STAGE 3 SCIENCE

Running Dry

FOCUS AREA - Digital Technologies

Outcomes explored

A student:

- Plans and uses materials, tools and equipment to develop solutions for a need or opportunity ST3-2DP-T

Skills Focus

- Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships
- Employ appropriate technologies to represent data
- Compare data with predictions
- Present data as evidence in developing explanations

Content:

- Using and Interpreting Data

Content focus

Students:

- Develop knowledge and understanding of project management
- Learn abstraction and the relationship between models and real-world systems they represent

Australian Syllabus Links:

- ACTDIK015

STAGE 3 MATHS

Running Dry

FOCUS AREA - Whole Numbers 2

Outcomes explored

A student:

- Selects and applies appropriate problem-solving strategies, including the use of digital technologies, in undertaking investigations MA3-2WM
- Gives a valid reason for supporting one possible solution over another MA3-3WM

Content focus

Students:

- Interpret integers in everyday contexts, eg temperature

Australian Syllabus Links:

- ACMNA124

Running Dry

FOCUS AREA - Data 1

Outcomes explored

A student:

- Gives a valid reason for supporting one possible solution over another MA3-3WM
- uses appropriate methods to collect data and constructs, interprets and evaluates data displays, including dot plots, line graphs and two-way tables MA3-18SP

Content focus

Students:

- Pose questions and collect categorical or numerical data by observation or survey
- Constructs displays, including column graphs, dot plots and tables, appropriate for data type with and without the use of digital technologies
- Describe and interpret different data sets in context

Australian Syllabus Links:

- ACMSP118
- ACMSP119
- ACMSP120

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Having access to fresh water is vital for cooking food, washing clothes, bathing, drinking and for businesses to provide products and services to the community. Water in the Central Coast is harvested from rivers, creeks, dams, weirs and underground aquifers. Water is accessed in a variety of ways and one such way is groundwater bores. A groundwater bore is when you drill down into the earth to find water locked under the soil. This water is pumped out of the ground to be utilised by the community. There are approximately 870,000 groundwater bores in Australia to provide fresh water to rural and metropolitan areas. The Central Coast has groundwater bores located in Woy Woy, Mangrove Weir, Wyong Creek, Somersby, Ourimbah and Narara. The Woy Woy borefields can extract the most water out of all the borefields in the Central Coast. This location can produce up to five million litres of water a day and send it directly to the Woy Woy Water Treatment Plant as an emergency supply in case of water shortages during drought.

The Central Coast has a mixture of hard rock and sand aquifers that contain water. The quality of water depends on the source of water, how long the water has been stored underground, the quality of the water coming into the aquifer and structure type of the aquifer. This activity uses a simulation developed by The **Concord Consortium** to demonstrate how groundwater bores acquire water and the various components that can affect how aquifers gain and lose water over time.

The variables to pay attention to are rain, soil types, aquifer structure, recharging points of aquifers and consumption of the bore. The Central Coast goes through cycles of droughts or an abundance of water.

Understanding how rivers, creeks, and aquifers can be impacted by over consumption is a very important issue for water security for the community.

Figure 1 Mardi Dam

Introduction

1. Open The link to "Exploring Groundwater Movement" https://has.concord.org/groundwater-movement.html
2. The initial start-up screen will look like Figure 2 below.
3. Notice the term "well" is used in this simulation. Groundwater bore is an Australian term that is equivalent to a "well" in the USA.

Icon Key

- Refresh icon (1) – allows you to restart the program and remove all options.
- Add Well (2) – allows you to choose either flowback or non flowback well (ground water bore). We will be using a *non-flowback* well option for this entire simulation.
- Start/Stop/Reset (3) —This button will allow you to start the simulation, pause it or reset.
- Template (4) – pre-made layers to for modelling.
- Rain Probability (5) —This is the control for the rain to fall during the simulation.

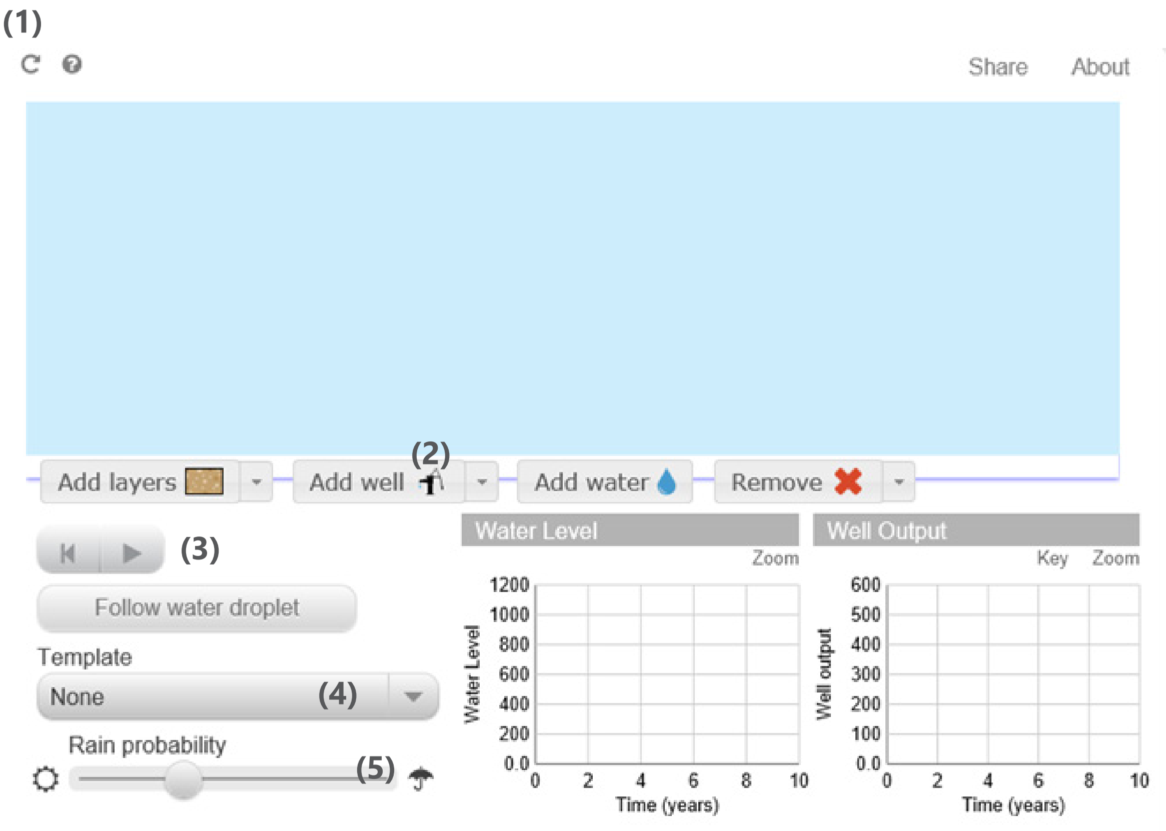

Figure 2 (Lab Licence https://github.com/concord-consortium/lab/blob/master/license.md)

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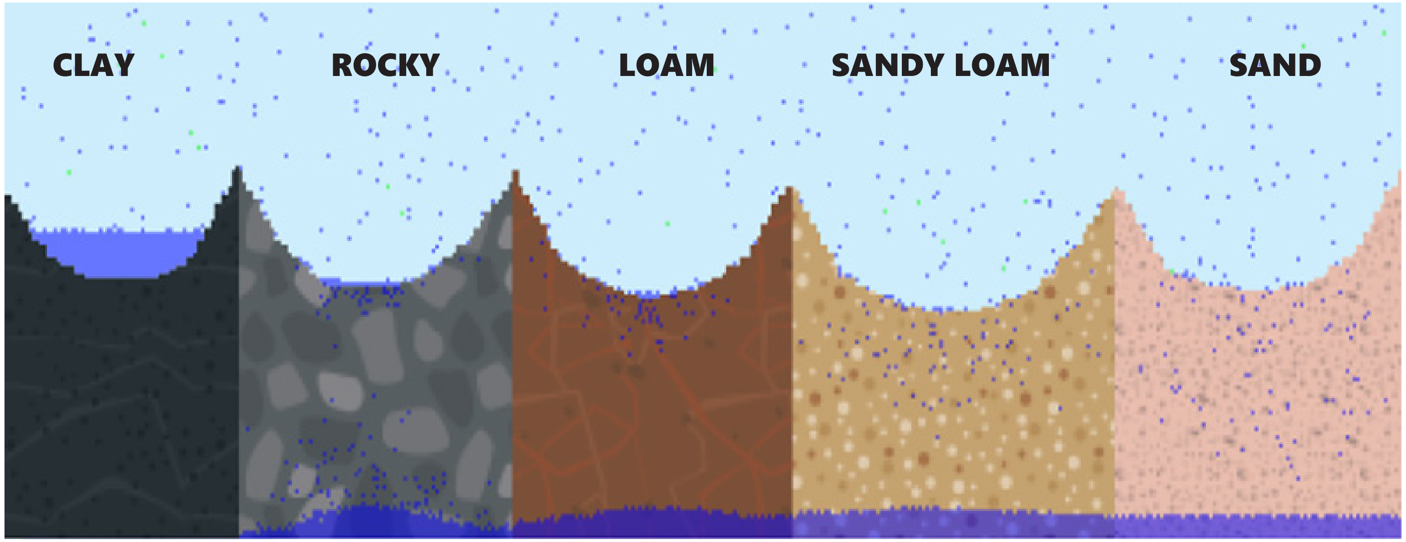
When running the simulation, first you want to understand what "permeability" is? Permeability is the ability of water to penetrate through different soil types. In the "**Template**" option select "**Compare permeabilities**". The image below shows you what the Compare permeabilities will look like.

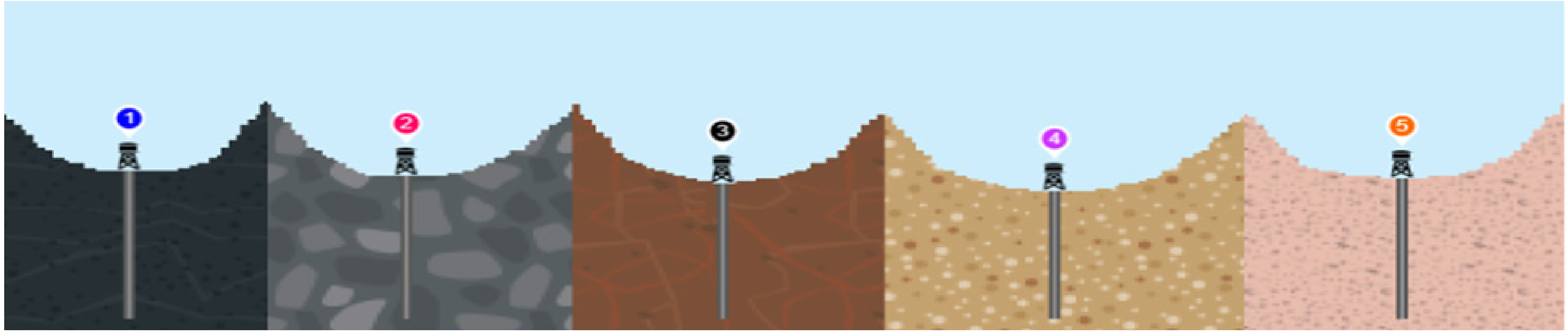
All five soil types should appear. Click on the "**start button**" and watch how water moves through the soil. Set the "**Rain probability**" dial to the middle so that a significant amount of water will fall so you can see how different soil types allow water to passes through. You will notice that the soil type on the left keeps most of the water on the surface while on the left it passes right through. The image below will provide you the names of the soil types that best match the permeabilities in the simulation.

Figure 3 Soil types and permeability



(Lab Licence https://github.com/concord-consortium/lab/blob/master/license.md)

Figure 4. groundwater bore on different soil types



(Lab Licence https://github.com/concord-consortium/lab/blob/master/license.md)

How to add a groundwater bore (well): Select "A**dd well**" tab to insert groundwater bore on the five different soil types. Choose the **"non-flowback well**" to use during this exercise. Place one groundwater bore on each soil type as shown in Figure 4. When you hold the left mouse button down when placing, you will notice it drilling down into the soil. Once you release the mouse button the drilling will stop and that is where you will be pulling water from. If you need to redo your groundwater bore just select the refresh icon and it will start the simulation over.

The two graphs represent the time in years for **Water level** and **Well Output**

-**Water Level** represents water on the surface. When there are large amounts of water on the surface it could indicate potential flooding. Also, it may be an area that seasonally fills to create lakes and then dries up in the hot summer months. The units of measurement are not specific, so it's just to demonstrates how surface water levels can change over time by rainfall, drainage and evaporation.

-**Well Output** (Groundwater Bore Output) will provide how productive the groundwater bore are over time. The measurements are not specific but an indication of how productive your groundwater bore pumps water. The different soil types where aquifers exist, how many groundwater bores in the area and accessing the same water source will affect individual groundwater bore output. This data will be indicated in the graph with colours matching the groundwater bores output.

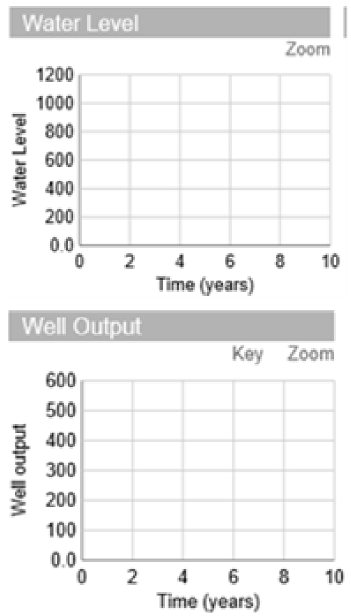
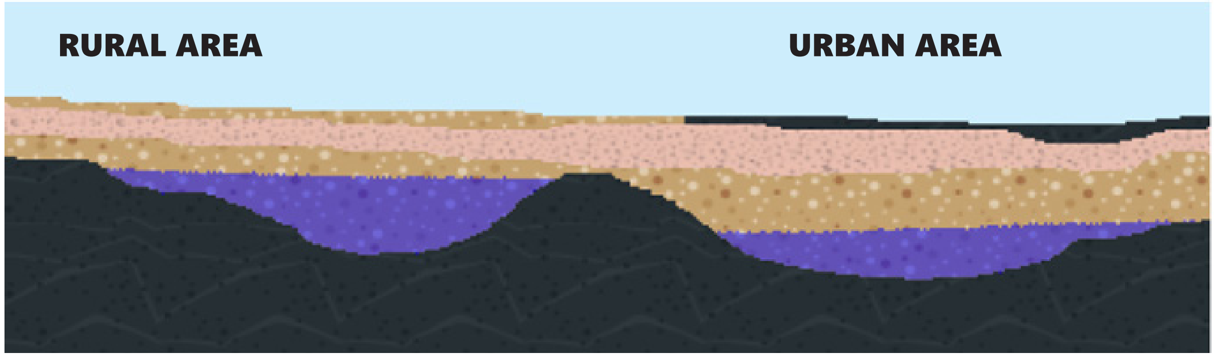


Table 1. Water level and Well Output

Figure 5 Rural vs Urban area template



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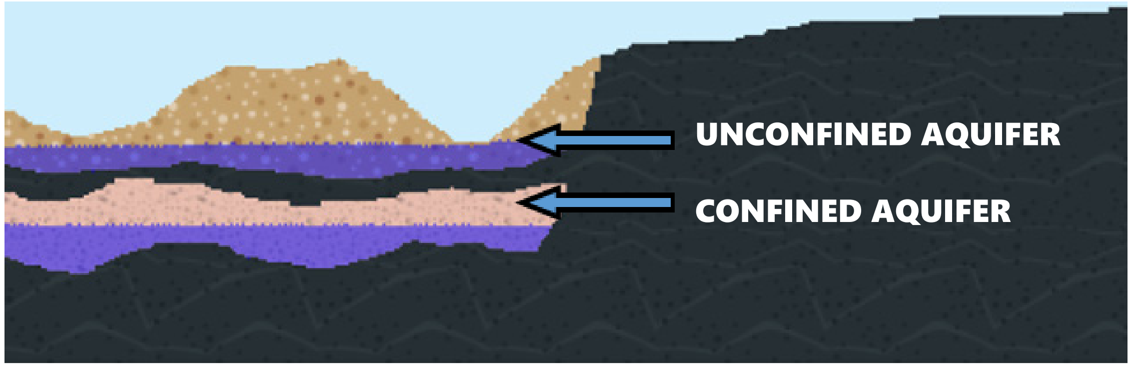
Simulation 1

Rural vs Urban Areas:

1. Select in the "**Template**" options "**Rural vs urban areas**". This will load a premade template that has a rural area on the left and an urban area on the right. Notice that the urban area has a soil that doesn't drain well or its non-permeable on the surface.
2. Set the "**Rain probability**" to the middle of the slider bar and then start the simulation. Allow the simulation to run for three years and then pause it.
3. Observe the "**Water Level**" graph. What do you notice about the water level over the three years?
4. Use Table 2. Rural vs Urban Areas graph to copy the first three years of the simulation.
5. Add two non-flowback wells (groundwater bores) to the simulation. Place one in the Urban Area and one in the Rural area. Make sure they drill down into the underground aquifer to access the water.
6. What do you think will happen to the water level by adding two groundwater bores?
7. Start the simulation for three more years and observe the Water Level graph and the **Well** (groundwater bore) **Output** graph.
8. What changes happened to the **Water Level** graph over the next three years? Graph the results to complete a six-year cycle. Why do you think that happened?
9. Looking at the **Well** (groundwater bore) **Output** graph what happened over the three years?
10. What may have affected the groundwater bores outputs after looking at the graph?

Figure 6) Confined vs Unconfined Aquifer

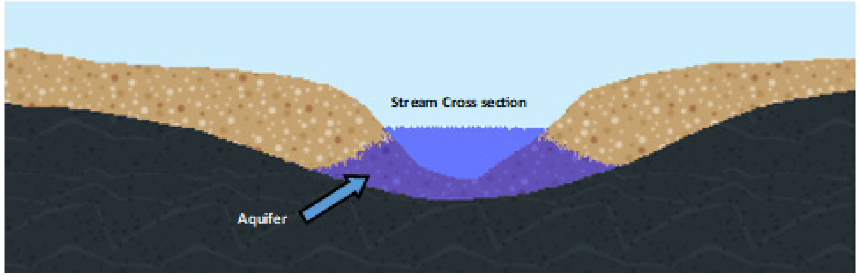


Simulation 2

Confined vs Unconfined Aquifers:

1. Select in the "**Template**" options "**Confined vs Unconfined aquifers**". This will load a premade template that has a Confined vs Unconfined aquifer labelled below. Notice the confined aquifer has a layer above that does not allow water to pass through.
2. Set the "**Rain probability**" to the middle of the slider bar and then start the simulation. Allow the simulation to run for three years and then pause it.
3. Observe the "**Water Level**" graph. What do you notice about the water level over the three years?
4. Use Table 3. Confined vs Unconfined Aquifer graph to copy data to the first three years of the simulation.
5. Add two non-flowback wells (groundwater bores) to the simulation. Place one so that it has access to the Confined Aquifer and the second one only to the Unconfined Aquifer.
6. What do you think will happen to the water level and well (groundwater bore) output.
7. Start the simulation for three more years and observe the **water level** graph and the **well** (groundwater bore) **output** graph.
8. What changes happened to the Water Level graph over the next three years? Why do you think that happened?
9. Looking at the **Well** (groundwater bore) **Output** graph what happened over the three years?
10. What may have affected the groundwater bores outputs after looking at the graph?

Figure 7 Losing Steam



(Lab Licence https://github.com/concord-consortium/lab/blob/master/license.md)

Simulation 3

Losing Stream:

1. Select in the "**Template**" options "**Losing Stream**". This will load a premade template that has a cross-section of a stream with an aquifer below allowing water to move into the stream.
2. Set the "**Rain probability**" so that it's rarely raining and put two groundwater bores that can access the aquifer on both sides of the stream. Allow the simulation to run for three years and then pause it.
3. Observe the "**Water Level**" graph. What do you notice about stream level?
4. Use Table 4 Losing Stream Graph and copy the data for the first three years of the simulation.
5. What would the "**Rain Probability"** need to be set at for the stream to go back to its original level?
6. Not having consistent rain to fill streams could be disastrous if groundwater bores are pumping water. What changes could you make if you ran the simulation over again to lower the stress on the stream?
7. Reset the simulation and make the changes you believe could lower the stress on the stream.
8. What changes happened to the **Water Level** graph over the next three years? Why do you think that happened?
9. Looking at the **Well** (groundwater bore) **Output** graph what happened over the three years?
10. What may have affected the groundwater bore outputs after looking at the graph?

Data Collection Graphs:

Water Level represents water on the surface. When there are large amounts of water on the surface it could indicate potential flooding. Also, it may be an area that seasonally fills to create lakes and then dries up in the hot summer months. The units of measurement are not specific, so it's just to demonstrates how surface water levels can change over time by rainfall, drainage and evaporation.

Well Output (Groundwater Bore Output) will provide how productive the groundwater bore is over time. The measurements are not specific but an indication of how productive your groundwater bore pumps water. The different soil types where aquifers exist, how many groundwater bores in the area and accessing the same water source will affect individual groundwater bore output. This data will be indicated in the graph with colours matching the groundwater bores output.

Simulation 1. Rural vs Urban Areas

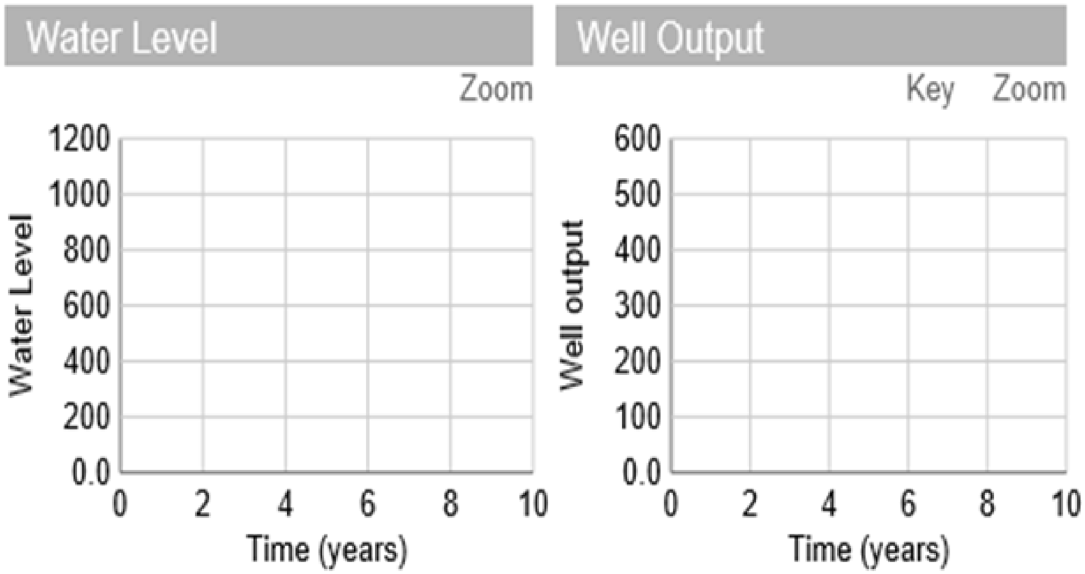


Table 2. Rural vs Urban Areas

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Data Collection Graphs:

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Simulation 2. Confined vs Unconfined Aquifers'

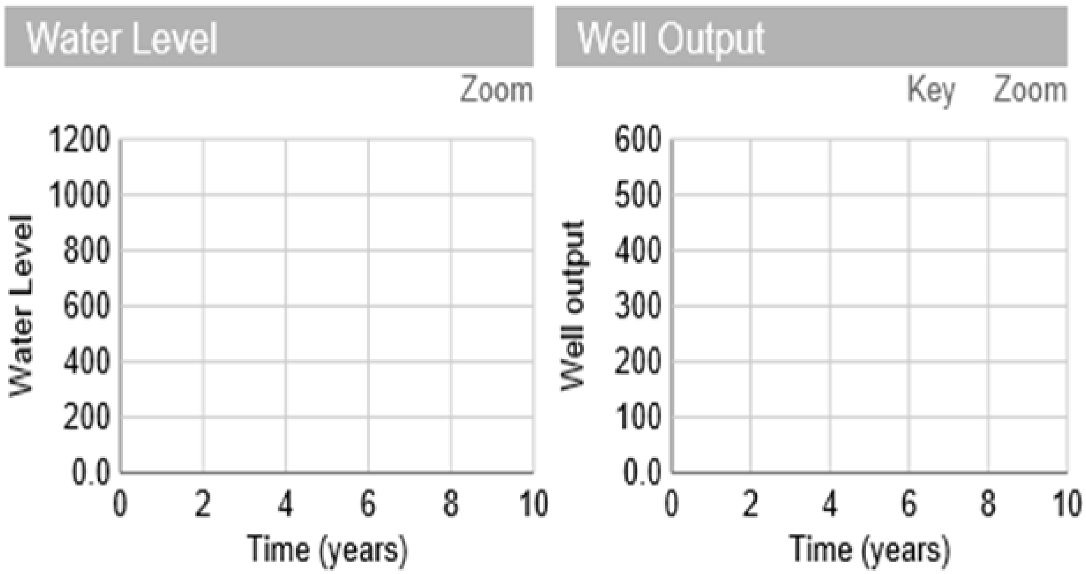

Table 3 Confined vs Unconfined Aquifer.

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Simulation 3. Losing Stream

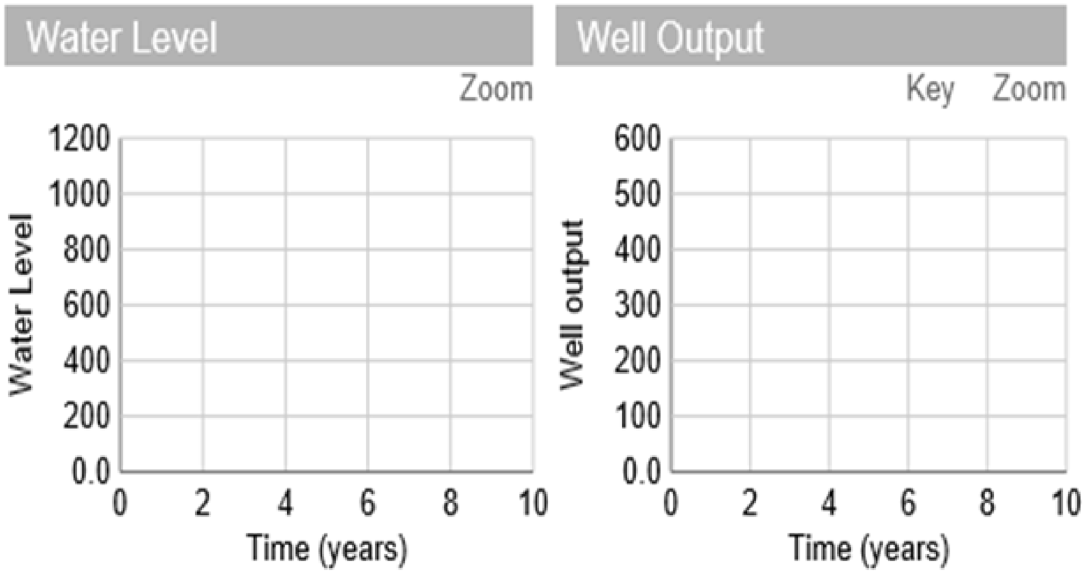

Table 4. Losing Stream

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Teacher Debrief Q&A Ideas

1. **The Central Coast has a mixture of rural and urban areas with a combination of soil textures and aquifer structures. Understanding this, why do you think groundwater bores are not found in more locations on the Central Coast to collect water?**
   Water may not be available in abundance in every location on the Central Coast for groundwater bores. The geology of the Central Coast plays a big part in where bore fields are located. Many of the borefields are located in sandy areas that allow water to make its way down into the aquifer. However, ground water also has an important environmental value and must only be used carefully

2. **Creeks and rivers are a major source of water for the Central Coast water supply system. How could extraction of water from aquifers affect creeks and rivers?**
   Water that enters the ground can travel through the soil to rivers and creeks; entering in through the banks and beds. Extracting too much water will not allow underground water to make its way to rivers and creeks. This could affect the aquatic life in creeks and rivers along with increasing the temperature of the water due to reducing the depth. Rivers and creeks that are deep will typically have a lower temperature which will also affect the oxygen levels of the water.

3. **In the simulations, the groundwater bores continually pump water regardless of use or availability of water. Discuss what are some possible impacts of unregulated pumping of aquifers.**
   Unregulated pumping of aquifers can have ecological impacts such as creeks and rivers drying up, the biodiversity of animal and plants decreasing, communities running out of water, displacement of people and businesses, water quality can change and the depth to access more water increases which also increases energy and costs.

4. **Why would having borefields spread out across the Central Coast be advantageous rather having them all in one location?**
   This allows aquifers not to be over-harvested in one location which then lessens the impact to streams and creeks in the area. Borefields spread throughout the Central Coast in areas where the geology is advantageous for water extraction lowers the costs of having to drill extra deep. If the borefields are relatively close they compete for the same water.

5. **Why are having borefields an important component for water security on the Central Coast?**
   Borefields provide a secondary measure during drought to access water. Using borefields for drought specific times enables accessibility of a water source in emergencies. It provides a water security insurance policy that supplements our main water supply sources such as the dams, creeks and rivers. Licensing is required to gain access to groundwater in NSW. The Central Coast Council needs to go through the NSW government Planning, Industry & Environment Department to create the borefields. Once the permits are granted the Central Coast Council can turn on the bores and start pumping water. The borefields are turned on periodically to sample the water quality and check if everything mechanically is working properly. The amount of water taken from the aquifer depends on environmental impacts along with the cost of pumping groundwater. Central Coast Council pays the NSW Government for the amount of water extracted from the borefields.