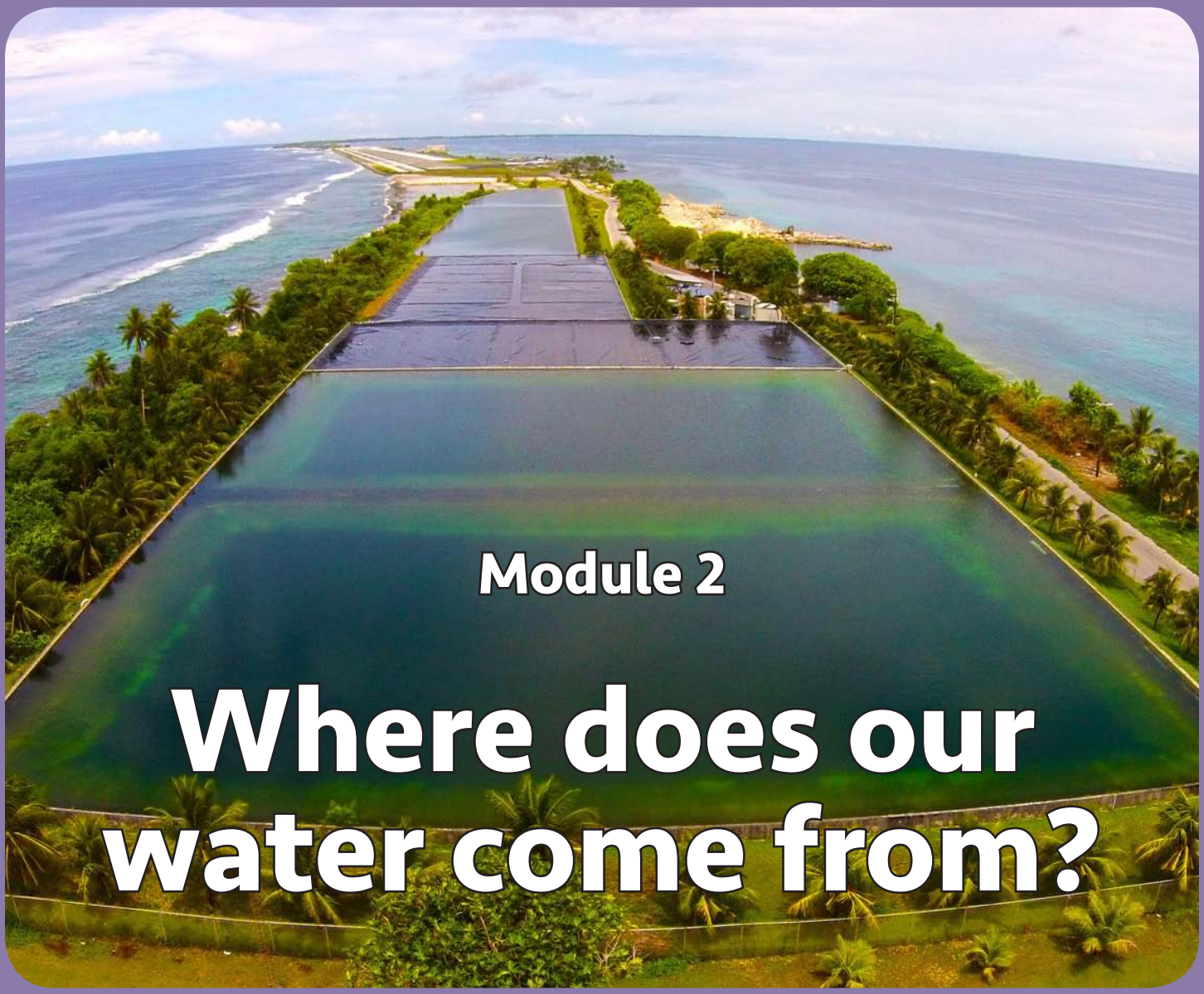
Water for Life

Place-based science outdoor learning module for Majuro Atoll, Republic of the Marshall Islands



Module 2

Where does our water come from?

Version date: September 15, 2017

Introduction

We have worked to create and implement engaging and locally relevant science outdoor learning units for Majuro Atoll, in the Republic of the Marshall Islands. Created for anyone with an interest in the environment and natural resources of Majuro, it can be used by community outreach and education specialists from local NGOs, as field trip guide during meetings and conferences, as professional development tool for persons employed in relevant fields at government and non-government agencies, as an outdoor learning guide for students engaged in school and extracurricular activities, and any other informal education efforts with youth and community members.

The content of these units is aligned with the science curriculum framework used in secondary schools in Majuro. The units were developed in collaboration with local education and utility authorities, community members, and local educators. Because they incorporate science education curriculum objectives, modern scientific concepts, and indigenous environmental knowledge, they can be used to better educate students in Majuro about their local environment. Engaging students in field-based learning activities improves awareness of the required science content, encourages mental connections between classwork and observations, and promotes the application of scientific concepts to understanding and appreciating the complexity of the students' island home. Specifically, this unit aims to improve informal youth and community education about the local water resource and water issues. This will enable participants to make better and more informed decisions on resource management and sustainable use.

Acknowledgments

This activity was carried out by iREi and PREL, under auspices of Water for Life project, with funding from the National Science Foundation, in collaboration with Majuro Atoll High School and the Marshall Islands Public School System.

This document was created by Danko Taborosi (iREi) and Charlin M. Donato or Marshall Islands High School (MIHS), with assistance from Dr. Ming Wei Koh (PREL). We would like to thank iREi, PREL, Water for Life network, Majuro Atoll High School, Marshall Islands Ministry of Education, Majuro Water and Sewer Company (MWSC), the Pacific Islands Climate Education Partnership, and the people of Majuro Atoll.

Curriculum Considerations

BASIC APPROACH

This informal science learning module is aligned with the Marshall Islands Ministry of Education science curriculum framework so that it can also be implemented within the school system. When using it as an outdoor science class, consider how this material fits into your curriculum. Note that in class context the words "participants" in this document will refer to students, and "guides" or "facilitators" refers to teachers.

KEY TOPICS

This outdoor learning activity can teach students the key aspects of the water cycle, hydrology, and water supply using local examples. The module is developed to address the core question: Where does out water come from? In the process of answering this question, students will be making use of science content and process skills they would have learned in 9th grade project-based learning. Specific references to 9th grade science curriculum framework and science textbooks are provided below.

SUGGESTED PREPARATIONS

Prior to implementing this module as an outdoor science class, teacher(s) review sections of the 9th grade science text and vocabulary identified below. The content/ concepts covered will provide the basic information students need to participate.

Suggested Classroom Preparation Activity: divide students into 3 equal groups. Assign each group between 3-4 vocabulary words listed in the section below. Have students work in groups to complete and present the vocabulary activity:

1) Provide textbook definition of word.
2) Provide sentence where the word is used in the textbook.
3) Provide a student-friendly definition (their own definition) of the word.
4) Create their own sentence using the word.

LAB AND CULMINATING ACTIVITY

School lab work (including hands-on and written exercises) and a culminating activity for this outdoor science class are suggested at the end of this document.

Time and Materials

SUGGESTED TIMING OF THIS ACTIVITY
This activity can be done at any part of the year. The timing of the day is flexible because there are no tide considerations. Guides (facilitators) should make prior arrangements with staff at the planned instructional site (see map below) to ensure that access will be granted at the intended time.

SUGGESTED DURATION
90 minutes

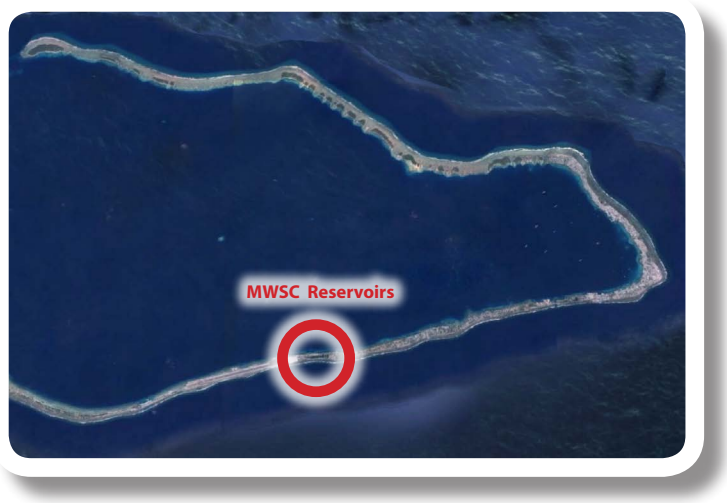
SUGGESTED GROUP SIZE
No more than 25 persons

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 facilitators and participants
- Drinking water for facilitators and participants

LOCATION OF INSTRUCTIONAL SITE



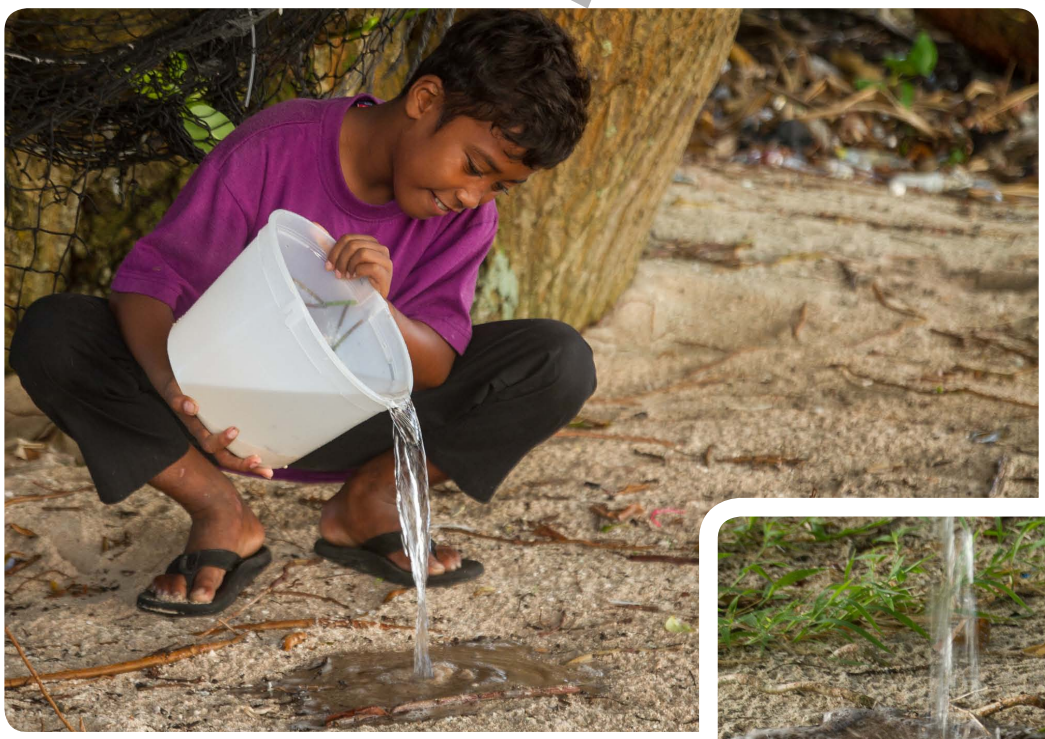
Outdoor Activities

Step 1 FROM RAIN INTO THE GROUND

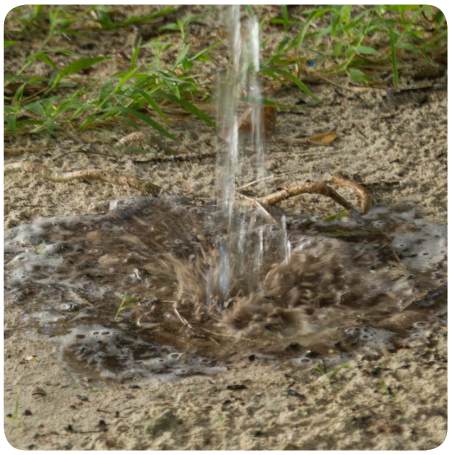
On the bus ride to the instructional site the facilitators and participants review knowledge about the water cycle. The group first visits any beach that is a convenient stop on the way to the Majuro Water and Sewer Company reservoirs, located near the airport. At the beach, the facilitator asks the participants: "How is the weather today?" The facilitator may suggest that the participants imagine that it is raining. To illustrate that, one or two participants slowly pour half-a-gallon of water onto the ground. They do not pour water on concrete or another unnatural surface, including ground compacted by vehicles. Instead, they select a spot where soil and grass are visible. The facilitator asks the participants to predict what will happen with that water. Within a minute or two, participants will be able to observe that most of the water has percolated into the ground. The facilitator can then ask questions and lead the participants to conclude that the ground is porous and every time it rains the rainwater percolates into the ground.

The guide then suggests that the same thing would happen anywhere else in Majuro. The entire island is made of the same or similar type of rock and soil so rainwater at any point on the island would percolate into the porous ground. As participants have observed, water moves downward, driven by gravity. (Any water that remains on the ground evaporates.)

A PARTICIPANT POURING WATER ON THE GROUND TO OBSERVE WHAT HAPPENS



WATER PERCOLATING INTO THE GROUND

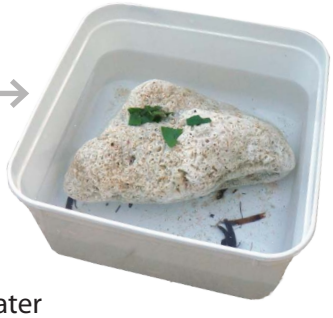


* If this activity is done as part of school work or extracurricular activities, please replace the words "facilitators" for "teachers" and "participants" for "students".

Step 2 THROUGH THE GROUND TO GROUNDWATER

The facilitator asks participants to think about how far down into the ground of Majuro 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 Majuro, 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.

Once the participants are satisfied with the idea of seawater permeating the rocks beneath them and extending through the entire island of Majuro, 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 ground of Majuro.
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 blue 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 RAIN OR GROUND TO THE RESERVOIR

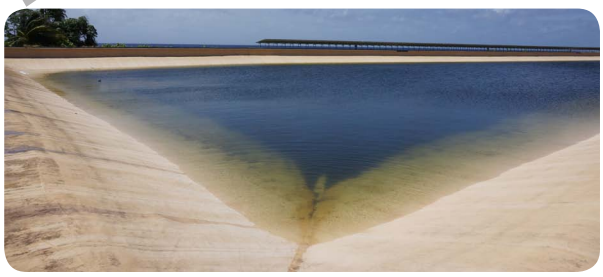
The group continues the trip toward the Majuro Water and Sewer Company reservoirs, located near the airport. On the way, the facilitator asks the participants "If there is so much fresh water in the ground, is there a way that we can get it out and use it?" Some participants probably know that wells serve this purpose. The question will be answered later in this step. For now, the participants can keep in mind that there is fresh water in the ground.

On arrival, the group is greeted by the facility managers and staff. Everyone climbs up the little hill to reach the edge of the massive water reservoirs. This is an impressive sight and the facilitators should make it clear to the participants that this is all fresh water. Facilitators ask "Where did this water come from?" The participants may answer that the water came from rain. The facilitator can direct the discussion so that participants consider the fact that while some rain certainly falls directly into the reservoirs, the vast majority of rain in Majuro falls outside of the reservoirs. Is all of that water lost to us? The facilitator can ask the participants to imagine a rainwater tank near their house. Is the rainwater inside the tank the one that fell directly from the sky into the tank? Participants will know that the rain was captured by the roof of their house and conveyed via gutters into the tank. The facilitator can draw the analogy that rainwater captured by the massive paved runway at the airport is put into these reservoirs in much the same way. However, what happens if there is no rain for a long time? If there is no rain, where can we turn to get water to fill these reservoirs? Can we get the water from the ground? Yes, we can use wells and pump water up from the ground. The participants are then reminded of the experiment in the previous step and can conclude that a well must go deep enough to reach fresh water in the ground, but not too deep to get into the underlying salty water. At this point, the facilitators informs the participants that during droughts, we pump water from the wells in the ground and bring it through a series of pipes into the reservoir they are all looking at. The participants understand that this is rainwater that percolated into the ground, was pumped out from the ground, and is now stored at that site. This can be further ellaborated on by the facility manager(s) if available to accompany the group.

Some of the reservoirs may be covered, making their water not directly visible. The facilitator and the facility manager ask the participants to think about why the water is covered. They can help the participants conclude that the cover prevents excessive water loss through evaporation, and also reduces the risk of contamination.

A VIEW OF ONE OF THE WATER RESERVOIRS NEAR THE AIRPORT

A VIEW WITH HALF-FULL RESERVOIR

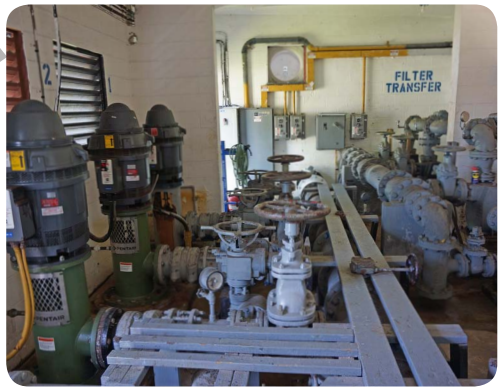


A VIEW OF A COVERED RESERVOIR

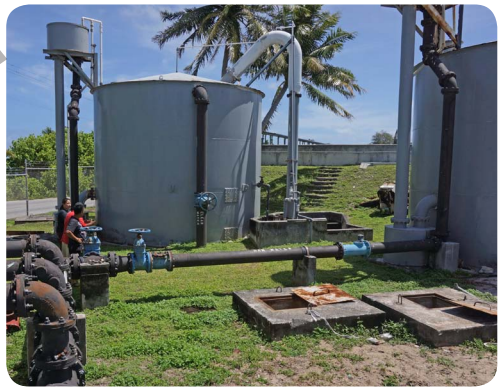
Step 4 FROM THE RESERVOIR TO THE TAP

Facilitators now announce that water coming out from pipes at participants' own homes (and schools and offices) comes from the reservoirs they visited. They ask the participants how is tapwater used in their homes. (Participants may say that they use water for all purposes, except perhaps for drinking). The facilitators then ask if the water in the reservoirs can also be used in those same ways? If the participants answer in the negative, that implies that the water somehow changes between being in the reservoirs and reaching the taps at households. The facilitator suggests that the group asks the facility manager about how the water from the reservoir gets to the household taps, and how does it change along the way.

PUMPING STATION



STORED FILTERED WATER



The facility manager will lead the group to the pumping station, where water from the reservoir is pumped, filtered, and placed in clean holding tanks. The facility manager explains that filtering remove sediments and physical contaminants, but not bacteria and other microbes. For that step, water is pumped to **Delap Treatment Plant** where it is chemically treated before it is distributed through pipes to individual households. This is the time to discuss why that is so, to point out the observed complexities in the water distribution system, and the possibility of contamination in different places, notably old and leaking pipes.
The facilitators and participants can together conclude that because of these risks, most families on Majuro prefer to catch the rainwater themselves and store it locally in their own tank. A smaller household rainwater catchment system is easier to manage and requires individual responsibility.

The participants can now start a discussion about "What is the problem with water from the tap?" If participants bring up the saltiness, the guide can lead them to conclude that this has occurred during a drought when water had to be pumped from the ground, where it may have mixed somewhat with underlying seawater. If participants bring up bad smell or taste, or perhaps past incidents of someone getting sick from drinking tapwater, 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. The facilitator can help the participants imagine steps and ways that contamination can take place. For instance, if pipes are old and corroded in places, they can contaminate the water that moves through them.

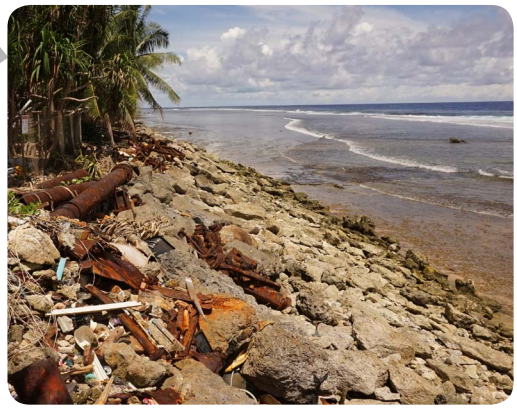
The purpose of this hypothesizing is to enable the participants to use their newly acquired knowledge of the pathways water takes through utilities infrastructure in Majuro. They will revise what they have learned and develop ability to trouble shoot in this context.

Step 5 AND AFTER THAT?

The story of the water in Majuro does not end at the tap. The facilitators ask "Where does the water go after the tap?" New terms "wastewater" and "sewage" are introduced, to mean water made dirty through human activities and water that includes human waste from toilets. Where does this water go on Majuro?

Facilitators explain that because Majuro has limited fresh water, toilets are flushed with seawater. It is seawater that goes into toilets (except in Long Island) and carries off the sewage. Wastewater and sewage together go to sewage tanks such as the ones located at Asumption, or near Uliga Dock, or in Rita, and from there are released into the ocean. The group can engage in discussion of how this affects the environment and people and how the system can be improved.

WASTEWATER/SEWAGE FACILITY



The participants cannot visit these tanks due to time constraints but may be familiar with them. A photo of one of those sites is shown above.

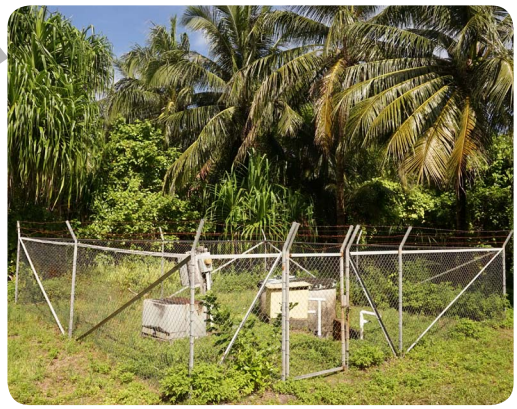
Note: *In a follow up lab exercise, the participants will complete the water cycle from wastewater and the ocean to water vapor that evaporates, forms clouds, and rains again. Wastewater, salty water, and other contaminated water are naturally purified during evaporation, and come back down as pure rain.*

Additional A VISIT TO THE WELLS?

If participants are interested in seeing an actual well, they may seek shallow hand-dug wells near where they live. There are not many such wells in urban Majuro, but there may be some known to participants' families and neighbors. For instance, there is such a well on private land on Rairok (Long Island).

Ideally, the facilitators can arrange a separate trip to Laura, where Majuro's prinicpal wells are located. Water is extracted from the ground through those wells and pumped to the reservoir beside the airport. It is no accident that the wells are in Laura. Laura is where the island is the widest and thus contains the most extensive amount of freshwater in the ground.

A WELL IN LAURA



Elsewhere in Majuro the fresh groundwater layer is too thin and limited to be useful. In fact, if water is pumped from such a thin layer of fresh groundwater, it could easily cause depletion and pulling up of the salty groundwater from deeper layers. This would not only be unhelpful to those seeking water, it would also be harmful to the environment because it would bring salty water close to plant roots and damage or kill vegetation.

Lab Activity 1

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

RAIN

Roof

Gutters

Tank

Tap on the water tank

Sewage

OCEAN

RAIN

Groundwater

Well

Reservoir

Filtration system

Treatment plant

Distribution pipes

Tap in a household

Sewage

OCEAN

Note:

Use either names written below in purple or the names in green. Do not mix them. The purple names represent the local pathway in a simple rainwater catchment system at a private residence. The green names represent the island-wide pathway of water within Majuro's public water supply and sewage system.

Lab Activity 2

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

  (Note: use either the steps written in purple 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
  or create new steps such as evaporation, condensation, rain striking land surface, etc.)

- 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 point, but ask each person to imagine and descibe the ways water can get polluted at his/her step.
- After the participant standing for TAP (People using water) describes what happens at that step, ask the entire group to think about what happens with water next. How does it become sewage (passes through our bodies and is expelled as waste OR is used to wash or in some other way, becomes dirty, 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 and water distribution on Majuro and make sure to include themselves. The cycle they describe is for water that at some point they themselves use to wash or 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 **Charlin M. Donato** (Marshall Islands High School - **MIHS**) in close collaboration with PREL staff in Majuro, students of the Marshall Islands High School, RMI Ministry of Education (**RMI MOE**), and Majuro Water and Sewer Company (**MWSC**). 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, please contact us at irei@islandresearch.org.