



MA UKA - MA KAI CONNECTION

How has the use of water in our ahupua‘a changed over time?

ACTIVITY AT A GLANCE

Students create, observe and analyze a model of the traditional Hawaiian irrigation system for growing kalo (taro) and draw insights and conclusions about water use in old Hawai‘i and today.

KEY CONCEPTS

- The traditional Hawaiian system of irrigating lo‘i ensured that water was distributed fairly and used wisely in the ahupua‘a.
- Moanalua Stream provided water to irrigate lo‘i in Moanalua. A lo‘i at ‘Īemi Spring grew large kalo for the ali‘i.
- Stream water once flowed into some of the fishponds in the ma kai area of the ahupua‘a. Today Moanalua Stream only flows to the sea during heavy rains since water at the source now goes to windward O‘ahu.
- Models provide a geographic representation to help us analyze how people used and cared for water resources.

ASSESSMENT

Students:

- Create a model that shows how water was distributed from ma uka to ma kai in ahupua‘a of old Hawai‘i.
- Compare the effects of land and water use in the ahupua‘a in old Hawai‘i and today.
- Assess the positive and negative consequences of such uses on the environment, and make connections to current environmental practices.

Hawai‘i State Standard Benchmarks

Social Studies 7: Geography: World in Spatial Terms

- **SS.4.7.3** Analyze the consequences of human modification of the physical environment in Hawai‘i using geographic representations (including lo‘i kalo and loko i‘a).

Common Core Benchmarks

Language Arts: Writing

- **LA.4.W.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information.

Nā Honua Maui Ola

- **‘Ike Honua: Sense of Place Pathway**
- **NHMO.8.5** Recognize and respond to the people, places, and natural elements in their community.

TIME

3 - 4 class periods

SKILLS

Observing, analyzing, inferring, writing



MATERIALS

Provided:

- ✓ Learning Logs 3 - 4
- ✓ Model-building Instructions
- ✓ Aloha 'Āina DVD (provided on DVD)
- ✓ Ma Uka - Ma Kai Connection PowerPoint (provided on CD)

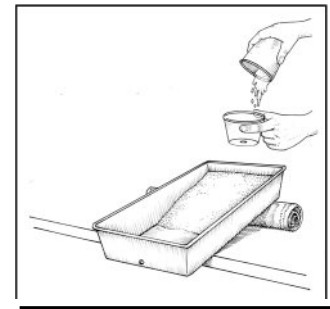
Needed (per group; see Advance Preparation):

- ✓ Trowel (for digging soil to fill half of a roasting pan)
- ✓ Tiny rocks or gravel
- ✓ Large 9" x 13" roasting pan (inexpensive pans are available in bulk at Costco stores)
- ✓ 2 containers
 - container for water source (such as a Styrofoam™ saimin bowl or plastic cup with a small hole poked through the bottom)
 - container to pour water into the water source (water pitcher or cup)
 - (optional: small bucket or container to catch water if models are done indoors)
- ✓ 1 bag of thinset
- ✓ 1 bag of sand
- ✓ Props to elevate pan at a "slope" (wood blocks, folded newspaper)
- ✓ Digging stick (chopstick or any other stick, plastic knife or spoon)
- ✓ Old newspaper
- ✓ Large mixing stick or spoon
- ✓ Index cards

ADVANCE PREPARATION

- Assemble earth materials. (Find grout and thinset mortar in the ceramic tile section of a hardware store. When you start the models, have students dig soil from an area of the schoolyard to fill half of their roasting pan.)
IMPORTANT: This model is not intended to demonstrate erosion, so very sandy earth material does not work well.
- You might want to pre-mix the thinset mortar with water before you start the activity, as it is quite messy. Mix with a large mixing stick or spoon since the mix takes time to wash off the skin if mixed by hand. Mix in a few handfuls of sand and then divide the thinset mixture evenly among student groups.

- Collect small rocks for students to use in building dams, channels and fishponds or purchase a bag of small gravel or cinders from your local garden store. (You can easily find tiny pieces of gravel at the edges of paved parking lots.)
- Use a sharp pencil to poke a very small hole through the bottom of each Styrofoam™ cup. This provides a steady water source for the "stream" in the student models.
- Plan for clean-up! When using thinset, you will need to have a place outside for clean-up such as outdoor faucet and/or hose.
- Plan your system for how students will get their materials, and organize the supplies accordingly.
- Preview websites students will be using for their research. See Resources at the end of this lesson.
- Optional: Make a model to use as a demonstration for students
- Copy the Learning Logs for each student.
- Copy the Model-building Instructions for each group of 3 to 4 students.
- Optional: Order the video, "*Ka Wai, Water of Life*," from the Hawai'i State Department of Education's "*Na Ki'i Hana No'eau*" series of videos.



VOCABULARY

- 'āina – land, earth
- 'auwai – channels or ditches built between streams and lo'i kalo that distributed water through the wetland agricultural system of old Hawai'i
- inference – the act of drawing conclusions from evidence or knowledge



kahawai – the Hawaiian word for stream;
streams were the source of water for lo‘i
kalo
kānāwai – the Hawaiian word for law; it
translates as the equal sharing of water
laulima – to work cooperatively
lo‘i – shallow pond for growing wetland taro
loko i‘a – Hawaiian fishpond

mālama – care for
po‘owai – a dam built to divert water from the
stream into ‘auwai; the literal translation of
this word is “water head, or water source”
(mānowai and paniwai are other terms used
for the dam)
wai – fresh water
waiwai – wealth or prosperity

TEACHER BACKGROUND INFORMATION

“From a very early time in their history, Hawaiians, to a greater extent than any other Polynesians, exhibited engineering and building skill, ingenuity, industry, and planning and organizing ability in three types of construction: the grading and building of terraces for growing wet taro; construction of irrigation ditches and aqueducts to bring water to these terraces; and construction of fresh-and salt-water fishponds.” (Handy and Handy, 1991)

Hawaiian Ingenuity

As the above quote so clearly states, early Hawaiians demonstrated exceptional organizational and engineering skills in their construction of irrigation systems and fishponds. The engineering involved constructing multiple stone lo‘i (terraces) for growing kalo (taro) and extensive ‘auwai (ditches) to transport water from the streams into the many terraces. The flow of water was diverted from the stream into the lo‘i, then back into the stream, and finally down to the fishpond, where the combination of fresh and salt water attracted fish.

This system of using water allowed for sharing of the resource among farmers within the ahupua‘a. Water was used wisely and returned to the stream, which allowed the fishpond or other nearshore fisheries to flourish.

Fresh water, wai, was equated with “wealth” in old Hawai‘i, which is “waiwai.” Kānāwai is the Hawaiian word for law, which translates into “the equal sharing of water.”

Water Diversion

In more recent times, technology has enabled us to divert water from one ahupua‘a to another,

which has the effect of diminishing the flow of stream water. While this has advantages to leeward developers and farmers, it can have negative consequences to windward farmers and

to stream plants and animals that require a steady flow of cool, running water.

In Moanalua, the streams were once fed by water that is stored within the mountains behind semi-impermeable dike rock. When this dike water was tapped for windward homes and businesses, the flow of streams in Moanalua was diminished. Today, Moanalua Stream is intermittent; it flows continually to the sea only during times of heavy rainfall.

Moanalua Watershed Today

A watershed is a land area that drains to a large body of water. The Moanalua watershed, which is nearly 9,000 acres in size, has three streams: Moanalua, Manaiki, and Kahauiki. Kalou Stream is a tributary of Moanalua. The streams converge near Moanalua Gardens. Water from Āliapa‘akai (Salt Lake) flows into Moanalua Stream at Mokumoa Street in an underground flow. All of this water then flows into Ke‘ehi Lagoon.





Water Quality

In old Hawai‘i, people collected drinking water directly from the streams. Lower reaches of streams were used for bathing and more pristine upper reaches provided water for drinking. Today it is not safe to drink water directly from our streams and the stream quality has been degraded by human activities. In Moanalua, there are two water bodies that are classified as impaired by the West Honolulu Watershed Study (Honolulu Board of Water Supply 2003). These are: Moanalua Stream, which is noted to have nutrients, turbidity and trash; and Salt Lake for its turbidity and trash. Turbidity refers to the lack of clarity of the water, and nutrients are from decomposition of plants and runoff from urban streets and neighborhoods.

Land Use in Moanalua

Despite the issues with water diversion and impaired water quality, the dominant land use in Moanalua (65.3%) is conservation and the remaining 34.7% is urban (Division of Aquatic Resources, 2008). Kamananui Valley is being managed by the Hawai‘i Department of Land and Natural Resources. This lesson introduces students to the importance of wai in their ahupua‘a and ways that they can help to mālama Kamananui. In the field study that culminates this unit, students will visit the conservation lands ma uka in Kamananui and show aloha for their ahupua‘a.

TEACHING SUGGESTIONS

1. **Discuss the water connection between mountains and reef in the Moanalua ahupua‘a.**
 - Project the ahupua‘a map from Lesson 2 and have students review the flow of water in their ahupua‘a.
 - Write the focus question for this lesson on the board and review the standards that students will be working on.

2. **Show the *Ma Uka - Ma Kai Connection* PowerPoint presentation provided with this unit.**
 - Ask students to identify the most important ideas in the PowerPoint and to take notes.

Important Ideas

 - Wai was sacred to early Hawaiians.
 - Moanalua Stream once flowed year-round and fed into lo‘i where kalo was grown.
 - Moanalua Stream now only flows to the sea during heavy rains since water stored in the mountains has been tapped for windward communities.
 - The traditional Hawaiian system of irrigating lo‘i returned water to the stream.
 - Nutrients from the lo‘i flowed down to the fishpond.

3. **Encourage students to gather more information about use of water in old Hawai‘i.**
 - Have students search the Honolulu Board of Water Supply on the Internet for more information about use of water in old Hawai‘i.
 - If available, show the video, “*Ka Wai, Water of Life*,” from the Hawai‘i State Department of Education’s “*Na Ki‘i Hana No‘eau*” series of videos.
 - Add key vocabulary words to a word wall or word bank.
 - Distribute **Learning Log 3**. (Refer to Vocabulary for definitions.)
 - Review the most important ideas students discovered about water in old Hawai‘i and go over the discussion questions on the Learning Log.



4. Introduce the model-making activity.

- Divide the class into small groups of three to four students.
- Distribute the instructions for model building to each group.
- Carefully go over the procedures and expectations. (If needed, demonstrate what you expect students to do, or show them a model constructed ahead of time.)
- Write the key objectives of this activity on the board or chart paper and emphasize them:

**How was water distributed in ahupua‘a of old Hawai‘i?
How has the use of water in our ahupua‘a changed over time?**

5. Take students outside and make the models!

- Students will need a full hour for gathering materials, building and trying their models, and clean-up. Distribute a roasting pan and a trowel to each team. Show students where they can dig and fill their pans half-way with soil
- Distribute the thinset and sand mixture to each team and have students mix it into their soil in the pans.
- This is a very engaging activity for students, but it is important that you keep them focused on the main objective. Monitor groups carefully and keep them moving towards completion.
- Make sure students have designed their system before applying the water.
- At about the half-hour mark, students should be starting to pour water into their Styrofoam™ cups.
- If any models are not working well because the earth material is eroding, challenge the students to problem-solve and figure out a way to make the model work. (Most likely they are pouring on too much water.)
- Give students 15 minutes for clean-up and remind them not to wash thinset in the indoor sinks.
- Find a place in the room to display the models. The students will be talking about them when you’re not looking!

6. Discuss the model-building activity with students, and review the main ideas of this lesson.

- Ask students to share their models with the class and answer the focus question for the lesson in their presentations.
- Have students write a reflection about what they learned on an index card. Have them refer to notes they took from the PowerPoint or other resources and draw from their notes in their reflections.
- Ask students to display their reflections next to their models.

7. Instruct students to complete Learning Log 4 illustrating and describing the water distribution system in old Hawai‘i.

ADAPTATION / EXTENSION

Show the *Aloha ‘Āina* DVD to students and discuss what “*Aloha ‘Āina*” means.
Refer to the DVD reflection in the Introduction to this teacher’s guide for discussion questions.

REFERENCES

Hawaii Division of Aquatic Resources and Bishop Museum. *Atlas of Hawaiian Watersheds and Their Aquatic Resources*. 2008. Accessed on May 1, 2012 from <http://www.hawaiiwatershedatlas.com/>



Handy E.S. Craighill, Elizabeth Green Handy and Mary Kawena Pukui. 1991. *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin No. 233. Honolulu: Bishop Museum Press.

Honolulu Board of Water Supply, Department of Land and Natural Resources. Engineering Division, and U.S. Army Corps of Engineers Honolulu District. *West Honolulu Watershed Study*. May 2003.



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LEARNING LOG 3

WAI IN THE AHUPUA'A

NAME _____

DATE _____

**Focus Questions: How was water distributed in ahupua'a of old Hawai'i?
How has the use of water in our ahupua'a changed over time?**

Vocabulary:

'auwai – channels built between streams and lo'i kalo that distributed water through the wetland agricultural system of old Hawai'i

kahawai – the Hawaiian word for stream; streams were the source of water for lo'i kalo

kānāwai – the Hawaiian word for law; it translates as the equal sharing of water

laulima – to work cooperatively

lo'i – shallow pond for growing wetland taro

mālama – care for

mahi'ai – farmer

'ohana – family

po'owai – a dam built to divert water from the stream into 'auwai; the literal translation of this word is “water head, or water source”
(mānowai and paniwai are other terms used for the dam)

wai – fresh water

waiwai – wealth or prosperity



Answer the following questions using the vocabulary above:

1. What words indicate the importance of water in old Hawai'i?
2. What words name the parts of the irrigation system?
3. What Hawaiian values are associated with the way that water was distributed in old Hawai'i? Use these words in a sentence to explain your answer.
4. What words refer to the people who take care of the 'auwai? Use these words in a sentence to explain your answer.



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MODEL-BUILDING INSTRUCTIONS



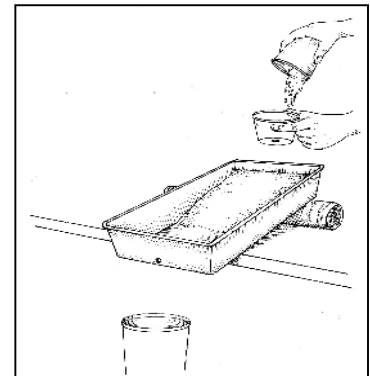
Focus Question: How was water distributed in ahupua'a of old Hawai'i?

Create and analyze a model of water distribution in old Hawai'i!

1. **Instructions:** In your group, decide on one person to be responsible for each different job:
 - Gathering supplies
 - Setting up model (see picture below)
 - Getting water
2. Start setting up when the teacher says, "Go!"
3. Before you begin making your model, make sure you have all your supplies and, if you are in the classroom, that the desktops and floor are covered with newspaper!
4. Steps to build your model (use the illustration as a guide):
 - a) Mix the earth material inside the pan.
 - b) Push the earth material against one end of the pan—NOT the end with the hole in it because that's where the water comes out!
 - c) Form a gentle "mountain slope" with the earth material.
 - d) When you are satisfied with the slope, carve a stream into the slope.
 - e) Try running water through the stream! If you are building your model inside, **MAKE SURE YOU HAVE A BUCKET or PAN UNDER YOUR MODEL TO CATCH THE WATER!** Place the Styrofoam™ cup at the top of the slope above the stream and slowly pour water into the cup. A small stream of water will begin to flow out of the hole in the cup. (Be sure to hold the cup in place so water flows only in the stream.)
 - f) After observing how water flows through your stream, make any adjustments you think the model needs.
 - g) Dig out a little of the earth material to create shallow ponds where your lo'i will be.
 - h) Dig 'auwai from the stream to the lo'i and back to the stream.
 - i) Place small rocks to make a dam in the stream, and line the 'auwai with small rocks.

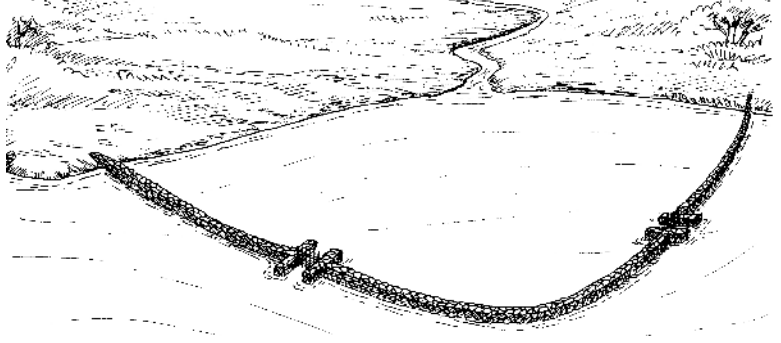
Supplies

- ✓ Earth material
- ✓ Handful of gravel
- ✓ Large pan
- ✓ Styrofoam™ cup with hole poked in the bottom
- ✓ Container for pouring water
- ✓ Bucket or pan to catch water that comes out of the pan (if done indoors)
- ✓ Wood blocks or rolled up newspaper to prop up one end of your pan a little
- ✓ "digging stick" (chopstick)





j) Use small rocks to build a fishpond where the stream flows down to the ocean. Use the illustration of a shoreline fishpond to guide you.



k) Try running water through the ahupua'a model. (Follow the same procedure as in "e" above.)

l) How does your model work? Does it accurately show how water was distributed in old Hawai'i? Make any adjustments you need.

5. Save your models for discussion!

6. Follow your classroom clean-up procedures.

> On an index card, write a reflection about what you learned from this model-building activity. Place the index card next to your model.

> Work with your team to present your model to the class. Be sure to answer the focus question for this lesson when you present.



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LEARNING LOG 4

NAME _____

DATE _____

In the picture below, illustrate how water was distributed through a system of lo'i kalo in old Hawai'i, and include the loko i'a (fishpond).



On a separate sheet of paper, describe the changes that Hawaiians made to the land in order to produce food. Explain how these changes affected the water. How does this compare to the way we use land and water today?