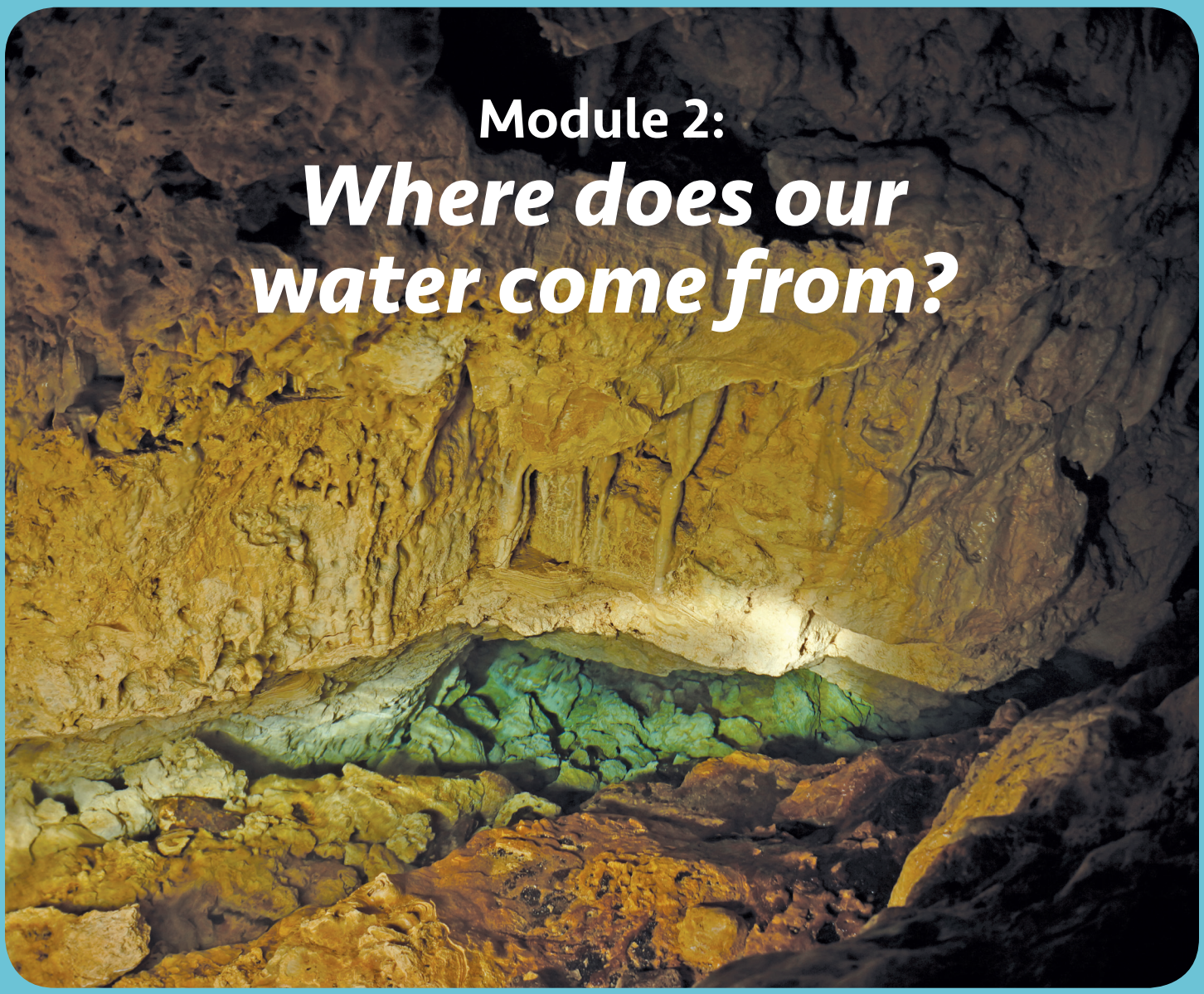
Water for Life

Place-based science learning resources



Module 2:

Where does our water come from?

Version date: September 8, 2016

Introduction

The purpose of this module is to plan and implement an engaging and locally relevant informal place-based science education activity. Its goal is to support youth and community learning about fundamental science concepts related to water resource issues within the context of the local environment and using local examples.

This module was developed in collaboration with municipal leadership, the national utility company, community members, and local educators. It incorporates western science content as well as indigenous environmental knowledge. This emphasizes participants' application of science-based and traditional knowledge to better understand and appreciate the complexity of their own island environment.

Improving informal youth and community education about their specific water resource and environmental issues will enable them to make better and more informed decisions on resource management and sustainable use. This module is best used by government and non-government agencies, specifically their community outreach and education specialists, in their informal education efforts with youth and community members.

Acknowledgments

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This document was created by Danko Taboroši (iREi) and Destin Penland (PREL), with support by Ethan Allen (PREL). We would like to thank iREi, PREL, Water for Life network, Angaur State Government, Palau Public Utilities Corporation, Palau Ministry of Education, Angaur Elementary School, the Pacific islands Climate Education Partnership and, most importantly, the people of Angaur island.

Time and Materials

SUGGESTED TIMING OF THIS ACTIVITY

This activity can be done at any part of the year. The timing of the day should be so that stop 3 occurs during low tide.

SUGGESTED DURATION

90 minutes

SUGGESTED GROUP SIZE

No more than 25 persons

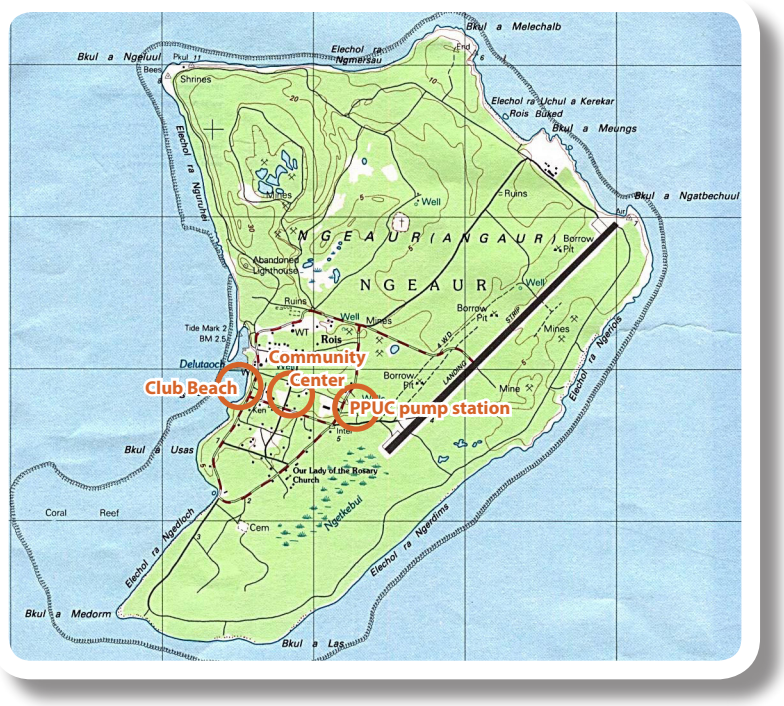
SUGGESTED ADULT TO YOUTH RATIO

1 adult for every 6 youths

MATERIALS AND RESOURCES NEEDED

- Supplies for step 1 and step 2
  - 1 gallon plastic bottle of water
  - 1 wide plastic tray,
  - 1 clear plastic bottle with label removed and top 1/3 cut off)
- Transportation for guides (facilitators) and participants
- Drinking water for guides (facilitators) and participants

LOCATION OF INSTRUCTIONAL SITES



SITE VISIT ORDER

1 • Club Beach
2 • PPUC Pump Station
3 • Community Center

Step 1 FROM RAIN INTO THE GROUND

The group assembles at ***Club Beach***, the sandy beach just south of the docks. The group will gather at a limestone outcrop with a rocky overhang, located just north of the shipwreck remains. On arrival, the guide asks the participants: "How is the weather today?" The guide suggests that the participants imagine that it is raining. To illustrate that, one or two participants climb atop the overhanging rock and slowly pour one gallon of water into the rock's central area with a few grassy plants and soil. They try not to pour water near the edge of the rock so that it doesn't spill over the sides. The guide asks the participants to predict what will happen with this water. Within a minute or two, participants will be able to observe that the water has begun to drip from the bottom side of the overhang. They will see that drip points are at multiple yet specific locations. The guide can then ask questions and lead the participants to conclude that the rock is porous, but not exactly in the same way everywhere. There are specific pathways that the water has taken as it moved through the rock.

The guide then suggests that the same thing would happen anywhere else in Angaur. The entire island is made of limestone so rainwater at any point on the island would percolate into the porous ground. As participants have observed, water moves downward, driven by gravity.

OVERHANGING LIMESTONE OUTCROP AT *NGARAMASACH*

Step 2 THROUGH THE GROUND TO GROUNDWATER

The guide asks participants to think about how far down into the bedrock of Angaur would the seeping rainwater go. "All the way down to ...?" -- participants offer their ideas.

To help the participants, the guide can take a wide plastic tray, place in it a chunk of limestone from the beach, and fill the tray with seawater. This is a small model of Angaur, made of limestone and surrounded by the ocean.

The guide and the participants together visualize that the rock is getting soaked with water. This assumption derives from what the participants had just observed -- that limestone is porous and lets water in. Participants can imagine that that the surface of the water in the tray extends through the rock. The rock does not stop seawater.

HYPOTHESIZING AND SKETCHING THOUGHTS IN THE SAND

Once the participants are satisfied with the idea of seawater permeating the rocks beneath them and extending through the entire island of Angaur, they are ready to perform an experiment. The purpose of the experiment is to answer the question of how far down rainwater percolates through the bedrock.

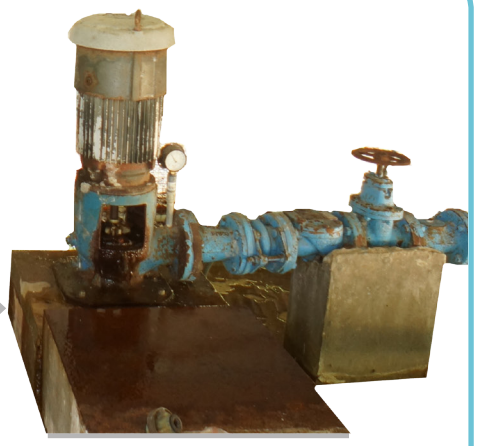
EXPERIMENT STEPS

1) Cut off the top of a clear plastic bottle and fill it with beach sand. This simulates the bedrock of Angaur.
2) Add seawater about half way into the cup. This simulates the salty groundwater (seawater) within the island.
3) Very gently add fresh water colored with food coloring. This simulates the fresh water coming down as rain and seeping into the ground.
4) The participants observe as colored fresh water percolates through the sand and hypothesize how far down it will go.
5) Everyone together observes that the colored fresh water has settled on top of the seawater. There is a little bit of mixing where they meet. This simulates the fresh groundwater sitting on top of the salty groundwater. The top of the fresh groundwater simulates the water table. The bottom of the fresh groundwater simulates the brackish water where fresh groundwater and underlying salty groundwater mix. This is called the mixing zone.

Step 3 FROM GROUNDWATER TO PUMP STATION

The group now leaves the beach and proceeds to the **PPUC Pump Station** (located across from the school). En route, the guide asks if there is so much fresh water in the ground, is there a way that we can get it out and use it? Some participants will probably know that wells serve this purpose.

The group arrives to the Pump Station and is led on a short tour by the facility manager (Mr. Ephraim Lewis, nickname Etam). Mr. Etam will explain that wells are deep enough to reach to the water table and will show to the participants one of the wells and its pump. The guide can ask Mr. Etam to show the key aspects of this system. Mr. Etam can show the pump being used to extract water from the well and how the extracted water is chlorinated to kill microbes. He can also point out the pipes that convey this treated water into people's homes and the Community Center.



VISITING PUMP STATION

CHLORINE TREATMENT

TRACING THE PIPE THAT LEADS FROM THE WELL TO THE COMMUNITY

Before proceeding to the next step, the group engages in a Questions and Answers session with Mr. Etam.

Step 4 FROM PUMP STATION TO THE TAP

After following the pipe from the Pump Station for a while, participants see that the pipe goes toward the village. Guide explains that the pipes that bring water to the school and participants' own homes are connected to this system and end with taps, from which people get water.

TAPWATER AT THE SCHOOL

En route to the Community Center, the guide asks the participants "Do you drink the water out of your tap?". The participants know that this water is not safe to drink and will likely respond that they use tapwater for washing things but not for drinking. Now that the whole group knows the pathway the water has taken, they can engage in discussion as to why their tapwater is not good to drink, what the problems with it may be, and where the problem(s) occurred.

The discussion can start with "What is the problem with water from the tap?" When the participants bring up the saltiness, the guide can lead them to conclude that this has occurred in the ground where the water may have mixed somewhat with underlying seawater. When the participants bring up the bad smell, bad taste, or perhaps past incidents of someone getting sick after drinking water from the tap, the guide will ask where the water may have been contaminated. The participants know that water came to the island as clean rainwater so the problem(s) must have occurred afterward -- while the water was in the ground or when it was pumped at the well and moved through pipes.

To make the discussion move faster, guide can ask, "Do you think that water can be contaminated while still in the ground?" If participants say "no," guide can remind them that water was chlorinated at the pump station. Participants will recall that this was done to kill microbes and will know that groundwater may contain microbes. The guide can then ask if all contaminants from the groundwater are removed when water is chlorinated? To help the participants answer, guide can ask name different contaminants and ask, "Is that contaminant destroyed by chlorination?" Chlorination destroys only microbes, it does not clean water from other pollutants.

The guide can also ask, "Do you think that water that is clean can get contaminated on the way to the tap?" Participants can recall the pipe they followed in the previous step and think whether it looked new or old. They can be asked to imagine what the pipes look like underground. If pipes are old and corroded, they can contaminate the water that moves through them.

The purpose of this hypothesizing is to enable the participants to use their acquired knowledge of the water pathways through the environment and infrastructure and learn to trouble shoot.

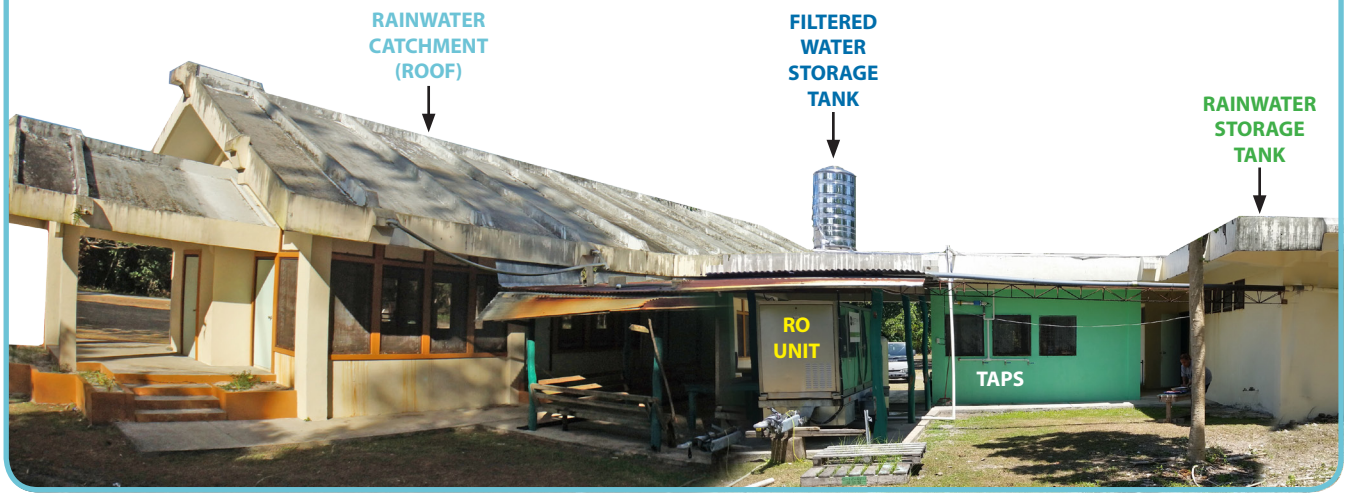
Step 5 AND TO THE CUP?

The group arrives to the **Community Center** and meets the manager of the facility. Here, they learn about a separate system that uses reverse osmosis (RO) to provide drinking water of excellent quality. As the facility manager guides the participants around, the guide can use the photograph below with labels to identify the key parts of the system. Here, falling rain is caught by the concrete roof that acts as a RAINWATER CATCHMENT SURFACE, and flows down into the RAINWATER STORAGE TANK. From there, the water is fed into the RO UNIT, where it is filtered and pumped up into the FILTERED WATER STORAGE TANK. That water moves down with gravity into TAPS from which community members that come here fill their 5-gallon bottles for drinking water use. The RO unit has its own solar power generator and nearly absolutely purifies the water. The participants now know this separate pathway that water takes from the rain to the Community Center catchment to the RO unit and to the cup from which they can safely drink.

The guide can prompt the participants to ask the facility manager about what happens when there is no rain for an extended period of time. The manager will say that at such times groundwater from wells (which participants visited in step 3) is pumped to Todai water tank (of which the participants are aware and may have visited in the past) and from there fed by gravity to the RO units. The guide will point out to the participants to notice that rainwater is preferred source for RO, and that groundwater is used only when there is not enough rainwater. The guide can ask the participants why they think this is so? With the help of the facility manager, they can together conclude that this is so because: 1) it is better for the machine to use water that is as clean as possible to begin with (so efficiency is greater when purifying rainwater as opposed to groundwater), and 2) Angaur's water supply in the ground is not overused.

At the end of the trip, the participants know where the water comes from into the taps at their home and what that water's limitations are (good for all uses except drinking and possibly cooking). They also know that the safest drinking water on Angaur is available from the Community Center and where that water comes from and how it is processed.

Note: *In a follow up lab exercise, the participants will complete the water cycle from wastewater into the ocean and evaporated water vapor and into clouds and rain again. Wastewater, salty water, etc. is naturally purified during evaporation, and comes back down as pure rain.*



Lab Activity 1

- Write the names of the different steps in the movement of water through Angaur on individual pieces of paper and ask the participants to arrange them in proper order.

RAIN	RAIN
Ground Surface	Rainwater Catchment (Roof)
Groundwater	Gutters
Well	Rainwater Storage Tank
Pump Station	RO Unit
Pipes	Filtered Water Storage Tank
Tap at Home or School	Tap at the Community Center

Note 1: Use either names written below in blue or the names in green.
Do not mix them. The blue names represnt the pathway of water served by PPUC to households. The green names represent the pathway of water collected, purified, and served at the Community Center. The set of green names can be modified to reflect a rainwater catchment system at any individual home by eliminating the RO Unit and Filtered Water Storage Tank.

Lab Activity 2

- Write a description of what is happening or what is shown in the four pictures below

Lab Activity 3

- Each participant is assigned a role from among the key steps in Activity 1

  (Note: use either the steps written in blue or in green, do not mix them;
  if participants are too few, guide takes over any missing steps;
  if participants are too many, assign the same role to multiple participants)

- Ask participants to stand up and use the knowledge from this module, including Lab Activity 1, to arrange themselves in proper order next to each other.
- Starting with the first participant (rain) and continuing in order, ask participants to describe what happens to water at her/his step. Participants can imagine that they themselves are water going through steps.
- Repeat the previous step but now ask each participant to imagine in what ways the water can get polluted at his/her step.
- After the last participant (person drinking) describes what happens at that step, ask the entire group to think about what happens with water next (as it passes through our bodies, is expelled as waste, goes into septic tanks or the ground, or sewage into ocean).
- Lead the participant's discussion to help them find an "end" of the water's journey. Ask, where does it go from the ground (into wells or ocean) and from the ocean (evaporates into air), and from there (rains down), completing the endless cycle.

Culminating Activity

- Participants will write a 1-page discussion of the water cycle on Angaur and make sure to include themselves. The cycle they describe is for water that at some point they themselves drink.

- Participants will develop an drawing, display, or model that
  > demonstrates their answer, or
  > illustrates their interest

This document was developed by **Danko Taboroši** (Island Research & Education Initiative - **iREi**) and **Destin Penland** (Pacific Resources for Education and Learning - **PREL**) in close collaboration with Governemnt of Angaur State, Palau Public Utilities Corporation, and educators at Angaur Elementary School. The project was funded by **National Science Foundation** under **Water for Life** grant to PREL (award 1224185). For more information, or to suggest corrections/ modifications to this document and its updated versions, please contact us at irei@islandresearch.org.