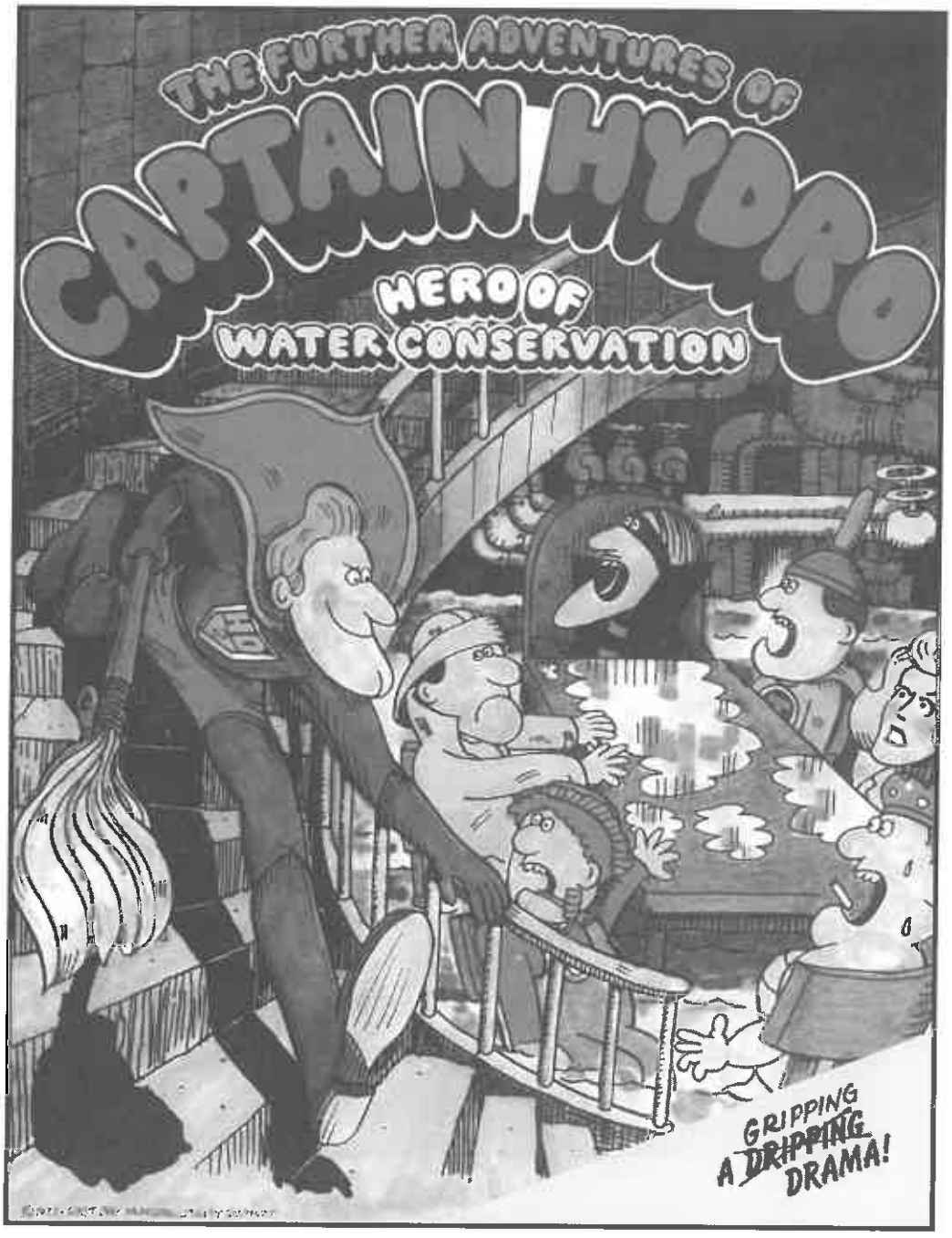
TEACHER'S GUIDE



Water and Ancient Civilizations

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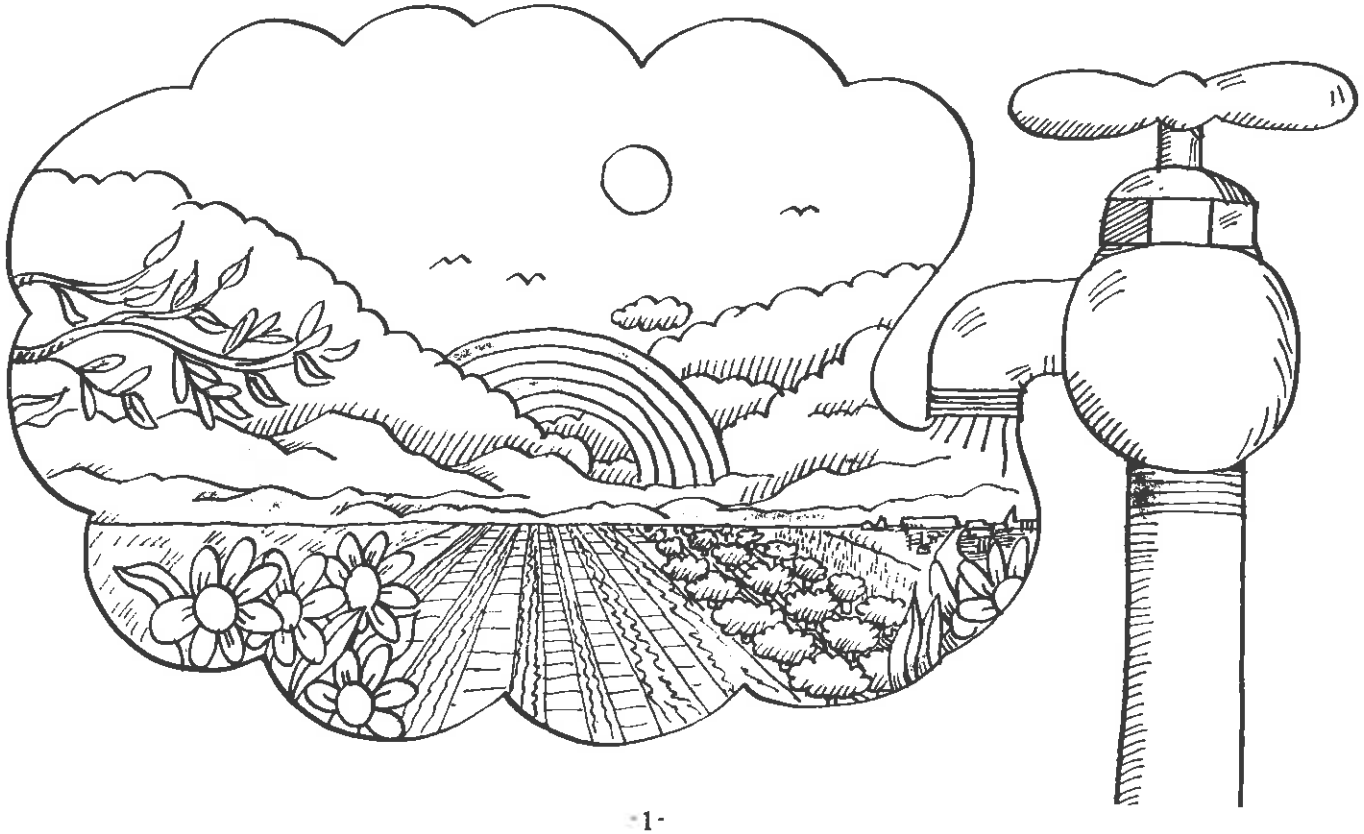


Foreword

This booklet has been prepared as a part of Project WATER (Water Awareness Through Education and Research), sponsored by the East Bay Municipal Utility District, Oakland, California. The goals of Project WATER are:

1. To develop an APPRECIATION of water's life-sustaining role in humanity's survival and an AWARENESS of the limitations of its abundance.
2. To acquire KNOWLEDGE of water, its physical properties and its function in our environment.
3. To identify the PROBLEMS relating to water and its use.
4. To select SOLUTIONS, after examining the alternatives, which take into consideration all facets of life for both short and long-term results.
5. To demonstrate the APPLICATION of knowledge and skills in functional water problem-solving.

The *Further Adventures of Captain Hydro*, the adventure comic book to which this publication relates, was intended to be a bridge between the format and content of the upper elementary publication, *The Official Captain Hydro Water Conservation Workbook*, and secondary materials. This new instructional resource booklet has been developed to replace the former Teacher's Guide to *Further Adventures of Captain Hydro*. It incorporates goals and objectives stated in the 1987 California Department of Education's *History-Social Science Framework*. Specifically, it concentrates on units in World History and Geography (Ancient Civilizations to 500 A.D.). The seven units of study, including a brief review of the hydrologic cycle, have been designed for use in grades 6 through 9. The intent has been to integrate basic knowledge about water issues with knowledge about responses to similar social and environmental concerns made by earlier cultures. The hope is that both the seriousness of the current water problems facing the planet and the wisdom implicit in the achievements of ancient civilizations will be illuminated and thus promote a new evaluation of our attitudes toward natural resources and their use.

A NOTE TO TEACHERS:

The units included in this guide can be used together as a total instructional package or singly as self-contained elements focusing on selected aspects of major water issues. It is assumed that there will be a text, or a set of basic reference materials, available to students for the History/Geography course itself, to which the topics in the booklet on water will relate for either total or modular treatment.

The worksheets are intended to be reproduced on a copy machine for classroom use by students. Time-lines, illustrations and maps have also been placed so that they can be copied for students if the teacher wishes.

The worksheets and the activities suggested are meant to be open-ended. Teachers can amplify, add other materials and/or activities, or create their own units relating to water as they see opportunities in the curriculum.

UNIT ONE: Introduction

OBJECTIVE: **To stimulate interest among students on the subject of water, particularly water conservation and related issues.**

BACKGROUND:

In the last decade, severe drought conditions have caused water rationing in California, grave drinking water shortages in New York and New Jersey, crop failures in Minnesota, and record long periods of over 100° temperatures in Texas and the Southwest. Groundwater levels in major aquifers have been dropping steadily in the great farm regions of the U.S., and pollution of supplies by acid rain, pesticides and poor underground drainage has been increasing around large agricultural and metropolitan areas.

Many reasons have been advanced for the seeming increase in periodic water shortages nationwide. From changing weather patterns over the last century to the nuclear disaster at Chernobyl, the causes given are mostly reasonable, but the major concern of areas most vulnerable to shortages—the West and the Southwest—is the growth and shifts in population that have put more and more people where there is less and less water.

The study of ancient civilizations represents a special opportunity to see how early cultures met the challenge of growth, in view of the fact that most were situated in fertile regions near major water sources, but were also on the edge of great, barren expanses of virtual desert land.

ACTIVITY:

Students read *Further Adventures of Captain Hydro* and discuss their impressions of the messages beneath the comic adventures depicted in the booklet.

Students complete Worksheet No. 1, making a preliminary estimate of their personal water use and discussing results of their tallies. They then keep a running tally of their actual use after one day, three days, and one week and bring it back to class for comparisons with other students' results.

WORKSHEET NO. 1

Name _____ Date _____

Personal Water Use Estimate

Keep this sheet with you for at least one day so that you can mark the proper space with a check for *each* time you use water.

HOW YOU USE IT	NUMBER OF TIMES PER DAY
taking a bath	
taking a shower	
flushing a toilet	
washing face/hands	
getting a drink	
brushing teeth	
washing clothes	
watering outside	
other	

Now you can estimate the amount of water you use by taking the average amounts given below and multiplying each by the number of times you used water for that purpose. The average figures might seem high, but they are based on the assumption that you probably let the water run to get hot or cold. You don't drink ¼ gallon of water each time you have a drink, but you probably use ¼ gallon of water each time.

HOW YOU USE IT	AVERAGE AMOUNTS	× TOTAL NUMBER/DAY	= TOTAL
taking a bath	25 gallons/bath		
taking a shower	50 gallons*		
flushing a toilet	5 gallons**		
washing face/hands	2 gallons		
getting a drink	¼ gallon		
brushing teeth	¼ gallon		
washing clothes	40 gallons/load		
watering outside	10 gallons/minute		
other	you estimate		

*25 gallons if the shower has a low-flow head **4½ gallons if the toilet has a displacement device

UNIT TWO: The Two Water Cycles

OBJECTIVE: **To understand how the water cycles function and to understand the problems in collecting, treating, distributing and disposing of a locality's water supply.**

BACKGROUND:

Of all the basic materials once thought to exist in superabundance, water may be the most important. Our bodies are 70 percent water; we must have a quart and a half a day just to survive; and we cannot grow our food without it. It is as basic to us as air. As our planet's population grows, our consumption of water increases. If future generations are to survive on this planet we must learn to conserve and recycle our water supply.

The Natural Water Cycle

Nature constantly "recyles" water, in the sense that rain, snow and hail that fall as the source of our water supply is returned to the atmosphere by *evaporation* from rivers, lakes and the ocean, condenses and falls over and over again as rain, snow and hail.

This water or *hydrologic cycle* is a natural machine, always running as a distillation and pumping system. The sun supplies heat and, together with the force of gravity, keeps the water moving. The heat causes the water from oceans, lakes, rives, glaciers, plants and animals to *evaporate* into the atmosphere, forming clouds. As the clouds move through the atmosphere and are cooled, the water vapor returns to the earth as *precipitation* and *condensation.*

Most rain falls directly into the oceans. Some, along with snow or hail, *runs off* the land and is collected by streams, rivers and lakes. The rest *percolates* into the ground, where it is taken in by plant roots or travels downward through the soil to the rock layers below to become *groundwater.* The water absorbed by plant roots is eventually given off as water vapor from the leaves. The groundwater is usually pumped back to the surface. Eventually the water returns to the ocean where the cycle begins again. All stages of the water cycle are happening simultaneously so that the earth's water supply is constantly in motion, constantly being renewed.

The "Built" Water Cycle

Most early civilizations began near available water. Even many fairly modern cities—Mexico City and Los Angeles, for instance—were founded near sources of water which were adequate to meet the demands of the people for a long time, but which are not now sufficient. Mechanical means became necessary to transport water from sources of supply to growing populations. There was also the growing need to treat and transport more and more used water (sewage and *wastewater*) to rivers and oceans from cities and towns which were springing up farther and farther from sources of water supply.

The *storage* of water—in dams, reservoirs, and man-made lakes; the *purification* of water in filtration plants; the *transport* of water via pipelines and pumping plants to houses, farms and industries; and the *treatment* and *disposal* of wastewater represents the "built" water cycle. The great systems of dams, canals, reservoirs and treatment plants around the world have permitted people to live in places quite distant from natural water sources: Arizona, Israel, Egypt and Arabia, for example.

ACTIVITY:

Teacher presents material on the two water cycles from the BACKGROUND section of this unit. After class discussion, students complete Worksheet Nos. 2 and 3. Completed worksheets are used for further discussion.

WORKSHEET NO. 2

Name _____ Date _____

The Natural Water Cycle

1. Study the diagram in Figure 1, then define, in your own words, the terms below.

   1. Evaporation _____

   _____

   2. Condensation _____

   _____

   3. Precipitation _____

   _____

2. Describe briefly the stages in the natural water cycle and indicate (1) how it affects our supply of water; (2) what part the sun plays in the water cycle; and (3) what happens to water which falls on the ground. (Use the reverse side of this sheet for your answer.)

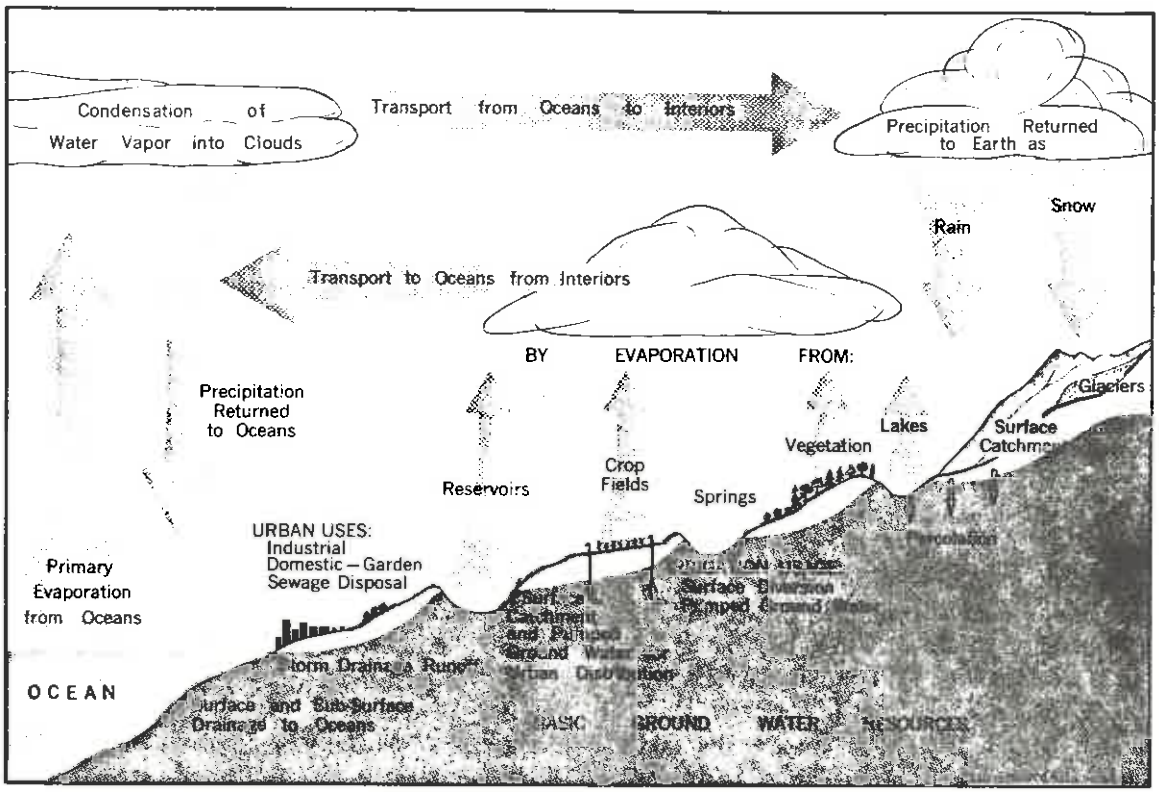
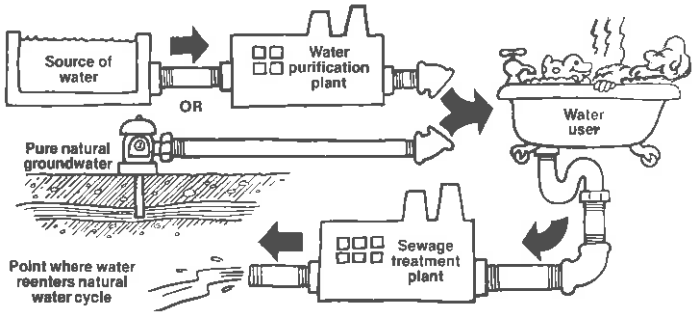


FIGURE 1: The Natural Water Cycle

WORKSHEET NO. 3

Name _____ Date _____

The Built Water Cycle



Study the diagram in Figure 2, then answer the questions following.

1. Where does the water you use in your house or appartment come from? A reservoir or directly from the ground? How far away is the source?

2. Where is your water treated (purified) for drinking? _____

3. Where is your wastewater and sewage treated? Where is the treated wastewater sent after it is processed?

4. How does nature purify water? _____

5. Discuss how long periods of drought could affect your city's life and economy.

6. How do heavy rains and flooding affect your city's sewer system? _____

UNIT THREE: Mesopotamia and the Ancient Middle East

OBJECTIVES:

- **To understand why the valley formed by the Tigris and Euphrates rivers, called Mesopotamia, became a magnet for early Middle Eastern cultures.**
- **To learn that the basic problems of water supply and distribution have not changed much over time and still require human cooperation and scientific technology for solution.**

BACKGROUND:

Point out the Middle East on a world map. Explain what the Fertile Crescent was and where it was located. Explain that the Sumerians were the first known society to develop in the lower valley of Mesopotamia.

The annual floods from the Tigris and Euphrates Rivers deposited fresh layers of fertile soil on the region which made farming easier for the Sumerians. Their culture seems to have advanced considerably around 4500 B.C. with their invention of the wheel. At this time they began to harness domestic animals to plows and drain the marshlands and irrigate the desert lands. They built extensive canal systems to control the flooding of the rivers. Their advanced system of agriculture allowed them to prosper. This prosperity eventually led to their overthrow by invading tribesmen from the north. These northern conquerors used the Sumerians' knowledge and expanded upon it. One group of conquerors were the Babylonians, and they built their capital city of Babylon on the Euphrates River. They built canals to run throughout the city so that they could drain the city's wastes into the Euphrates. This eventually led to serious health problems, because malaria was spread by the mosquitoes that bred in the polluted irrigation canals. However, the Babylonians had plenty of fresh water stored in cisterns placed throughout the area, connected by a complex set of pipes which delivered water to various parts of the city. This water was collected during the rainy season and stored for the dry periods. The Babylonians began to build windmills around 1700 B.C. so they could pump water from the Euphrates to irrigated fields several miles away.

Babylon's most noted achievement was its hanging gardens. These gardens became known as one of the "Seven Wonders of the Ancient World." The gardens were built on terraces 6′ high, 32′ wide, and 400′ long. They were watered by a hydraulic screw which went down from the highest terrace to the level of the Euphrates.

As time went on, the Euphrates completely changed its course due to the massive amounts of silt deposited in its bed. Today the river is many miles from the deserted ruins of Babylon.

ACTIVITY:

Have students complete Worksheet No. 4. Review responses on the worksheet, then discuss with students selected differences between the pre-Christian Middle East and the Middle East today: the multitude of religions there; the effect of oil on the culture; the problems of water. Discuss specific questions such as:

Q.1 Why do you think so many *different* peoples settled in the Mesopotamian region?

Q.2 What countries are located in Mesopotamia today? What are their sizes in terms of population and how do they support themselves?

Q.3 What are the water problems of the Middle Eastern countries today? Are they like ours?

Q.4 Could there be a future problem with the water supply where you live? Why? How do you think the problem would be solved?

TIME LINE

3500 B.C. Sumerians begin to harness domestic animals to plows, drain marshlands, irrigate desert lands, and extend areas of permanent cultivation.

2800 B.C. The sickle is invented by Sumerian farmers.

2500 B.C. The Sumerians develop a cuneiform script alphabet.

1950 B.C. Babylon's sixth king, Hammurabi, conquers all of Mesopotamia, and imposes a uniform code of laws.

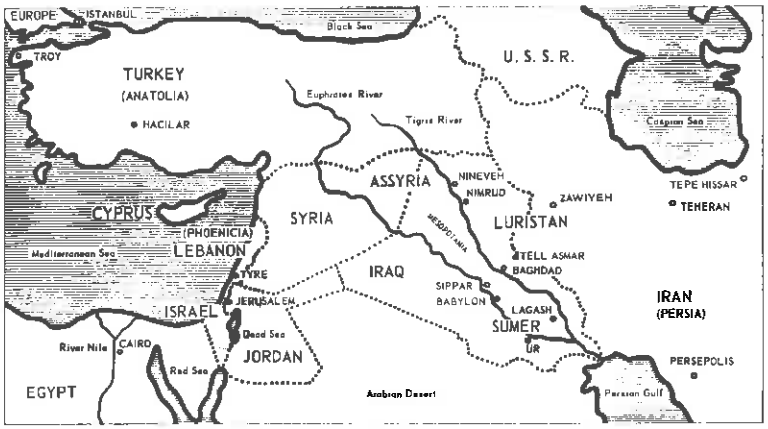
1700 B.C. Babylonians employ windmills to pump water for irrigation.

700 B.C. Aqueducts are built to carry water to the cities developing in the Near East.

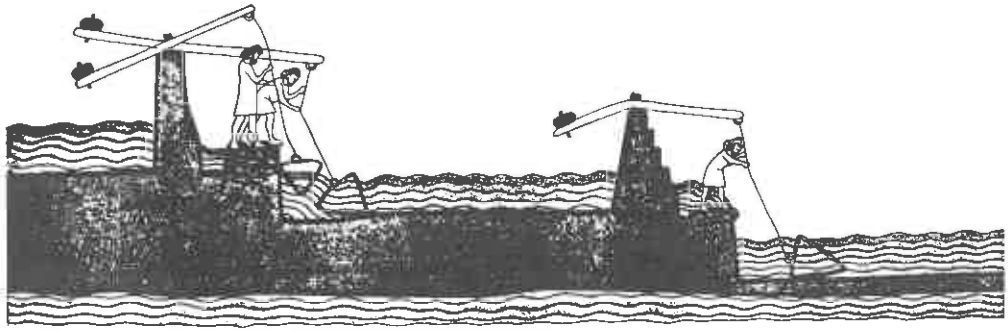
693 B.C. Babylon is destroyed by Assyrian king Sennacherib.

605 B.C. Babylon is rebuilt by the Chaldean king Nebuchadnezzar II. At this time the hanging gardens are built.

331 B.C. Alexander the Great conquers the Persians and occupies the city of Babylon.



The Middle East: Ancient and Modern Place-Names



Assyrian peasants operating a *shaduf* to raise water from a canal to irrigation channels (in picture redrawn from a relief in the palace of Sennacherib, 7th century B.C.). This simple mechanism, a bucket on a pole, counterbalanced by a weight, demanded constant labor from the operator who lowered the bucket into the canal. It typifies the difficulties involved in water control in the Mesopotamian region.

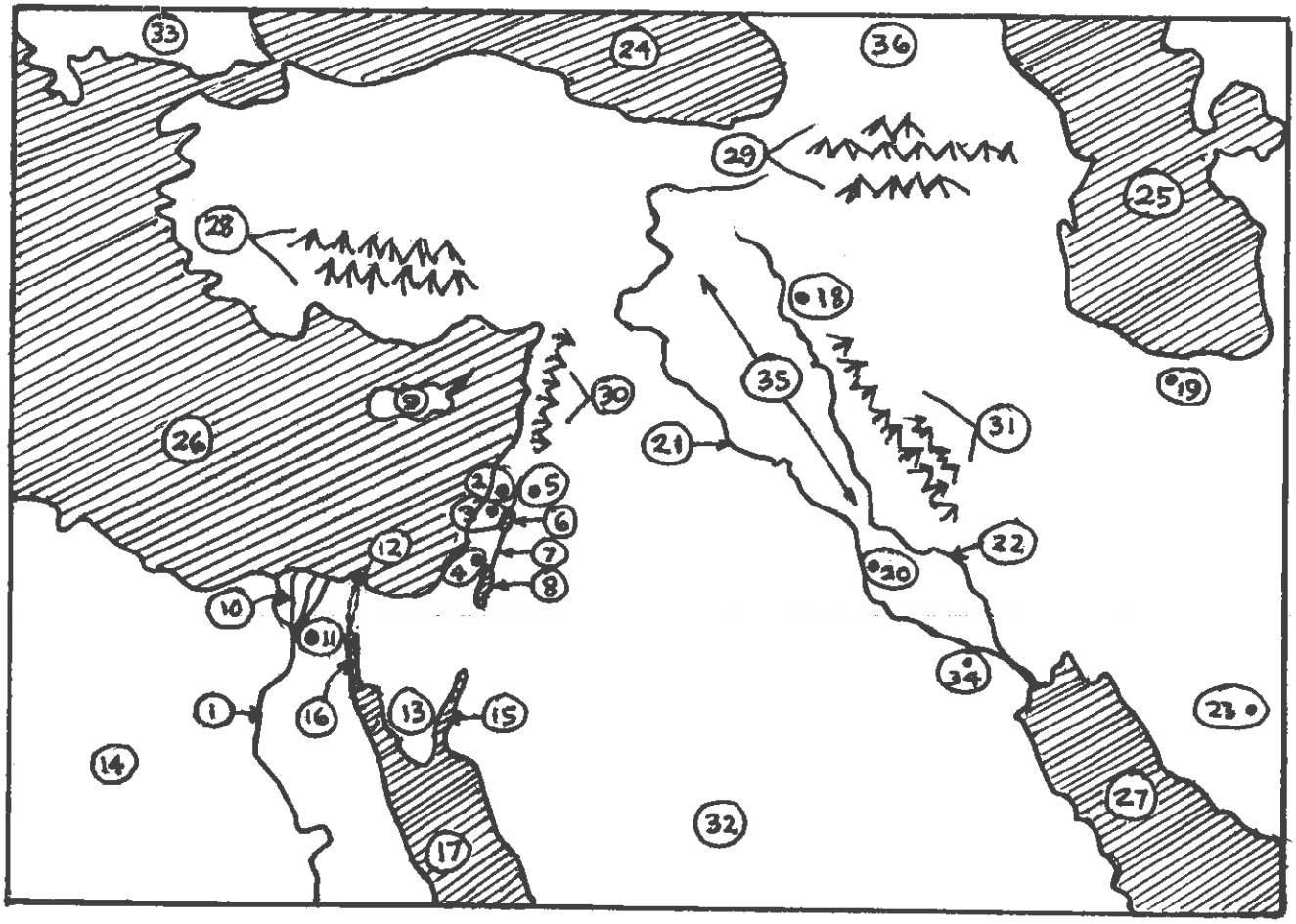
WORKSHEET NO. 4

Name _____ Date _____

Mesopotamia and the Ancient Middle East

Directions: Identify the following geographical locations numbered on the map below. Write the number of each next to the correct identification in the list of place-names given.

____Arabian Desert
____Teheran
____Babylon
____Black Sea
____Cairo
____Caspian Sea
____Caucasus Mountains
____Cyprus
____Damascus
____Dead Sea
____Gulf of Aqaba
____Greece
____Jerusalem
____Jordan River
____Lebanon Mountains
____Mediterranean Sea
____Mesopotamia
____Nile Delta
____Nile River
____Nineveh
____Egypt
____Persian Gulf
____Red Sea
____Persepolis
____Sea of Galilee
____Sidon
____Sinai Peninsula
____Suez Canal
____Russia
____Tarus Mountains
____Euphrates River
____Tigris River
____Tyre
____Ur
____Zagros Mountains
____Gulf of Suez



UNIT FOUR: Ancient Egypt

OBJECTIVES:
- **To understand how vital the Nile River was to the formation of the ancient Egyptian culture.**
- **To show that if a water source is managed properly it can serve people for a very long time.**

BACKGROUND:

Point out the location of the Nile River on a world map. Begin the discussion by brainstorming the reasons for forming a settlement on or near a major waterway.

The Nile is the world's longest river. It is 4,160 miles long, and one of the world's *few* northward flowing rivers. It has two sources. One, the White Nile, starts deep in central Africa. The other, the Blue Nile, springs from the mountains of Ethiopia. The white source keeps steadily flowing all year. The blue source changes regularly from a spreading flood each summer when the mountain snows of Ethiopia melt, to a trickle the rest of the year. If the White Nile were the only water source, Egypt's soil would have been worn out long ago. If the Blue Nile were the only source, Egypt's soil would be nourished with fresh muddy flood water every summer (the "milk of the Nile"), but for the rest of the year it would be practically dry. The combination of these two rivers creates the fertile Nile valley. The Egyptians thought of the year as divided into three seasons of about four months each: *coming forth*, or *flood time*, when the Nile flowed muddy; *cultivation*, when the fields were planted and a more subdued Nile flowed clear; and *drought*, when the crops were harvested and the Nile, discolored with algae, flowed green.

Because the Egyptians depended for life on the flow of the Nile, they had to find a way to control it. They learned to capture the flood water from the Nile in large, shallow storage basins, and then to draw this off through a system of canals, so that large stretches of otherwise dry land could be watered.

The Nile was also used as a means of transport for the Egyptian people, and it played a major role in the building of the pyramids. The massive granite stones (some weighing as much as 5 tons) were transported six hundred miles from the south on large barges during the flood season. The Nile was also used to level the ground for the base of the pyramids (see illustration). This lengthy process produced a perfectly flat surface of over a half a million sq. feet. The Egyptians no longer use the Nile for building pyramids, but it is still vital to the prosperity of their country.

TIME LINE

5000 B.C. Lands bordering the Nile River begin to dry out. The Egyptians build dikes and canals for irrigation and start to develop a civilization in North Africa.

3400 B.C. Egypt's 1st Dynasty (Thinite dynasty) unites northern and southern kingdoms under the Pharaoh Menes.

1887 B.C. A canal through the Nile's first cataract is dug.

1500 B.C. Geometry helps the Egyptians survey boundaries of fields whose dividing lines are effaced by the annual floods.

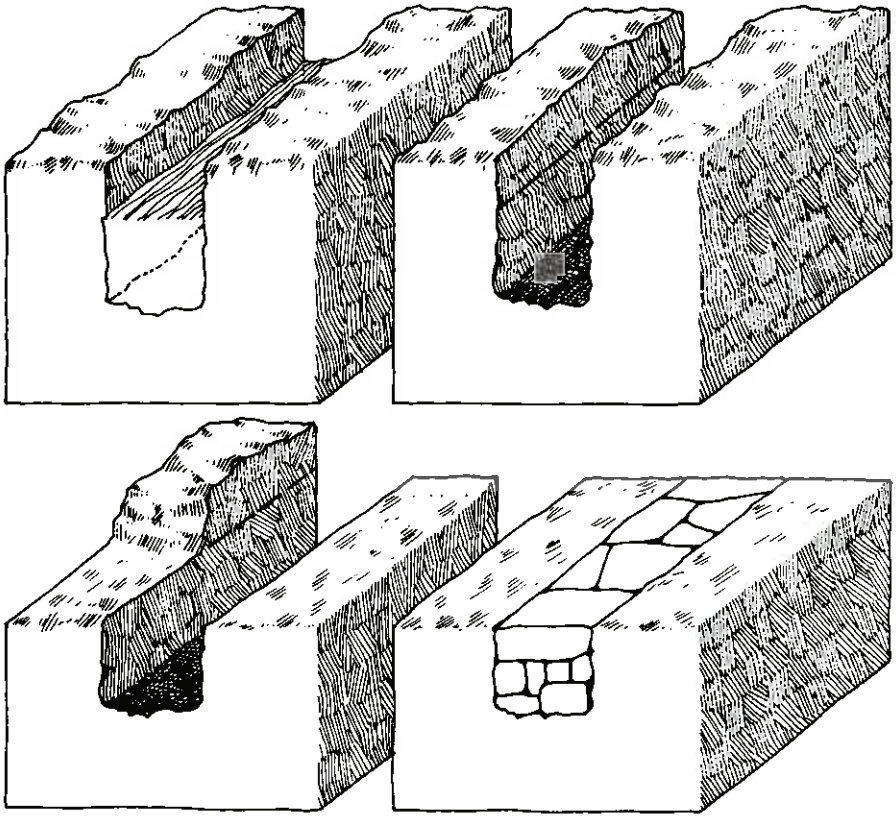
1380 B.C. A canal to connect the Nile with the Red Sea is built.

332 B.C. Alexander the Great conquers Egypt.

969 A.D. City of Cairo founded as a port on the Mediterranean Sea. (Today it is separated from the sea by 80 miles of sand and mud from the Nile's silt deposits.)

1869 A.D. Construction of Suez Canal completed.

1970 A.D. Completion of Aswan High Dam. The dam created Lake Nasser and provides Egypt with 2 million acres of irrigated land.

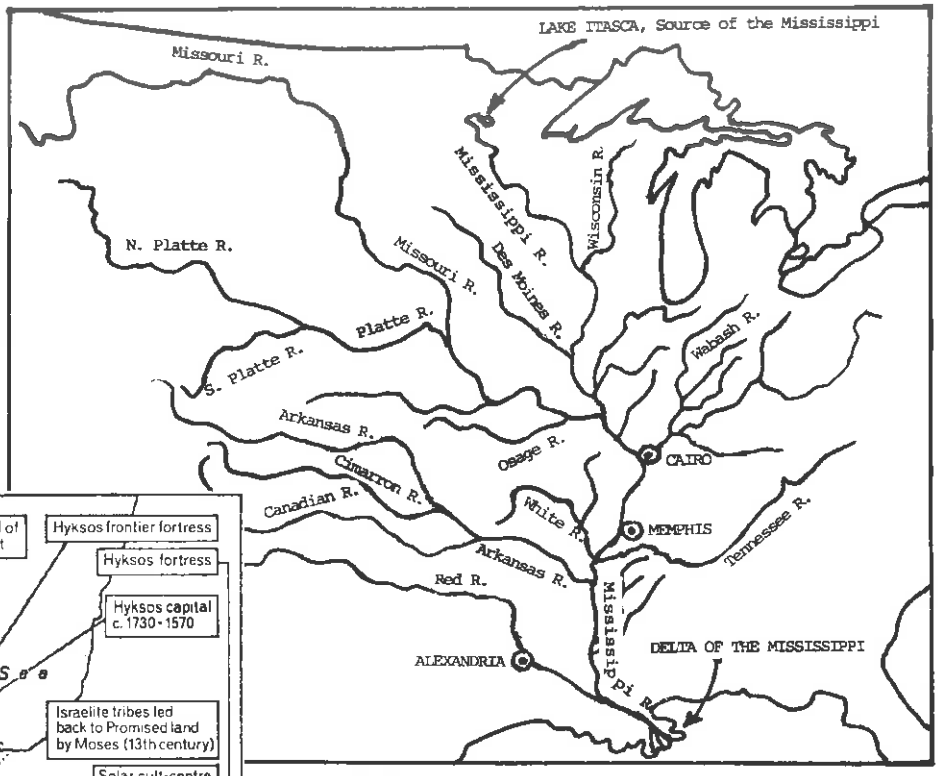


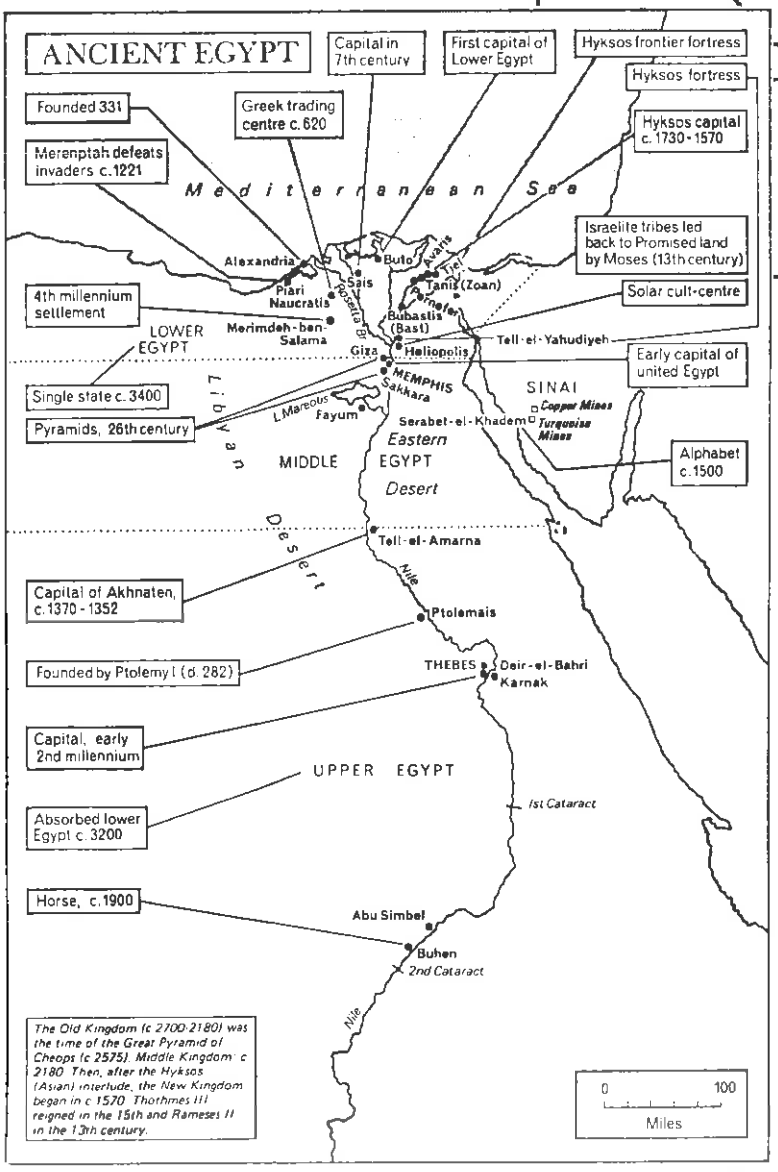
Before construction of a pyramid began the site was leveled. A network of narrow connecting trenches was cut into the rock over the entire area and filled with water, which acted as a level. When the top of the water had been marked on the sides of all the trenches they were drained. The spaces between the trenches were then cut down to the height of the marks and the trenches themselves filled with stone.

WORKSHEET NO. 5

Name _____ Date _____

Directions: Compare the drainage basin of the Mississippi River (right) with that of the Nile River below. Then answer the questions which appear on the right-hand side of this page. (Use the reverse side of this page to record your answers.)





Q.1 What accounts for the differences in the number of smaller streams feeding into each main river?

Q.2 A big desert lies on each side of the Nile. What does this tell you about Egypt *millions* of years ago?

Q.3 Cairo, Memphis and Alexandria are place-names which occur on rivers of both countries. In which states are these cities located in the U.S.?

Q.4 The deltas of both large rivers seem equal in size, yet they differ in what they produce for market. Look up resource maps in an atlas. What are reasons for the differences?

Q.5 Religion has played a large part in developing both regions, along the Nile and the Mississippi. Why do you suppose that Egypt, which has been under Roman, Greek, Arab and other rulers over the centuries, now has almost a single state religion, while the U.S. has an almost infinite variety of faiths represented?

Q.6 Are the rivers used in about the same ways? Name some similarities and some differences.

Q.7 It is said that Egypt is the only desert culture in history which has survived. Much of the southwestern U.S. is very nearly desert land, with serious water problems. Do you think we will be able to prevent true desert wastelands from developing within our heavily populated areas? How?

UNIT FIVE: The Indus River Valley

OBJECTIVES:

- **To understand the importance of controlling an area's water supply.**
- **To show that a major waterway is vital to the survival of a major civilization.**

BACKGROUND:

Point out the Indus River on a world map. Explain to the students that the ancient civilization of the Indus River valley was unknown to modern man until 1920. At that time archaeologists began excavating many ancient cities which before then were not known to exist. The most advanced and well-preserved was that of Mohenjo-Daro. This ancient city was believed to have been founded about 2500 B.C. and existed until about 1500 B.C.

The city boasted wide, straight streets unlike the narrow crooked streets of ancient Middle Eastern cities. The city's construction was also very much influenced by a concern for public hygiene. Running along the sides of the streets were neat, brick-lined open sewers, much like those in old Asian cities today. At intervals the sewers had catch basins dug to trap debris that might have clogged the drainage flow. The sewers were connected to each house by an open gutter, and the houses had a system of clay pipes leading to the streets.

Many houses had bathrooms, their floors built of water-proof brick and fitted with drains leading directly to the sewer pipes. The houses also had their own wells and an interior plumbing system made of clay pipes. The city also had a large pool (39′ long, 23′ wide and 8′ deep). The pool was believed to have been used for religious ceremonies. The outskirts of the city were laced with irrigation canals which supplied the crops with water from the Indus River. This incredibly advanced city was abandoned around 1500 B.C. Archaeologists are not sure why this mass exodus took place. Some believe it was due to a change in the course of the Indus River, because much of the city was buried under tons of silt. Others believe that invaders from the north called Aryans drove out the populace. We may never know *why* they left the region, but *what* they left is indisputable evidence that theirs was a highly advanced civilization.

ACTIVITY:

Complete Worksheet No. 6. Discuss possible reasons why ancient civilizations arose on *all* the five continents and why all were in temperate climate zones. Note some differences and similarities among these cultures, and how water supply was important to all of them.

Discuss how the fate of a body of water serving as a supply source for a city or country can influence the destiny of that city or country. Note the changes that have occurred in Western United States, where many lakes and rivers have dried up; in Africa, where the Sahara covers a third of the continent; and in cities like Babylon and Mohenjo-Daro, which were buried by silt and left to die when rivers changed their courses.

Discuss how technology available to modern civilizations can prevent, or at least delay, the shrinking of water supplies to growing population centers: dams, importing of water, desalinization of salt water, conservation, etc.

TIME LINE

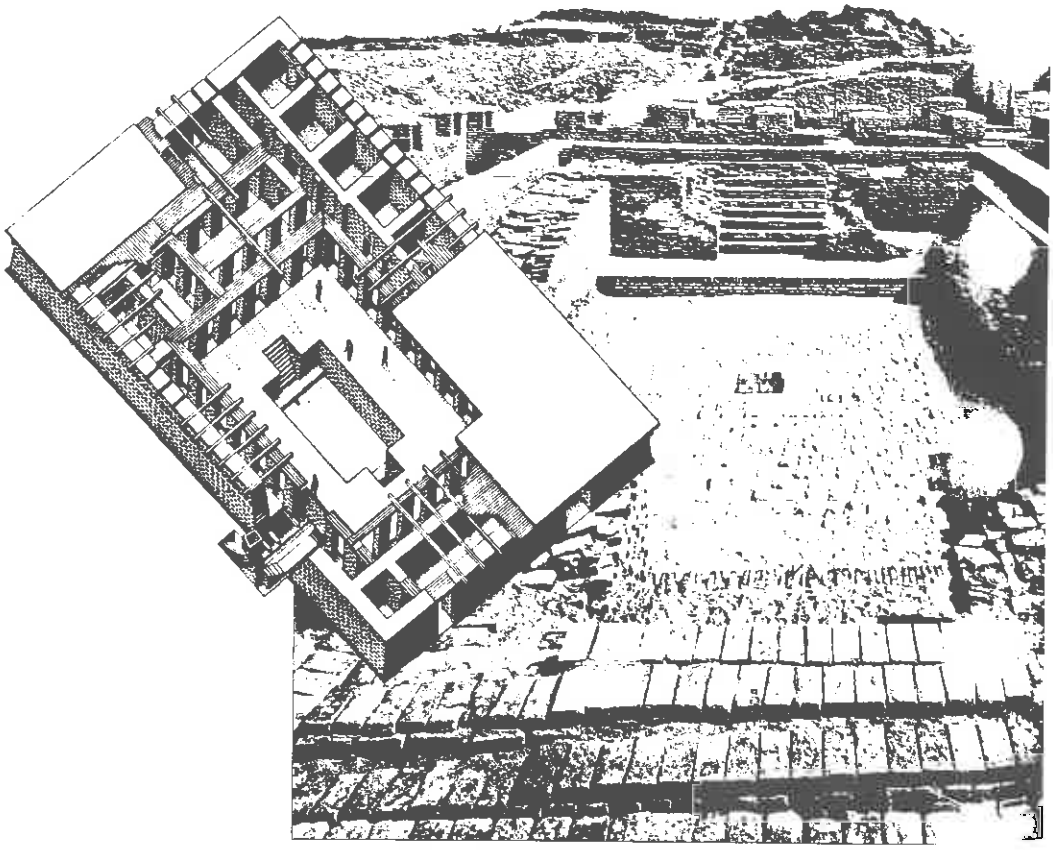
4000 B.C. Peoples of the Indus Valley raise wheat, barley, peas, sesame seeds, mangoes, and dates in irrigated fields.

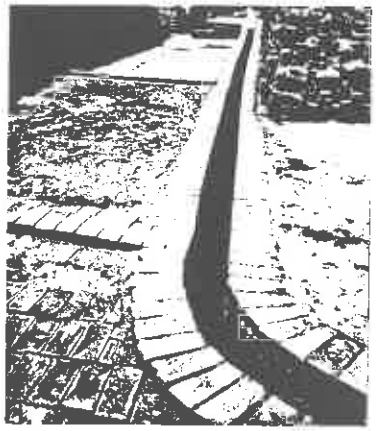
3000 B.C. Cotton fabric is woven in the Indus Valley.

2300 B.C. Rice from the Indus Valley is introduced in northern China.

1750 B.C. The great Indus Valley cities of Mohenjo-Daro and Harappa begin to collapse. The soil of the region has become too saline to support extensive crop growth.

1500 B.C. Aryan nomads from the Eurasian steppes push into the Indian subcontinent, bringing with them flocks of sheep and herds of cattle.





The Great Bath of Mohenjo-Daro and example (right) of the drainage systems found throughout the ruins of the city.

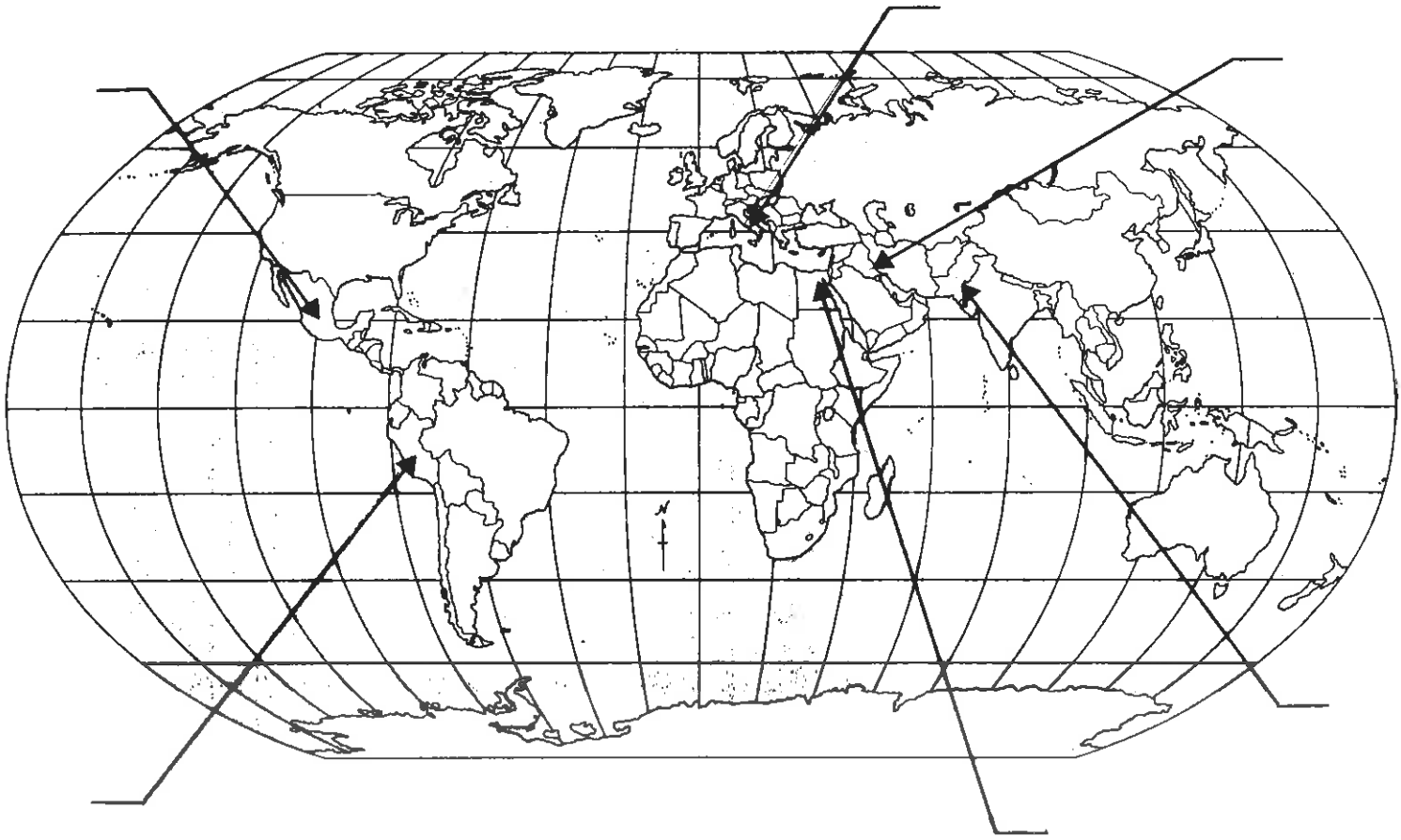
WORKSHEET NO. 6

Name _____ Date _____

Geography of Ancient Cultures

Directions: Indicate the geographical location of each of the following ancient civilizations by placing its number on the flat line connected to the arrow pointing to the area where the civilization was located.

1. Aztec 2. Inca 3. Indus River Valley 4. Mesopotamia 5. Nile River Valley 6. Rome



UNIT SIX: Ancient Rome

OBJECTIVES:

- **To understand how the ancient Romans managed their water supply for their collective benefit.**
- **To show that the management of water supplies can lead to changes in people's personal habits that both enhance and endanger their way of life.**

BACKGROUND:

Point out the location of Rome on a world map, making note of its location on the Tiber River. Have students brainstorm the importance of founding a city on or near a major waterway. Explain to the students that the Tiber River was too polluted for drinking or bathing. In order to supply the growing populace with fresh drinking water, aqueducts had to be built.

Rome had three major aqueducts, the Aqua Appia (312-308 B.C.), the Anio Vetus (279-269 B.C.), and the Aqua Marcia (144 B.C.). The combined aqueducts supplied 50 million gallons of fresh water to Rome every day. Most of the city's buildings did not have running water, but the tenants were able to get plenty of fresh water from the countless pools and fountains located throughout the city. Groups of toilets, connected with efficient sewers, were stationed everywhere. These stations were maintained by the city. The wealthy could arrange with city officials for a special line of lead pipe to bring them water straight from one of the aqueducts.

The Romans placed a great importance on public bathing. Their public baths were immense and could accommodate thousands of people each day. They became a place for gathering and exchanging news (gossip). It was not unusual for Romans to take 7 or 8 baths a day. The Romans did not treat their river as well as they treated their bodies. They threw their trash and emptied their chamber pots into the streets at night. During the early hours of the morning, large amounts of water would be released from the aqueducts to flush the refuse from the streets into the Tiber River. It was said that the ancient city of Rome could be smelled long before it could be seen.

ACTIVITY:

Have the students compare their city's uses of water and its supply system with those of Ancient Rome.

Q.1 List the personal and business/industry uses of water you see in your city. List ways you know or can imagine how Romans were using their water supply. What are the differences?

Q.2 Baths, indoor plumbing and raw sewage being flushed down slanting streets in Rome: what dangers do you recognize in these practices, even though they were very advanced for their time?

Q.3 How does a river "clean" dirty water or sewage? What are the dangers of dumping sewage into rivers, lakes or the ocean? Are there places where people get drinking water from the same river or lake where they dump their wastewater? Discuss this practice and how some of us might some day have to re-use treated water for drinking.

Q.4 Point out how toxic substances get into groundwater used for agriculture or drinking supplies. What steps are we taking to prevent that?

Q.5 Some of the Roman aqueducts are still being used today to transport water for fairly long distances. What are some of the things that prevent us from building aqueducts from places where water is plentiful to places where it is scarce?

You may not realize how big the Roman Empire was. Complete Worksheet No. 7: the dotted line encloses the lands under Roman rule and includes France, Spain, England, Ireland and what is now modern Turkey.

TIME LINE

753 B.C. According to legend Rome is founded on the Tiber River.

605 B.C. Rome's Cloaca Maxima is built. The giant drainage system will drain the marshy area that will become the Roman Forum.

312 B.C. Rome gets its first pure drinking water as engineers complete an aqueduct into the city.

270 B.C. Rome's subjugation of Italy is completed.

179 B.C. Rome's Pons Aemilius is completed across the Tiber. It will be the world's first stone bridge.

110 B.C. Oysters are cultivated in the first Western efforts to domesticate marine wildlife, near Naples, Italy.

101 B.C. The Romans apply water power to milling flour and are the first people to do so.

44 B.C. Julius Caesar is assassinated.

19 B.C. The Pont du Gard is completed by Roman engineers across the Gard River. It is an aqueduct bridge 600 yards long, with three tiers of arches rising 160 feet above the river.

40 A.D. A power shortage halts Rome's flour mills, and the emperor Caligula commandeers all draft animals to keep the mills in operation.

64 A.D. Two-thirds of Rome is destroyed by fire. The city will be rebuilt with straight, broad streets and wide squares.

71 A.D. A palatial public lavatory is opened in Rome. The city now has an extensive system of waterworks with toilets which can be flushed.

80 A.D. Roman Colosseum is built.

95 A.D. At least 10 aqueducts supply Rome with 250 million gallons of water per day.

213 A.D. The Baths of Caracalla are completed. They have public baths, reading rooms, auditoriums, running tracks, and public gardens that cover 20 acres. The main building alone covers 6 acres and can accommodate as many as 1,600 people at a time.

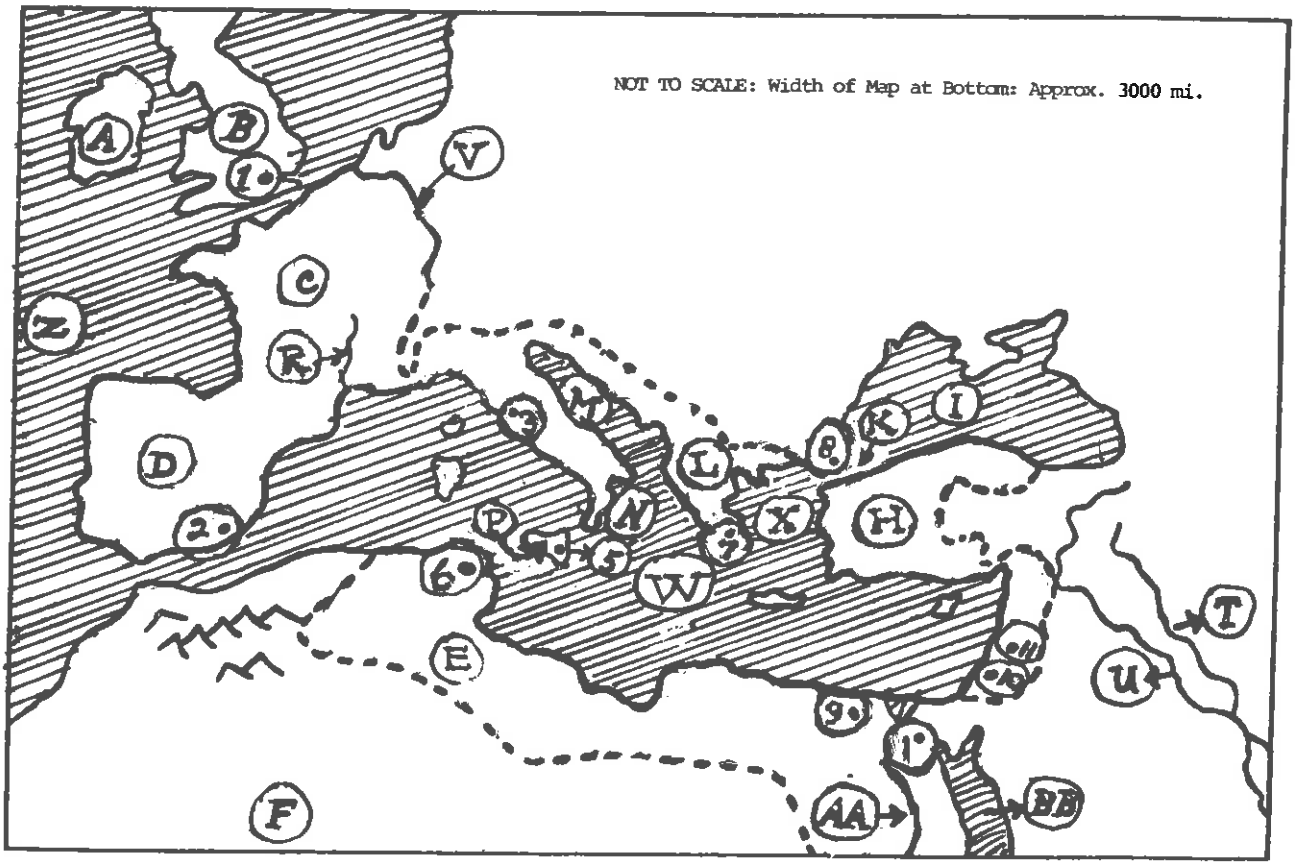
WORKSHEET NO. 7

Name _____ Date _____

Geography of the Ancient Roman Empire

Directions: Look up the area shown below on a world map, identify each numbered or lettered location, and write the number or letter on the map next to the correct location in the list below.

____Ireland
____Athens
____Spain
____Rome
____Gaul
____Carthage
____Sicily
____Britain
____Greece
____Algeria
____Sahara Desert
____New Carthage
____Nile River
____Byzantium
____London
____Asia Minor
____Adriatic Sea
____Ionian Sea
____Syracuse
____Alexandria
____Red Sea
____Tigris River
____Dardanelles
____Euphrates River
____Damascus
____Black Sea
____Rhone River
____Jerusalem
____Atlantic Ocean
____Rhine River
____Aegean Sea
____Mediterranean Sea
____ Cairo



UNIT SEVEN: Ancient America: The Aztecs and Incas

OBJECTIVES:

- **To understand how important water was to the formation of the ancient cultures of the American continents.**
- **To show that areas without adequate water supplies can become productive regions with proper management of water.**

BACKGROUND:

Point out the location of the Inca and Aztec empires on a map. Explain that the Incas were hydraulic engineers, which was necessary because of their location.

Peru's coastal valleys are almost rainless but every inch of available land was used for cultivation. This was accomplished by an intricate system of canals. The first irrigation canals were built about 2,000 years ago and as the population increased, the engineering skills improved. The canals were built up the sides of the valleys following their contours for as much as 50 to 75 miles and sometimes they crossed divides to bring water to valleys with no rivers of their own. The canals were stone-lined, with stone sluice gates to regulate the flow of water from the rivers. The canals served a double purpose. In addition to irrigating the fields, the waters enriched their soil with silt and dissolved plant nutrients carried from the rivers, especially during flood seasons.

The most spectacular engineering feat of the Incas is the mountain city of Machu Picchu. It was built on a narrow ridge between two mountain peaks. The city is made of solid close-fitting granite blocks, and there are over 100 acres of buildings, walls and plazas carved into the mountainside. The city had fountains fed by aqueducts which supplied the inhabitants with water. To make the city as self-sufficient as possible, the steep slopes below it were banked with rows of narrow agricultural terraces, which also acted as defense lines against attack. For unknown reasons the city was abandoned about 400 years ago and remained unknown until its discovery in 1911.

The Aztecs were another advanced early American culture. They settled in the central region of what is now Mexico. Their capital, Tenochtitlán, stood on a low island in Lake Texcoco.

During the early years of the city, the water in the lake became so full of salt dissolved from the surrounding mainland that it damaged the city's crops. To solve this problem, the Aztecs built a 10-mile dike across the lake. The lake cut the Aztec capital off from the main body of the salty lake and sheltered it in an enclosed bay. The water in the bay soon became fresh because of the rivers flowing into it. The lake water never became fit for drinking, but the engineers of Tenochtitlán solved this problem by constructing an aqueduct three miles long to springs on the mainland. Each of the aqueduct's two earthenware channels was about two feet wide and while one was in use, the other was being cleaned. Another aqueduct of masonry was later built along one of the three man-made causeways linking the island capital to the shore. Water from both aqueducts was carried to the canals that laced the city on what the Spanish conquerors called "hollow bridges."

As the city's population grew, the amount of available land for crops diminished. The Aztecs solved this problem by making chinampas, "floating gardens." These gardens were made of large reed-woven baskets, 8 feet in diameter, filled with earth and anchored to the lake bottom. The roots eventually reached the bottom of the lake, making the chinampas a permanent part of the lake. Today the former Aztec capital of Tenochtitlán and the lakes which surrounded it are buried under the sprawling metropolis of Mexico City, the largest city in the world.

WORKSHEET NO. 8

Name _____ Date _____

TIME LINE

1000 B.C.	Olmec culture of Mexico and Chavin culture of Peru well established.
900 A.D.	Toltecs subjugate the Valley of Mexico.
1200 A.D.	Aztecs invade Mexico, Incas invade Peru.
1521 A.D.	Spanish conquest of Mexico.
1532 A.D.	Spanish conquest of Peru.

Directions: Compare the problems of water supply and distribution in the Inca and Aztec empires to those of modern populations. Use the following questions; write your answers on the reverse side of this page.

Q.1 The Incas built extensive canal systems to carry water to dry mountain valleys. Compare them to the systems used to bring water from Colorado and the Sierra Nevada in Northern California to Los Angeles over 300 miles away.

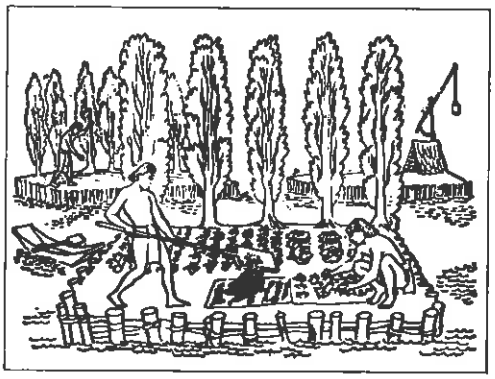
Q.2 The Incas grew their crops on terraced fields. Why don't we grow our crops on terraced fields in the mountains?

Q.3 Why do you think Mexico City was built on the former Aztec capital?

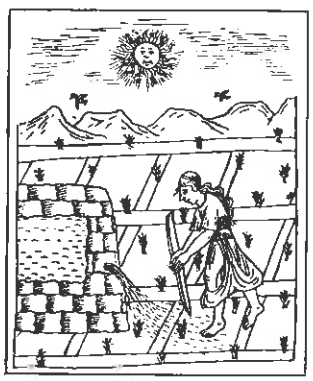
Q.4 Mexico City gets most of its water from the ground, which is spongy and 85% water. The constant drain on the water content of the soil has caused the central part of the city to sink about 20 feet since 1900. Some parts of the city have sunk about a foot every year since the 1930s. Compare this to the sinking occurring in the great aquifers in California, Kansas and other parts of the Midwest. Are the reasons the same? What are the possible answers to this problem?

Q.5 Mexico City is also Mexico's largest industrial center. Why is this a major problem for Mexico's future water supply?

Q.6 Where does your water come from? Is there any danger that your city will face any water shortage problem in the future? If your city did have a shortage, what would you personally do to cut down your water use?



Chinampas, the Aztecs' "floating gardens"



Inca peasant watering his crops from a stone canal

Answer Keys

pp. 4, 7 — WORKSHEETS 1 & 3: answers are personal and local information only.

p. 6 — *evaporation:* the change of a liquid to a vapor or gas, usually by heat; *condensation:* the change of a vapor or gas to a liquid, usually by cold; *precipitation:* rain, snow, hail.

p. 8 — Mesopotamia: Q.1 — (a) water, which facilitated farming, transportation, sanitation, etc.; (b) climate; (c) access from all sides to areas with differing religious and cultural groups. **Q.2** — Iraq occupies most of the land, but parts of Iran, Syria and Turkey also abut the area. **Q.3** — Shortages, contamination and sewage disposal. Unlike our problems, in that boundaries between countries are barriers to some solutions and religious differences prevent solving other problems.

p. 10 — WORKSHEET 4:

32 Arabian Desert	1 Nile River
19 Teheran	18 Nineveh
20 Babylon	14 Egypt
24 Black Sea	27 Persian Gulf
11 Cairo	17 Red Sea
25 Caspian Sea	23 Persepolis
29 Caucasus Mountains	6 Sea of Galilee
9 Cyprus	2 Sidon
5 Damascus	13 Sinai Peninsula
8 Dead Sea	12 Suez Canal
15 Gulf of Aqaba	36 Russia
33 Greece	28 Tarus Mountains
4 Jerusalem	21 Euphrates River
7 Jordan River	22 Tigris River
30 Lebanon Mountains	3 Tyre
26 Mediterranean Sea	34 Ur
35 Mesopotamia	31 Zagros Mountains
10 Nile Delta	16 Gulf of Suez

p. 13 — WORKSHEET 5: Q.1 — age of the terrain: North American land features are the result of far more recent geological phenomena; the Ice Age particularly, which produced many lakes, gorges and streams. **Q.2** — It was undoubtedly buried under water. **Q.3** — Illinois, Tennessee, Louisiana. **Q.4** — Technology and nearness to other almost limitless resources. The Nile Delta is still farmed extensively, while the Mississippi delta is ringed by offshore drilling for oil. Recreation also dominates the latter, along with offshore commercial fishing. Farming is very limited. **Q.5** — The age of the region, primarily: it not only underwent many "melting pot" periods of assimilating other cultures and invaders, but the opening of the entire Western hemisphere (and the Orient as well) tended to stabilize the population which has remained in the region. **Q.6** — The Nile is used primarily for agricultural irrigation and transport. The Mississippi is heavily used for transportation and for basing industry near cleaning, cooling and power sources. Both rivers are used a great deal for recreational purposes.

p. 16 — WORKSHEET 6: starting at top left of map and counter-clockwise: 1, 2, 5, 3, 4, 6.

p. 17 — Q.2 — Health hazards and pollution of the Tiber River. **Q.3** — By *digestion*, through microbes and bacteria which live in the water; and by *solution*, through mixing the material with the millions of gallons of water in its volume, rendering the material harmless. The danger is that each river can handle just so much sewage before it becomes polluted. People in many parts of the world drink water which comes from rivers that also have raw sewage dumped into them. 25,000 people die every day in the world from poisoned drinking water or from diseases carried by their drinking water. We have the technology to treat heavily polluted water and make it drinkable again; in some parts of the country, water may become scarce enough to have to resort to this technology.

Q.4 — By pesticides and chemical fertilizers seeping into the ground, by poor subsurface drainage; by overuse of the land, leaving it alkaline and salty; and by toxic dumps leaking into nearby farmland. We have banned many harmful pesticides; we are placing underground drainage systems in poorly drained areas; we have taken acreage out of production where the ground has been degraded by overuse; and we have created a "Superfund" to rid the country of the most dangerous toxic dumps. **Q.5** — Cost; the political differences between people who live where there is a lot of water and those who don't; and the competing uses for water—recreation, wildlife sanctuary, scenery, ecological balance of an area, and others.

p. 19 — WORKSHEET 7:

A Ireland	F Sahara Desert	T Tigris River
7 Athens	2 New Carthage	K Dardanelles
D Spain	AA Nile River	U Euphrates River
3 Rome	8 Byzantium	11 Damascus
C Gaul	1 London	I Black Sea
1 Cairo	H Asia Minor	R Rhone River
6 Carthage	M Adriatic Sea	10 Jerusalem
P Sicily	N Ionian Sea	Z Atlantic Ocean
B Britain	5 Syracuse	V Rhine River
L Greece	9 Alexandria	X Aegean Sea
E Algeria	BB Red Sea	W Mediterranean Sea

p. 21 — Q.1 — The Inca canal systems were almost totally open waterways, dug into the terrain and lined with rocks. At a maximum of 70 to 75 miles from the water source, they were indeed marvels for their time. The Los Angeles-Owens River Aqueduct is 233 miles long; the Los Angeles-Colorado Aqueduct is 300 miles long. In addition, these systems include numerous dams, reservoirs, pumping stations, tunnels (one of which runs 54 miles in mountainous terrain), hydroelectric plants and power transmission lines. The U.S. Bureau of Reclamation operates more than 700 dams and 70,000 miles of canals, pipelines and drains in eleven Western states alone. **Q.2** — We have no need to—our major agricultural lands are vast, flat regions in various parts of the country convenient to transportation. Farms are huge, unlike the small farms in Japan or India or early cultures. **Q.3** — At the time, there were large lakes there, which were a convenient water supply, just as they had been in earlier times. **Q.4** — The water tables in the great aquifers in the Midwest (the Ogallala), California and the Southwest are all getting lower, causing sinking of the land from the depleted water supplies. Same reason: overuse of the land for farming. Answers: importing water to recharge groundwater tables; taking land out of production; use more efficient irrigation methods. **Q.5** — Already plagued with water shortages, Mexico City industrial plants can only add to the problem by contributing pollutants to the water supply and the atmosphere.

A PROUD PAST

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