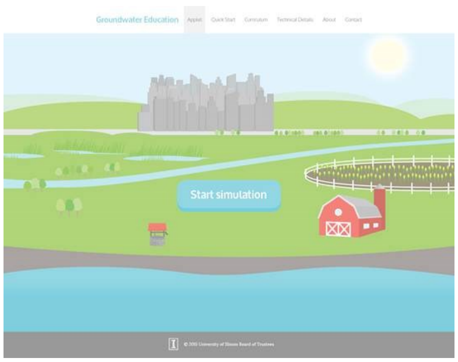
See teacher plans for alignment to the Next Generation Science Standards

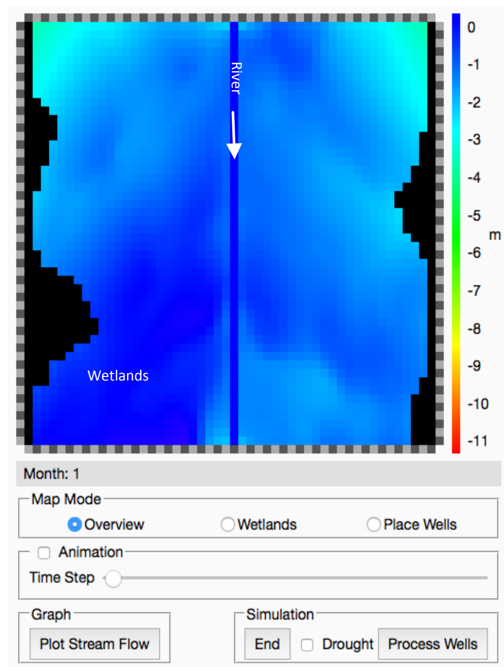
Aquifer Exploration

Task 1: The Groundwater Simulation



Engineers use models to help them test solutions, make predictions, and draw conclusions. In this activity, you will be using an online simulations that models the relationships between an aquifer, human activity, and natural disasters. After exploring the simulation, you'll be collecting and analyzing data so that you can create your own model to explain how to keep the aquifer healthy and stable.

Open the Groundwater Simulation in a web browser. Click on *Start Simulation* and load the ***No Development*** scenario. http://groundwater.cee.illinois.edu/



A **map** will load showing the water table of a region in which *no human activity* or development has occurred. Each cell represents an area of 0.2 km by 0.2 km and is measured to a depth of 100 meters. Each cell on the map is a color that indicates how far beneath the surface the water table is found, as shown by the key on the right side of the map. Cells that are black are not part of the aquifer.

- Click the *Animate* box to observe the changes that occur to the aquifer over the course of 60 months. The animation will continuously loop, until you uncheck *Animate*.
- Record your initial observations below:

Part I: City Scenario

Load the ***City*** scenario. In this scenario, three city wells have been drilled to meet society's needs. The city wells in this scenario pump a constant –15,000 m^3/day.

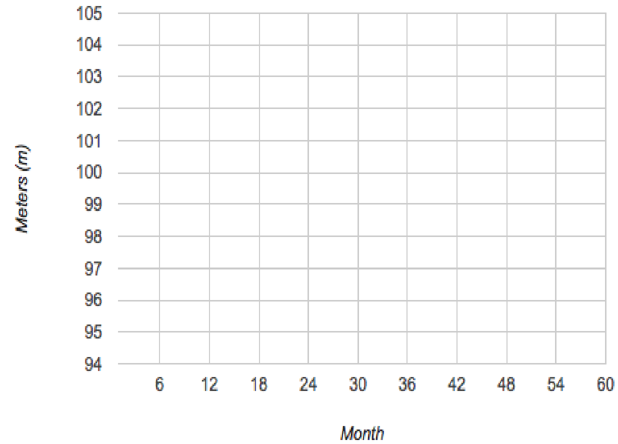
- What does the negative sign mean?

- Look for ***patterns*** as you watch the model animate. Stop the model at any point and describe your observations below:

- How are these patterns and observations different than those you observed in the *No Development* scenario?

Click on any cell in the **City** scenario.

Cell: (_____ , ______)



- Sketch the graph that is displayed on your screen on the axes to the right. Be sure to label all lines—refer to the *Data Bar* under the map for help.
- Using the information in the *Data Bar* or the graph, explain how you can find the depth a well must be drilled in order to reach the aquifer. Write this in words and as an equation. Draw a picture.

- Find the water table depth from the surface for the cell above for months 6, 12, 18, 30, 26, 54, and 60. Is there a pattern in this data? Is it similar to the pattern you described earlier? If yes, how?

- What causes the pattern(s) you observed in this scenario? List all ideas.

Part II: City + Farm Scenario

In this scenario, two farm wells are added to the city wells, which continue to pump at –15,000 m^3/day. The wells on the farm pump only during the growing season, and the amount that is pumped varies each month as shown in the table below.

	May	June	July	August	Sept	Oct
Farm Pumping Rate (m^3/day)	-203.20	-4836.16	-8717.28	-6238.24	-1930.40	-772.16

Load the ***City + Farm*** Scenario and watch the five-year animation loop.

- Click on the same cell as you did in Part I, and compare the graph on your screen to the graph you sketched on your paper. List all similarities and differences that you observe.

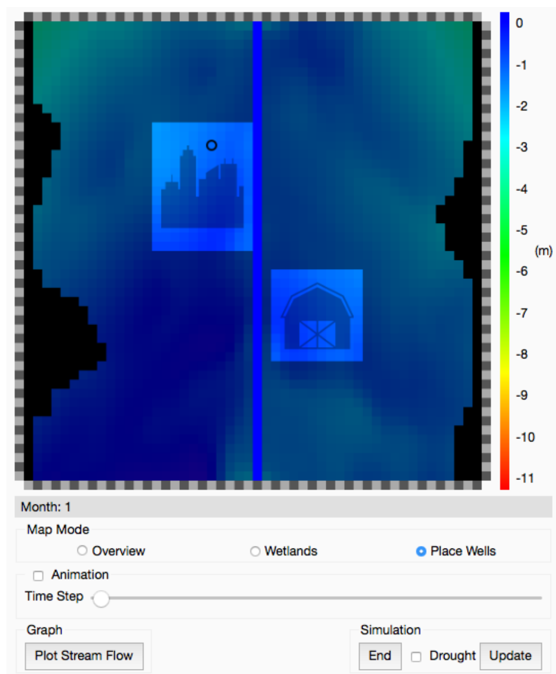
- Are the pattern(s) you observed in the ***City*** scenarios present in this scenario? Explain.

- Make the same calculations in this scenario (using the same cell as before) that you did on the previous pages for months 6, 12, 18, 30, 26, 54, and 60. Is there a pattern in this data?

- Let the animation cycle again. Pause when you see a cell turn red. How far below the surface is the water table for a red cell? What does this tell you?

- In *Map Mode* select *Wetlands*. All wetland cells are highlighted in bright blue in the simulation. Select any wetland cell and calculate how depth of the water table. Using this information, write a definition for *wetland*.

Part III: No Development



This scenario starts with no human activity, and allows you to experiment so that you can observe the cause and effect of pumping water for the city, the farm, or both.

Add A Well

Select *Place Wells*. The city and the farm area will be highlighted. Click on any cell in one of these regions to place a well there. To remove a well, click on it again. Choose a pumping rate between 5,000 and 15,000 gallons a day for city wells. Farm wells pump at different rates throughout the growing season as shown in the table on the previous page.

After placing a well, click *Update* so that the simulation can make changes to the data.

Pump It Up

- Add two more wells, click *Update*, and then check *Animate.* Record some observations below:

- Add as many wells as possible. What did you choose the city pumping rates to be? What looks different when you have 8 wells pumping at the same time? Record your observations below.

Aquifer Sustainability

Task 2: Computational Models

Human activity directly impacts the surface of the earth and can alter its natural processes. When towns are being developed, hydrologists, engineers, and city planners must make careful decisions about how to use the region's natural resources to support the community. To maintain stability, a balance must be struck between society's needs and what the earth can provide. Pumping more water than what can naturally be replenished is a recipe for disaster.

Task: Your group will create a computational model of the simulation's aquifer to be used by hydrologists, city planners, and engineers as development of a community is planned. Your model must allow city planners to make recommendations on how big the community's population can grow while maintaining the aquifer responsibly.

In order to complete this task, your group first needs to decide what a healthy, sustainable aquifer looks like. Look back at your work from the *Aquifer Exploration* handout and revisit the simulation. What can you examine and/or measure that would indicate that the aquifer is stable? For instance, your group might decide to examine the area of the wetlands as an indicator of aquifer health (this has been done as an example for you).

Choose: 3 Indicators of Aquifer Sustainability using the Claim-Evidence-Reasoning to support your work.

	Indicator of Aquifer Sustainability	Indicator of Aquifer Sustainability	Indicator of Aquifer Sustainability	Indicator of Aquifer Sustainability
Claim A statement about the health of the aquifer	*Example: The area of the wetlands indicates the overall health of the aquifer*			
Evidence Data, graphs, etc. from the simulation that support your claim	*In the No Development scenario:* *In January of each year for five years, the wetland area is approximately 250 cells on the map* *After adding 5 city wells at maximum pumping rates, and 1 farm well, the wetland is only 59 cells in January of year 5.*			
Reasoning An explanation or justification for how the evidence supports your claim	*When "over pumping" in Part III on the first task, the area of the wetlands significantly decreased. This means that the water table is no longer at the surface, and to get to the water, one would have to drill a well.*			

Part II. Developing the Model

The model your group will develop with be mathematical and be done using a spreadsheet. Models are used to represent a system, understand problems, and to find or test solutions. Models should always be based on evidence, and are refined over time as more is learned.

The data that is collected for your computational model should be well thought out, and organized. Your answers to the questions below will describe your procedure for constructing your model.

1.) Choose 2 of your Indicators of Aquifer Sustainability to investigate. Why were these chosen?

2.) You will collect data for both of these indicators. What data will you collect? Be specific.

Indicator 1: Indicator 2:

3.) *How* will you collect data from the simulation (e.g. monthly, yearly, every six-months, etc)? Explain your reasoning.

4.) What are your independent and dependent variables for each data set?

Indicator 1: Indicator 2:

More Information:

- The city (residential) part of the community is 6.16 km^2. The farm is 3.99 km^2.
- The city can have up to five wells. Each well can pump between –5,000 and –15,000 m^3/day.
- The farm can have a maximum of three wells for crop irrigation during the growing season, May through October.
- The average 4-person American household uses 1.5 m^3 of water every day. 70% of this water comes from inside use such as flushing the toilet, taking a shower, and doing laundry.
- 1.0 m^3 = 264.17 gallons