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# Water Education ... With Emphasis on Deer Creek Reservoir - Provo River Drainage Area (Grades 5-8)

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**Mountainland Association Of Governments**
**2545 North Canyon Road**
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*In Cooperation with the*
*United States Environmental Protection Agency Region VIII*

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# ACKNOWLEDGMENTS

This manual was made possible by a Clean Lakes Grant from the United States Environmental Protection Agency (USEPA) Region VIII. It is dedicated to the teachers and students in the area of the Deer Creek Reservoir and Provo River Drainage and others interested in maintaining and enhancing the quality of water in the State of Utah. Artwork was done by Marianna C. (Nancy) Israelsen. The materials were reviewed and field tested by Utah teachers and students in the Utah State University teacher preparation program. They were also reviewed by the following:

Ray Loveless, *Water Quality Director*
Mountainland Association of Governments

Harry Judd, *Utah State Clean Lakes Coordinator*
Bureau of Water Pollution Control

C. Elden Laird, *Assistant Manager*
Central Utah Water Conservancy District

Additionally, we would like to acknowledge the State of Utah Department of Natural Resources, Division of Wildlife Resources. They have courteously given us the right to reproduce black and white drawings from their publication "Fishes of Utah."

# CONCEPTUAL FRAMEWORK

Curriculum components are organized by the following framework:

1.0 HISTORICAL PERSPECTIVE

1.1 Defining a watershed

*Goal: Introduce the concept of a watershed.*

1.2 Planning ahead

*Goal: Introduce topics related to area water development.*

2.0 CLEAN WATER

2.1 What is water?

*Goal: Stimulate discussion about the concept that quality of life is related to quality of water.*

2.2 Chemicals found in water

*Goal: Investigate the concept of solubility.*

2.3 Organisms in water

*Goal: Increase an awareness of organisms found in water and relate this concept to the concept of water quality.*

2.4 What does dirty water mean to me?

*Goal: Introduce the concept of water pollution and relate water quality to human welfare.*

2.5 What does dirty water mean to plants and animals?

*Goal: Introduce the concept of ecological relationships.*

2.6 Water chemistry

*Goal: Investigate the relationships which exist between pH, dissolved oxygen, and organisms found in water.*

3.0 WATER RIGHTS AND LAWS

3.1 What factors influence water use?

*Goal: Familiarize students with laws governing water use.*

4.0 WATER USE

4.1 Agricultural use

*Goal: Familiarize students with current water use practice for agriculture.*

4.2 Recreational use

*Goal: Familiarize students with current recreational water use.*

4.3 Urban use

*Goal: Familiarize students with current and planned water use for culinary and industrial purposes.*

The authors used the above framework as a means for organizing the activities in the book. Though each activity can stand alone, there is a logical progression in the framework. Students will better understand activities toward the back of the book if they have first reviewed the activities that appear earlier in the book.

# CORRELATION GUIDE

The following guide keys *Water Education . . . with emphasis on Deer Creek Reservoir – Provo River Drainage Area* lessons and topics to both the preceding Conceptual Framework and the 1987 Utah State Core Curriculum Standards and Objectives for Science. The State Curriculum Guide is available in published form or on 5 1/4" computer disks from the Utah State Office of Education, 250 East Fifth South, Salt Lake City, Utah 84111, (801) 538-7500.

The first listing on the guide correlates both Lessons 1, "You Have Come a Long Way Baby," and 2, "The Deer Creek Watershed," to Framework Reference 1.1, "Defining a Watershed," and to six standards and seven objectives in the Utah State Core Curriculum Standards and Objectives for Science. The first standard is read as: "Standard 3050, Objective 8."

| Lesson | Framework Reference | Topic | State Core Standard |
|---|---|---|---|
| 1,2 | 1.1 | Defining a Watershed | 3050-08, 6050-03, 3200-07, 3220-04, 3500-01, 3500-02, 6100-03 |
| 3 | 1.2 | Historical Perspective | 3050-08, 3200-08, 3500-02, 3500-06, 3600-06, 6100-02 |
| 3 | 1.3 | Present Concerns | 3050-08, 3200-08, 3500-02, 3500-06, 3600-06, 6100-02 |
| 4 | 2.1 | What is Water? | 3050-08, 3240-02 |
| 5 | 2.2 | Chemicals Found in Water | 3050-08, 3240-02 |
| 6 | 2.3 | Organisms in Water | 3050-08, 3240-02 |
| 7 | 2.4 | What Does Dirty Water Mean to Me? | 3050-08, 3200-07, 3500-01, 3500-02, 3600-06 |
| 8 | 2.5 | What Does Dirty Water Mean to Plants and Animals? | 3050-08, 3060-01, 3200-07, 3500-01, 3500-02, 3600-06 |
| 9 | 2.6 | Water Chemistry | 3050-08, 3060-01, 3200-07, 3240-02, 3500-01, 3500-03, 3600-06 |
| 10 | 2.7 | Bacteriology | 3050-08, 3060-01, 3200-07, 3500-01, 3500-02, 3500-03, 3600-06 |
| 11 | 3.1 | Water Rights and Laws | 3500-02, 6060-06 |
| 12 | 4.1 | Agricultural Use | 3050-08, 3200-07, 3200-04, 3500-01, 3500-02 |
| 13 | 4.2 | Recreational Use | 3050-08, 3200-07, 3500-01, 3500-02 |
| 14 | 4.3 | Urban Use | 3050-08, 3200-07, 3500-01, 3500-02 |

# INTRODUCTION

The major goals of this publication are to:

- promote an awareness of the importance of water resources associated with the target watershed;
- provide teachers with learning resources which are easily used in the classroom or in the field; and
- provide teachers with teaching materials which help satisfy State Core Standards.

*Water Education . . . with emphasis on Deer Creek Reservoir – Provo River Drainage* is designed to integrate water resources, conservation, management, and environmental education into the regular school curriculum. A multi-disciplinary, activity oriented approach is used. Students are involved in problem solving; they learn concepts and principles of science while working together. Such involvement enhances retention of concepts and tends to be highly motivating.

Teachers may use activities as they are or revise them to meet personal teaching styles and local classroom situations. Topics are presented in what was perceived by the authors as a logical order; however, teachers may reorganize or pick and choose. Other activities may also be utilized to fit curriculum needs and interests.

Each major topic includes two sections: *Background Information for the Teacher,* and *Activities. Background Information for the Teacher* provides convenient informational references for the major topics which the teacher should understand in directing the learning activities. The background is not intended to be used as a student text, but rather as a teacher reference. Student materials may be reproduced without prior permission.

*Activities* are set-up in standard lesson plan format. Every effort has been made to use easily obtainable materials. The teaching procedure for each lesson is presented in a simple outline form. Teaching procedures achieve the basic objective for each activity. Most activities are followed by extensions which expand the basic lesson into a number of curriculum areas and/or use the local environment, which in formal school settings is the school playground area or athletic field.

**Note:** The contents of this volume do not necessarily reflect the views of the Utah Water Research Laboratory or the Department of Elementary Education at Utah State University.

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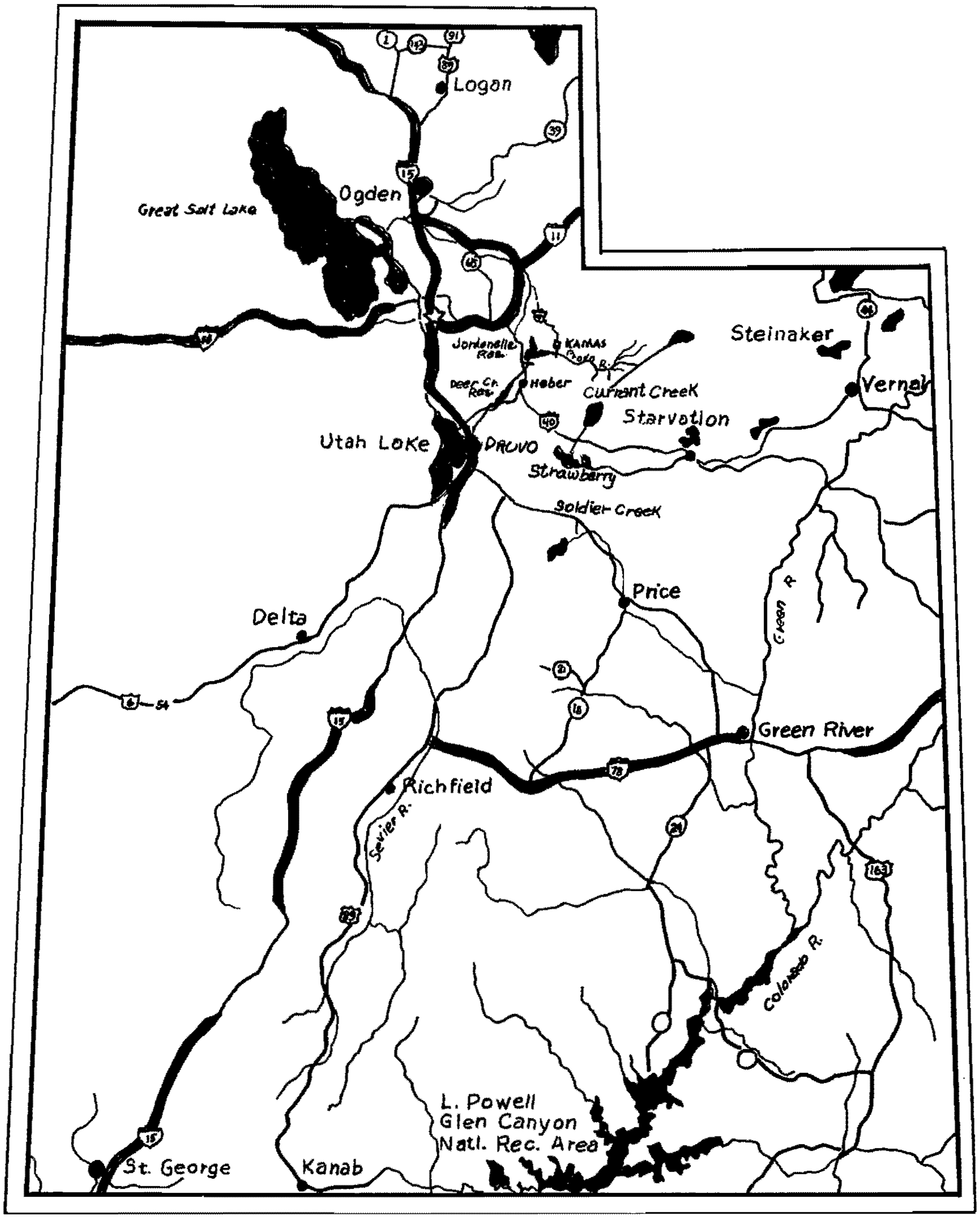
# CHAPTER ONE

# HISTORICAL PERSPECTIVE



# Background Information for Teachers

Most Utah towns and cities were established where they are because of available water supplies. Water is needed for drinking, transportation, industry, irrigation, and waste disposal. Most of Utah's water begins as precipitation in the mountains. Snow melt in the spring provides a surge of run-off that usually goes unused into the Great Salt Lake.

Because of varying water supplies and the demands upon them, water management plans have been essential. As early as 1856 Brigham Young recognized this need and outlined a plan for the use of Provo River water. Eighty years later the Bureau of Reclamation followed a very similar plan.

Utah Lake, fed by the Provo River, supplied irrigation water for some areas in the Salt Lake Valley, but during the drought years, 1931 to 1935, storage in Utah Lake fell from 850,000 acre-feet to 20,000 acre-feet. It became apparent that construction of a water development project was essential to provide an adequate water supply. The first project plan was the result of extensive investigations conducted at various times after 1922 by the Bureau of Reclamation in cooperation with the Water Storage Commission of Utah. The desperate water shortage experienced by Salt Lake City in the 1930s, and the consequent request to the U.S. Government for assistance in obtaining a dependable water supply for the Salt Lake Valley, gave rise to the Provo River Project. The city of Provo and five other communities in Utah County, as well as Salt Lake City, joined with the irrigation interests to sponsor the project. The Provo River Water Users' Association agreed to repay the United States for the cost of the project in accordance with Reclamation Law.

Construction of the project began in May 1938, with the first water becoming available in 1941, upon completion of Deer Creek Dam. Construction of some features of the project was severely hampered by WWII wartime scarcities of manpower, materials, and funds. Work on the Duchesne Tunnel Unit had to be stopped in 1942, although construction continued on a small scale on the canal system and Salt Lake Aqueduct. In 1947 full-scale construction was resumed. The Deer Creek Power Plant was completed in 1958.

The Provo River provides a supplemental water supply for thousands of acres of highly developed farmlands, thus assuring the maturity of valuable crops. Principal crops are alfalfa, grain, small fruit, peaches, apples, pears, sugar beets, and canning crops, such as sweet corn, peas, and tomatoes. The project also provides a supplemental domestic water supply for the Metropolitan Water Districts of Salt Lake City, Provo, Orem, Pleasant Grove, Lindon, American Fork, and Lehi.

Deer Creek Reservoir is on the Provo River about 16 miles northeast of Provo, Utah. Since a main highway crosses the dam, many visitors see the dam and reservoir during the year. The surface area of the reservoir is 2,680 acres at total capacity. The reservoir provides boating and excellent fishing in season, primarily for perch, bass, walleyes, and cut-throat, rainbow, and brown trout.

# Lesson 1
# You Have Come A Long Way Baby

Framework Reference 1.1

**OBJECTIVE:**
*Assist students in developing an appreciation for events and actions that have shaped the Provo River Watershed over time.*

**MATERIALS:**
*historical background sheet*
*game boards*
*cards*
*markers (beans, pennies, or whatever)*

**CORE STANDARDS:**
*3050–08, 3200–08, 3500–02, 3500–06, 3600–06, 6100–02*

**VOCABULARY:**
*flood irrigation*
*pollution*
*sprinkler irrigation*

## TEACHER PREPARATION/PLANNING:

The *Background Information for Students* sheet needs to be duplicated for each student. The game sheet and cards should be duplicated in quantities sufficient for groups of four students.

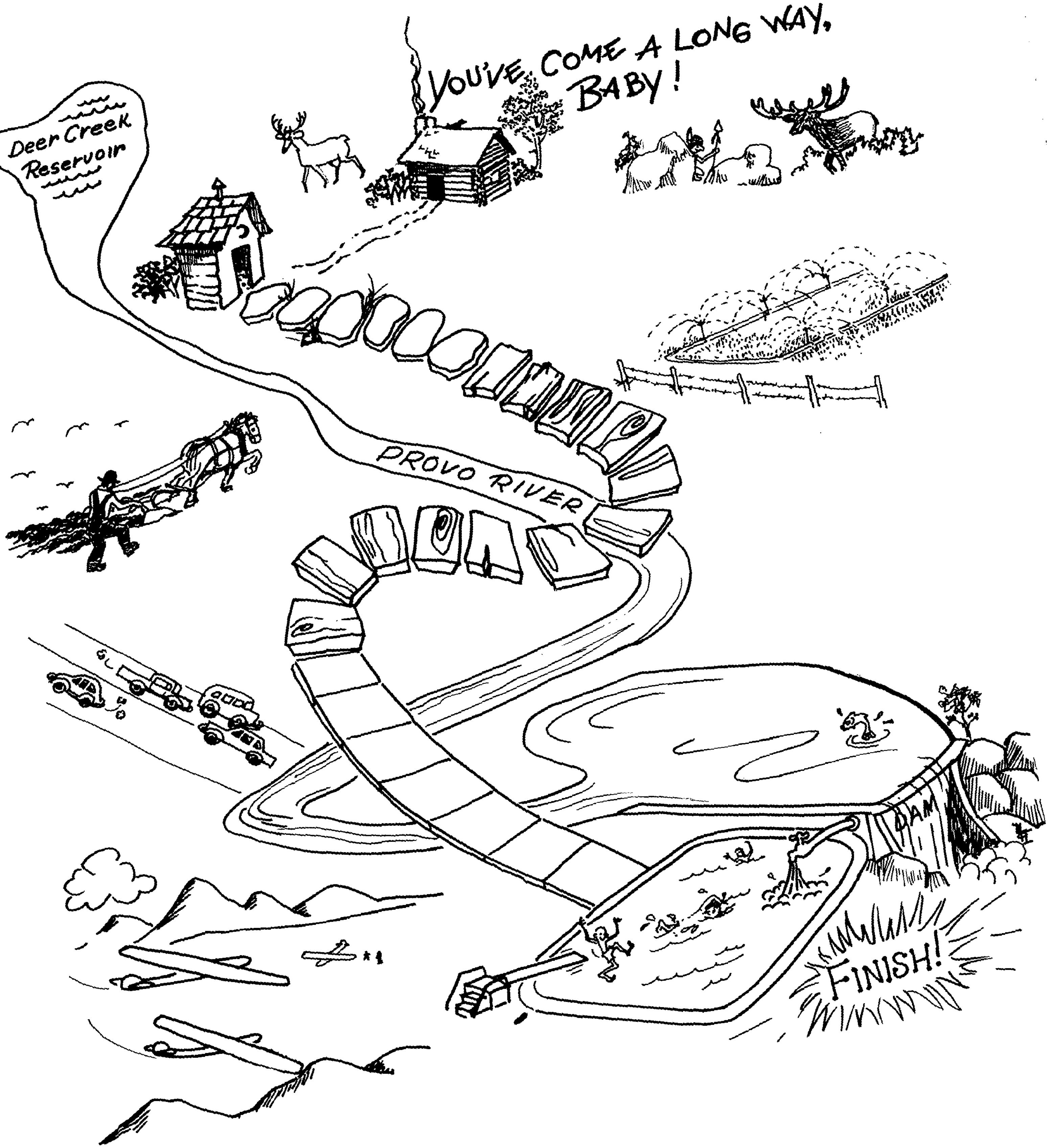
To play the game, each player places a marker on the outhouse. Cards are drawn from the top of the shuffled pile of cards. The objective is to get to the end of the pathway. If needed the cards can be reshuffled and reused.

## PROCEDURES:

1. Read and discuss the information on the *Background Information for Teachers* pages.
2. Distribute the game boards, cards, and markers to groups of four students. Introduce and define all of the game–card vocabulary. Explain the game rules and allow students to cut out the cards and play the game for approximately 15 minutes.
3. Discuss the game. Ask students to share what they learned from the game. Establish the fact that the game relates to the Provo River. Use this discussion to introduce the Historical Background sheet. Distribute the sheets and assign students to read to find out more about the history of the Provo River.

## EXTENSIONS:

1. Ask students to interview family members and neighbors who may recall historical events related to Deer Creek Reservoir and the Provo River Drainage. Request that students make oral reports to the class.
2. Discuss the changes in life–style which would occur if we went back to pioneer living.



YOU'VE COME A LONG WAY, BABY!
Deer Creek Reservoir
PROVO RIVER
DAM
FINISH!

| | | |
|---|---|---|
| ***Go Straight to Finish***<br>Discover Caleb Rhodes Mine | ***Move 1 Space***<br>Make Friends with Indians | ***Move 2 Spaces***<br>Put in Hand Pump |
| ***Move 1 Space***<br>Build a Log Cabin | ***Move 1 Space***<br>Land Opened to Homesteaders | ***Move 2 Spaces***<br>Install Septic Tank |
| ***Move 1 Space***<br>Work on Deer Creek Dam--1937 | ***Move 1 Space***<br>Shoot an Elk | ***Move 5 Spaces***<br>Enjoy the Scenery |
| ***Move 1 Space***<br>Build Paved Road, Provo Canyon--1920 | ***Move 1 Space***<br>Visit Heber City Airport | ***Lose One Turn***<br>Caught in a Flash Flood |
| ***Move 1 Space***<br>Collect Fees for Toll Road | ***Move 1 Space***<br>Shoot a Deer | ***Lose One Turn***<br>Wheel Fell off of Wagon |
| ***Move 1 Space***<br>Salt Lake Aqueduct Completed | ***Move 2 Spaces***<br>Got Job in Power Plant--1958 | ***Trot Back to Outhouse***<br>Outhouse Occupied--Wait One Turn and Then Start Over |
| ***Move 1 Space***<br>Brown Trout Introduced | ***Move 2 Spaces***<br>Change From Flood Irrigation to Sprinklers | ***Move 1 Space***<br>Plant a Garden |

## HISTORICAL BACKGROUND FOR STUDENTS:

*(From the notes of C. Elden Laird, Assistant General Manager, Central Utah Project, and Reed Olsen, United States Bureau of Reclamation)*

Lake Bonneville once filled the entire Utah Valley. After the Lake Bonneville era, the Shoshone Indians who lived in the mountains used the Provo Canyon as a trail so they could raid the Ute Indians who lived in Utah Valley. The first wagon trail was developed in 1850, and by 1887 a toll road was established. Each wagon and two animals were charged $1.50 per trip; pack animals, 15 cents each; horsemen, 15 cents; goat, swine, and sheep, five cents; and horses and cattle, 10 cents. These were rather high fees for the time. The road was turned over to the state in the late 1800s and was replaced by a paved road in the 1920s.

In 1899, Brigham Young initiated the construction of the Utah Eastern Railroad which followed the path of the original toll road through Provo Canyon. The Utah Eastern Railroad was turned over to the Denver Rio Grande in 1900 and was discontinued in 1969. In 1971, the Heber Creeper excursion train was started, using the abandoned track.

Heber City was settled in the late 1840s. Thomas Rhoades and 25 other men spent the first winter in the Kamas-Heber Valley in about 1850. When he was 24 years old, Caleb Rhoades came into Kamas Valley. He was instructed by Brigham Young to settle the area. Mr. Rhoades was in good standing with the local Indians and had won their favor by feeding them in the winter. The Indians responded by telling him about a money rock found in the hills—a one day ride from Kamas. Caleb was taken by an Indian to the gold pocket. He mined the gold that was used to plate the Angel Moroni statue on the LDS Temple in Salt Lake City.

The location of the mine was kept secret. Caleb's son, who had heard his father's stories, looked for the mine but never found it. When the son discovered that the area was to be opened to homesteaders, he wrote the government in Washington, D.C. They sent out a mining company to search for gold, but only found gilsenite at a site more than one day's ride from Kamas.

In 1937, the construction of Deer Creek Dam began. It was the main feature of a power project that was completed in 1958. The project cost $38.5 million; $36.5 million will be repaid by the water users. The irrigation water from the dam services 37,500 acres. An important function of the reservoir is to supply culinary (drinking) water to Salt Lake City. A 41.7 mile-long aqueduct carries water at the rate of 150 cubic feet per second. Provo, Orem, Lehi, American Fork, and Pleasant Grove all have interest in Provo River water.

# Lesson 2
# The Deer Creek Watershed

Framework Reference 1.1

**OBJECTIVE:**
*Introduce the student to the major physical features of the Deer Creek Watershed.*

**CORE STANDARDS:**
*3050–08, 3200–07, 3220–04, 3500–01, 3500–02, 3500–03, 6100–03, 6050–03*

**MATERIALS:**
*map of Deer Creek Reservoir Watershed area*

**VOCABULARY:**
*acre–foot*
*nonpoint source pollution*
*point source pollution*
*precipitation*
*watershed*

## PROCEDURES:

1. Distribute copies of the Deer Creek Watershed map (Figure 1). Ask the students to suggest an operational definition for the term "watershed."
2. Share the lake statistics and information with the students and discuss them.

## EXTENSIONS:

Enhance the concept of a watershed by using butcher paper, washable tempra paint, and water to create watershed art. Take a large sheet of butcher paper and spread it out over rocks, cans, or other objects. This surface represents a land surface. Use tempra paints to make several pints of different colored water. Have students take turns pouring small amounts of water on the paper. Discuss flow patterns and relate them to the concept of a watershed. Allow the paper to dry and use it as a watershed art piece.

### Description of the Lake

| | |
|---|---|
| Elevation | 5,417 feet |
| Maximum Surface Area | 2,965 acres |
| Maximum Volume | 193,614 acre–feet |
| Mean Depth | 65.3 feet |
| Maximum Depth | 137.1 feet |
| Mean Annual Drawdown | 70,413 acre–feet |
| Mean Annual Vertical Fluctuation | 30 feet |
| Length | 5.7 miles |
| Width | 1.2 miles |
| Shoreline Length | 18.4 miles |
| Major Inflows | Provo River, Main Creek, Daniels Creek, Decker Creek, Snake Creek |
| Outlet | Provo River |

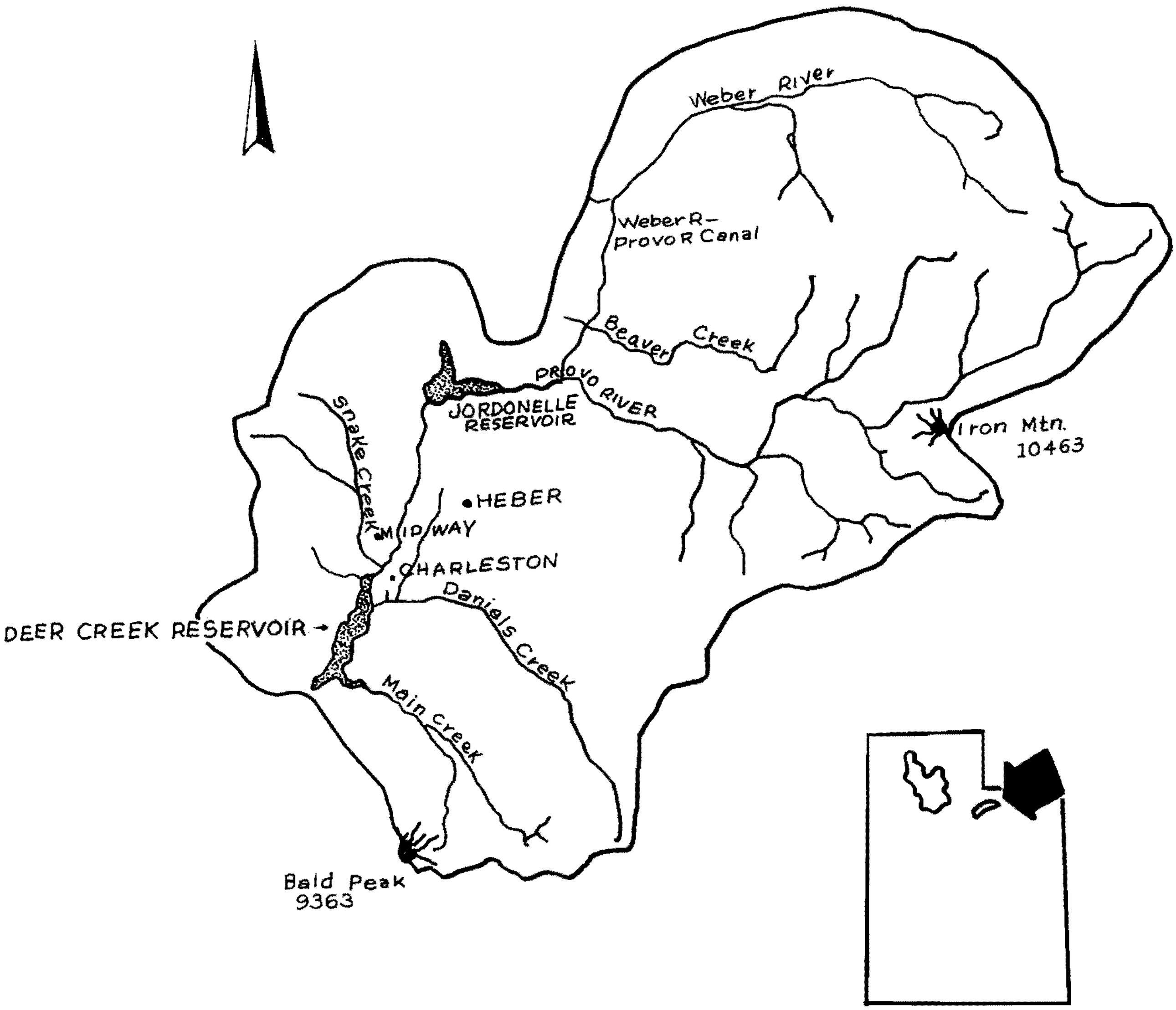



**Figure 1. Deer Creek Reservoir Watershed Area**

### *Watershed Description*

High mountains, plateaus, and valleys make up the watershed which has an area of approximately 700 square-miles. Precipitation varies with elevation from 16 to 40-inches per year. The watershed's high point is nearly 12,000 feet above mean sea level. The frost-free season extends from 80 to 100 days per year. Pine, spruce-fir, oak, maple, and sagebrush-grass are the principal vegetations.

The greatest amount of land (72%) in the watershed of Deer Creek Reservoir has multiple use and is administered by the State of Utah and the U.S. Forest Service. Recreation, grazing, and logging also occur on this land. Agriculture uses 26% of the land area, and urban and recreational use make up the remainder. Multiple use land includes recreation and grazing that occur on Forest Service land.

The shoreline of Deer Creek Reservoir is publicly owned and administered by the Provo River Water User's Association, the Bureau of Reclamation, and Utah State Parks and Recreation or their concessionaires. However, access across privately owned land to the shoreline may be restricted.

Deer Creek Reservoir is a very fine fishery and is stocked by the Division of Wildlife Resources with rainbow trout. Brown trout, largemouth bass, smallmouth bass, yellow perch, walleye, carp, and green sunfish are also present.

The reservoir is a very important culinary water source for Wasatch Front communities in Salt Lake and Utah Counties and provides a regulated water supply for four irrigation companies in Utah County. The reservoir is used extensively for recreation, including fishing, boating, swimming, and water skiing. Other water uses downstream include hydroelectric power and flood control. The impact of nonpoint agricultural and recreational pollutants, along with point source discharges (wastewater treatment plants and fish hatcheries) is significant. Nutrient levels are high and algal blooms are prevalent throughout the summer. These algal blooms may adversely affect the use of the water by causing discoloration, and taste and odor problems.

**Current and Potential Point and Nonpoint Pollution Sources**

| Source | Pollutants | Management Agencies |
|---|---|---|
| feedlots, dairies, grazing, agriculture, land erosion, recreation in Deer Creek State Park, septic tanks, and construction | nutrients, sediment, phosphate, nitrate, and coliform | Wasatch Soil Conservation District, U.S. Forest Service, Utah Division of Parks and Recreation, and Wasatch County Health Department |

The State beneficial use classification for the waters of Deer Creek Reservoir includes: Class 1C--culinary source with treatment; Class 2B--boating, waterskiing, etc. (excluding swimming); Class 3A--cold water game fish and aquatic life; and Class 4--agriculture irrigation and stockwatering.

# Lesson 3
# Present Concerns

Framework Reference 1.2

**OBJECTIVE:**

*Show the need for planned, intelligent use of water resources in the Provo River Drainage area.*

**CORE STANDARDS:**

*3050–08, 3200–08, 3500–02, 3500–06, 3600–06, 6100–02*

**MATERIALS:**

*various writing and art supplies for poster making*
*Central Utah Project (CUP) background material*

**VOCABULARY:**

*CUP*

## PROCEDURES:

1. Review the background covered in Lessons 1 & 2.
2. Introduce the CUP by distributing and discussing the CUP background handouts.
3. Challenge/assign students to design posters or cartoons which depict present concerns and possible solutions about water use procedures, population impact, and the total environment in the Provo River Drainage.

## EXTENSIONS:

1. Invite an authority from the State Division of Natural Resources, U.S. Bureau of Reclamation, or CUP to visit the class to discuss present concerns. See the Utah Water Education Speakers Bureau Organizational Listing (Appendix A) for names and addresses of resource organizations.
2. Submit cartoons to a local paper for publication and/or use the posters for a PTA Night theme in conjunction with a resource speaker as in Extension 1.

## CENTRAL UTAH PROJECT--STUDENT BACKGROUND INFORMATION:

### *Project Description*

The CUP is located in the Central and East Central part of Utah. It is the largest water resource development program ever undertaken in the State. The project provides Utah the opportunity to beneficially use a sizable portion of its allotted share of Colorado River water. Utah's rural areas in the Uintah and Sevier River Basins receive project water. Water is also provided to meet the municipal and industrial requirements of the most highly developed part of the State on the Wasatch Front. Here, the population growth and industrial development are continuing at a rapid rate. Water developed by the CUP is also used for irrigation, hydro–electric power, fish and wildlife conservation, and recreation. It also improves flood control capability and assists in water quality control.

In addition to substantial use benefits derived from the CUP, there are also environmental trade–offs. These programs involve biological inventories, operation studies, and other activities that are carried out by the U.S. Bureau of Reclamation to adjust for any environmental effects of the project.

Four of the five CUP units are situated entirely within the Uintah Basin: the Jensen, Vernal, Upalco, and Uintah units. They make additional water available for irrigation of both Indian and non–Indian land and for municipal and industrial use in Duchesne and Uintah Counties. The fifth unit, Bonneville, involves water collection and distribution in both the Uintah and Bonneville Basins.

### *The Central Utah Water Conservancy District*

The Central Utah Water Conservancy District was formally created on March 2, 1964, by order of the Fourth Judicial Court of Utah. The counties within the district are: Salt Lake, Utah, Summit, Wasatch, Duchesne, Uintah, Juab, Garfield, Sanpete, Millard, Piute, and Sevier. Representatives from these areas form a 19–person board of directors who provide a check–and–balance between rural and urban representation. This citizen board governs the affairs of the district and establishes policies.

The district serves as a legal agency to develop water resources to meet the water requirements of the 12 counties. One responsibility of the district is to sponsor units of the CUP. This project consists of a series of dams, pipelines, reservoirs, tunnels, and aqueducts designed to meet the water needs of the 12 counties through approximately the year 2020. As a sponsor of the CUP, the district has the responsibility to maintain and operate project facilities, administer the sale and delivery of project water, and repay the Federal Government the reimbursable costs of the CUP. The district also constructs and operates other facilities, as needed, to meet the water requirements of the citizens within the district.

The district has developed water treatment facilities in several communities within the project area. These water treatment plants have been built and paid for with the tax dollars that the citizens of the 12 counties have paid over the past several years. All of these treatment facilities are for supplying quality water which many of the communities within the CUP did not have prior to the project.

# CHAPTER TWO

# CLEAN WATER

# Background Information for Teachers

It is important that all students have a basic understanding of what water is and how it behaves. The understanding of pollution and water distribution cannot be fully achieved without some appreciation for the chemical and physical properties of water.

Water is the most abundant, unique, and important compound on earth. Without water, life on earth could not exist. Availability of water is a major factor in determining habitat preference of organisms. Not only does water play a major role in the external environment of organisms, but it is also a major component of living cells. Water makes up 60 to 90 percent of the body weight of most living things (Figure 2). Water inside the cell acts very similar to water outside the cell.

Water is the only substance that occurs naturally in all three physical states (solid, liquid, gas). Mercury is the only other noncarbon containing substance that occurs naturally in the liquid state within a wide temperature range, 32° F to 212° F, which is the range suited to most life forms. In the pure liquid state, water is odorless, colorless, and transparent.

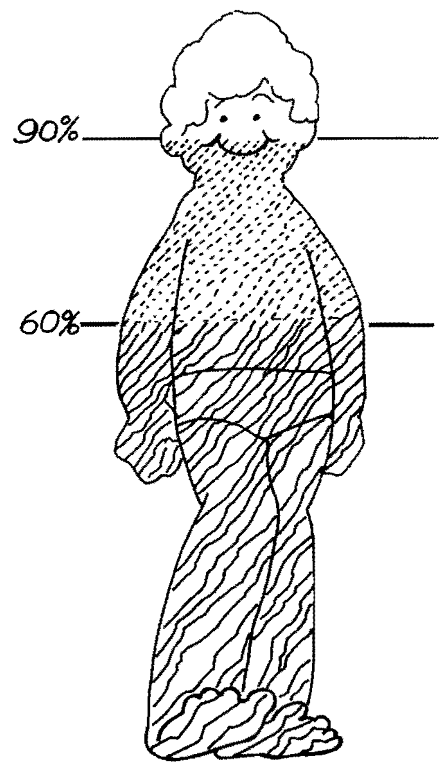



**Figure 2. Our Bodies are 60–90% Water**

### *The Water Molecule*

Chemically, each water molecule is composed of two atoms of hydrogen and one atom of oxygen. At normal temperatures, hydrogen occurs as a very reactive gas. This means it will combine chemically with other elements. Hydrogen is explosive and can be used as a fuel.

Oxygen is by far the most abundant element in the earth's crust. Free oxygen occurs as $O_2$ molecules in the atmosphere. Oxygen also combines chemically with many other elements. When cooled to –183° C, oxygen condenses and becomes a liquid, and at –219° C it becomes a bluish-white solid.

The atomic weight of an element is the average weight of an atom of that element. Hydrogen has an atomic weight of 1, and oxygen has an atomic weight of 16. The atomic number is the number of protons in the nucleus of a given element's atom; therefore, it is also the number of electrons normally surrounding the nucleus. The atomic number of hydrogen is 1, and oxygen has an atomic number of 8. The nuclei of hydrogen and oxygen could be pictured as shown in Figure 3.


+ is the symbol for proton

N is the symbol for neutron

**Figure 3. Hydrogen and Oxygen Nuclei**

Atom nuclei are surrounded by electrons. It is the electron structure of an atom that determines major chemical properties. Normally, the number of electrons in an atom equals the number of protons. The models for hydrogen and oxygen could be pictured as shown in Figure 4.

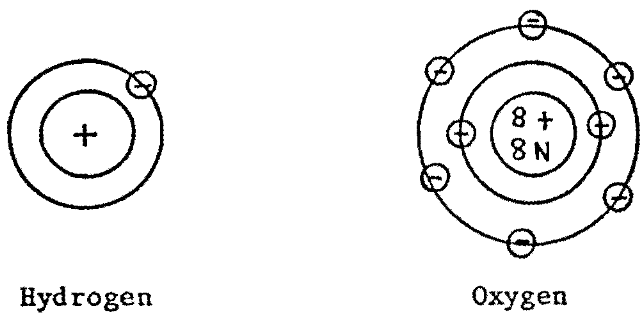



**Figure 4. Hydrogen and Oxygen Atoms**

Electrons exist in energy level rings resembling planetary orbits. The closest ring to the nucleus may contain up to two electrons. The second ring may hold up to eight electrons. From the models in Figure 4, it can be observed that hydrogen is short one electron in its first ring and oxygen is short two electrons in its outer ring to give these rings their full complements of electrons. These shortages make them chemically unstable.

If one oxygen and two hydrogen atoms come close together and react, the oxygen will tend to fill its outer ring by using hydrogen electrons. The atoms then share the electrons, giving the water molecule remarkable stability. Large amounts of energy are released when water is formed from hydrogen and oxygen. In forming a gallon of water, enough energy is released to keep a 100 watt light bulb lit for 167 hours.

Water is an oxide. Oxides are chemical compounds that are composed of oxygen bonded to one or more other elements. In a water molecule, the two hydrogen atoms bond to an oxygen atom at an angle of 104°. This bonding is determined by the interactions of the electrons in the rings. The atoms in a water molecule are held together by sharing the electrons (Figure 5).

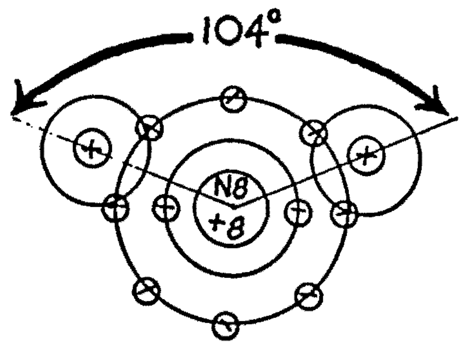



**Figure 5. The Water Molecule**

Density refers to how closely the molecules are packed together. In water, maximum packing occurs at about 4° C. Most materials contract as they cool and expand when heated. For water this is only true down to 4° C. From 4° C to 0° C water expands. Frozen water is less dense than liquid water. If this were not so, ice would sink to the bottoms of rivers and lakes and they would freeze solid.

The way in which the oxygen and hydrogen atoms share electrons causes water molecules to exhibit polarity (Figure 6). That is, the hydrogen ends of a molecule have a plus electrical charge and the oxygen end a minus electrical charge. This causes water molecules to be mutually attractive. This molecular attraction is the property that produces many of the unusual characteristics of water, such as cohesion and adhesion.

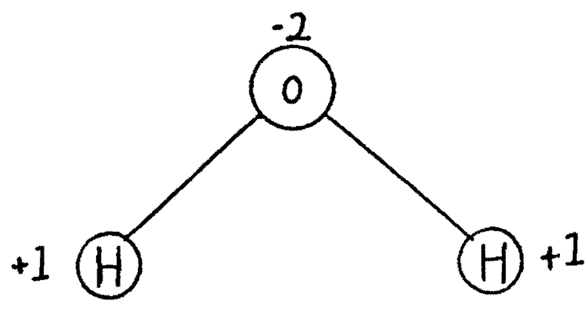



**Figure 6. Water Molecule Polarity**

All particles of matter, whether solid or liquid, exert an attractive force upon each other. This force is directly proportional to the product of their masses and inversely proportional to the square of the distance between their mass centers.

Quite distinct from such mass attraction is an electrochemical force known as molecular attraction (described above). As shown in Figure 7, a molecule at point A, a short distance from the surface, will be attracted equally in all directions, but a molecule at point B, on the surface, will have a smaller force exerted by the fewer molecules near the surface. This difference in forces in effect "compresses" the water surface and produces a condition called surface tension. Some insects depend on this property to travel on the surface of water.

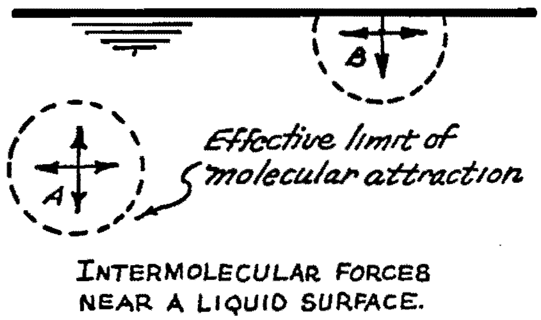



**Figure 7. Intermolecular Forces Near a Liquid Surface**

Water also has the ability to flow uphill. This property, called capillary action, contributes greatly to movement of liquids in plants. Capillary action results when water molecules respond to substances that attract them. For instance, in a small-diameter glass tube inserted in water, molecules at the surface are attracted to the glass. As they are pulled up, they also pull along other water molecules from below, and rise above the surface of the water.

### *Solutions and Suspensions*

Water is the most common solvent in both nature and the laboratory. Energy is required to break up bonding before a material can dissolve in water.

Material dissolved in a solvent is called a solute, and the resulting material a solution. When solids or gases are dissolved in a liquid, the liquid is always considered the solvent. Thus, when sugar is stirred into water, the water is the solvent. The resulting sugar solution is a homogeneous mixture. The concentration of sugar can increase until the solution becomes saturated. Saturation refers to the conditions in which no more of a solute will dissolve in a solvent. Generally the higher the temperature of the solvent, the more material dissolves. A few liquids will dissolve in each other in any proportion. For example, any amount of alcohol and water will dissolve in each other. Gases will also dissolve in water. Solubilities of gases decrease as the temperature increases. Thus, the Arctic Ocean teems with aquatic life due in part to the fact that the cold water contains larger amounts of dissolved oxygen than are found in tropical waters.

The term alkalinity refers to the content of carbonates, bicarbonates, and a few other chemicals that may be dissolved in water. Hard water is caused by the presence of calcium ions ($Ca^{++}$) and magnesium ions ($Mg^{++}$). Ions are electrically charged particles. Hardness limits the lathering or foaming ability of soaps and increases the tendency of water to produce scale in pipes, heaters, and boilers. Other ions may also cause hardness (e.g., $Sr^{++}$, $Mn^{++}$, $Fe^{++}$) but they usually are not present in large amounts in most water supplies. These ions enter water as it comes in contact with soil, rock, industrial waste, and sewage.

Water hardness may be of two types: temporary or carbonate hardness, and permanent or noncarbonate hardness. Temporary hardness can be removed by boiling the water. This causes calcium carbonate to form. We see this as scale on the bottom of pans used for boiling water. The $Ca^{++}$ ions can also be precipitated out of the water by adding baking soda. Added carbonate ions, $CO_3^{--}$, react with $Ca^{++}$ to form soluble calcium carbonate.

Hard water impurities can also be removed by using chemical water softeners. Water softeners are large molecule exchangers. Ionic exchangers remove calcium and other divalent ions like magnesium from water and replace them with sodium ions. The sodium ions do not influence the lathering ability of soap. Thus, hardness of water can be removed by running hard water over an ion exchanger. Ionic exchangers must be recharged by allowing them to be in contact with a brine solution in which the sodium ion replaces the unwanted ions from the water being softened. The sodium ions are supplied by common table salt.

Dissolved material can also be removed from water by distillation. Distillation is the process of vaporizing water and then condensing the resulting water vapor. This process leaves the dissolved solids behind.

### *Acidity*

Water molecules tend to dissociate to form ions. This reaction can be written:

$$H_2O \leftrightarrows H^+ + OH^-$$

The double arrow indicates that in pure water there is a balanced reaction and that $H^+$ and $OH^-$ ions occur in equal concentration. The concentration of $H^+$ ions determines the acidity of the water. The pH of water is an indication of the concentration of the $H^+$ ion. Acids all contain hydrogen ions and when dissolved in water taste sour, turn blue litmus paper red, and release carbon dioxide from carbonates.

Bases are compounds of a metal with oxygen and hydrogen. In water solution, they turn red litmus paper blue, have a bitter taste, and feel soapy. When an acid and a base react together, they form a salt.

In water, only 1 gram in 10,000,000 liters ionizes. Since acids yield $H^+$ ions and bases yield $OH^-$ ions when dissolved in water, water itself could be classed as neither an acid nor a base since there is an equal distribution of $H^+$ and $OH^-$ ions. Pure water is therefore said to be neutral. Adding an acid to water increases the $H^+$ concentration and adding a base increases the $OH^-$ concentrations. The relative acidity or basicity of the solution can be measured by determining the relative number of either $H^+$ ions or $OH^-$ ions in a liter of water. The most commonly accepted method is to measure the $H^+$ ion concentration and express it as the logarithm of the number of liters of water which must be taken in order to contain 1 gram of hydrogen ions. Since the log of 10,000,000 is 7, the relative acidity-basicity or pH of water is 7. A pH of 4 would indicate 10,000 liters of water per gram of $H^+$, an acid. A pH of 9 would indicate 1,000,000,000 liters of water per gram of $H^+$, which is a base. Remember that the pH values are logarithmic. A solution having a pH of 6.0 contains 10 times as many H ions as one having a pH of 7.0, and a solution with a pH of 5.0 contains 100 times as many H ions as a solution with a pH of 7.0.

### *Pollution*

Pollution affects water quality. By pollution, we mean any unfavorable change in the environment, wholly or largely as a by-product of human actions. These changes may have direct human impact or indirect impact through water supply, agricultural products, or opportunities for recreation. The changes may also have impact on other organisms. When water quality changes, there tends to be a shift in the numbers of given species. For example, as water warms, the number of trout may decrease while the number of carp increases.

# Lesson 4
# Clean Water Implications

Framework Reference 2.1

**OBJECTIVE:**
*Show that quality of life is directly related to quality of water.*

**CORE STANDARDS:**
*3050–08, 3240–02*

**MATERIALS:**
*two baby food jars*
*water*
*tape*
*quality of life worksheet*
*quality of life indicators worksheet*
*map*

**VOCABULARY:**
*operational definition*
*quality of life*

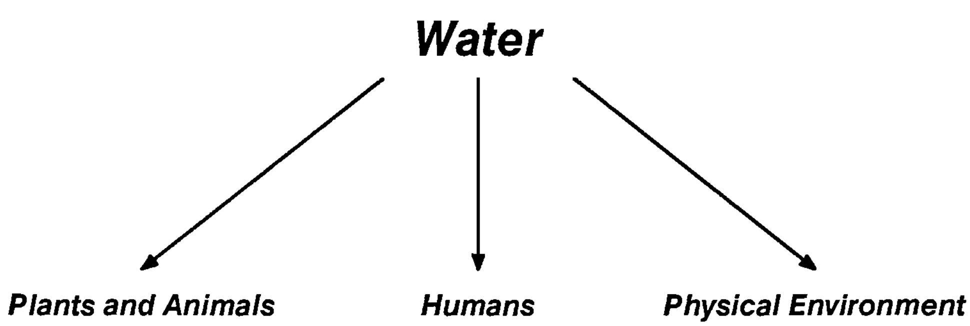
## TEACHER PREPARATION:

Make the mini-water cycle demonstration by placing three drops of water in one of two baby food jars. Invert another jar over the first and tape them together, mouth to mouth.

## PROCEDURES:

1. Place the mini-water cycle demonstration in a warm sunny location or under a strong light. Ask the students to observe what happens. Discuss the water cycle and relate this to Utah precipitation patterns.

2. Draw the diagram below on the chalkboard.




Have students list ways that water influences each of the three categories: humans, plants and animals, and the physical environment. Discuss the answers.

3. Reverse the arrows in the diagram and have students list ways that man, plants and animals, and the physical environment affect water. Discuss the answers.

4. Discuss the term "quality of life." In our society specialized groups, ranging from nuclear physicists to artists, speak their own language. The meanings of existing words are changed to express ideas entirely different from definitions in the dictionary. In the context of relevance for a group of people, it is appropriate to define operationally.

An operational definition explains objects and events in the context of a group's own experience. Form an operational definition of the relationships that exist between "quality of life" and "quality of water."

5. Distribute and discuss the quality of life worksheet. Have students complete the assignment at the top of the page.

## EXTENSIONS:

1. Catch fish and use them to make "quality of life" fishprints. Wipe the fish dry and paint them with various colors of India ink. A little ink goes a long way on small fish. Carp are great as the scales are well defined. Carefully lay a piece of bond paper over the painted fish. Then peel it off for your fish print.

2. Catch fish and have a class fish fry.

**QUALITY OF LIFE WORKSHEET:**

Brown trout are able to survive under very heavy fishing pressure. They reproduce well in mountain streams and adapt well to relatively warm waters found in reservoirs. Fish weighing more than a few pounds generally feed on smaller fish. Fish under this size feed on insects such as mayflies, caddisflies, and stoneflies.

Rainbow trout are the most important game fish in Utah. They are easily raised in hatcheries and are easily caught by fishermen. The raising, releasing, and catching of rainbows is often referred to as "put-and-take fishing." Rainbow trout eat insects, small fish, and even algae. Rainbows prefer water temperature in the lower 60s.

Yellow perch are warm-water fish. They are able to reproduce in enormous numbers, often to the extent that they will over-populate a body of water, resulting in stunted fish. They often swim in schools of 50 to 200 fish of the same size. They do not prosper in small ponds or cold-fast streams.

The walleye is a relative of the yellow perch, but grows much larger. Walleyes feed in schools, preferring to eat small fish. They prefer cold, clean water. During daylight hours, they go into deep water.

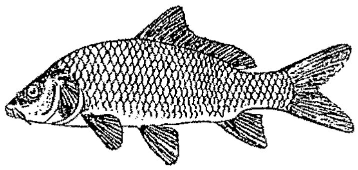
Carp prefer warm, shallow water. Here they feed on all sorts of plant and animal matter, including the eggs of other fish. Twenty pound carp are not uncommon in Utah waters.

The Utah sucker is native to most Utah streams. It lives in lakes, rivers, or creeks in warm (above 80° F), to very cold water. Its diet consists of a variety of small organisms, including plants.

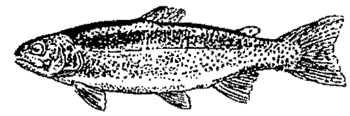
Water in the Provo River Watershed originates in high-clear water lakes. As water flows down to Deer Creek Reservoir it becomes warmer and carries more dissolved solids.

**QUALITY OF LIFE INDICATORS WORKSHEET:**

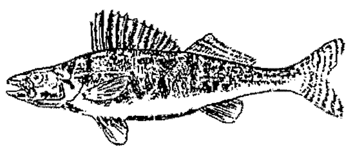
If you were a brown trout, rainbow trout, yellow perch, walleye, carp, or sucker, you would prefer different habitats for a "quality life." Draw a line from each fish picture to a location on the map where the fish may be found. Write a brief note to explain your choice of location.



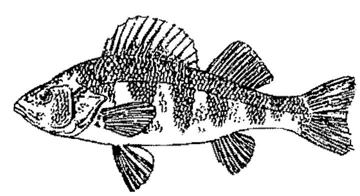
Carp



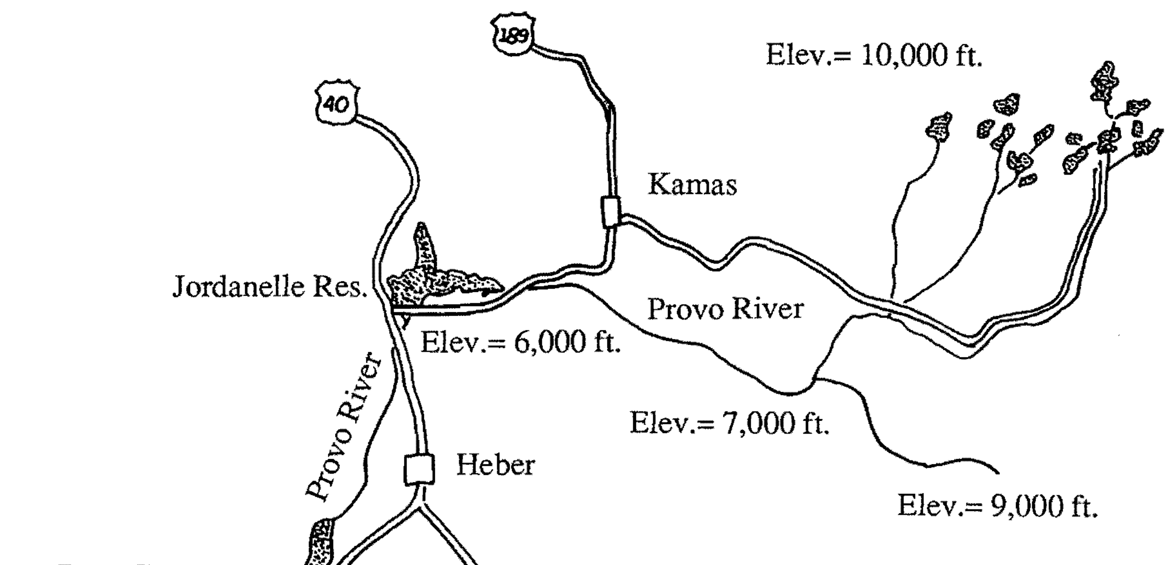
Rainbow Trout

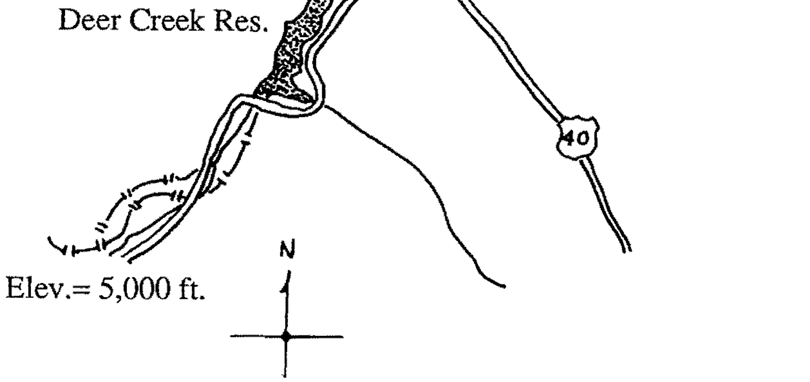


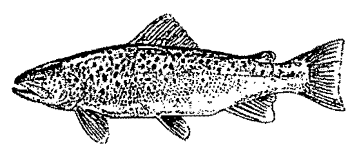
Walleye



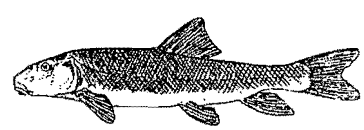
Yellow Perch



Brown Trout



Utah Sucker

# Lesson 5
# Not Everything In Water Swims

Framework Reference 2.2

**OBJECTIVE:**
*Investigate the solubility of various chemicals and show that water quality can be greatly influenced by dissolved solids.*

**CORE STANDARDS:**
*3050–08, 3050–01*

**MATERIALS:**
*plastic cups*
*water with different substances dissolved in them: salt, sugar, alum, distilled water, plain tap water, carbonated water, vinegar*
*petri dishes*
*beaker*
*stirring rod*
*plastic pop bottles*
*salt*

**VOCABULARY:**
*dissolve*
*homogeneous*
*saturation*
*solubility*
*solute*
*solution*
*solvent*

## PROCEDURES:

1. Introduce the lesson by having a taster's table. Set up plastic pop bottles with various substances dissolved in tap water. Give each student a plastic cup and let them sample from each bottle, describing the taste, reaction in their mouth, and what they think they have identified. Lead to the conclusion that you cannot always tell what is in water by looking at it. Label petri dishes with what students predict was in each sample. Pour a small amount of each sample into the appropriate petri dish and allow the contents to evaporate. Examine the residue.

2. Share the student reading material with the students.

3. Ask students to give examples of solutions, identifying the solvent and solute in each example, e.g. sugar solution with water as solvent and sugar as solute.

4. Discuss what happens to molecules as they go into a solution. How could you determine if a solute was distributed uniformly in a solution? (Evaporate equal volumes of solution and see if there was an equal amount of solute.) Is there a limit to how much solute can dissolve in a given volume of solvent? Introduce the concept of saturation. Demonstrate this concept with salt and a beaker of water. Stir in salt until no more will dissolve.

## EXTENSIONS:

1. *Materials*: Feen–a–mint laxative pills, household (nonsudsing) ammonia, soda straws, quart jar, medicine dropper, distilled water.

   Dissolve one Feen–a–mint laxative in about three to four tablespoons of water. (Crushing the tablet will help it dissolve; some solid material will remain.) The laxative tablet contains a substance known as phenolphthalein. This substance will change color when a certain chemical characteristic of water changes (pink in a basic solution, clear in an acidic solution). This solution will be called an indicator solution because it indicates the chemical character of the water by its color change. Put about 1/2 cup of distilled water into a quart fruit jar or large glass and add one drop of household ammonia. Add 20–25 drops of the prepared indicator solution. The water should now have a faint pink color. Have the students take turns blowing through soda straws placed in the water. After several minutes of blowing, the solution should become colorless.

*Questions:*

a. What changes occurred?

b. What gas is being blown into the water? (carbon dioxide)

c. Is the gas changing the chemical nature of the water?

d. How can we tell? (by the change in color)

***Teachers' Note:*** The Indicator Solution should be prepared prior to use to allow settling of the solids. Use the clear liquid portion as the indicator. The teacher should use care, not to add excessive household ammonia. One drop should be sufficient to produce the desired pH adjustment and should not pose any problems if some is swallowed or spilled. The students should be warned, however, to blow on the straw—not suck. DO NOT SUCK UP THE LIQUID! The chemicals in the solution would taste very bad.

2. Solubility Experiments

*Materials*: starch, tap water, beakers (250 ml), tincture of iodine, silver nitrate, salt, celery, distilled water.

*Procedure A*: Put a pinch of starch into 250 ml of water. Add one tablespoon of starch to 250 ml of water in another beaker. Drop four or five drops of tincture of iodine into each beaker. What happens? (NOTE: Tincture of iodine added to a solution containing starch turns the solution blue). Why is one jar darker than the other? Do they both contain starch?

*Procedure B*: Put a pinch of starch in one beaker and one tablespoon in the other. Add an equal amount of saliva to each. Let sit for one day. After one day, test with tincture of iodine. Record what happens. Some substances are biodegradable (mixed with bacteria, a chemical change takes place and a new substance is formed). What caused the change? (CAUTION: Do not get any liquid from this experiment on your hands. Use plastic gloves as there is potential of disease organisms in the solution.)

*Procedure C*: Pour some salt into a beaker of water to make a solution. Add four or five drops of silver nitrate (purchase at a drugstore). Notice what happens. A white cloud always appears when silver nitrate is mixed with a sodium chloride (salt) solution. Tear up a sheet of paper and submerge in a beaker of salt water. Soak for 10 minutes. Dry the paper, put it into another beaker that contains distilled water. Let paper soak for 10 minutes. Take out the paper and try the silver nitrate test. What did you discover? How can you be sure there wasn't any sodium chloride in the water before the experiment started?

*Procedure D*: In two beakers, pour equal amounts of distilled water. In the first beaker, stir in some salt to make a solution. Put a piece of celery into each beaker. Leave the celery in the beakers for one day. Take the celery out of the beakers, dry them off with a towel, and put them into two beakers of distilled water. Let them sit in the new beakers for one day. Apply the silver nitrate test. What happens? Try other materials. Test them with silver nitrate. Is the salt biodegradable?

## NOT EVERYTHING IN WATER SWIMS--STUDENT READING

Water is called the universal solvent because it dissolves more substances than any other liquid. Naturally occurring water always contains dissolved substances. These include other liquids, solids, and gases. Many chemical reactions take place more readily when the reactants are dissolved in water. Water in living cells plays an important role in supporting reactions needed for life processes.

Substances dissolved in water can have an effect on the solubility of other substances. For example, carbon dioxide dissolved in rain can give the water a slightly acid character. This increases the solvent power of the water. As rain passes through soil and rock, the acid dissolves some minerals.

A material dissolved in a solvent is called a solute and the resulting material a solution. When solids or gases are dissolved in a liquid, the liquid is always considered the solvent. Thus, when sugar is stirred into the water, the water is the solvent. The resulting sugar solution is a homogeneous mixture. This means that the sugar is uniformly distributed in the water. The concentration of sugar can increase until the solution becomes saturated. Saturation refers to the condition where no more of a solute will dissolve in a solvent. Generally, the higher the temperature the more material can be dissolved in a solvent. A few liquids will dissolve in each other. Gases will also dissolve in water. Solubility of gas decreases as the temperature increases. The Arctic Ocean teems with life, due in part to the fact that the cold water contains larger amounts of dissolved oxygen than are found in tropical waters.

Water hardness is determined by solids dissolved in water. Hardness limits the lathering or foaming ability of soaps and increases the tendency of water to produce scale in pipes, heaters, and boilers. Hard water is caused by the presence of calcium ($Ca^{++}$) and magnesium ($Mg^{++}$) ions. Ions are electrically charged particles. Other ions (e.g., $Sr^{++}$, $Mn^{++}$, $Fe^{+}$) may also cause hardness but are usually not present in large amounts in most water supplies. Ions enter water as it comes in contact with soils, rock, industrial waste, and sewage.

Dissolved material may be removed from water by distillation. Distillation is the process of vaporizing water and then condensing the resulting water vapor. Distillation leaves the dissolved solids behind.

Hard water impurities can also be removed by using water softeners. Water softeners are large molecules called zeolites. Zeolites remove calcium and other ions from water and replace them with sodium ions. The sodium ions do not influence the lathering ability of soap. Water hardness can be removed by running hard water over a zeolite. Zeolites must be recharged by allowing them to be in contact with a brine solution in which sodium ions replace the unwanted mineral ions. The sodium ions are supplied by common table salt.

Water may also contain larger particles. Suspended particles are those that have a diameter greater than 1 micron. Such particles are large enough to settle out at a reasonable rate and can be removed by a filter. They are large enough to reflect light so they tend to make water cloudy.

Colloidal particles are smaller than suspended particles and take an extremely long time to settle out. They cannot be removed by ordinary filtration. Water that contains colloidal particles looks cloudy when observed at right angles to a beam of light.

# Lesson 6
# Plant And Animal Identification

Framework Reference 2.3

**OBJECTIVE:**
*Help students identify common plants and animals found in the Provo River Watershed.*

**CORE STANDARDS:**
*3050–08, 3500–01*

**MATERIALS:**
*Figures 8–10 as worksheets*
*Fishes of the Provo River Watershed worksheet*
*scissors*

**VOCABULARY:**

| | |
|---|---|
| *algae* | *nekton* |
| *bacteria* | *organism* |
| *benthos* | *plankton* |
| *chlorophyll* | *phytoplankton* |
| *diatom* | *pigmented flagellate* |

## PROCEDURES:

1. Share the following information:

   Organisms living in water are often good indicators of water quality. Dissolved materials and suspended pollutants kill some species without harming others. Some pollutants actually promote the growth of some species. Before anyone can study the relationship between water quality and organisms, one must be able to identify the organisms found in the water.

   Water organisms are usually categorized by where they are found in the water. The usual categories are plankton, nekton, benthos, and bacteria.

   Plankton are small organisms that float about in water currents. Phytoplankton contain chlorophyll and are a primary source of food for other organisms. They consist of various algae, diatoms, and pigmented flagellates. Zooplankton consist of small animals including rotifers, protozoa, and small crustaceans (see Figure 8). The nekton community is made up of organisms that swim freely. These include fish and insects (see Figure 9). Benthos refers to all living things found on the bottom of a body of water. This includes many plants and animals (see Figure 10).

2. Distribute Figures 8–10, identify and discuss the organisms listed. Think of plankton as very small drifters.

3. Distribute the Fishes of the Provo River Watershed worksheet (Figure 11). Indicate that these fish are found in different habitats in the Provo River Drainage. The purpose of this activity is to develop a key to help identify these fish. The process used is called a "branching key." It might help to cut out each picture so that they can be sorted.

   Instruct the students to sort the fish into two groups by some "either–or" characteristics. An example would be "with two fins on back/with other than two fins on back." Then continue dividing each group so that each fish stands alone and can be named. Use only characteristics that can be observed in the pictures.

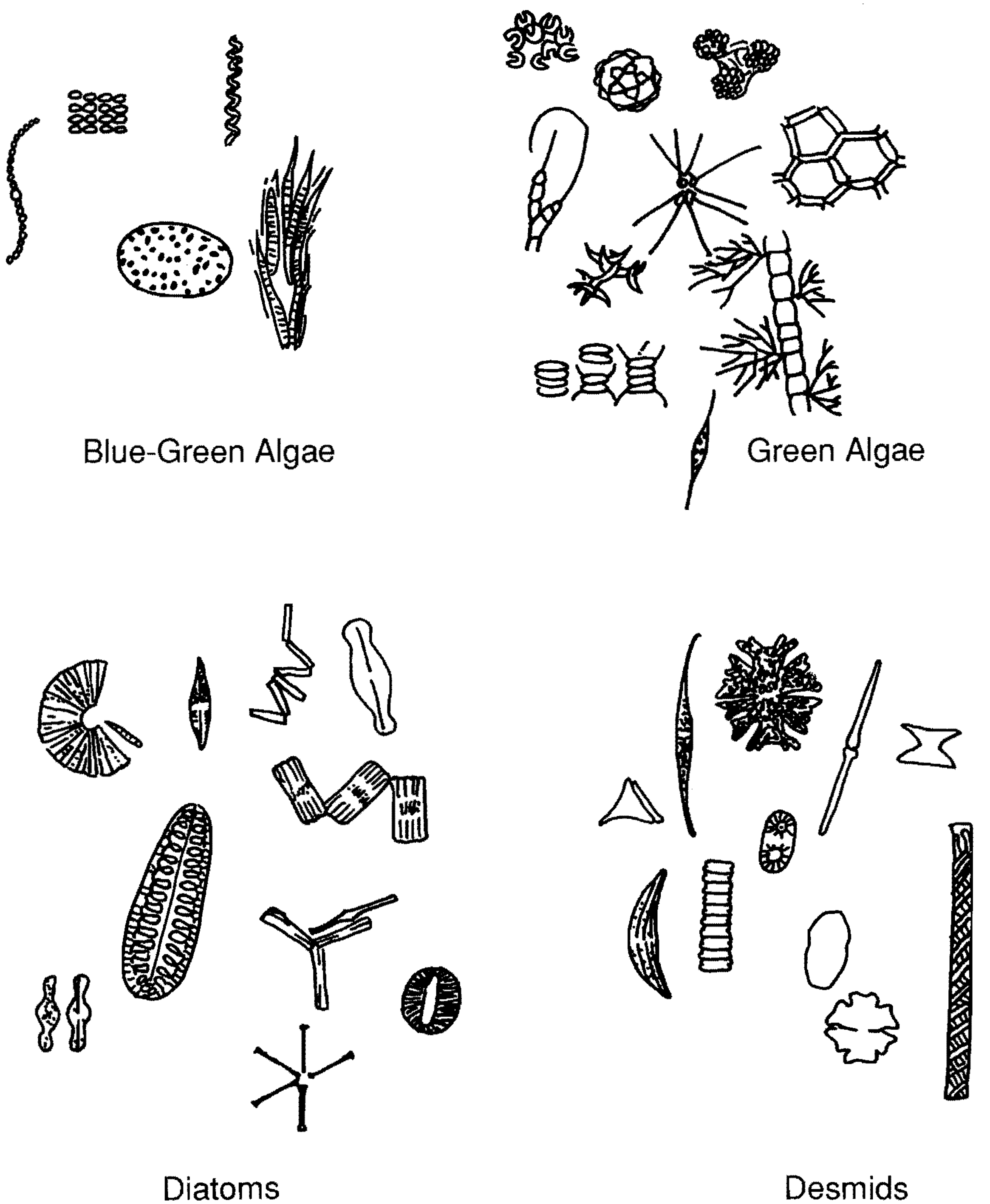



**Figure 8. Phytoplankton (with Chlorophyll)**

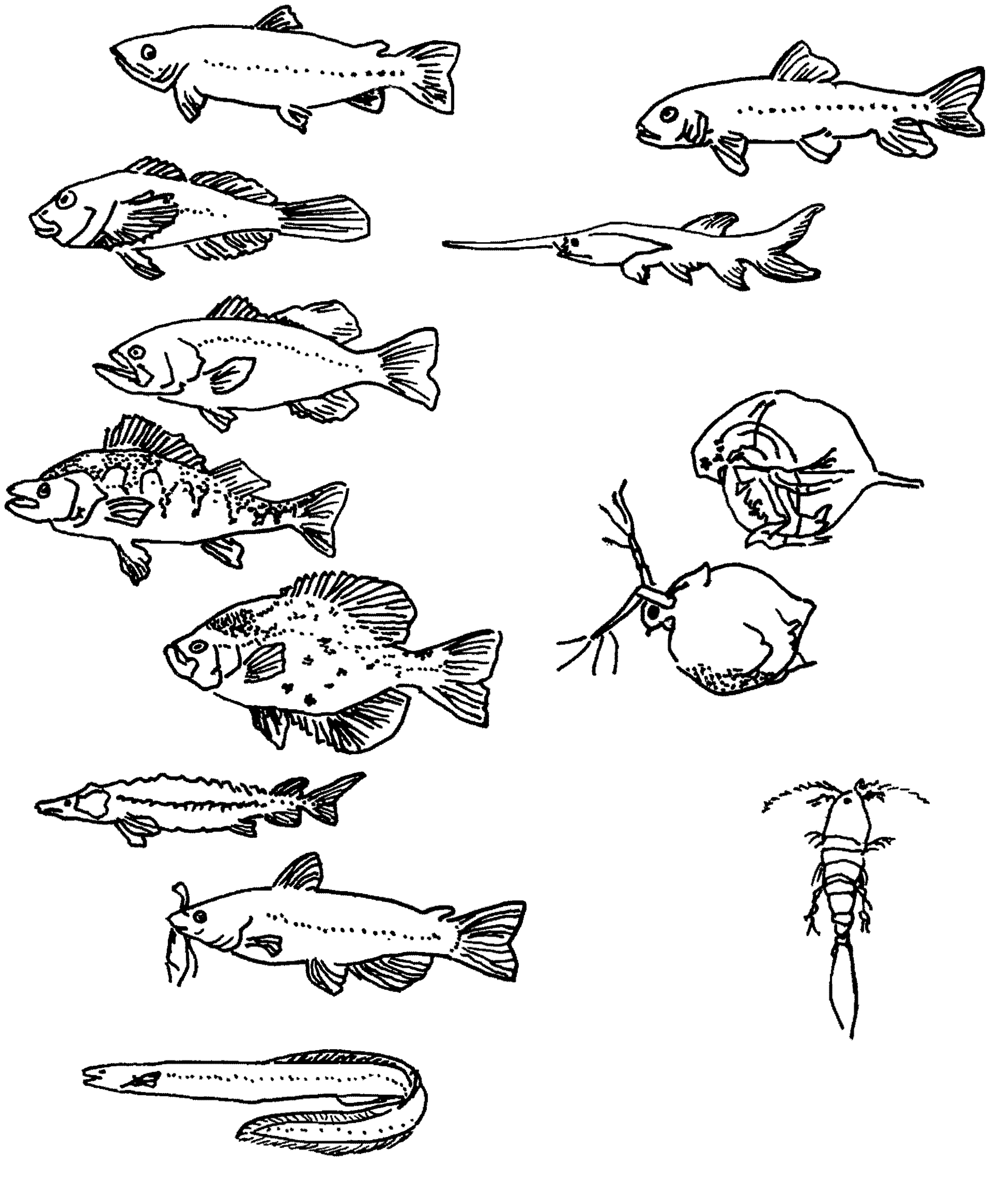


Figure 9. Nekton *(think of Nekton as swimmers)*

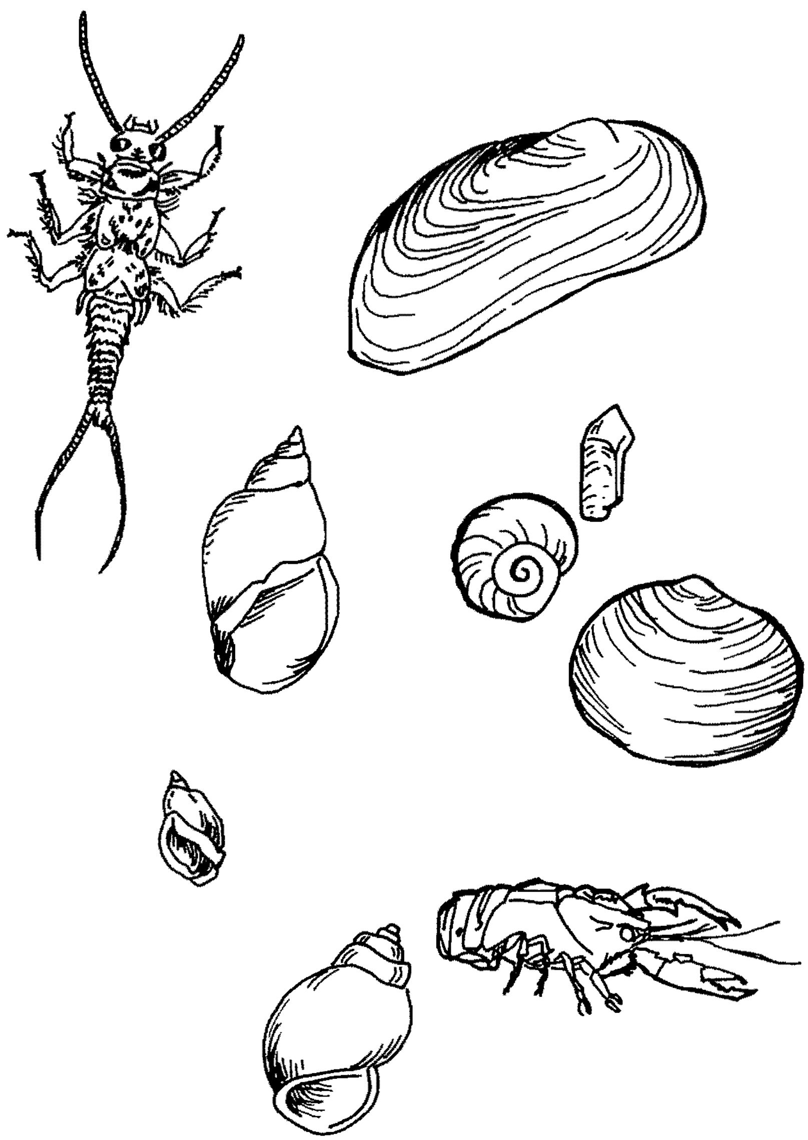


**Figure 10. Benthos *(Benthos are bottom dwellers)***

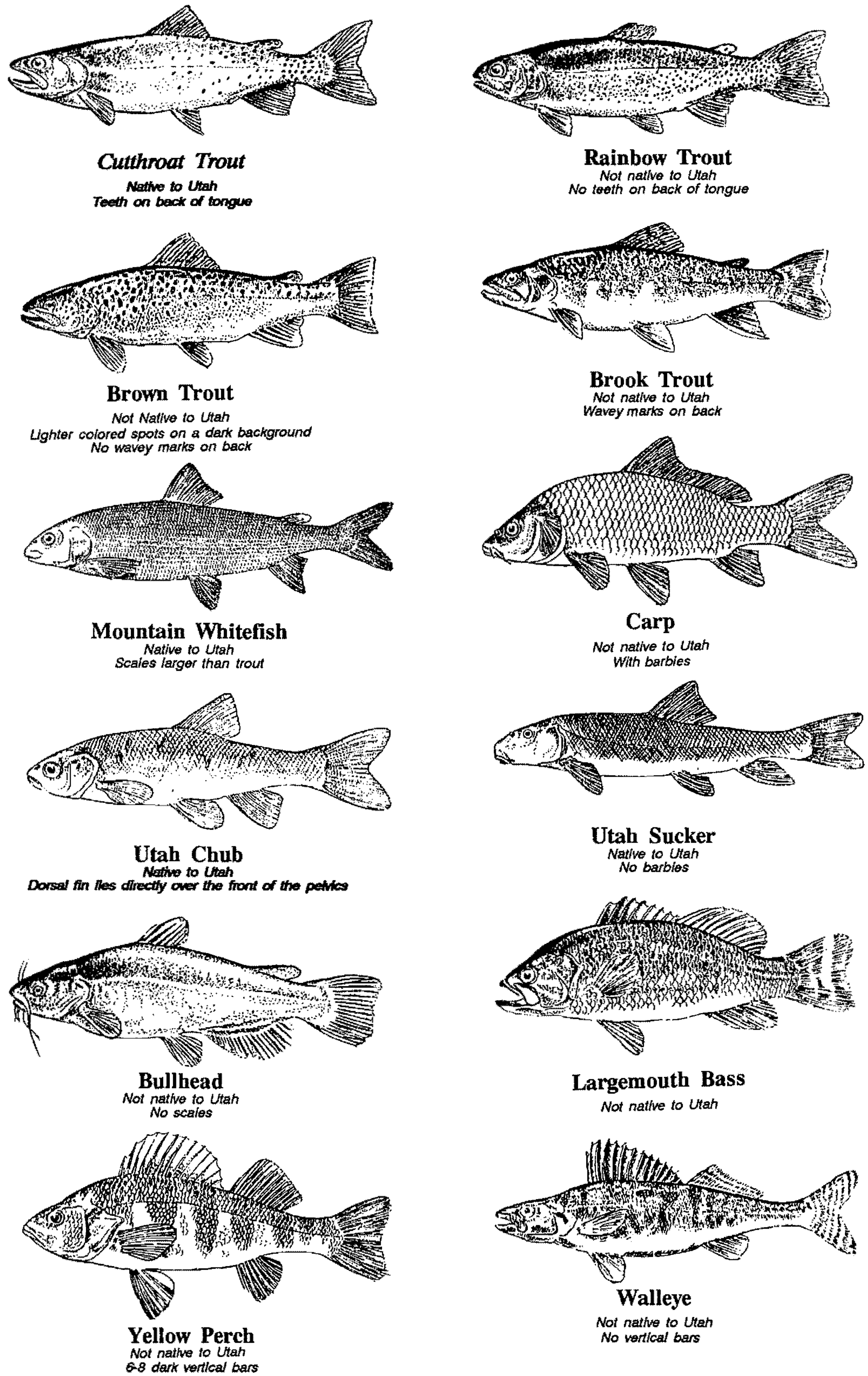
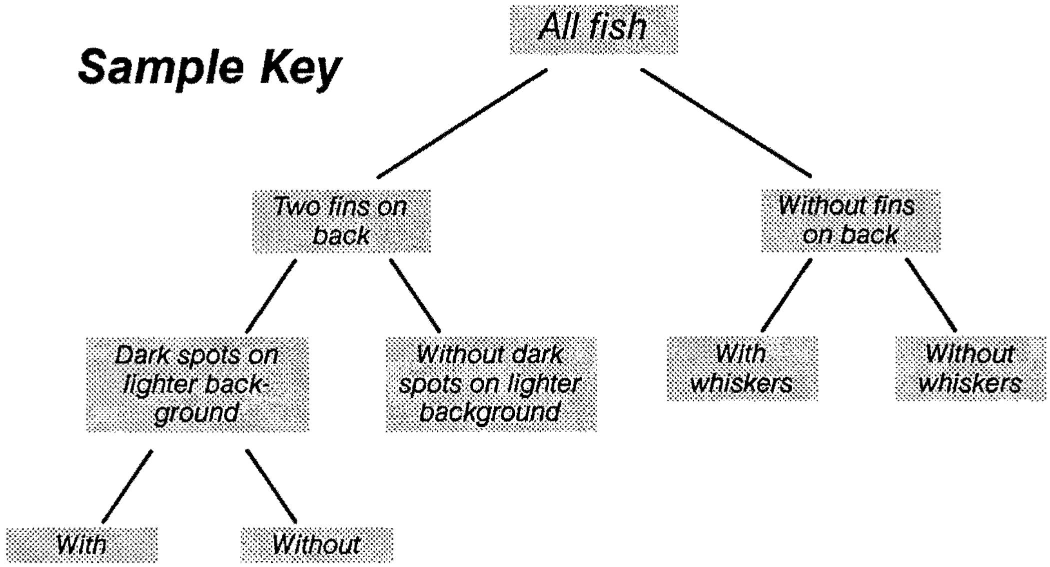



**Figure 11. Fishes of the Provo River Watershed**

## *Sample Key*




**EXTENSIONS:**

1. Have students do reports on the fish found in the Provo River Drainage. Use *Fishes of Utah* by Sigler and Miller if it can be found in your library. Please note the additional useful references.

   Sigler, W. F., & Miller, R. R. (1963). *Fishes of Utah.* Salt Lake City: Utah State Department of Fish and Game (Currently the Division of Wildlife Resources, Dept. of Natural Resources), 203 pages.

   Sigler, W. F., & Sigler, J. W. (1987). *Fishes of the Great Basin: A Natural History.* Reno: University of Nevada Press, 425 pages.

   Sigler, W. F. (1980). *Wildlife Law Enforcement* (3rd ed.). Dubukue, Iowa: Wm. C. Brown Co., Publishers, 403 pages.

2. Collect a variety of fish and examine their digestive tracts to determine what they have been eating and what parasites are in them.

3. Investigate methods of preserving fish and report on the topic to the class.

4. Invite local sportsmen to demonstrate fishing techniques for various species. Hold a fishing clinic. Ask your local sportsman club to sponsor an event for the school.

# Lesson 7
# Clean Up Your Act

Framework Reference 2.4

**OBJECTIVE:**
*Relate water quality to human welfare.*

**CORE STANDARDS:**
*3050–08, 3200–07, 3500–01, 3500–02, 3600–06*

**MATERIALS:**
*fine filter paper*
*analytical balance*
*1–liter bottle*
*funnel*
*Figure 12 visual*

**VOCABULARY:**
*culinary water*
*nutrients*
*phosphorus*
*plankton*
*total suspended solids*

## TEACHER PREPARATION/PLANNING:

Either make copies of Figure 12 for the students or make a transparency for overhead projection.

## PROCEDURES:

1. Begin the activity by sharing the following information:

   Deer Creek Reservoir is important to many people. It provides culinary (drinking) water, agricultural irrigation water, fishery resources, and recreational opportunities. In 1984, a Clean Lakes study showed that the water quality in Deer Creek Reservoir needed to be improved. Water was being polluted by too many nutrients. The main pollutant was phosphorus. Phosphorus is found in every living cell and is vital for life. Phosphorus, like other nutrients, goes through a natural cycle. The phosphorus in Deer Creek Reservoir originated from various sources. These sources included dairy and agricultural areas, erosion of soils naturally high in phosphorus, mine tailings, a fish hatchery, and sewage wastewater. In 1984, Deer Creek Reservoir received about 27.6 tons of phosphorus.

   Phosphorus stimulates the growth of algae. In turn, algae influence the taste and smell of water, turns it a pea green color, depletes its oxygen supply, and increases water treatment costs. Efforts to improve Deer Creek Reservoir water quality included a new 15 million dollar sewage treatment system, new planning and zoning ordinances with strictly enforced health standards, construction of dairy animal waste storage areas, a new settling pond at the Midway Fish Hatchery, and restrooms around Deer Creek Reservoir. The control of water released from Jordanelle Reservoir also lowered the phosphorus level. Plankton use phosphate to make molecules in their bodies. When the plants die, or are eaten by other organisms that then die, decomposers return the phosphorus to the water as dissolved organic matter. More phosphorus is returned to the water in animal waste. Phosphorus can then go through the cycle again.

2. Determination of the phosphate level in a water sample is a rather complex process. However, an indirect estimate of the phosphate level can be made by measuring the total suspended solids (TSS) from stream water samples. Figure 12 shows how TSS nearly parallels phosphorus levels.

Obtain stream water samples and use the following procedure to measure TSS:

a. Weigh a filter paper.

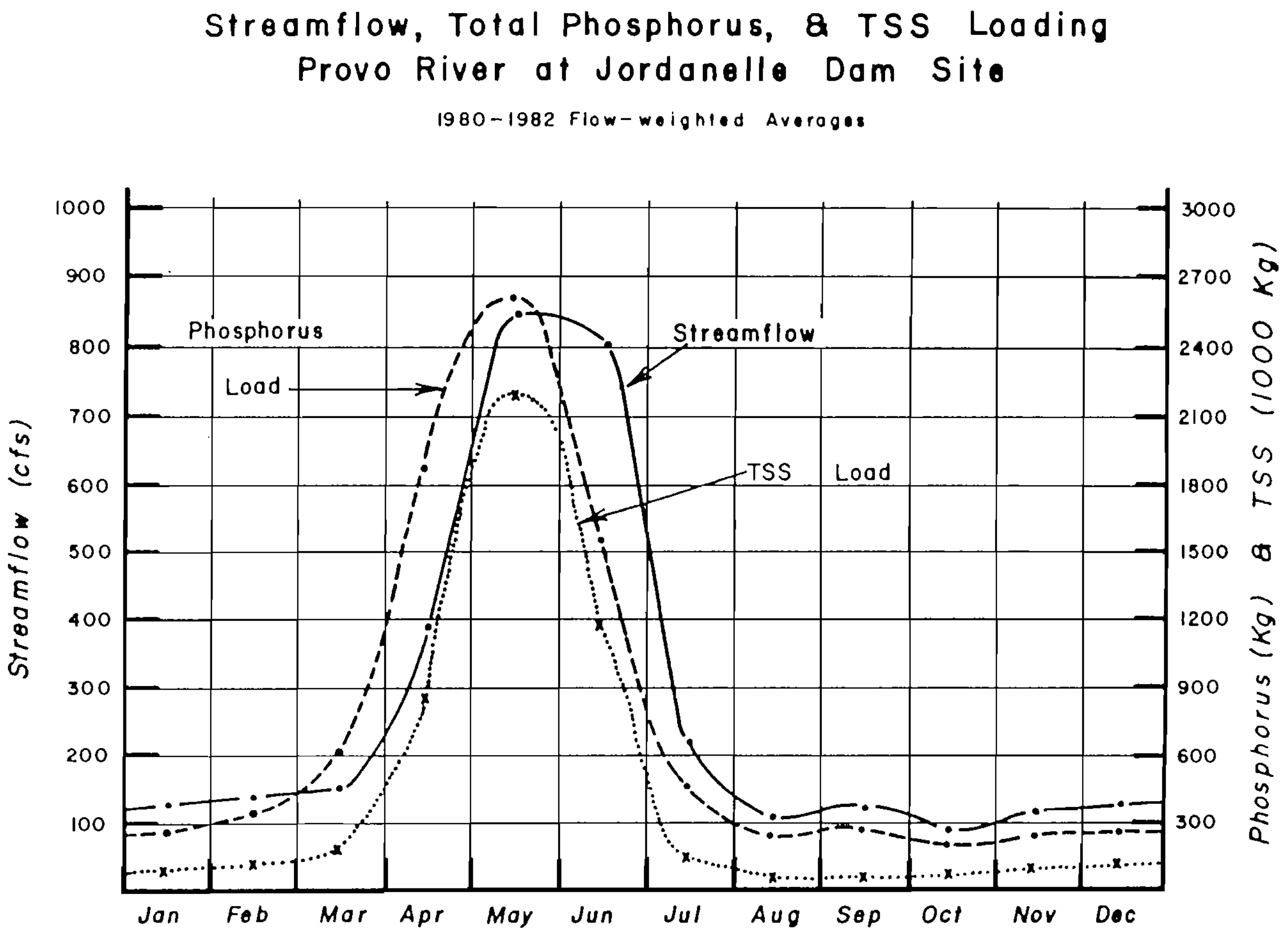
b. Filter a l-liter sample of water through the weighed filter paper.

c. Allow the paper to dry.

d. Reweigh the dry filter paper. The increase in weight is the weight of the total suspended solids (TSS) in l-liter of water. Express the TSS in PPM (parts per million). Use Figure 12 to estimate the amount of phosphorus.

**EXTENSIONS:**

Plan a field trip to visit the Heber Valley Special Service District. Arrange for personnel to discuss phosphorus control measures. Visit the Midway Fish Hatchery and view the settling ponds.



Streamflow, Total Phosphorus, & TSS Loading
Provo River at Jordanelle Dam Site
1980-1982 Flow-weighted Averages
Streamflow (cfs)
Phosphorus (Kg) & TSS (1000 Kg)
Phosphorus
Load
Streamflow
TSS Load
1000
900
800
700
600
500
400
300
200
100
3000
2700
2400
2100
1800
1500
1200
900
600
300
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Figure 12

# Lesson 8
# Ecology

Framework Reference 2.5

**OBJECTIVE:**
*Show ecological relationships of plants and animals in Deer Creek Reservoir.*

**CORE STANDARDS:**
*3050–08, 3060–01, 3200–07, 3500–01, 3500–02, 3600–06*

**MATERIALS:**
*Ecology Background (with this lesson)*
*beef bouillon cubes*
*gelatin*
*pan*
*baby food jars*
*medicine droppers*
*large box of breakfast cereal*
*three different colors of sandwich bags*
*three different colors of cloth for headbands*
*rubbing alcohol*

**VOCABULARY:**

| | |
|---|---|
| *abiotic* | *ecology* |
| *biotic* | *environment* |
| *carnivore* | *food chain* |
| *consumer* | *food web* |
| *daphnia* | *predator* |
| *decomposers* | *producers* |

## TEACHER PREPARATION/PLANNING:

1. Reproduce sufficient copies of Ecology Background handouts.
2. Gelatin culture jars should be made up at least a day before they are to be used. Culture jars can be made by the teacher or by an individual student under teacher supervision.
   a. Sterilize six to eight baby food jars and lids by washing them in rubbing alcohol. Allow them to completely dry upside down on a paper towel in air before adding culture medium. Additional baby food jars for collecting samples and the medicine droppers should be cleaned in the same manner.
   b. Medium preparation:
      1) Dissolve two beef bouillon cubes in one cup of boiling water.
      2) Allow to cool.
      3) Sprinkle two tablespoons of gelatin into a saucepan containing the cool bouillon mix.
      4) Place over low heat and stir until gelatin dissolves.
      5) Pour the hot mixture into baby food jars to a depth of about one inch. Place lids on the jars and allow the medium to cool and gel before use.

## PROCEDURES:

1. Distribute the Ecology Background handouts. Discuss and/or have students read the material.
2. Use the following procedure to observe some decomposer organisms.

a. Using a clean, sterile baby food jar, collect a water sample from a stream, pond, or reservoir. In another jar, collect some bottom sediment and cover it with water.

b. Place the following labels on four different culture jars: Pond Water, Sediment, Tap Water, Control.

c. Shake the water samples, then use a sterile medicine dropper to transfer 10 drops of pond water to the appropriately labeled culture jar. Use a different sterile medicine dropper and transfer 10 drops of pond sediment suspension to its culture jar. Turn on a water faucet and allow it to run for about 1 minute, then cut the faucet off until it drips slowly. Allow 10 drops of tap water to drip into its culture jar. Do not add anything to the jar labeled "control."

d. Swirl each culture jar to cover the gelatin with the sample added. Be sure lids are on tight, then turn the jars upside down and place them in a dark, warm spot to incubate. A water heater closet would be a good place, or an incubator could be made from a cardboard box and a heating pad. Incubation temperature should be 85–95° F. If a heater closet is used, do not place the culture jars directly on top of the heater because the medium will melt.

e. Allow the cultures to incubate for approximately 24 hours. Examine the gelatin and count the colonies of bacteria and fungi. Do not remove the lids. Incubate the cultures for an additional 24 hours and count the colonies again. Colonies have grown from single spores or cells that were in the water samples. The "control" jar is incubated to be sure the culture jars were sterile. If the "control" jar has bacteria or fungi growing in it, you will know that the jar or medium was not completely sterile and that some of the growth in the other culture jars may not be from the sample. If the "control" jar is free of growth after incubation, it can be assumed that all the growth in the other cultures came from water that was added. Anytime that a scientist does an experiment, he should have some kind of control.

   Bacteria and fungi are called decomposers because as they get their food materials from dead plant and animal matter, they help to decay the dead material.

*Questions:*

1. Why are bacteria and other fungi called decomposers?

   They cause decay of dead plant and animal material.

2. Why are they important in nature?

   They help to recycle elements and molecules which are necessary for other living organisms.

3. What would happen if there were no decomposers on earth?

   Dead plants and animals could not decay.

4. Why is it necessary to kill bacteria in drinking water?

   Some bacteria cause disease if they are taken into a human body.

***Teacher's Note*:** Dispose of the used culture jars in a garbage container. Do not remove the lids from the jars because the cultures may have an unpleasant odor and could contain disease causing bacteria.

The activity could be expanded for the class or used as a science fair type project by taking samples from several different water sources.

3. Use the game outlined below as a way of reviewing or introducing a food chain. Cereal is used to represent phytoplankton and is spread out in a grassy area. Students are bass, minnows, and daphnia. There should be twice as many minnows as bass and twice as many daphnia as minnows. The daphnia feed only on cereal, the minnows feed only on daphnia, and the bass feed only on minnows. Daphnia simulate feeding by picking up phytoplankton (cereal) and placing it into their sandwich bags. When a bass catches a minnow, the minnow is out of the game and must give his/her food bag to the bass. Similarly, the minnows collect food bags from the daphnia. Organisms are handicapped by only being able to take short steps: daphnia less than six inches; minnows less than 12 inches; and bass less than 24 inches. No one can run.

   Explain the rules and place cloth headbands on students to identify bass, minnows, and daphnia.

   Begin the game by releasing the daphnia. In approximately one minute, release the minnows and finally the bass. Allow the game to go on for a few minutes, but stop playing before any group of prey is completely captured. Divide the class into survivors and nonsurvivors. Students who were caught or who collected no food will be nonsurvivors and those who do have food will be survivors. Conduct a class discussion to answer the following:

   *Questions:*

   a. How many daphnia, minnows, and bass have survived?

   b. Do our results indicate a balanced community? Why or why not?

      ***Teacher's Note*:** If the community was not balanced, adjust the ratio of consumers and play again. By balanced we mean that there was enough food for both bass and minnows.

   c. What would happen in nature if there was not enough phytoplankton?

      No food could be produced and all animals would die.

   d. In nature if there were no surviving daphnia, what would happen to the phytoplankton?

      The population would grow out of control.

   e. If there were no surviving minnows, what would happen to phytoplankton and bass?

      The population of daphnia would increase and they would eat too much phytoplankton, causing its population to decrease. There would be no food for the bass and they would starve.

   f. Do bass need phytoplankton? Why or why not?

Yes, without phytoplankton there would be no food for animals that bass feed upon.

g. Do you know of any organisms that are not a part of a food chain?

h. Suppose that this year there are a lot of bass and that they eat so many minnows that the minnow population decreases but survives. How will daphnia, phytoplankton, and bass populations be affected next year? How will they be affected year after next? Why is this process a part of the balance of nature?

**EXTENSIONS:**

1. Play the game in step 3 of the procedure above, except this time, place two marbles in the sandwich bag of each daphnia. The marbles represent pesticides that may be passed through the food chain. Discuss the accumulative effects of pesticides in a food chain.

## ECOLOGY BACKGROUND:

*Ecology* is the study of interactions between plants and animals (including humans) with each other and with the environment in which they live. *Environment* refers to the total set of conditions, both living (biotic) and nonliving (abiotic), that surround organisms and influence where and how they live. Organisms can survive in their habitat only if they have adapted to the biotic and abiotic factors that surround them. Since humans have a greater capacity to control their environment than any other organism, the activities of humans have potentially the greatest influence, both good and bad, upon ecological relationships.

BIOTIC FACTORS: Some interactions are among members of the biotic community. All biotic factors can generally be grouped as *animals*, *green plants* (those that contain chlorophyll), and *nongreen plants* (those that do not contain chlorophyll, such as bacteria and fungi). Some living organisms depend on other organisms for food or for a place to live. Some living organisms compete with others for food, light, oxygen, or a place to live.

ABIOTIC FACTORS: Some interactions are between the biotic community and the abiotic environment. Some abiotic factors that determine where and how plants and animals live are temperature, water, atmosphere, topography, soil, and energy flow.

A *food chain* represents the transfer of the sun's energy from *producers to consumers* as organisms feed on one another. Figure 13 is a diagram of a simple aquatic food chain. The ultimate source of energy is the sun. The sun's energy is converted into usable energy (food) by green plants through *photosynthesis*. Green plants are called *producers* since they manufacture food for themselves and animals. Animals get their food either directly or indirectly from green plants. Animals that feed directly on green plants are called *primary consumers*, and animals that get their food by preying upon other animals are called *secondary consumers*. Even though food for the secondary consumers comes from tissue of the primary consumers, it was first derived from green plants; therefore, we say that the secondary consumer gets its food indirectly from green plants. People and some animals may be both primary and secondary consumers. In addition to producers and consumers, there is a third group of organisms called *decomposers*. Some examples of decomposers are bacteria, mold, and other fungi. Decomposers are plants that do not contain chlorophyll; therefore, they cannot produce their own food. They get energy and food as they cause the decay of animal waste products, fallen leaves or other plant parts, and dead plant and animal remains.

Figure 13 shows a food chain in which the bass has no predator, so it is the top carnivore. Carnivore means flesh-eating. If a person were to catch the bass and eat it, then that person would be the top carnivore.

In nature, a simple food chain is rare. More often several primary consumers may prey on the same producer or on several producer organisms. Secondary consumers may also be found in several different pathways. A *food web* is a representation of all food pathways. A simple *food web* is given in Figure 14. The greater the number of alternate pathways in a food web, the more stable the community of living things because there are more sources of food for each organism. This increases the chances of survival of some individuals of both predator and prey species; the individuals can then continue to reproduce their kind.

*Energy* is not recycled as chemical elements and compounds are. Producers (green plants) fix or store the sun's energy during photosynthesis. Primary consumers get their energy from food, i.e., green plants. Primary consumers use most of their food energy for their own life processes. Only a small portion of their energy intake is stored as body tissue and is available as food for secondary consumers. Secondary consumers also use most of their food

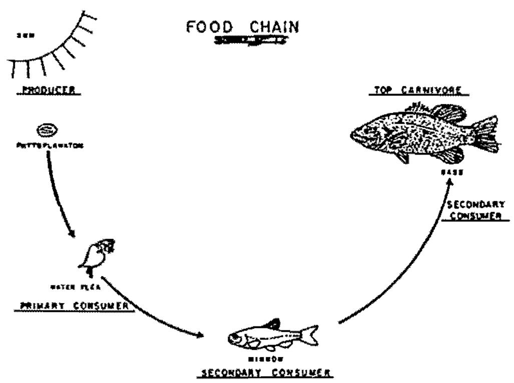



**Figure 13. Food Chain**

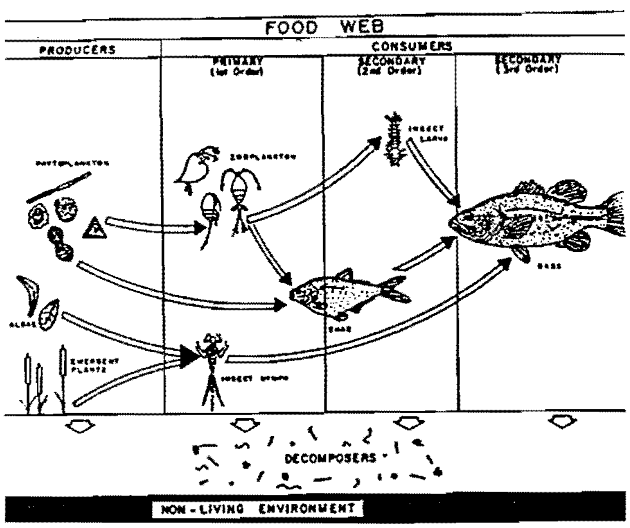



**Figure 14. Food Web**

energy for life processes, so more energy is lost from the food chain. The process continues through the food chain with energy being lost at each feeding level. Only a small fraction of food consumed is converted into tissue of the living organism. It takes more than ten units of prey to support one unit of predator because of the high energy requirement for the life processes. For this reason, food chains are sometimes shown as *food pyramids* to more truly reflect the food mass necessary to meet the energy requirements of consumers. A food pyramid is shown in Figure 15. The top carnivore in a food pyramid is usually the largest animal in the food chain. The animals at the bottom of the food pyramid are usually the smallest but most abundant members of the community.

The chemist thinks of "pure" water as a substance composed only of water molecules. Pure water does not exist in nature. The kinds and amounts of dissolved or suspended materials in water determine its quality and thus what uses can be made of it. Water has a tremendous

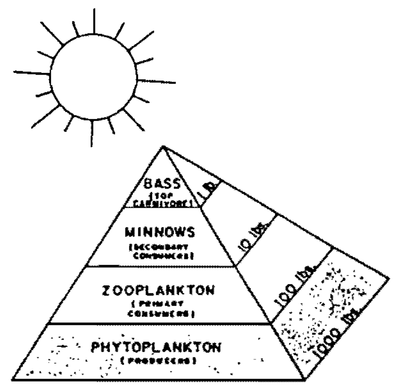



**Figure 15. Food Pyramid**

solvent power, and precipitation falling through the atmosphere begins to dissolve atmospheric gases such as carbon dioxide and oxygen immediately. The dissolved carbon dioxide makes the precipitation slightly acidic which further increases the solvent power. As the rainwater flows across the earth or percolates into the ground, common ions such as calcium, magnesium, sodium, carbonates, chlorides, sulfates, nitrates, iron, and others are dissolved into the water. Water accumulating in reservoirs or flowing down streams will also contain suspended solids and debris obtained during its overland journey.

Any dissolved or suspended materials in water might be considered a *pollutant.* Many naturally occurring water quality conditions exist that prevent various water uses. *Water pollution,* however, is generally considered to occur when substances entering a water resource alter the native water quality to an extent that prevents the normal uses of that particular water resource.

Water pollutants that affect organisms in Deer Creek Reservoir include:

1. *Oxygen demanding wastes.* Wastewater resulting from sewage, livestock production, and fish cleaning may influence oxygen levels as they decay.

2. *Disease causing agents.* Human disease producing organisms are almost totally related to disposal of human waste. Appropriate sewage treatment eliminates these agents.

3. *Plant nutrients.* Inorganic chemicals considered to be plant nutrients are generally compounds of nitrogen and phosphorus. These compounds may result in excessive algal blooms causing bad tastes and odors in drinking water, unsightly surface water, and possible fish kills. In the Deer Creek Watershed, these chemicals come from natural runoff, sewage, and agricultural waste.

# Lesson 9
# Water Chemistry

Framework Reference 2.6

**OBJECTIVE:**
*Investigate relationships that may exist between pH, dissolved oxygen, and organisms found in water.*

**CORE STANDARDS:**
*3050-08, 3060-01, 3200-07, 3240-02, 3500-01, 3500-03, 3600-06*

**MATERIALS:**
*tap water*
*vinegar*
*two drinking glasses*
*red and blue litmus paper*
*hot water*
*food color (blue & red)*
*waxed paper*

**VOCABULARY:**
*acidity*
*alkalinity*
*dissolved oxygen*
*pH*
*ppm*
*spring turnover*
*stratification*

## PROCEDURES:

1. Have a student taste a sample of tap water and a sample of tap water that has had a small amount of vinegar added. Discuss the response. Introduce the term pH and test the pH of both samples using litmus paper.

   Indicate that pH refers to acidity or alkalinity of water and is measured on a scale of 0 to 14 with 0 to 7.0 acid, 7.0 neutral, and 7.0 to 14.0 alkaline.

   Studies have shown that waters with a pH of 6.7 to 8.6 will generally support a fish population. Waters in the Provo River Watershed fall within this range.

2. Copy the information from Table 1 onto the chalkboard or a transparency. Ask the students to explain what they think the table means. Explain the term ppm (parts per million). Seven parts per million would mean that if you had one million grams of a water solution, seven of the one million total would be solute and the remaining 999,993 would be water. Indicate that temperature, presence of photosynthetic plants, light penetration, turbulence, and decaying organic matter can all influence oxygen levels.

**Table 1. Solubility of Oxygen in Water (Standard Air Pressure)**

| Temperature (C) | Solubility (ppm) |
|---|---|
| 0 | 14.7 |
| 5 | 12.7 |
| 10 | 11.3 |
| 15 | 10.1 |
| 20 | 9.1 |
| 25 | 8.3 |
| 30 | 7.5 |

3. Introduce the concept of stratification by filling one drinking glass with hot water and another with cold water. Place a drop of blue food color in the cold water and a drop of red food color in the hot water. Put a square of waxed paper on the glass of hot water and invert it. Air pressure will hold the square in place. Then set the hot water container on the cold water container and slowly remove the waxed paper. This will illustrate water in a stratified reservoir.

   Stratification occurs in most Utah reservoirs during the summer. The dissolved oxygen in the lower layer is often used up by decaying organisms. If the top layer gets too warm, trout do not survive due to high temperatures and low oxygen levels.

   Repeat the above procedure with the cold water on top. Compare this situation with the changes that take place in fall and spring when reservoirs and lakes turn over.

4. Discuss the implications for oxygen level and temperature when water is removed from the top, middle, or bottom of a reservoir.

   The Jordanelle Dam has a number of outlet valves so the temperature and quality of the discharge water can be controlled.

## EXTENSIONS:

Use a test kit to determine oxygen levels in various water samples.

# Lesson 10
# Coliform Bacteria

Framework Reference 2.7

**OBJECTIVE:**
*Show that bacteria can be used as indicators of pollution.*

**CORE STANDARDS:**
*3050-08, 3060-01, 3200-07, 3500-01, 3500-02, 3500-03, 3600-06*

**MATERIALS:**
*none*

**VOCABULARY:**
*bacteria*
*coliform*
*host*
*parasites*
*pathogens*

## PROCEDURES:

1. Introduce the lesson by providing the students with the following information:

   Bacteria are classified by their feeding habits. The house cleaners feed on dead organic matter. Others live in or on, but do not harm, other organisms. Parasites get their food from living hosts. Pathogens cause disease and are among the parasitic bacteria.

   Certain species of a group of bacteria, coliforms, are normal inhabitants of the digestive systems of humans and other mammals. Human wastes, therefore, contain many coliform bacteria. They may also contain pathogenic (disease causing) bacteria. Most pathogens die quickly when in water, so the few survivors are hard to detect. However, the billions of coliform bacteria (a type of bacteria commonly found in waste) have more survivors and are more easily detected. If coliform bacteria are detected, then it can be inferred that pathogens may also be present.

   Coliforms include a group of rod shaped bacteria that will ferment sugar (lactose) at 95°F within 48 hours. This property is used to detect the bacteria in water samples. Table 2 shows the limits set for coliform bacteria in various water supplies.

   **Table 2. Total Coliform Water Quality Criteria**

   | Type of Water | Bacterial Count |
   | --- | --- |
   | Domestic Source | 0 |
   | Recreation | 1000 |
   | Aquatic Wildlife | no min. set |
   | Agriculture | no min. set |

2. Discuss possible sources of coliform bacteria found in Deer Creek Reservoir. Include sewage (septic tank - municipal), recreation facilities, and agricultural waste in the discussion. Students should consider the need for sanitary waste disposal. Potential sources of pollution include pets and people that do not use toilet facilities on the lake.

**EXTENSIONS:**

1. Arrange a field trip to the Heber Valley Special Service District.
2. Visit the Salt Lake County Health Department Laboratory for a demonstration of laboratory methods used to detect coliform bacteria.

# CHAPTER THREE

# WATER RIGHTS AND LAWS

# Background Information for Teachers

Utah pioneers came from areas of the United States that had much more water than the West. Most were familiar with problems of too much water, not a lack of water. In their homeland they were subject to riparian water rights. The riparian, or common law doctrine, gives a land owner certain rights if his property is bounded or crossed by surface water. These rights include use of water for domestic and household needs, livestock watering, fishing, and recreation. Rights may even include power generation. Most states have modified the law to permit owners to take water for "extraordinary and artificial" uses, so long as those uses do not interfere with the riparian owners downstream, thus allowing for municipal use, industry use, and irrigation.

Prior appropriation doctrine applies in most Western states. The pioneers appropriated surface waters when they settled in Utah. Under this doctrine, a party may apply to divert a specified quantity of water from a public source for private use. When such a claim is filed, the first claimant has priority over all later claimants. This is a "first in right" doctrine (see Figure 16).

Unlike the riparian right, the appropriation right can be lost through misuse or nonuse. The appropriation right is a property right, and as such has value and can be exchanged. Most Western states also apply the prior appropriation doctrine to groundwater.

Under the prior appropriation doctrine, later settlers cannot get any water until earlier settlers have received their shares. In dry years they may receive none at all.

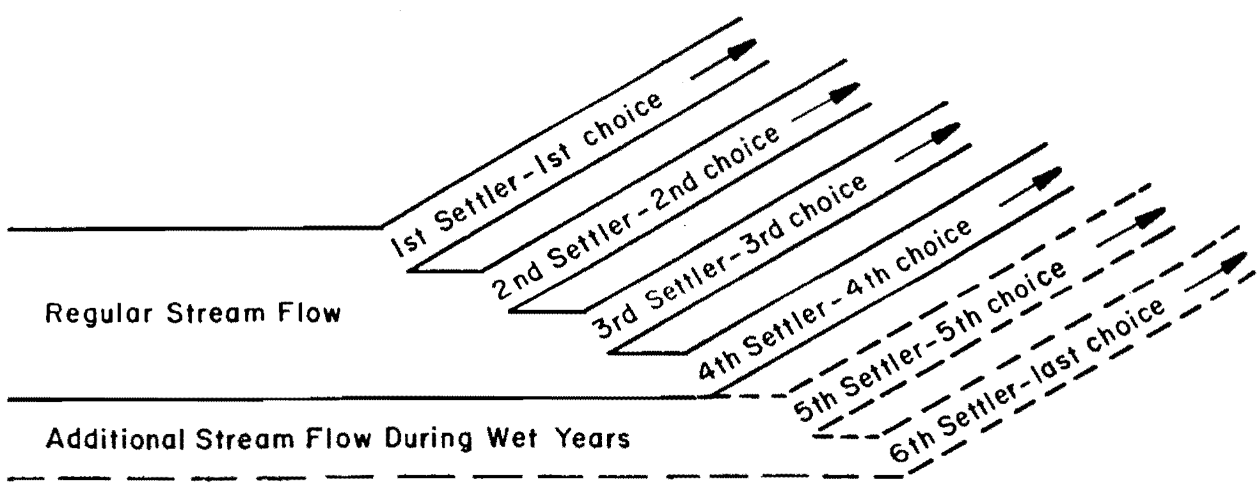



**Figure 16. The Prior Appropriation Doctrine**

# Lesson 11
# Water Rights And Laws

Framework Reference 3.1

**OBJECTIVE:**
*Help students develop an appreciation for the complexity of, and need for, water laws.*

**CORE STANDARDS:**
*6060–06, 3500–02*

**MATERIALS:**
*glass of water*
*plastic cups*

**VOCABULARY:**
*riparian rights*
*prior appropriation*

## PROCEDURES:

1. Give one student a glass of water. Indicate that this represents all of the water in Deer Creek Reservoir in a year. The individual with the glass controls (owns) all of the water. Designate some students as representing recreationists, Provo City, Salt Lake City, and agriculture. Class members may bid on the water and use it for whatever they want. The objective of the exercise is to demonstrate that water has value and its use must be regulated by law.

2. Introduce and discuss the terms "riparian rights" and "prior appropriation," as presented in *Background Information for Teachers.*

3. Read the following:

   Early Utah settlers acted on the assumption that waters of the streams and lakes belong to the public. Initially, the leaders of the Mormon Church controlled the use of the water. As legal units were formed, control of water use was passed on. For example, in 1852 county courts received jurisdiction over all timber and water privileges (or any water from any water course or creek) to grant mill sites and exercise such power as in their best judgment.

   As early as December 4, 1852, the General Assembly of the State of Deseret passed an act which gave Ezra T. Benson the exclusive privilege of controlling the waters in Tooele Valley. On that same day Brigham Young was given rights to City Creek and canyon. In 1853 the legislature gave Provo Canal and Irrigation Company rights to one–half the water of the Provo River. They then sold stock to others that might want to use the water. This first irrigation company became the model for the rest.

## DISCUSSION:

1. What are the advantages and disadvantages of prior appropriation?

2. What would Utah development have been like under riparian law?

3. Why were both individuals and corporations given water rights?

4. What was the significance of the Provo River legislation?

## EXTENSION:

Arrange to interview some "old timers" to obtain stories about water disputes. Share these with the class in the form of taped or written reports.

# CHAPTER FOUR

# WATER USE

# Background Information for Teachers

The Provo River Project provides a supplemental water supply for the irrigation of about 47,000 acres of highly developed farmlands in Utah, Salt Lake, and Wasatch Counties, as well as an assured domestic water supply for the Metropolitan Water Districts of Salt Lake City, Provo, Orem, Pleasant Grove, Lindon, American Fork, and Lehi. The key structure of the project, Deer Creek Dam, is located on the Provo River. Other major structures are the power plant at the dam, the 42-mile Salt Lake Aqueduct and Terminal Reservoir, Weber–Provo Diversion Canal, Duchesne Tunnel, and the South Lateral. The Salt Lake Aqueduct and Terminal Reservoir make up the Aqueduct Division; all other features are included in the Deer Creek Division.

The Deer Creek Reservoir stores Provo River flood water, surplus water of the Weber River (diverted by the enlarged Weber–Provo Diversion Canal), and surplus water from the headwaters of the Duchesne River (diverted by the six-mile Duchesne Tunnel).

Releases from the reservoir for the Aqueduct Division are diverted at the dam into the 42–mile Salt Lake Aqueduct which carries water to a point near Salt Lake City to supplement the city's supply. The Provo Reservoir Canal takes water from the Provo River at the Murdock Diversion Dam, about seven miles below the storage dam. This 23–mile long canal serves the 46,609 acres in the Deer Creek Division.

The Jordan Narrows Siphon and Pumping Plant furnishes water from the Provo Reservoir Canal and Jordan River to lands on the west side of Utah Lake and the Jordan River. The South Lateral delivers water supplied from the Jordan Narrows pump to the area south of the pump and west of the Jordan River. Deer Creek Power Plant generates 4,950 kilowatts of power.

Deer Creek Dam is located on the Provo River, about 16 miles northeast of Provo, Utah. It is a zoned earthfill structure 235 feet high with a crest length of 1,304 feet. The dam contains 2,810,000 cubic yards of material and creates a reservoir of 152,600 acre–feet capacity. The spillway is a concrete chute at the right abutment controlled by two gates. The capacity of the spillway is 12,000 cubic feet per second. The outlet works through the left abutment is a concrete-lined tunnel from the trashrack to the gate chamber where two steel pipes lead to the power plant. Releases are controlled by two tube valves. The outlet works have a capacity of 1,500 cubic feet per second.

The Provo River Project is part of the CUP. The CUP includes a trans–basin diversion of water from the Uintah Basin in the Colorado River drainage to the Bonneville Basin in Central Utah. The project provides water for municipal and industrial use, irrigation, hydro–electric power, recreation, and fish and wildlife. It also provides benefits to flood control, water quality control, and area redevelopment.

The Jordanelle Dam is a major component of the project. Jordanelle Reservoir, with an eastern arm extending about five miles up the Provo River and a northern arm extending about four and one–fourth miles up the tributary Drain Tunnel Creek, has a storage capacity of more than 300,000 acre–feet, with a corresponding surface area of about 3,000 acres. About 200 acre–feet will remain as dead storage

The reservoir has a surcharge capacity of about 12,800 acre–feet to temporarily store flood inflows until they can be safely discharged through the outlet works and spillway. No storage space is allocated for sediments, since they will occupy less than one percent of the normal capacity of the reservoir over a 100 year period.

The construction and operation of Jordanelle Reservoir required the relocation of portions of U.S. Highways 40 and 189 around the site. The design and construction of these roads were accomplished by the Utah Department of Transportation in cooperation with the United States Bureau of Reclamation. A substation, owned and operated by the Utah Power and Light Company, was relocated to a site near the downstream base of the dam. Other relocations included power and telephone lines, natural gas pipeline, 38 residences occupied by about 100 people, two privately-owned ranches, a commercial trout farm, a church-owned farm, and two small family cemeteries with seven graves. The relocations of residents with their homes, businesses, and farms were conducted in accordance with the Federal Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

# Lesson 12
# Water For Agriculture

Framework Reference 4.1

**OBJECTIVE:**
*Help students to become aware of current and planned agricultural water use in the Provo River Watershed.*

**CORE STANDARDS:**
*3050–08, 3200–07, 3220–04, 3500–01, 3500–02*

**MATERIALS:**
*Tables 3 and 4*

## TEACHER PREPARATION:

Make student copies or a transparency of Tables 3 and 4.

## PROCEDURES:

1. Share the following information:

Land in the Deer Creek Reservoir has been placed in each of five categories: 1) multiple use, 2) grazing and pasture, 3) mountain home development, 4) irrigated agriculture, and 5) urban development. Table 3 shows the number of acres in each category by sub–basin.

**Table 3. Present Land Use in Deer Creek Watershed**

| Land Use Category | Acres | % of Total |
|---|---|---|
| Multiple Use | 281,338 | 53.75 |
| Grazing and Pasture | 191,153 | 36.52 |
| Mountain Homes | 10,573 | 2.02 |
| Irrigated Agriculture | 33,865 | 6.47 |
| Urban Development | 6,490 | 1.24 |
| | 523,419 | 100.00 |

The multiple use category, containing only land under state and federal control, covers 281,338 acres or 53.75 percent of the study area. Land use for agriculture totals 43 percent, while lands devoted to mountain homes and urban development amount to only 17,063 acres, or 3.25 percent.

Table 4 identifies the projected land use by category in each of the sub–basins. Increases were based on projected population increases assigned to areas of probable development through the county. Very little change is projected. Agriculture and grazing lands will be reduced by about 3,256 acres, or 0.62 percent, while mountain home and urban lands will increase by the same amount. If land use is not going to change significantly, efforts need to be directed to deal specifically and effectively with current uses and problems.

**Table 4. Projected Year 2000 Land Use in Deer Creek Reservoir Watershed**

| Land Use Category | Acres | % of Total |
|---|---|---|
| Multiple Use | 281,338 | 53.75 |
| Grazing and Pasture | 187,384 | 35.80 |
| Mountain Homes | 13,033 | 2.49 |
| Irrigated Agriculture | 34,441 | 6.58 |
| Urban Development | 7,223 | 1.38 |
| | 523,419 | 100.00 |

Discuss the above information. Note the slight changes in percentages for land use—agriculture down, mountain homes up.

2. Discuss irrigation practices such as flood irrigation and sprinkler irrigation. Over application of water in flood irrigation results in a return flow of water to the stream that is high in phosphorus which contributes to downstream pollution. This is not usually a problem with sprinkler irrigation.

   Areas under pasture also contribute to phosphorus loads. Dikes and levies could reduce this return flow.

3. Discuss dairy farm and feedlot impact on water supply. Animal wastes need to be kept from entering the water supply.

**EXTENSIONS:**

1. Take a field trip to observe good and bad agricultural land use practices.
2. Have a Soil Conservation Service agent visit the class to discuss agricultural land use practices.

# Lesson 13
# Water For Recreation

Framework Reference 4.2

**OBJECTIVE:**
*Become aware of current and planned recreational uses of water in the Provo River Watershed.*

**CORE STANDARDS:**
*3050-08, 3200-07, 3500-01, 3500-02*

## PROCEDURES:

1. Ask the students what types of water related recreation are possible in the Deer Creek Reservoir Watershed. List their answers on the chalkboard. Be sure the list includes: fishing, hunting, boating, wind surfing, water skiing, photography, and bird watching. Discuss each topic using the following information as a guideline. Emphasize the need for appropriate environmental effects.

    a. Deer Creek Reservoir is a tourist attraction as well as a place for Utah citizens to enjoy recreational activities. Trash along the shoreline detracts from the reservoir's natural beauty. Leaving trash can also be harmful to wildlife. Autopsies reveal that deer eat bits of plastic bags which block their digestive systems, resulting in death. Large numbers of waterfowl use the reservoir. Waterfowl can get tangled in fishing lines, plastic pop can holders, and other trash left behind. Birds are often attracted to shiny metal such as fishing hooks; if they swallow these objects, they die.

       Trash tossed in the reservoir drifts to shore and litters, or it decomposes in the water, adding more undesirable nutrients. Trash causes a serious health hazard for those who use the water.

    b. Motorized boats can become a safety hazard if not properly operated. Additionally, they can disturb fishermen and wind surfers. On hot summer days, a west wind generally prevails up Provo Canyon, making Deer Creek Reservoir a popular spot for wind surfers and sail boaters. These same weather conditions can give rise to sudden thunderstorms, resulting in dangerous water conditions.

    c. All wind surfers are required by law to wear flotation devices. Sail boards longer than 12 feet are required to be registered with the State of Utah. Although wind surfers do have the right-of-way, be aware that common courtesy dictates respect for other water recreationists.

    d. You never know when you might be drinking a glass of water from Deer Creek Reservoir. In an effort to protect water quality, new restrooms have been conveniently placed around the reservoir. Human waste along the shoreline is not only unsightly, but it causes a serious health hazard and could result in the closure of Deer Creek Reservoir to recreation. It is also illegal to have pets on the shoreline.

    e. There is year-round fishing on Deer Creek Reservoir. Each year many rainbow trout are stocked in the reservoir. Yellow perch, brown trout, largemouth bass, walleye, carp, and crayfish reproduce naturally in the reservoir.

In the past ice fishermen have added to the pollution problem. They have left trash, human waste, and fish debris on the ice. When the ice melts in the spring, this residue provides nutrients for harmful bacteria and undesirable algae growth in the reservoir.

**EXTENSIONS:**

1. Go on a recreation trip.
2. Visit the Kamas or Midway Fish Hatchery.

# Lesson 14
# Urban Water Use

Framework Reference 4.3

**OBJECTIVE:**
*Become aware of current and planned urban Provo River water use..*

**CORE STANDARDS:**
*3050-08, 3200-07, 3500-01, 3500-02*

**MATERIALS:**
*pails, jars, etc., to total 250 gallons capacity*
*Figure 17*

## PROCEDURES:

1. Share the following information:

   Assume that at a particular moment in time the four counties influenced directly by the Deer Creek Reservoir Watershed contain 724,500 people, of whom 533,000 live in Salt Lake County, 177,000 in Utah County, 7,200 in Summit County, and 7,300 in Wasatch County. It has been estimated that this total area will grow at the rate of about 2.5% annually. The present water supply for urban use is adequate, but with continued growth, future needs may not be met in low water years.

2. Calculate the time it will take for the given population to double. The formula for calculating doubling time is:

   $$DT = \frac{70}{\text{\% of annual increase}}$$

   example:

   $$DT = \frac{70}{2.5} = 28 \text{ yrs.}$$

   Discuss possible water use conflicts with population growth.

3. Share the following information:

   An adequate water supply is basic to human existence in Salt Lake County. Water is needed to maintain a high standard of living. In 1976 about 50 billion gallons of water were used for municipal and residential purposes in the Salt Lake Valley. That represented nearly 100,000 gallons per day per person.

   Assuming an annual rate of increase in population of 2.5 percent since 1976 and the annual per capita consumption of water remaining constant, what will be the water demand in Salt Lake County in the year 2000? In the year 2020?

4. Using tap water, fill the containers to represent 250,250 gallons. This represents daily water use per person. Discuss what impact pouring this down the drain has on the wastewater system.

   Share and discuss the information in Figure 17.

**EXTENSIONS:**

1. Assign library research on urban water quality.
2. Assign students to estimate their daily personal water use and then have them actually measure the quantity they use.
3. Arrange a field trip to one of the Salt Lake County waste treatment plants.

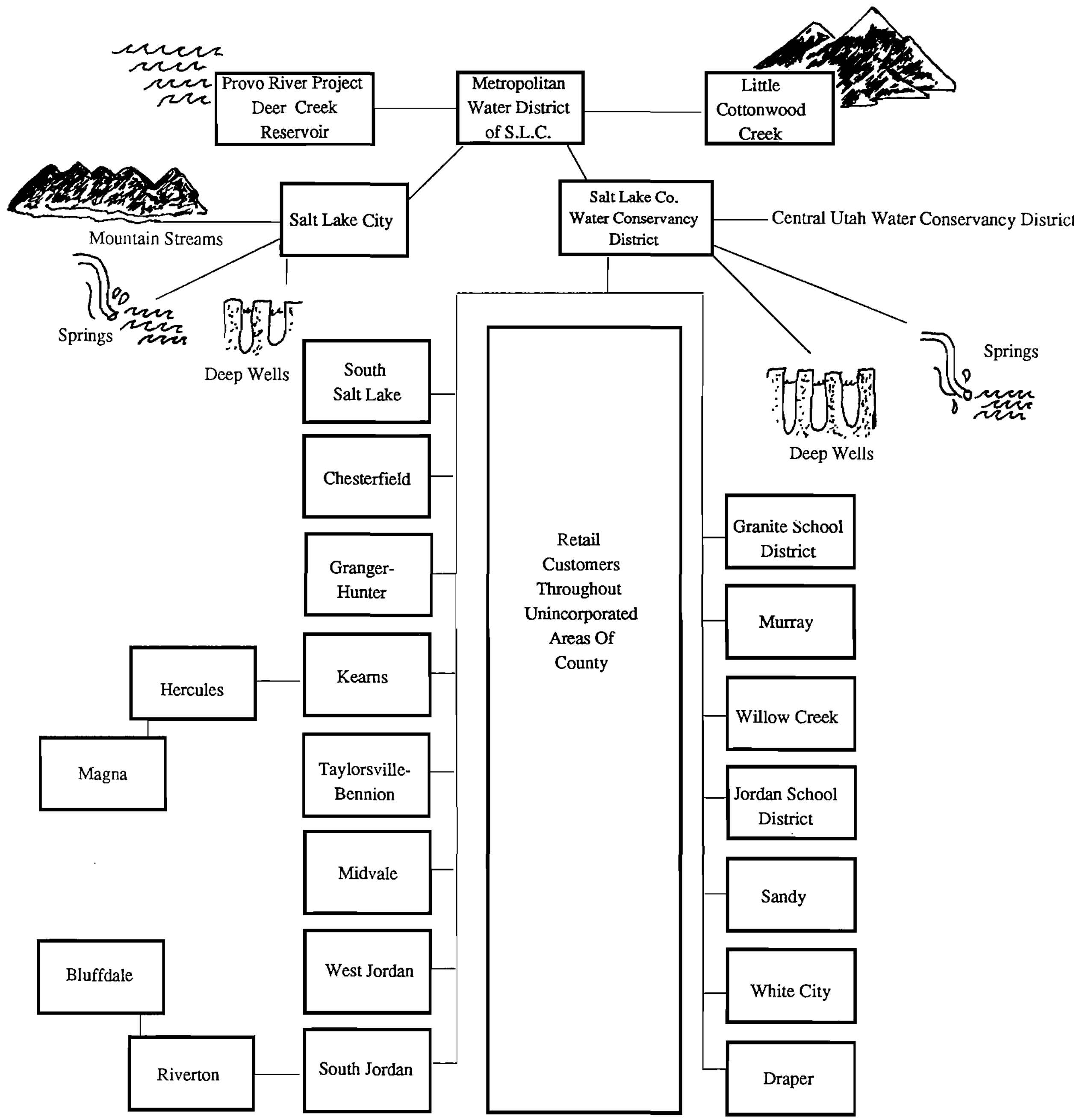



**Figure 17. The Water Distribution Chain in Salt Lake County**

# APPENDIX A

# UTAH WATER EDUCATION SPEAKERS BUREAU ORGANIZATIONAL LISTING

| | |
|---|---|
| Department of Natural Resources | (801) 538–7200 |
| Division of Water Resources | (801) 538–7230 |
| International Office for Water Education | (801) 750–3176 |
| Utah Water Education Committee | (801) 750–3176 |
| Utah Water Research Laboratory | (801) 750–3155 |
| Division of Water Rights | (801) 538–7240 |
| Bureau of Drinking Water/Sanitation | (801) 538–6159 |
| Central Utah Water Conservancy District | (801) 521–5346 |
| Bureau of Water Pollution Control | (801) 538–6146 |
| Bureau of Reclamation | (801) 524–6477 |
| Rural Water Users Association of Utah | (801) 259–6207 |
| Soil Conservation Service | (801) 524–5052 |
| Ashley Valley Water & Sewer Improvement District | (801) 789–9400 |
| Ballard Water Improvement District | (801) 722–2402 |
| Bona Vista Water Improvement District | (801) 621–0474 |
| Bountiful Water Subconservancy District | (801) 295–5573 |
| Carbon Water Conservancy District | (801) 472–5375 |
| Castle Valley Special Service District | (801) 381–5333 |
| Emery County Water Conservancy District | (801) 381–2311 |
| Grand County Water Conservancy District | (801) 259–8121 |
| Granger–Hunter Improvement District | (801) 968–3551 |
| Jensen Water Improvement District | (801) 789–2781 |
| Johnson Water District | (801) 722–4737 |
| Maesar Water Improvement District | (801) 789–2353 |
| Magna Water and Sewer Improvement District | (801) 250–2118 |
| Metropolitan Water District of Orem | (801) 224–2118 |
| Metropolitan Water District of Pleasant Grove–Lindon | (801) 364–5578 |
| Metropolitan Water District of Provo | (801) 377–0502 |
| Metropolitan Water District of Salt Lake City | (801) 364–5578 |

| | |
|---|---|
| Millard County Water Conservancy District | (801) 864-3194 |
| Miller Creek Water Special Service District | (801) 637-5074 |
| Ogden River Water Users Association | (801) 621-6555 |
| Ouray Park Water Improvement District | (801) 545-2425 |
| Price River Water Improvement District | (801) 637-6350 |
| Salt Lake County Water Conservancy District | (801) 262-7421 |
| South Davis County Water Improvement District | (801) 295-4468 |
| South Ogden Conservation District | (801) 621-6555 |
| Spanish Valley Water District | (801) 259-8121 |
| Taylor-West Weber Water Improvement District | (801) 731-1668 |
| Thompson Water Improvement District | (801) 564-3531 |
| Timpanogas Special Service District | (801) 756-5231 |
| Tridell-LaPoint Water Improvement District | (801) 247-2475 |
| Uintah Highlands Water and Sewer Improvement District | (801) 476-0945 |
| Uintah Water Conservancy District | (801) 789-1651 |
| Washington County Water Conservancy District | (801) 673-4892 |
| Weber Basin Water Conservancy District | (801) 825-1677 |
| Weber-Box Elder Conservation District | (801) 621-6555 |
| Sowby & Berg Consultants | (801) 756-4642 |
| James M. Montgomery Consulting Engineers | (801) 272-1900 |

# APPENDIX B

# GLOSSARY OF TERMS

## A

ABIOTIC: Pertaining to the absence of life or living organisms.

ACIDITY: Excessive acid quality; sourness, tartness.

ACRE-FOOT: An expression of water quantity. One acre-foot will cover one acre of ground one foot deep. An acre-foot contains 43,560 cubic feet, 1,233 cubic meters, or 325,829 gallons (U.S.).

ALGAE: Simple plants, many microscopic, containing chlorophyll. Most algae are aquatic and may produce a nuisance when conditions are suitable for prolific growth.

ALKALINITY: In general, a compound that will neutralize an acid, having marked basic properties.

## B

BACTERIA: Microscopic, one celled plants.

BENTHOS: The entire system of life, plant and animal, found on the bottom of a body of water.

BIOTIC: Pertaining to life or living organisms.

## C

CARNIVORE: A flesh eating mammal.

CHLOROPHYLL: The green coloring matter of leaves and plants.

COLIFORM: Bacteria found in the large intestine of man and animals. Their presence in water indicates fecal pollution.

CONSUMER: An organism that feeds on plants or animals.

CULINARY WATER: Water for drinking and cooking.

CUP: Central Utah Project.

## D

DAPHNIA: Fresh-water fleas having transparent bodies, used in research and as food for tropical fish.

DECOMPOSERS: An organism that breaks down the cells of dead plants and animals into simpler substances.

DIATOM: Microscopic unicellular marine or fresh-water algae having siliceous walls.

DISSOLVE: A condition where solid particles mix, molecule by molecule, with a liquid, and appear to become part of the liquid.

DISSOLVED OXYGEN: The amount of oxygen dissolved in water or sewage. Concentrations of less than 5 parts per million can limit aquatic life or cause offensive odors. Low dissolved oxygen is generally due to excessive organic matter present in water as a result of inadequate waste treatment and runoff from agricultural or urban land.

## E

ECOLOGY: The branch of biology that deals with the complex of relations between a specific organ and its environment.

ENVIRONMENT: An organism's surroundings. Water is a major part of an organism's surroundings in many instances.

## F

FLOOD IRRIGATION: Irrigating by applying water to cover the soil as opposed to using furrows or sprinklers.

FOOD WEB: A series of interrelated food chains.

FOOD CHAIN: A series of organisms wherein the smallest is fed upon by a larger one, which in turn feeds still a larger one, etc.

## H

HOMOGENEOUS: Corresponding in structure because of a common origin.

HOST: A living animal or plant from which a parasite obtains nutrition.

## N

NEKTON: Free swimming water creatures.

NONPOINT SOURCE POLLUTION: Forms of pollution caused by sediment, nutrients, organic and toxic substances originating from land use activities, which are carried to lakes and streams by surface runoff. Nonpoint source pollution occurs when the rate of materials entering these waterbodies exceeds natural levels.

NUTRIENTS: Substances that provide nourishment or nutriment.

## O

OPERATIONAL DEFINITION: Explanation of objects and events in the context of a group's own experience.

ORGANISM: Any living thing, either plant or animal.

## P

PARASITES: An animal or plant that lives on or in an organism of another species.

PATHOGENS: Any disease-producing organism.

pH: A way of expressing both acidity and basicity on a scale of 0–14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity.

PHOSPHORUS: A solid nonmetallic element. It is a necessary constituent in plant and animal life in bones, nerves, and embryos.

PHYTOPLANKTON: The plant organisms in plankton, those passively floating or drifting organisms in a body of water.

PIGMENTED FLAGELLATE: Colored protozoan having one or more flagella or whips.

PLANKTON: A collective term for the organisms, large and microscopic, that float or drift at random in a body of water.

POINT SOURCE POLLUTION: This type of water pollution results from the discharges into receiving waters from easily identifiable "points". Common point sources of pollution are discharges from factories and municipal sewage treatment plants.

POLLUTION: The presence of matter or energy whose nature, location or quantity, produces undesired effects upon the normally existing environment.

PPM: The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages.

PRECIPITATION: A deposit on the earth of hail, rain, mist, sleet, or snow. It is the common process by which atmospheric water becomes surface water.

PREDATOR: An animal that preys upon other animals.

PRIOR APPROPRIATION: A doctrine for appropriating water which recognizes the right of early appropriation as having priority over those who appropriated later — "First in time is first in right."

PRODUCERS: Organisms that are able to produce their own food from inorganic substances.

## Q

QUALITY OF LIFE: The degree to which one's needs and wants are provided in a particular environment.

## R

RIPARIAN RIGHTS: The legal right held by an owner of land bordering on a natural stream or lake, to take water from the source for use on that land.

## S

SATURATION: The state of containing the maximum amount of solute capable of being dissolved under given conditions.

SOLUBILITY: Relative capability of being dissolved.

SOLUTE: The substance dissolved in a given solution.

SOLUTION: The act or process of dispersing one or more liquid, gaseous, or solid substances into another, usually a liquid, so as to form a homogeneous mixture.

SOLVENT: A substance that dissolves another to form a solution.

SPRING TURNOVER: A physical phenomenon that may take place in a body of water during the early spring. The sequence of events leading to spring turnover include: 1) melting of ice cover; 2) warming of surface waters; 3) density change in surface waters producing convection currents from top to bottom; 4) circulation of the total water volume by wind action; and 5) vertical temperature equality, 4° C. The turnover results in a uniformity of the physical and chemical properties of the water. A similar phenomenon may occur in early autumn when the surface waters begin to cool.

SPRINKLER IRRIGATION: Irrigating crops with water applied from above through pipes and nozzles, as opposed to applying water by flooding or in furrows.

STRATIFICATION: The forming or placing of beds or layers.

## T

TOTAL SUSPENDED SOLIDS: All of the suspended solids in a given quantity of water.

## W

WATERSHED: The area drained by a river or river system.