When We Speak of the Future

This book shows you the multifaceted nature of the water issues in our region. You may already be familiar with some of the details from other study frameworks and information sources such as newspapers, TV, etc. The goal of the study units in this book is not only to shed light on water awareness for study purposes, but also to begin working toward feasible solutions concerning some of the water problems in the region. Many of us tend to think that solving such water problems is the domain of experts (engineers, hydrologists, politicians, etc.) and thus ask ourselves: "Whom do we think we are, ordinary people to assume that we hold any influence over the “endless” reserve of water? So what if I wasted a little water while brushing my teeth! Whom are we to think that we can affect the stream of water flowing down the Jordan River, the ground water in the great coastal aquifer, the Tiberias, and… the clouds in the sky?"

The truth is that everyone can be part of the solution each time we use water (even when no one is looking). Every liter of water saved by one person at home can eventually become millions of liters, if every person does the same. If everyone fixed a leaky faucet (private or public) the little pool that once formed beneath the tap could amount to a big lake of water that was not wasted in vain. In fact, if every one in the region “saved” only one drop of water per day - one drop - the amount of water saved would supply the needs of seven people!

This study unit invites you to closely observe the way in which you use water and then plan your own ways of using water more efficiently. After all, to run water through a home faucet is indeed a practical, scientific, and technological challenge. But, when we are considering the ways we exploit our available water resources, we are confronted with a moral challenge - what shall we leave to the next generations? And you! You are the next generation!
“We drank you, and we say we drank the rain…
And we ate you and we say we ate the trees…”

(From the poem “The Sea” by the Lebanese poet, Elia Abu Madi)
Our Freshwater Source ... The Ocean

A tiny drop of water hangs from the mouth of a faucet. If we were to retrace the path of this little drop, what kind of journey would lead us to its source?

The sea is the beginning and the end of the water cycle, a cycle in which water relentlessly moves in all its physical states (solid, liquid, and gaseous) in the ocean, in the air, and on land. The water cycle is driven by the sun’s energy: the sun heats the ocean’s surface, causing water to evaporate, releasing a light, almost salt-free vapor into the atmosphere. When the vapor cools, it condenses to form clouds, and falls back to earth as precipitation (snow, hail and rain) over ocean, other water bodies, and land. Gravity causes precipitation to fall, and it also is the force that causes water to flow down mountain slopes, percolate into rocks and soil, and return to the ocean, where the sun’s radiation causes water to evaporate, and the cycle begins once again. Some of the precipitation percolates into the soil and enriches the ground water, and eventually flows back to the ocean.
**We Have Only The Sky Above Us**

All the water in our region – streams, rivers, lakes, and ground water - comes from the sky above us, from precipitation that falls on our land. The Mediterranean Sea is our principal source of water vapor and it produces clouds that are carried eastward toward our region, releases rain and the cycle is repeated again. Rainfall distribution in our region is uneven; some desert areas receive very little rain, while other areas (small!) receive very substantial rainfall.

The amounts of rainfall in various parts of the region vary due to a combination of several factors:

**Proximity to the sea** - As the moist air, carrying water vapor, streams away from the sea, it gradually loses moisture. Therefore, as we move eastward in our region, the amount of rainfall decreases.

**Topographic altitude** – The higher the topographic altitude, the greater the precipitation. The mountain ridge located between the Mediterranean and the Jordan Valley obstructs the air flowing from the sea, “forcing” it to climb. As the air rises it cools and its water vapor condenses into drops and falls as rain, snow, or hail. This phenomenon also occurs at the mountain ridge east of the Jordan Valley (see insert: “Rain Shadow”), as well as in other high regions (Galilee and the Central Mountain Range), where the precipitation rate is higher than in the adjacent lower regions.

**Geographical altitude** - Our region borders the northern part of the Earth’s desert zone, located between latitudes 15 – 30 degrees north (see insert: “World Desert Zone”). This explains why the prevailing climate in many parts of the region is arid (average yearly rainfall less than 200 mm), or semi arid (200 – 400 mm rain per year). When you look at the precipitation map, you will notice at once that as one travels further south, the amount of rainfall decreases.

For more information on precipitation in our region, refer to the “Water Facts” section on the WaterCare Web Site at: [www.watercare.org](http://www.watercare.org).

Go to the Overview report Table of Contents and look for “Climate: Large Changes in Small Distances”.
Quantity of rain in region decreases as we travel eastward and southward. In fact, 70% of the region is defined as a desert, receiving a meager 50 mm to 200 mm of rain per year. In the rest of the region, precipitation is 300 mm to 750 mm per year and only on mountain tops in the northwestern areas is there more rainfall.
Rain Shadow

When you examine the region’s precipitation map, the lines of equal precipitation create a fingerlike shape along the valley between the Dead Sea and Lake Tiberias. The quantity of rainfall in the Valley region is much lower than in the adjacent regions to the east and west. The topographic altitude of the Central Mountain Ridge causes moisture-laden air arriving from the sea, to release rain on its summit and its western slopes. With the loss of part of its moisture due to precipitation, the air becomes drier and passes the summit on its way eastward. When it descends toward the Jordan Valley and the Dead Sea, it becomes warmer. As the temperature rises, the relative moisture of the air decreases, and the probability of water condensation and rainfall is reduced. The valley region is therefore called a “rain shadow” region – namely, a region poor in precipitation located behind a (relatively) rain-rich mountain area. When the air “climbs” towards the Jordanian Plateau, it cools again, the water vapor within it condenses, and falls again as precipitation over the Jordanian Plateau.

World Desert Zone

The formation of the Earth’s desert zone is related to the movement of air channels and streams from the equator to the poles. The equator region receives high levels of solar radiation throughout the entire year, causing the air to heat and rise. When air rises, it cools, and the water vapor in it condenses to form clouds that release heavy rain in the Equatorial Zone. The air continues its movement (in the form of air currents) towards the north and south poles. Due to the earth’s rotation, at the latitude of approximately 25 degrees, the air begins to descend toward the surface. As the air descends, it compresses and warms, thus reducing the likelihood of clouds forming. Therefore dry regions – deserts – form on both sides of the Equatorial Zone.
Cross-section showing precipitation rates and the rain shadow across the region

Before you is a list of sites grouped in pairs. Study the precipitation map and charts above and complete the following tables.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Local altitude above sea level (meters)</th>
<th>Precipitation rate</th>
<th>Main factor causing difference in precipitation rate</th>
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<tr>
<td>EILAT/AQABA</td>
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Forecast – Unclear

Following careful and empirical scientific observation, climate researchers and staffers of the Meteorological Service collect rain data for a specific area and arrange the findings on a precipitation map. Is there truly anyone (including meteorologists) who can use this information, say, in order to plan a “laundry day” during the winter? Is there anyone who can recommend in midwinter, a week in advance, a hike in the bed of a wadi (stream) in the desert?

The precipitation map shows average rain levels in each region, calculated over decades. This map tells us how much rain falls within a given season; however, it cannot offer any clues as to the rain’s distribution and intensity. These attributes are known to those of us who are residents of the region, from our own experience – and we can testify about them first hand as personal experience is more reliable than information found on the precipitation map.

Precipitation rates fluctuate drastically from year to year. In our region, residents are used to unpredictable cycles as we “swing” between very dry years, drought years, and other years with plentiful rain. We cannot predict the nature of the coming rainy season, nor can we predict the beginning or the end of the season. In our region the rainy season usually lasts from November to April, yet we all remember years when the rains came much later or earlier than in these months.

The distribution rate of rainy days during the rainy season is also subject to extreme variations from year to year. As a result, it is not unusual to discover that even during years when the quantity of rainfall was reasonable, “agricultural droughts” occurred, meaning that even in such years crops could be damaged if the rain arrived too early or too late, or if there were very long breaks between the rains.

Even though in 1990 Jerusalem received sufficient rain, there were four months that year with no rainfall at all and another three with very little rain. However, Birmingham, in the UK, had rain every month of the year, even though the annual total was much less. How do you think this affects the growth of plants in each of the two cities?
Rainy Year, Dry Year

A. Locate your village or town on the precipitation map, mark it on the map and write down the average annual precipitation in your residential area.

B. Find in the data table below a station representing precipitation rates similar to that in your area. (Row A – dry year, row B – rainy year)

C. According to the data of the station you selected in the table, prepare a bar diagram showing rain data in the driest year and the rainiest year between October and May.

D. Describe the differences between the two years that you examined in rain quantity and its distribution throughout the year. What can you conclude?

<table>
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With A Little Help For The Clouds

Observes on duty are watching their radar screens. Orders come in over the radio for aircraft to take off immediately. Their mission - to fly into the clouds and... “seed” them.

Scientists have discovered that if particles of certain materials are dispersed, “seeded”, into clouds, moisture in the cloud will be attracted to the particles and form larger drops of water. As the water drops increase in size, the possibility that they would fall as precipitation increases. One of the materials used for “seeding clouds” is crystals of silver iodide (AgI - a compound of the chemical elements silver and iodine).

These crystals usually are sprayed from aircraft directly into the clouds, but sometimes they are added by heating the material in large furnaces on land. The furnaces are activated when clouds appear, and the hot air containing silver iodide particles rises and disperses among the clouds. Research shows that “cloud seeding” increases rainfall, however, scientists are still debating whether this method is really effective and whether it can be applied in different regions, rainy and dry. Research and experiments are still being conducted.

The light aircraft takes off when there are clouds laden with sufficient water vapor. Besides the pilot, the aircraft also carries a meteorologist who is updated constantly regarding the condition of the clouds.

**Mapping clouds:** The radar screen shows a large mass of clouds approaching the region’s shoreline. This preliminary observation permits advance planning of their seeding.
The Rain’s Contribution

As the sky pours rain over the Earth (sometimes generously and sometimes sparingly), we must ask ourselves whether any of this rain reaches our streams, springs and lakes? Most of the rainfall in our region evaporates and returns to the atmosphere. Part of it evaporates directly from the air as it falls from the clouds; part evaporates directly from the surface; and part of the water that already has been absorbed in the soil, also evaporates. Plants also contribute to evaporation. Plants absorb water from the upper layer of the soil and accumulate a portion of rainwater, then release it to the air by a process called transpiration.

The rates of evaporation and transpiration increase as the temperature rises. That is why, in desert areas, already poor in precipitation, more than 90% of rainwater evaporates. In other areas of the region, the volume of evaporation is 70% of the precipitation.

Rainwater that remains after evaporation and seepage into the soil, estimated at 10%, flows as surface runoff down mountain slopes and rivers, eventually reaching the Mediterranean, as well as the Dead Sea and other closed basins. (See map of drainage basins on page 33).

We get water for our disposal and use from two types of sources: natural resources (fed by rainwater) and alternative water resources.

**Natural water resources:**
Ground water - water that seeps into the soil and accumulates in aquifers deep below the surface.
Surface water - water that flows on the soil surface in streambeds, rivers and lakes.

**Alternative water resources:**
Water that is used after treatment - Purified sewage water, known as wastewater. Desalinated water.
A Treasure in a Sponge: Ground Water

Most of the freshwater treasure, which sustains life as we know it, lies beneath our feet, in the solid rock on which we tread. The Earth’s surface is composed of many types of rocks, such as sand, gravel, sandstone, limestone, granite, and basalt. Some of the rocks upon which we tread are not quite as solid and sealed as they appear. If we look at the rocks closely under a microscope, we would notice that it is not quite as solid as we might have thought. We would detect pores and cracks, which form a large part of the rock’s volume.

Porosity of loosely arranged (unconsolidated) rock formations such as sand and gravel, depends on the extent of variation in the size of its particles and on their shapes. Generally speaking, layers of loosely arranged rock materials of fairly uniform size (such as sand) tend to have a greater porosity than layers of loosely arranged rock materials containing materials of different sizes. In addition, we may note that rock materials composed of very small particles, such as clay, will pack very tightly, and materials such as granite are essentially solid. The ability of the water to enter and move within the rock determines the permeability of the rock.

Note the differences in the amount of water stored in each type of rock in the illustration below.

Porosity is the ability of a rock to hold liquids. The degree of porosity is the ratio between the spaces in the rock and its total volume, expressed as a percentage.
Which Is More Porous, and Which Holds More Water?

This experiment will help you understand the relationship between uniformity/homogeneity of grain size and the degree of porosity.

**Equipment:** Four clear graduated measuring tubes, beads/marbles/balls/peas of different sizes, beaker, water dropper, and water.

**Procedure:**
Mark the measuring tubes with the letters A, A1, B and B1.
Place beads/marbles/balls/peas of one size in tube A.
Place beads/marbles/balls/peas of different sizes in tube B (to the same height as in A).
Fill each tube with water from the beaker, until the water reaches the top of the beads. (It may be easier to use a water dropper as you get close to the top of the materials.)
Pour the water from tubes A and B separately into tubes A1 and B1 respectively, making sure that no beads/marbles/balls/peas are poured into A1 or B1. Measure the amount of water in Tubes A1 and B1.

According to the experiment results (amount of water used for each tube), define what is the “degree of porosity” and the factors that affects the degree of porosity.
Water Path in the Rocks

Ground water exists below the land surface in two different zones. The unsaturated zone is immediately below the land surface and contains water and air. This zone almost always is underlain by a saturated zone (zone in which all the pores and fractures are full of water). The top of the saturated zone is called the water table. The water table may be just below the land surface or hundreds of meters under the Earth’s surface.

Surface water (from rainwater and streams) percolates from the surface into the ground and continues to penetrate the permeable rock layers until it encounters an impermeable layer, called “aquiclude”, and collects above it. This is ground water. The rock layer that holds the ground water is called an “aquifer”. Some aquifers are composed of sandstone or pebbles, in which water collects in the spaces between the sand grains and pebbles. There also are aquifers of limestone or other sealed rock, in which the water collects in cracks and cavities. The water in the aquifer doesn’t stand still, but flows by gravity within the rock layers, and, when it encounters the sealed aquiclude layer, it flows on top of it, below the ground, toward the drainage basins in the area.

1. **Aquifer:** An underground body of porous sand, gravel, or fractured rock filled with water and capable of supplying useful quantities of water to a well or a spring.

2. **Aquiclude:** A sealed rock layer impermeable to water.

3. **Confined aquifer:** A water bearing layer between two sealed layers (aquicludes).

4. **Recharge area:** Area on the ground surface through which rainwater penetrates into the aquifer.

5. **Perched aquifer:** Free aquifer that lies on a local and not continuous aquiclude layer. A perched aquifer is usually of small dimensions.

6. **Water table:** Height of the water in a free aquifer, or the height reached by the surface of the water where wells are being drilled.

7. **Spring:** Place where the ground water flows naturally to the surface.

8. **Well:** Excavation or bore that reaches the ground water.
A Drinking Straw in the Rock

In order to exploit ground water, we drill or dig a hole into the aquifer below the water table. Water from the aquifer flows into this hole to replace water removed by pumping water from the well. Even in ancient times, people noticed that pumping water from one well would cause a decrease in the water table in an adjacent well. This happens when both wells are drawing water from the same aquifer, namely the water in them comes from the same reservoir of ground water. In such a case, pumping water from one of the wells causes the water table to fall in the adjacent well, as well as a decrease in the water table of the entire aquifer.

Today, due to increasing needs of the population, the number of drilling sites and the amount of water being extracted from ground water has increased considerably. This, in turn, means an increase in quantities of water pumped from the aquifer. Thus, we notice that over-pumping of the aquifers, defined as pumping more water than is replenished annually during the rainy season, results in significant water deficits, and can even cause a well to dry up. For this reason, and due to an increase in the general public’s awareness, water pumping from many wells in the region has stopped in hopes that the reservoirs would be recharged.

Where would you drill a well?

A. Look at the illustration on the previous page. Where would you drill in order to pump water? To which depth would you drill? Would you drill to the uppermost layer of ground water? Would you drill to the bottom of the aquifer? Explain.

B. Based on the “communicating vessels” principle, mark in the illustration where water could rise to the surface on its own and where pumping would be necessary.

C. What would happen if a residential development (houses, asphalt roads, parking lots, etc.) were built on the recharge area of the confined aquifer?
Who “Pours” Water into the Depths? Enriching Ground Water

“Directing” somewhat the sky’s blessing of rainfall into the aquifer is a plausible feat. During rainy years we could prevent some of the rainwater, primarily floodwater, from “escaping” to the sea, by collecting it in reservoirs (man-made lakes or ponds) and allowing it to infiltrate the soil to become ground water. This process is called “artificial recharge” or “enriching ground water”. The extra water that would accumulate in aquifers could serve the people of the region during the summer season and drought years. In addition to replenishing ground water sources, using floodwater may be advantageous in other respects, such as improving the ground water quality (by mixing it with high quality water) and potentially stopping salinization in a well caused by intrusion of saltwater from the bottom of the well. Adding floodwater is important, particularly along the coastal aquifer, since adding water raises freshwater pressure and prevents the infiltration of seawater into the aquifer (read about the Coastal Aquifer on p. 28).

During the winter, it is customary to pump water from one aquifer and transfer it to another, thus enabling more efficient usage based on need, such as, for example, from the Mountain Aquifer to the Coastal Aquifer.

Recharging is accomplished by two principal methods:

1. Impounding (collecting in a pool or lake) rainwater and pouring it directly into existing wells.
2. Impounding floodwater and distributing it on the surface of porous formations such as sand or sand dunes. This method enables water to percolate directly into the aquifer, while in the process, silt and debris carried by the floodwater is filtered out by the sand.

Between 400 to 500mm of rain falls each year on the western slopes of Mt. Carmel, but the rock formations in the area don’t permit the water to percolate and reach the ground water. Most of the water flows down the slopes and ultimately reaches the Mediterranean Sea. Diversion facilities were constructed in the area recently, directing the water from the natural riverbeds to a canal that transfers the water to the coastal sands near Caesarea, where a special reservoir was built to allow the silt to settle. The clean water is transferred to percolation ponds, where it percolates through the sand directly into the Coastal Aquifer.