FRESHWATER RESOURCES IN MICRONESIA

An Island-by-Island Overview

by Danko Taboroši

ver 3.2
date 08SEP2016

A product of

WATER FOR LIFE

USP Library Cataloguing-in-Publication Data

Taboroši, Danko.
Freshwater resources in Micronesia : an island-by-island overview / Danko Taboroši. -- Palikir, Federated States of Micronesia : Island Research & Education Initiative, 2016.
30 p. : col. ill. ; 21 cm.
ISBN 978-982-9170-19-4
1. Fresh water--Micronesia. 2. Water-supply--Micronesia.
3. Groundwater--Micronesia. I. Title.
TD324.M5T33 2016
553.7--dc23

TABLE OF CONTENTS

INTRODUCTION

THIS BOOK PROVIDES AN ACCESSIBLE GUIDE FOR ALL MICRONESIANS TO LEARN ABOUT FRESHWATER RESOURCES ON THEIR ISLANDS.

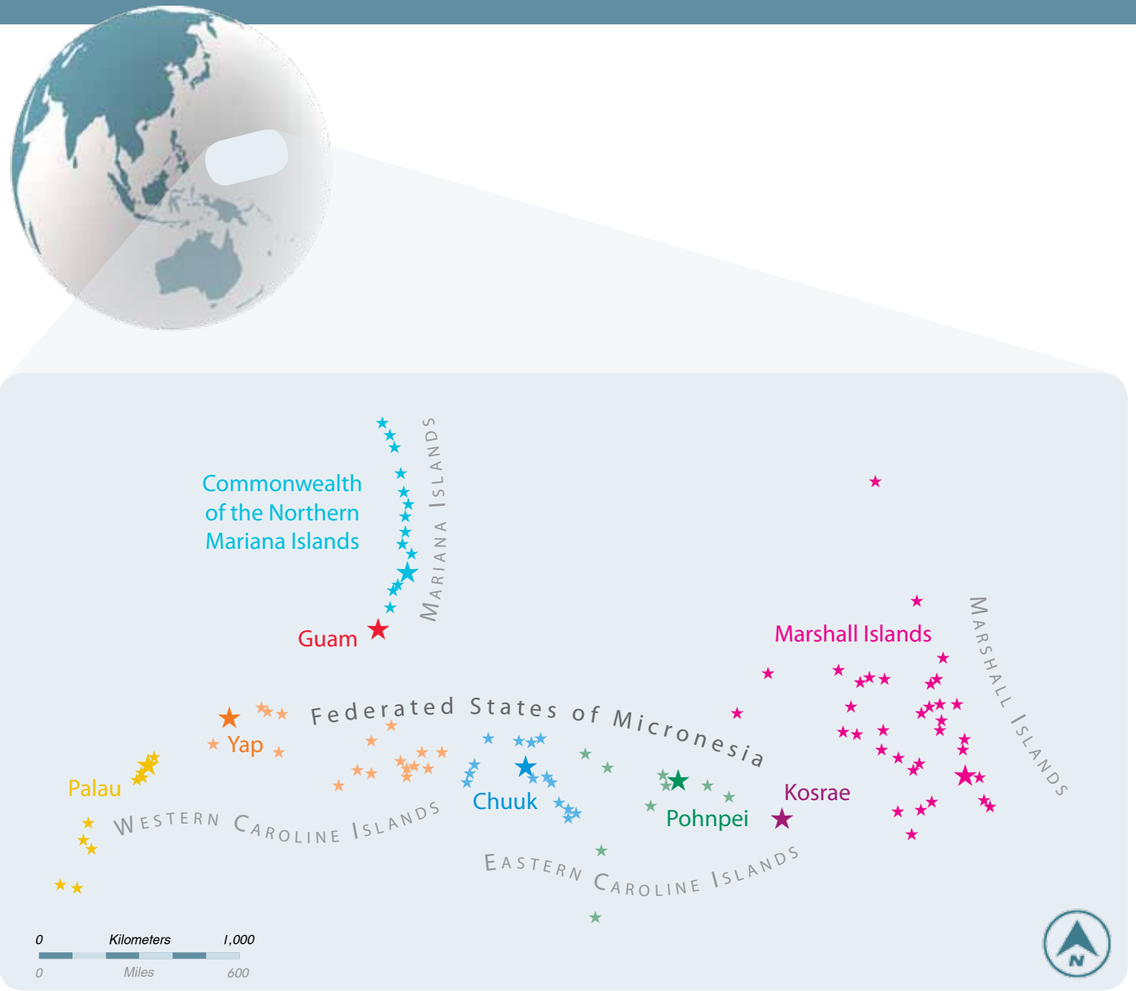
Water enables life. Every single cell in every living creature on Earth depends on water.

Access to fresh water has been pivotal throughout human history, from the earliest beginnings of civilization to the making of vast empires. Current issues of water pollution and water rights are dynamic topics of political debate within and among all nations on Earth.

Water has special relevance to the peoples of Micronesia, who live on small islands surrounded by ocean. No other landscape on earth and cultural worldview is so dominated by water. Micronesians have developed advanced skills in traditional management of water over many generations, as they have depended on and honed their stewardship of their small islands' limited freshwater supplies.

Today, with changing patterns of weather and climate making more extreme droughts and floods both likely in Micronesia's future, it is more important than ever that Micronesians understand their freshwater resources. While many aspects of water systems and water cycling are common to all Micronesian islands, each has unique resources and faces unique challenges.

This book provides an accessible guide for all Micronesians to learn about fresh water on their islands.



Micronesia is one of the three major regions of the tropical Pacific ocean, along with Melanesia and Polynesia. Most of Micronesia is in some way affiliated with the United States of America. At the center of the region is the independent nation of the Federated States of Micronesia (FSM). It is a federation of four states: Yap, Chuuk, Pohnpei, and Kosrae. Each state is centered on a high volcanic island of the same name, and each of the first three states also contain a group of outlying atolls collectively known as "outer islands". To the east and to the west of the FSM are two other independent republics, Marshall Islands and Palau, respectivelly. To the north are U.S. territories of Guam and the Commonwealth of the Northern Mariana Islands (CNMI). Finally, Micronesia contains two additional countries, Kiribati and Nauru, which are located toward the central Pacific and are not affiliated with the U.S. They are not included in this guide.

FRESH WATER IN THE ISLANDS

ESSENTIALLY THREE TYPES OF FRESH WATER CAN BE ENCOUNTERED ON AN ISLAND: RAINWATER, SURFACE WATER, AND GROUNDWATER.

All fresh water on an island originally comes to that island as rain. In the tropical heat of the Pacific Islands, a part of that **rainwater** evaporates right away and returns to the atmosphere.

Depending on the local geology, some of the remaining water may flow over the land surface as streams and rivers, or accumulate in depressions as ponds and lakes. Water moving over the land surface or sitting at the land surface is called **surface water**.

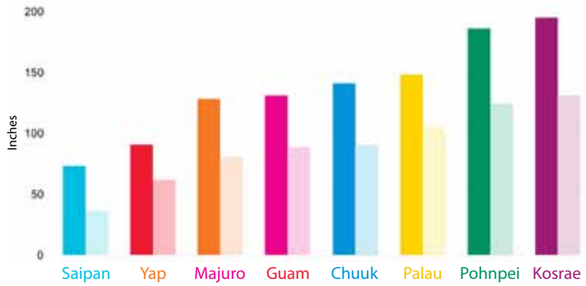
Part of the water soaks into the soil. Some of it is absorbed by plants via their roots embedded in the soil, and the rest continues to percolate downward into the ground and becomes **groundwater**.

On many islands, the land is so permeable that no water can remain at the land surface. In such places, especially where land is made of sand, limestone, or other porous sediments or rocks, everything that does not evaporate or get absorbed by plants becomes groundwater. There are no surface waters there.

A boy using a swamp taro leaf as a natural umbrella.

RAINWATER

Rain does not fall just the same everywhere. Some islands in Micronesia are significantly wetter than others. Rain also varies over time. On many islands, there are a distinct rainy season and a dry season. On most islands of Micronesia, people use **rainwater catchments** to capture rainwater rain as it falls and store it for drinking and other uses.



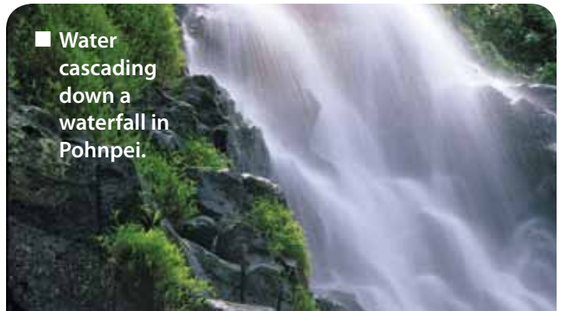
Average and minumum annual rainfall on different islands.

SURFACE WATER

Rainwater that neither evaporates nor soaks into the ground trickles across the land surface. It moves downhill, combines into streams, and streams merge with others and become bigger. The largest streams are called rivers. They flow downhill until they reach the coast, where they finish their journey and enter coastal swamps, lagoons, and the ocean.

Essentially, like a roof catches rain and gutters move it to a storage tank, the land catches rain and valleys move that water to the ocean. The ocean is the world's largest water storage place. Land that catches the rain for a particular stream or river is called a **watershed**. All rain falling in a particular watershed flows to the same place.

Surface waters are common on high islands, where streams and rivers carve deep valleys as they flow from the mountains in the interior to the coast. Streams and rivers do not exist on low-lying islands, where sand and limestone are too porous and soak up any rainwater so quickly that none is left to move across the land.



Water cascading down a waterfall in Pohnpei.

Groundwater inside a cave in Guam.

GROUNDWATER

Some of the rain that seeps into the ground becomes soil moisture and supports growth of plants. The rest percolates deeper into the ground. It cannot go deeper than sea level because it meets salty water from the ocean, which fills the island underground near sea level and everywhere below. As fresh water is less dense than salty water, the two waters do not mix much and fresh water essentially "floats" on the deeper salty water. The "body" of fresh groundwater is the thickest in the island interior and thinnest along the edges. It has an overall shape of a lens. That is why fresh groundwater on islands is often referred to as the **groundwater lens**.

Water from the lens constantly seeps out of the island along the shore, where the lens thins out. During droughts, the amount of fresh water in the ground is reduced because there is little rain to replenish it. The lens gets thinner, causing the underlying salty groundwater to move up, closer to the surface. That can harm taro patches and other vegetation, as most plants cannot tolerate saltwater entering their roots. This problem worsens with climate change, as the sea level rises and rainfall and storm patterns change.

YAP
(YAP PROPER)

MOST PEOPLE IN YAP GET THEIR WATER FROM THE PUBLIC SUPPLY. THE WATER COMES FROM THE LAND SURFACE AND FROM THE GROUND.

Yap is a tightly packed group of four islands, separated by narrow channels and surrounded by mangroves and reefs. Most of Yap is covered by grassy areas called savanna, and with gardens and agroforests around villages.

Mukong Stream, on Tomil-Gagil island, is one of the few permanent streams on Yap.

KEY POINTS

Population	7,500
Climate	The driest of the four main FSM islands, pronounced dry season, typhoons common.
Rainwater catchments	Important only in the remote parts of the island, notably Rumung.
Surface water	Many small streams, but most dry out completely during the dry seasons.
Groundwater	Primary source of water for the public supply. Metamorphic and volcanic bedrock yields little groundwater, but is important in absence of other sources.
Utilities	Public supply available throughout the island. Three separate companies provide water to households in different areas.

RAINWATER

Rain is not always abundant in Yap, as rainfall is very seasonal. There is relatively little rain in the dry season, roughly from January to April.

In Yap, utility companies provide good public supplies of fresh water across the island, including rural communities, so most people do not maintain rainwater catchments for their drinking water. Only in certain areas, particularly the island of Rumung (highly traditional island at the north end of Yap) and some of the newer settlements inhabited by people from the outer islands, the lack of suitable public supply requires communities to maintain rainwater catchment tanks.

SURFACE WATER

Yap is too small to have large rivers, but there are many streams. Most of them become dry when there is no rain for a long time. In contrast, during heavy rains, streams are full of water. They rush down to the coast and empty into the mangrove swamps that surround Yap.

Though most of Yap's public water supply comes from groundwater, the people in Yap's capital town, Colonia, depend on surface water. Nearby Gitam Dam blocks the flow of surface water to the ocean and creates a large reservoir where water is stored for latter use. During droughts, when little water flows in the streams, some remains in the reservoir.

GROUNDWATER

A part of the rain that falls in Yap seeps into the ground. It makes the soil wet, allowing plants to take up water that they need. Water in the soil slowly percolates deeper underground and becomes groundwater.

People have drilled deep wells and use pumps to extract groundwater and use it for drinking. Most of the public water supply in Yap comes from groundwater. Rocks in Yap are very dense and do not have many pores. Because of that, underground water in Yap moves slowly and wells do not produce large amounts of water. Fortunately, this is enough for the number of people who live in Yap.

Pipes that are part of a drilled well used to bring underground fresh water to the surface.

OTHER PARTS OF YAP STATE
("OUTER ISLANDS OF YAP")

PEOPLE IN THE OUTER ISLANDS OF YAP GET WATER FROM RAIN CATCHMENTS AND WELLS.

The outer islands of Yap are low-lying islands. They rise only a few meters above sea level*. All of these islands are composed of limestone rock and sand derived from skeletons of corals and other marine organisms. These materials are highly porous, so any rainfall quickly seeps into the soil and rocks and disappears underground. There are no streams or ponds in the outer islands.

Without surface water, people have limited sources for drinking water and other needs. The only fresh water sources available to them are rain and groundwater. Additional difficulty is posed by remoteness and lack of infrastructure, including any public utilities. That means that each household needs to independently satisfy own water needs. They harvest rainwater using rooftop catchments and access groundwater via shallow, hand-dug wells.

Because supplies of fresh water can be very limited, people in the outer islands of Yap use seawater for some purposes that would normally involve fresh water. For example, they may rinse dishes, wash laundry, and take baths in the ocean. Especially during dry periods, clean fresh water is reserved for drinking and cooking only.

* The island of Fais is exceptional in that it reaches over 10 meters above sea level because it has been pushed up by powerful movements within the Earth's crust.

■ Getting water from a rain catchment tank.

■ A hand-dug well with walls strengthened by coral rock.

■ Children helping their mother work in the swamp taro patch.

RAINWATER

Everyone in the outer islands depends on private rainwater catchments for drinking water. Each family typically has its own water storage tank coupled with a rooftop catchment. Larger tanks are shared by several related and/or neighboring families. On some, but not all, islands, larger tanks are available to communities as backup sources during shortages. Shortages are common and may last for several months at the beginning of each year. Coconuts are relied upon as an important supplementary and emergency source for drinking.

KEY POINTS

Population	4,000
Climate	Little rainfall in the dry season, from January to May. Typhoons are common.
Rainwater catchments	Families build and maintain own catchments that provide essential drinking water for everyone. Materials for building and repairing are costly and not locally available.
Surface water	No surface water.
Groundwater	Limestone bedrock and sandy soil are highly porous, but there is relatively little groundwater because of small island size. Groundwater is important and a widely used source for all non-drinking needs (and for drinking during shortages).
Utilities	No public supply. Few communal rainwater catchments exist.

SURFACE WATER

There are no freshwater streams, rivers, ponds, or lakes in the outer islands. Standing water at land surface exists only in taro patches and other man-made depressions.

GROUNDWATER

People in the outer islands of Yap access fresh groundwater by digging wells. They typically use this water for washing laundry, showering, rinsing after garden work or swimming in the ocean, and for washing and cooking certain foods, especially taro.

The favorite type of taro in the outer islands is swamp taro. This local staple requires wet conditions to grow. As there are no natural wetlands in the outer islands, over the centuries, people have excavated large depressions in islands' interiors to get closer to level of groundwater in the ground. The result are wet areas suitable for planting swamp taro.

CHUUK
(CHUUK LAGOON)

ONLY THE URBAN PART OF THE MAIN ISLAND IN CHUUK HAS A PUBLIC WATER SUPPLY SYSTEM. PEOPLE ELSEWHERE IN CHUUK LAGOON GET THEIR WATER FROM RAINWATER CATCHMENTS, SPRINGS, STREAMS, AND SHALLOW WELLS.

Chuuk is a large lagoon with 17 high islands and a number of smaller low islands, all surrounded by single barrier reef. The reef itself contains a series of additional low islands. All high islands and one low island on the barrier reef are inhabited.

RAINWATER

Only Weno has an island-wide public water supply. Smaller public networks exist on a few of the other islands in Chuuk Lagoon. Everywhere else, families must secure their own water.

Rainwater catchments are the primary way of acquiring clean water that is good for drinking. This is done using rooftop catchment systems, where rainwater falls on the roof of a house and flows through gutters into concrete or plastic tanks. However, this is not available everywhere and many families rely on springs, streams, and wells for their water. Chuuk has the highest percentage of reliance on unimproved water sources in Micronesia.

SURFACE WATER

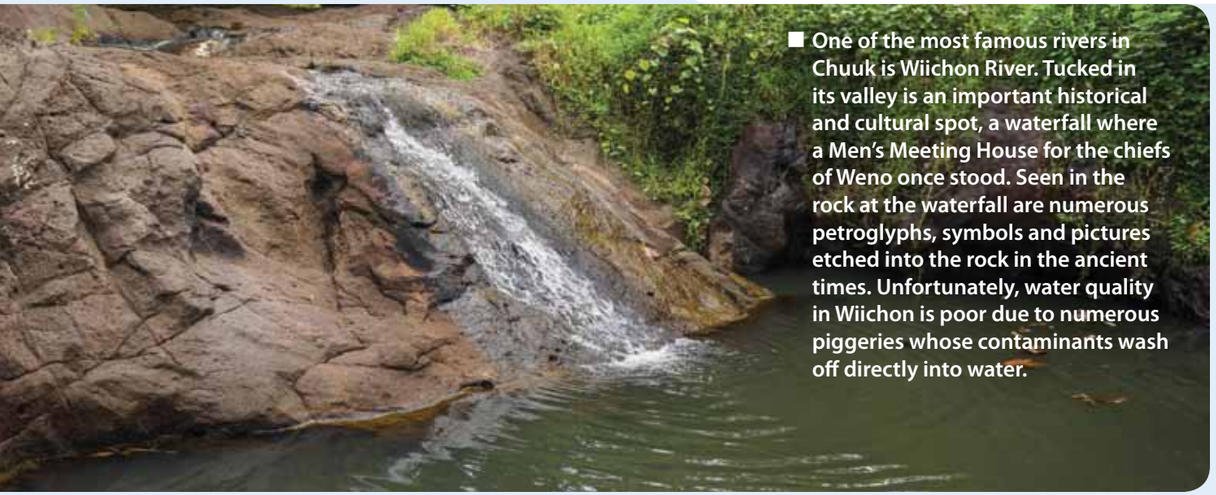
Only high islands in Chuuk Lagoon have surface water, but most of them are too small and too steep to have any significant rivers. There are many relatively small streams that flow only during the rainy season. The amount of water in them varies with rainfall. Only a few streams on Weno and some of the bigger islands can be called rivers and flow during the entire year.

In much of Chuuk Lagoon, people use surface water by immersing plastic pipes in streams and letting water flow by gravity to downstream communities. Regrettably, due to uncontrolled dumping of household and other waste and pollution from humans and animals, the surface water quality is generally poor.

GROUNDWATER

Rainfall that does not run off in streams seeps into the ground. It percolates through the soil and bedrock and becomes groundwater. On high islands of Chuuk Lagoon, the rocks are not very porous and contain little groundwater.

Nevertheless, groundwater is important. On Weno, Chuuk Lagoon's main island, water in the public supply system comes from about 30 drilled wells. Though the wells do not yield a lot, they are an important source because many people live in Weno and there is simply not enough surface water there. On other islands, people access groundwater from natural springs, where water seeps from the ground, or make shallow hand-dug wells.



■ One of the most famous rivers in Chuuk is Wiichon River. Tucked in its valley is an important historical and cultural spot, a waterfall where a Men's Meeting House for the chiefs of Weno once stood. Seen in the rock at the waterfall are numerous petroglyphs, symbols and pictures etched into the rock in the ancient times. Unfortunately, water quality in Wiichon is poor due to numerous piggeries whose contaminants wash off directly into water.

KEY POINTS

Population	35,000
Climate	Relatively wet, with two distinct seasons. Droughts and typhoons are common.
Rainwater catchments	Primary source of drinking water nearly everywhere.
Surface water	Most streams flow only during rainy seasons. There are only a few permanent rivers.
Groundwater	Bedrock on high islands is volcanic. It yields little groundwater, but is used due to absence of ample surface sources.
Utilities	Regular public supply, from groundwater, is available only on Weno and Tonoas islands. None available elsewhere in Chuuk Lagoon.

■ A lady on Piis Paneu, Chuuk Lagoon's only inhabited low island, getting water from a rudimentary well.

OTHER PARTS OF CHUUK STATE

("OUTER ISLANDS OF CHUUK")

Typical scenery in the outer islands of Chuuk. Shown is Oneop, in the Mortlock Islands group.

Bathing a baby using rainwater.

THE ONLY FRESHWATER SOURCES AVAILABLE TO PEOPLE ON THE OUTER ISLANDS OF CHUUK ARE RAIN CATCHMENTS AND WELLS.

Outer islands of Chuuk are low-lying sandy islets that formed atop coral reefs. Most are atolls -- only Nama, Houk, and East Fayu have no lagoons. Because the islands are small and the sandy land surface very porous, there are no streams or rivers. Any rainwater that does not evaporate, seeps into the ground and disappears from the land surface. People can only get fresh water if they capture rain before it falls on the ground or get groundwater out from the ground.

It is significant that the outer islands of Chuuk are much more populous than the outer islands of neighboring Yap and Pohnpei states, but do not have more land area or more rainfall. Nearly 30% of all people in Chuuk State live in the outer islands. The needs for fresh water are very high. Communities have been known to run out of fresh water during droughts, and to require emergency supplies brought in by ship.

RAINWATER

Rainwater is the only viable source of drinking water in the outer islands of Chuuk. People capture rainwater using rooftop catchments and store it in concrete or plastic tanks. The quantity of water that can be captured and stored depends on the amount and frequency of rainfall and the availability of sufficient roof catchment areas and water tanks. Any problems with the roofs, gutters, and tanks, especially poor design and poor maintenance, badly affect the quality of stored water.

SURFACE WATER

There are no fresh surface waters in the outer islands of Chuuk, other than in depressions that reach down to groundwater. These include taro patches and a large pond on Houk Island.

KEY POINTS

Population	14,000
Climate	Two seasons (breadfruit season and windy season). Droughts and typhoons are common.
Rainwater catchments	Rainwater catchments are the primary and essentially only source of drinking water. Every household or compound maintains own catchment.
Surface water	No surface water.
Groundwater	Widely used, from shallow hand-dug wells. It is used mostly for washing laundry, showering, and for cooking/drinking when rainwater is not available.
Utilities	No public supply. There are a few communal rainwater catchments.

GROUNDWATER

Each island contains a small lens-shaped body of fresh groundwater that floats (due to lower density) on top of deeper, salty groundwater. People get fresh groundwater from shallow, hand-dug wells. They use groundwater for laundry, showering, and for domestic animals. On some islands, they may also use it for drinking and cooking during emergencies when there is not enough rainwater. Groundwater must be boiled or otherwise treated before it can be safely used for drinking.

Unfortunately, salty groundwater is being reported from many islands. Outer islands of Chuuk are affected by both saltwater intrusion from the underlying seawater and by waves and storm surges spilling over the land. That makes the groundwater an unsuitable option for emergency water supplies, and also causes great problems to local agriculture and food security because it harms plants. This is especially true for low-lying areas where islanders grow swamp taro, one of the local staple foods.

POHNPEI
(MAIN ISLAND)

POHNPEI IS ONE OF THE WETTEST PLACES IN THE WORLD, WITH MANY STREAMS AND RIVERS. PEOPLE IN POHNPEI GET THEIR WATER FROM STREAMS AND FROM RAIN.

Pohnpei is a large, tall island surrounded by mangroves, lagoon, and a barrier reef. The interior is mountainous and covered by lush rainforest.

RAINWATER

One of the wettest places in the world, Pohnpei receives an average of about 190 inches of rain per year, with higher regions and mountain peaks getting over twice that much. Rainfall is distributed evenly throughout the year (only January through March receive somewhat less rain than other months). People in urban areas, particularly the town of Kolonia, get water from the municipal supply. Elsewhere, people make small dams that block the flow of surface water and create reservoirs, from which pipes take water down to households. As this water quality is not always good, most people in rural areas use rainwater catchments to get the clean water needed for drinking and cooking needs.

SURFACE WATER

Surface water is the main source for Pohnpei's public water supply. A dam on the Nanpil River and many smaller dams on streams around the island provide water that is distributed to people's homes. The abundance of rainfall feeds over 40 rivers and many streams around the island. They are fast on steep mountain slopes, but slow down in the lowlands and empty into mangrove swamps along the coast. Droughts are rare on Pohnpei, so availability of fresh water is typically not a problem. Unfortunately, due to land clearing, erosion, pollution, and human and animal waste, water quality is often reduced. Many Pohnpei rivers are contaminated and pose health hazards.

GROUNDWATER

Volcanic rocks that make up Pohnpei are not very porous and cannot hold or transmit much water. Therefore, groundwater is not an important water source and water from wells only supplements the supply derived from surface water. The FSM National Government in Palikir is an exception; its offices are supplied by groundwater from wells.

Just like surface waters, groundwater is also driven by gravity and moves downward toward the lower parts of the island. This is a slow process because groundwater moves through the rocks underground. Springs, where groundwater naturally emerges at the land surface, are popular places to get fresh, cool, and clean drinking water.

■ Two boys travel in a paddling canoe down a river.

■ Mangrove swamps and estuaries (places where fresh water from rivers mixes with ocean water) are important habitats for marine life.

KEY POINTS

Population	35,000
Climate	One of the wettest places in the world. No pronounced dry season. Typhoons uncommon. Droughts are very rare.
Rainwater catchments	Common in rural areas throughout the island.
Surface water	There are many permanently flowing streams and several major rivers.
Groundwater	Bedrock of tight, rather impermeable volcanic rocks yields little groundwater and is not used much as a water source.
Utilities	Public water supply, derived from surface water, is available in most communities.

■ A lady in Kitti, southern Pohnpei, filling a bottle for drinking from a pipe that brings groundwater from a natural spring.

OTHER PARTS OF POHNPEI STATE

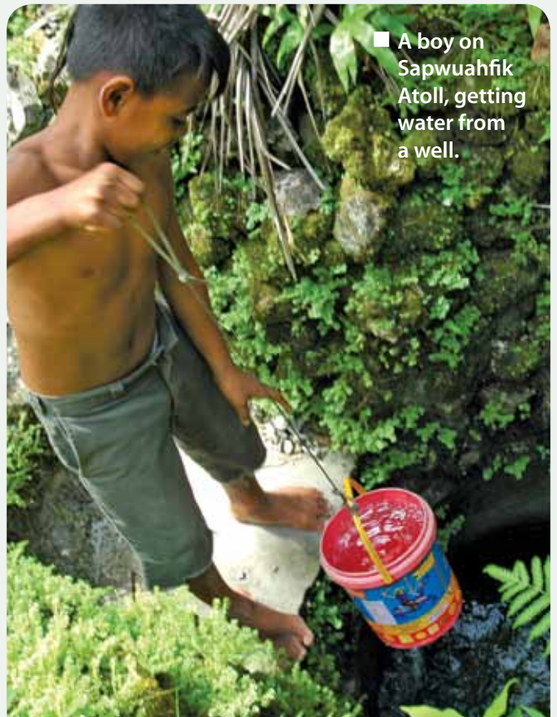
("OUTER ISLANDS OF POHNPEI")

THE OUTER ISLANDS OF POHNPEI LACK SURFACE WATER. THE ONLY AVAILABLE FRESHWATER SOURCES ARE RAIN CATCHMENTS AND WELLS.

All outer islands of Pohnpei are atolls. Their higly porous land surface absorbs rainfall quickly, like a sponge. No streams exist, even after heavy rainfalls. To get fresh water, people must catch the rain before it falls on the ground, or dig wells to get to water in the ground. There is no public supply of water on the outer islands, so every family or group of families must have its own rainwater catchment and well.

■ Rainwater catchment system (roof, gutters, tank) on Pingelap Atoll.

■ Rainy day on Pakin Atoll.



■ A boy on Sapwuahfik Atoll, getting water from a well.

RAINWATER

Rainwater is the only viable source of drinking water. People use guttered tin roofs to catch rain as it falls and use plastic or concrete tanks to store it. On Mwoakilloa Atoll, many storage tanks are built into houses and are accessible from inside the house.

The outer islands receive much less rainfall than the main island of Pohnpei. Kapingamarangi Atoll is particularly dry. It is located so close to the Equator that it gets less rain than any other atoll in in Micronesia. The quantity of water available to people in the outer islands can be a significant problem. There have been droughts when people ran out of fresh water and emergency supplies needed to be brought in by ship. Another issue is the fact that many people are moving away from their atolls. On Pingelap Atoll, neglected water tanks, many of which are in unoccupied households, contain cesspools that are mosquito breeding habitats and health hazards.

KEY POINTS

Population	1,500
Climate	Typhoons are less common the outer islands of Pohnpei than in Chuuk and Yap states. Less rain falls than on Pohnpei main island. Droughts occur.
Rainwater catchments	Absolutely necessary on all outer islands. Everyone needs access to a rainwater catchment tank.
Surface water	Streams and rivers are absent.
Groundwater	Used as a secondary source of water, and emergency source when rainwater is not available. Relative importance varies greatly among islands.
Utilities	Public supply is not available, but municipal buildings, schools, and dispensaries may have communal reserves in large tanks.

SURFACE WATER

The outer islands lack surface waters. Standing water can be seen at times in man-made depressions excavated by people to reach to groundwater and plant swamp taro (which requires wet conditions to grow).

GROUNDWATER

Groundwater on atoll islands exists as a thin layer of fresh water underlain by salty water from the ocean. The availability of fresh groundwater depends on island size and rainfall, and diminishes during droughts. Typically, people in the outer islands of Pohnpei use groundwater for showering and rinsing and for watering animals. If stored rainwater is running low, groundwater is used to wash laundry and cook. In emergencies, groundwater is boiled and used for drinking.

KOSRAE

KOSRAE IS A VERY HUMID PLACE, WITH LOTS OF RAIN. MANY STREAMS AND RIVERS FLOW THROUGHOUT THE YEAR.

Kosrae is a mountainous island surrounded by mangrove swamps and a fringing reef. The interior of the island is covered by a lush rainforest, and people live mostly in coastal areas. Most residents of Kosrae have access to public water supply in their villages. Water served by the public networks comes from streams, which are plentiful on the island.

RAINWATER

Kosrae is an extremely wet island. On average, the weather station in Lelu records about 200 inches of rain per year. Places higher up in the mountains receive even more. The rainfall is well distributed throughout the year and there is no noticeable dry season. Droughts are quite rare on Kosrae. Prior to the drought at the beginning of 2016, the last significant one was in 1983.

People in places away from village centers, such as in Walung in southeastern part of Kosrae, do not have access to public water supply. They can get water from nearby streams, but obtain good quality drinking water only by capturing rain.

SURFACE WATER

The abundance of rainfall feeds many streams and rivers. They run quickly through narrow valleys on steep mountain slopes and create a number of beautiful waterfalls. The rivers slow down as they reach lowlands along the coast and then empty into the mangrove swamps and reefs around the island.

People intercept rivers to get water. Small dams and intake pipes installed at Malem, Palusrik, Tafuyat, Yekula, Mutunte, and Walung rivers feed separate water supply systems for Kosrae's villages.

GROUNDWATER

Most rainfall that falls on Kosrae goes into streams and rivers and flows over the land surface to the ocean. This is easily seen after a major rainfall, when streams swell up and torrents rush down mountain slopes.

Relatively little water seeps through the soil and into cracks and pores in the volcanic rocks. With water plentiful at the land surface, groundwater is not an important water source on Kosrae and wells are not needed. There are, however, many natural springs that issue water from the ground and are highly respected as sources of water of excellent quality.

Rooftop rainwater catchment system in Kosrae. Water from the roof is transferred by gutters to the PVC tank.

A fast-flowing mountain stream in its narrow valley. The large boulders in the streambed are rolled down by torrents when streams swell up after major rainfalls.

KEY POINTS

Population	6,600
Climate	Very wet, no pronounced dry season. Droughts are rare. Typhoons uncommon.
Rainwater catchments	Needed at households without public water supply, away from village centers.
Surface water	There are very many streams and rivers. The amount of water in them heavily depends on the amount of rainfall.
Groundwater	Bedrock is relatively dense volcanic rock that does not hold or yield much groundwater and is thus not an important water source.
Utilities	Public water supply, derived from surface water, is available in all villages.

PALAU

PEOPLE IN MOST OF PALAU HAVE ACCESS TO PUBLIC WATER SUPPLIES DERIVED FROM SURFACE OR GROUNDWATER SOURCES.

Most of Palau's islands, including Babeldaob (the largest) and Koror (the most urban), are surrounded by a single large lagoon and barrier reef. The majority of Palau's population has access to a public water supply. However, in Palau it is not only the local people who need water. The rapidly growing tourism industry exerts additional pressures on resources. That makes the country extremely sensitive to water shortages, the most recent of which was in 2016 and was severe. Desalination is becoming more important. It is currenly used on Peleliu and Angaur to purify groundwater, and can be employed with seawater in emergencies.

RAINWATER

Though Palau is rapidly developing and infrastructure delivering public water supply to individual households exists in most of the country, private rainwater catchment systems remain important. People often prefer the taste of rainwater to tapwater. Catchments are the primary source of drinking water for over 20% of the population, and up to 100% in rural areas.

■ Ngardok Lake, Babeldaob Island.

SURFACE WATER

Significant surface waters exist only on the island of Babeldaob. The island is divided into a number of watersheds, feeding rivers that discharge into mangrove swamps along the coast. The main sources for Palau's public water supply are Ngerikiil River and the reservoir behind Ngerimel Dam. Together they supply Koror and Airai states, which corresponds to about 80% of Palau's population. Smaller dams elsewhere in Babaledaob feed water to smaller distribution networks in local communities.

The longest river is Ngerdorch River and its watershed contains Ngardok Lake, the largest freshwater lake in Micronesia. Ngardok Lake is a natural preserve that provides habitat to many native species of plants and animals.

GROUNDWATER

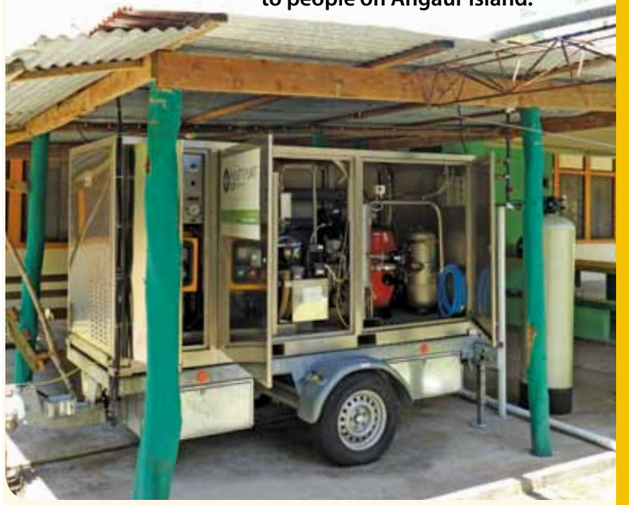
All islands have groundwater, but aquifers that can be utilized are not everywhere. An aquifer is body of rock that is sufficiently porous and permeable that it can yield useful quantities of groundwater.

In Palau, there are not many good aquifers. Most of the public water supply comes from surface water sources. Only four communities in Palau (Peleliu, Angaur, Kayangel, and Ngiwal) rely on wells for the local public supply systems. Unfortunately, the location and small size of these aquifers makes them susceptible to saltwater intrusion, so groundwater quality needs constant monitoring and management.

KEY POINTS

Population	21,000
Climate	Generally wet, but droughts occur. May to August are the wettest months.
Rainwater catchments	Important throughout Palau. People prefer the taste of rainwater to tapwater.
Surface water	Streams/rivers exist only on Babeldaob. They are dammed to create surface reservoirs for public water supply. That is the primary source of water on Palau.
Groundwater	Groundwater is the primary source in four communities, where it is treated by desalination or chlorination before use.
Utilities	Public supply available throughout the country, except in the most remote parts.

■ Desalination unit that yields the best quality water to people on Angaur Island.



MARSHALL ISLANDS

AN INTERMITTENT PUBLIC WATER SUPPLY EXISTS IN URBAN AREAS. PEOPLE DEPEND ON PRIVATE RAINWATER CATCHMENTS.

The Marshall Islands consist entirely of atolls and other low-lying islands. Land area is very small and reaches no more than a few meters above the sea level. Water resources are extremely limited and consist of rainwater and groundwater only. Desalinated seawater is becoming more important.

RAINWATER

Rainwater is the source of water for nearly all needs in the entire nation. Water for the public supply in Majuro is pumped from a large rainwater catchment system built near the airport. The only of its type in Micronesia, this system uses the airport runway as the catchment area and an array of interconnected concrete-lined pools for storage. The pools are covered to minimize evaporation and contamination.

Nearly all households in the country collect and store their own rainwater using rooftop catchments and tanks. These are the only drinking water sources for nearly everyone. Droughts are, therefore, an existential threat.

SURFACE WATER

The Marshall Islands completely lack streams and rivers. Ponds exist on Wotje Atoll, Kwajelein Atoll, and Lib Island. They are filled with water from the ground and their water level varies with the tides.

GROUNDWATER

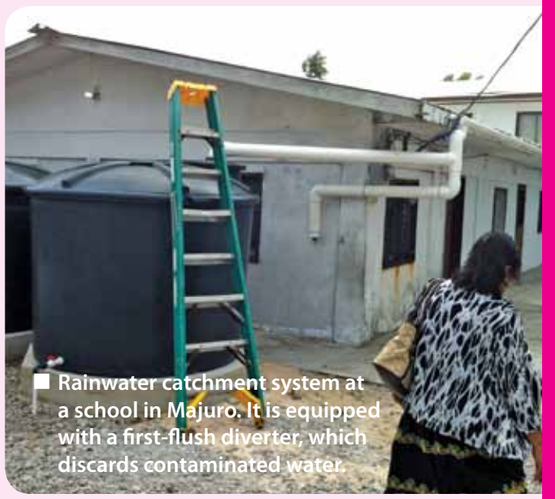
The amount of groundwater varies from place to place. In general, the wider the islet (from lagoon to the ocean) and the finer the sediments, the greater the amount of the groundwater below the land surface. The most groundwater is on islets that are relatively large and located on atoll's leeward sides (sediment is coarser on windward sides). The relatively thick groundwater body in Laura in Majuro has several drilled wells that supplement the public water suply.

■ Results of the 2013 drought on Ailuk Atoll.

■ Aerial view of the large rainwater reservoir in Majuro. It receives water captured by the airport runway and stores it for distribution in the public utilities system.

KEY POINTS

Population	53,000
Climate	Pronounced differences in rainfall among atolls. Northern atolls are drier than the southern ones.
Rainwater catchments	Essential everywhere. Majuro has a large-scale public rainwater catchment system, which uses airport runway as the catchment area.
Surface water	No streams or rivers anywhere in the country.
Groundwater	Groundwater found on all islands, but is limited due to small island size.
Utilities	Public supply in Majuro and Arno atolls, but it is not available 24 hours due to chronic shortages. On Ebeye, there is a distribution network that serves desalinated water from the ocean.



■ Rainwater catchment system at a school in Majuro. It is equipped with a first-flush diverter, which discards contaminated water.

GUAM

PUBLIC WATER SUPPLY EXISTS THROUGHOUT GUAM. MOST OF THAT WATER COMES FROM THE GROUND.

Guam is a single island, but its northern and southern halves are quite different. The north is made of limestone and has lots of groundwater, but no water at the land surface. The south is made of volcanic rocks and has many streams and rivers.

■ Talofofo River is the longest river on Guam and has the largest watershed.

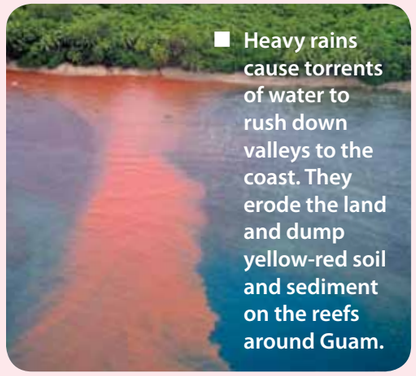
■ An aerial view of Fena Reservoir.

RAINWATER

As public water supply exists throughout Guam, rainwater is not widely harvested. Tapwater is used for all needs except for drinking. Most people drink bottled water, especially that dispensed from 5-gallon bottles purchased from companies that purify it using reverse osmosis.

SURFACE WATER

Southern Guam has a dozen major watersheds, over 50 named rivers, and hundreds of smaller streams. One of the rivers flowing through central part of southern Guam, Fena River, was dammed to create a large, man-made lake called Fena Reservoir. This is the source of water for the public utilities and military use in southern Guam. Northern Guam, in contrast, lacks surface waters. It is made mostly of limestone, which is readily permeable and allows any rainfall to percolate into the ground, rather than flow over the land surface as streams and rivers.



■ Heavy rains cause torrents of water to rush down valleys to the coast. They erode the land and dump yellow-red soil and sediment on the reefs around Guam.

■ A building protecting one of many wells that tap into the Northern Guam Lens Aquifer.

GROUNDWATER

The majority of people on Guam live in the northern half of the island. The rocks there are so permeable that any rainfall quickly percolates into the ground and becomes groundwater. This water-saturated body of rock is known as the Northern Guam Lens Aquifer and is the vital source of water in Guam. Water is extracted from the aquifer using many drilled wells.

As Guam's population grows, people are faced with the challenge of providing enough water for everyone. Like on all islands, fresh groundwater is replenished by rain. As new water percolates down from the land surface and is added to the aquifer, it pushes other water sideways toward the coast and into the ocean. That is why freshwater springs exist along the coast. They are seen especially at low tide on beaches, when trickles of water make rills in the sand. When we extract water in wells, we can only take this extra water. If we take more, we exceed the amount of natural recharge from rain and reduce the total amount of fresh water in the ground. That causes salty water from the ocean to enter and occupy spaces in rock previously held by fresh groundwater. This saltwater intrusion makes our water not potable due to high salt content and causes long term damage to the aquifer.

KEY POINTS

Population	166,000
Climate	Pronounced dry season (January to May) and rainy season (July to November). Typhoons are common.
Rainwater catchments	Practically absent. Bottled water is the main source of drinking water.
Surface water	Streams and rivers are found only on volcanic terrain, in the southern half of the island.
Groundwater	Large aquifer in the northern half of the island supplies drinking water to most of the population.
Utilities	Public supply is available throughout the island, provided by Guam Waterworks Authority.

CNMI

COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

ALMOST EVERYONE IN THE CNMI HAS ACCESS TO A PUBLIC WATER SUPPLY, BUT THE SUPPLY IS NOT ALWAYS RELIABLE AND OF GOOD QUALITY.

The Commonwealth of the Northern Mariana Islands (CNMI) is a chain of volcanic islands. The three southern islands, Saipan, Rota, and Tinian, are the largest and home to virtually the whole population. Other islands are uninhabited, except Pagan, which sometimes has people.

RAINWATER

CNMI gets receives less rainfall than other parts of Micronesia. After Guam, Saipan is the most populous island in Micronesia, but its average annual rainfall is less than any other major island in the region. Saipan gets about half of what falls in Palau, Chuuk, and Majuro, and just over a third of what falls in Pohnpei and Kosrae.

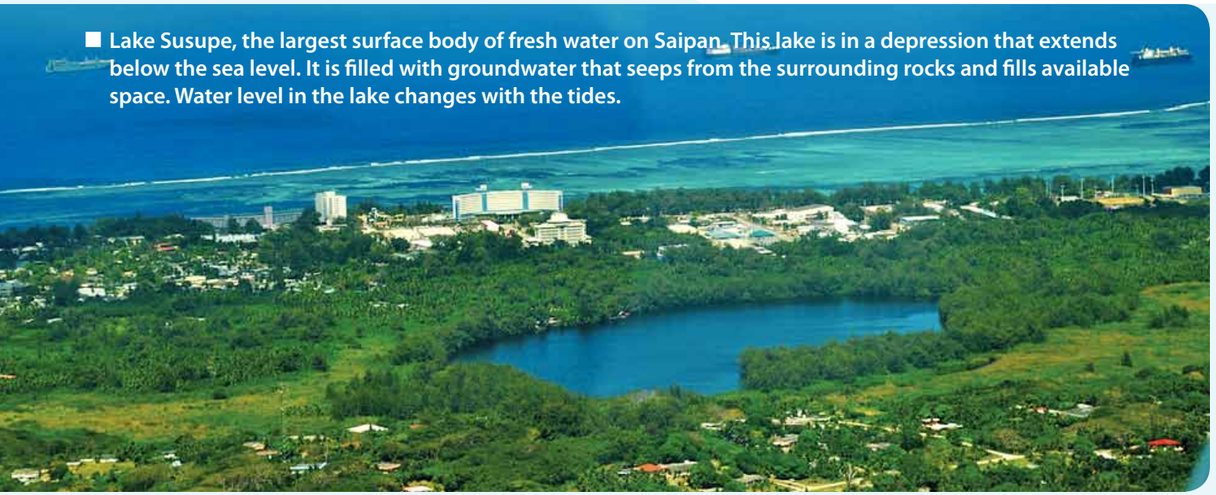
Though nearly everyone in the the CNMI gets their water piped to their home from the utilities company, many households and businesses collect rainwater for their drinking and other needs. This is because water in the public supply is unreliable and often saltier than it should be.

SURFACE WATER

Surface water in the CNMI is limited to ponds, marshes, a couple of lakes, and a few streams that dry out during parts of the year. Because surface water is so limited, it is virtually unused in the CNMI. However, due to high demand on limited groundwater resources in Saipan and resultant problems with saltwater intrusion due to overpumping, the use of water from Saipan's largest stream, Talofofo Stream, has been considered as a possibility to augment the public water supply.

GROUNDWATER

The three main islands have aquifers contained in limestone bedrock. These aquifers are used as the sources for public water supply networks. Water is pumped from wells, but because of high demand and limited supply, there has been overpumping. That means that more water is removed from the aquifer than is naturally added by rainfall. This has led to intrusion of saltwater into the aquifer and has significantly reduced groundwater quality. On Saipan, all water in the public supply comes from the local aquifer and is not always potable due to high salt content. Rota and Tinian have much lower populations and thus less issues with water quality and quantity.



■ Lake Susupe, the largest surface body of fresh water on Saipan. This lake is in a depression that extends below the sea level. It is filled with groundwater that seeps from the surrounding rocks and fills available space. Water level in the lake changes with the tides.

KEY POINTS

Population	54,000
Climate	The driest islands in the Micronesian region. Pronounced rainy and dry seasons.
Rainwater catchments	Many households and businesses collect rainwater to replace or supplement public supply.
Surface water	Some lakes, ponds, and wetlands. A few streams form during the rainy season, but dry out entirely during the dry season.
Groundwater	Essential source for public supply. Overpumping on Saipan has caused saltwater intrusion.
Utilities	Public supply available on Saipan, Rota, and Tinian, but the service is sometimes unavailable and the water is brackish at times.

■ A well on Saipan.

ABOUT THIS BOOK

Text and photographs: **Danko Taboroši**
Creative support: **Ethan Allen**
Layout: **Island Research & Education Initiative (iREi)**

Additional photographic credits:
Majuro Water and Sewer Company (p. 24), David Burdick (p. 27 top),
CNMI Bureau of Environmental and Coastal Quality (p. 29)

For more information about the Water for Life project, please see

http://prelw4l.wordpress.com

For more information about Micronesia, please see

http://islandresearch.org

For books about Micronesia, please see

http://islands.fm/bookstore

Disclaimer: The materials in this book are based upon work supported by the National Science Foundation under Grant Number 1224185. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

ISBN 978-982-9170-19-4