1.0 Humans depend on water supply and quality.

Living systems need water to survive. Ecosystems depend on it. The land is changed by it. Industry uses large amounts of it. Climate and weather are determined by it.
Our **'blue planet'** – *as viewed from space* - is unique among the planets in our solar system, because 74% of its surface is covered by water.

1.1 The Distribution of Water on Earth

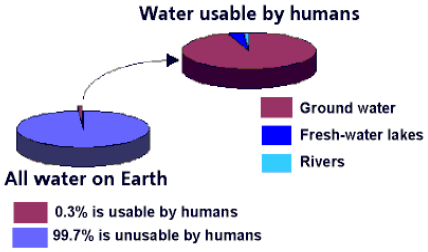
The water on our planet exists in many different forms and is evenly distributed over the entire planet.

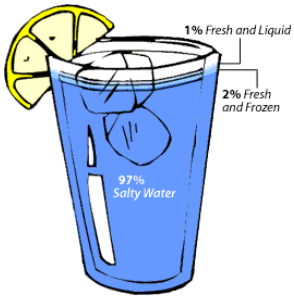
Drinking Water For Humans

Drinking water must be fresh water, not salt water. Not all freshwater on the Earth is drinkable. Water that is drinkable (safe to drink) is called **potable** water.

Water On Earth

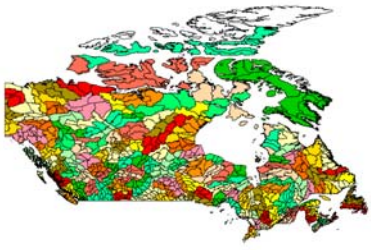
To put this into perspective.



Water source	Model	% of Earth's total water	Potable, or not?
Oceans		97.24%	Saltwater
Icecaps, Glaciers		2.14%	Frozen
Ground water		0.61%	Fresh - but not entirely accessible
Fresh-water lakes		**0.009%**	**Potable**
Inland seas		0.008%	Saltwater
Soil moisture		0.005%	Indirect access
Atmosphere		0.001%	Indirect access
Rivers		**0.0001%**	**Potable**

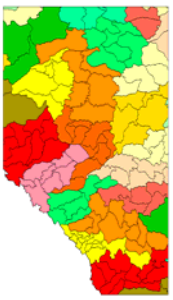
A **watershed** (also called a drainage basin) is a region of interconnected rivers and streams.

Watersheds In Canada



Canada has 9% of the world's freshwater.

Watersheds In Alberta



A reservoir is an artificial lake. It is used for storage and management, because many of the larger populated centers in Alberta are far from major river systems.

1.2 Water Quality

Water quality describes how pure (clean) the water is. Water quality can be measured by the types of substances that are found in it; including living organisms, organic material, minerals and other chemicals. Check out the source to tap story that traces the movement of water in the environment: http://www.ccme.ca/sourcetotap/story.html

Substances Dissolved In Water

Many different substances can be present in water. Most substances that are found dissolved in water are ***salts***. The most common salt is sodium chloride (table salt). The total amount of ***all salts*** found in water is called **salinity**. Saltwater (found in oceans) has a higher salinity (average of 3.5%) than freshwater.

Hard Water

Water described as "hard" is high in dissolved minerals, specifically calcium and magnesium. Hard water is not a health risk, but a nuisance because of mineral buildup on plumbing fixtures and poor soap and/or detergent performance.

Organisms In Drinking Water

Fresh water contains organisms and organic matter, some of which are harmful and some which are not. ***Escherichia coli*** (E coli) is a type of microscopic bacteria that can cause sickness and even death.

Water Quality Testing

Water that comes from deep below the ground is protected from pollutants. However, most cities and towns get their drinking water from surface water sources (lakes and rivers). The water they use needs to be filtered and treated with chemicals.

Water Testing Criteria

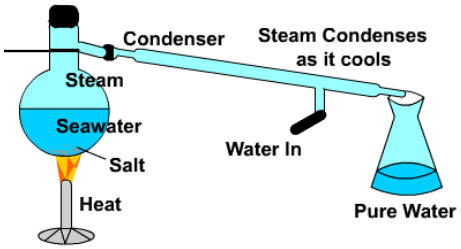
Just looking at water in a glass will not tell you if the water is safe to drink. Smelling it may give you additional information – like it may contain *hydrogen sulphide* (which is harmful to humans) giving it a rotten egg smell. Ocean water is very clear, but cannot be consumed because of its high salinity. Some of the things to test - to determine water quality - are:

- *Taste and odour*
- *Turbidity (cloudiness) and colour*
- *Toxic substances and other pollutants*
- *Bacteria*
- *Hardness or mineral content*
- *pH (how acidic or basic the water is)*
- *Dissolved oxygen level*
- *Suspended solids (including those floating)*
- *Dissolved solids*

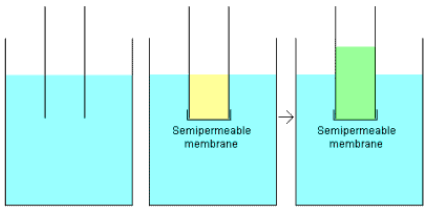
Changing Salt Water to Fresh Water

There are two common processes that can change saltwater into freshwater. These processes are distillation and reverse osmosis.

Distillation - a process in which a liquid or vapour mixture of two or more substances is separated into its parts, by the application and removal of heat.



Reverse Osmosis – forces saltwater through a filter (membrane) allowing water to pass but not salt.



2.0 Water in its various states affects Earth's landforms and climate.

Water exists in all three forms on the Earth: solid, liquid and gas. It is found underground, on the surface and in the air. Water affects living and non-living things within the Earth's environments.

2.1 Waves and Tides

Waves and tides are just two examples of how water moves on the Earth. Waves are movements on the surface of water. Tides are the regular rising and falling of very large bodies of water.

What Is A Wave?

Waves are surface movements "a disturbance, or variation transferring energy progressively from point to point in a medium" occurring whenever a force comes in contact with water. A boat on the surface of the water will cause a **'wash'** or **'wave action'** – which can affect other objects in the water, as well as the shoreline. There are different kinds of waves: http://members.aol.com/nicholashl/waves/waves.htm

The Movement Of Water Waves

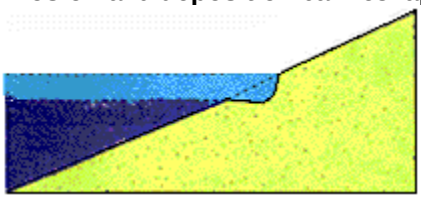
Waves are changes in patterns that move along the water's surface. Although waves can move a very long distance, the water doesn't move – it acts as the medium for the '*wave action*' to occur. Within each wave the particles of water move in a circular motion.
All about waves (animations): http://id.mind.net/~zona/mstm/physics/waves/partsOfAWave/waveParts.htm
Water Waves (dynamics of movement): http://www.eng.vt.edu/fluids/msc/my_pages/ocean/w_waves.htm

Causes of Water Waves

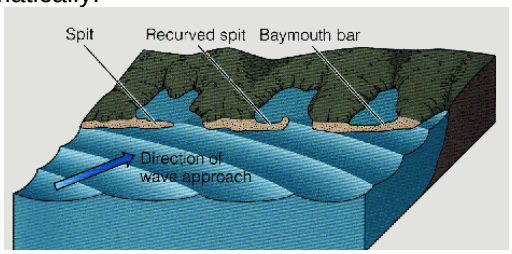
Most waves are caused by the wind (a force). Stronger forces cause larger waves. As ocean waves move closer to the shore their bottoms drag on the ocean floor and their tops rise and break onto the shore (causing damage by their force).

Effects of Waves On Shorelines

The force of waves crashing against a shoreline can cause changes to the shape of the shoreline, whether it is hard rock or soft rock.
Erosion and **deposition** can reshape the shoreline dramatically.



Erosion – animation showing the formation of a cliff
http://www.fluidmech.net/tutorials/ocean/w_waves.htm



What are Tsunamis? http://www.es.flinders.edu.au/~mattom/IntroOc/notes/figures/animations/pngtsunami.gif
When an earthquake occurs on the ocean floor, a huge damaging wave can be created. These waves are called **tsunamis** (which means 'harbour wave).

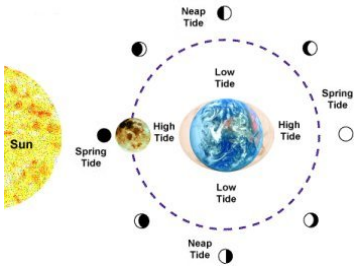
What are Tides?

The water level along the coast of continents changes constantly. This water level is called a **tide**. **High tide** is the highest level the water will reach on shore, while low tide is the lowest level it will reach onshore. Usually there are two high tides and two low tides each day.

What Causes Tides?

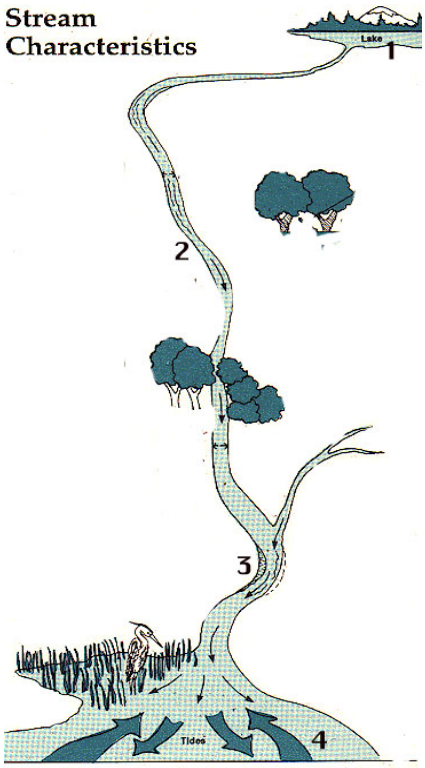
The gravitational force of the moon and the rotation of the Earth on its axis cause tides.

Animation
http://www.pbs.org/wgbh/nova/venice/tides.html



2.2 Erosion and Deposition

Stream characteristics help scientists understand where different organisms live in a stream and how they might be affected by human activities. Engineers use the se characteristics to plan projects such as dams and bridges.



A stream profile is a description of its characteristics, including flow rate, steepness of stream's bed, erosion rate of its banks.

The **source** of a river may be high in the mountains, where a glacier is melting. As small streams form together into one **channel**, the volume and speed of the river grows. In the early stages, the river is flowing very quickly and usually fairly straight. As the river reaches lower elevations it begins to slow, causing curves to form (**meanders**), until it reaches a fairly flat **flood plain** and the sediment it has picked up is deposited in a fan-shaped deposit called a **delta**.

Erosion and Deposition

Moving water is a powerful force. When water wears away rock the fragments are carried as sediment and deposited elsewhere. A river's sediment-load is the amount of *water-borne* materials (rock, soil, organic matter) it carries. The faster the river flows, the more water-borne materials it can carry. As it slows these water-borne materials are deposited as sediment.

Topography Website: http://education.sdsc.edu/optiputer/teachers/shapingtopography.html

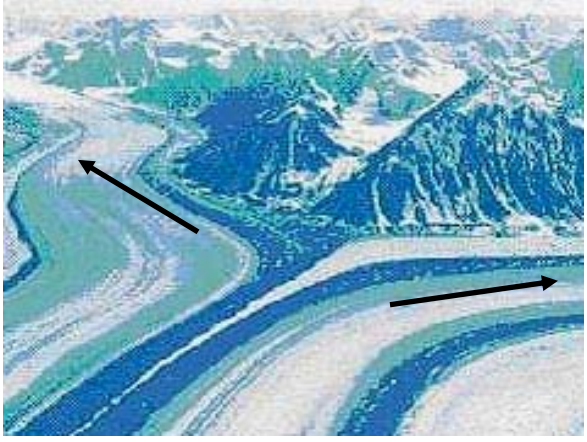
Chemical Weathering

Erosion of the landscape can also occur as a result of chemicals in the water. These chemicals can eat away rock forming caves and sink holes.

What Makes A Watershed?

A watershed is all the area of land that drains into one main lake or river. It can contain many smaller streams, rivers and even lakes, which all eventually drain into a larger lake, sea or ocean.
The location of the highest land on the continent determines the direction that a watershed drains. This high land is called the **Continental Divide**. In North America it is in the Rocky Mountains.

On the west side of the divide, the rivers all flow into the Pacific Ocean.



On the East side of the divide, the rivers flow into either the Arctic Ocean or the Atlantic Ocean.

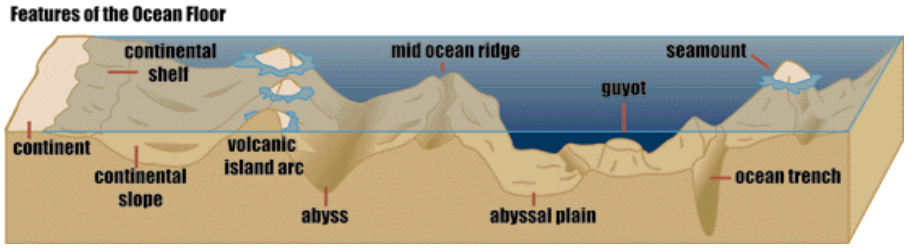
Streams and Drainage Systems: http://www.tulane.edu/~sanelson/geol111/streams.htm

2.3 Processes That Shape Ocean Basins and Continental Drainage

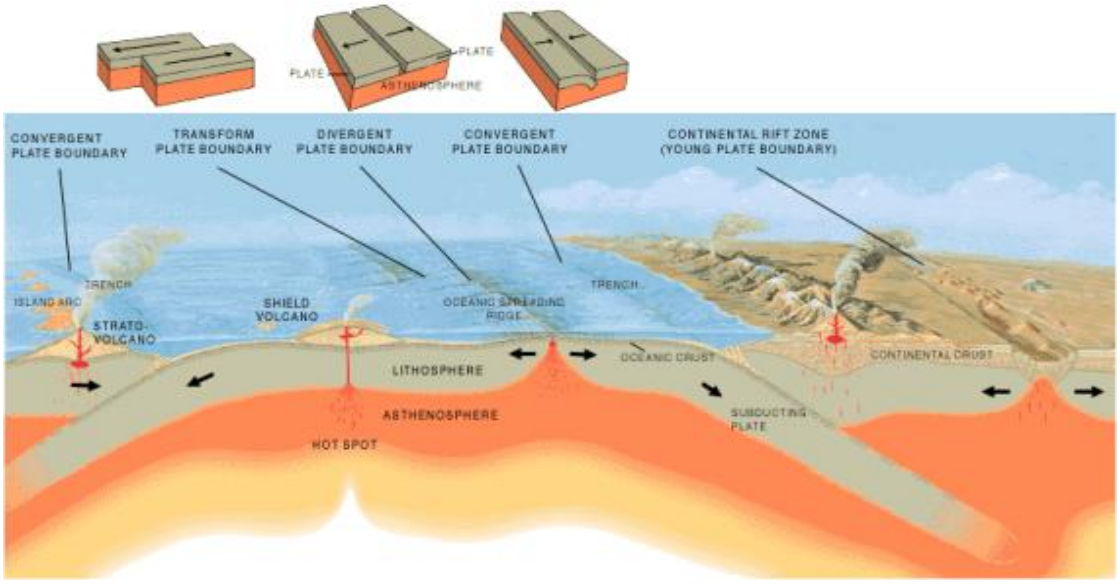
The Earth is in a constant state of change.

Processes That Form Ocean Basins

The **Theory of Plate Tectonics** (you learned about in Grade 7) explains how the lithosphere (crust of the Earth) is in pieces and these pieces are moving because of convection currents in the magma. Some of these plates are moving toward other plates, some are moving away and some are moving in opposite directions beside each other.



This illustration shows how the features on the ocean floor are formed.



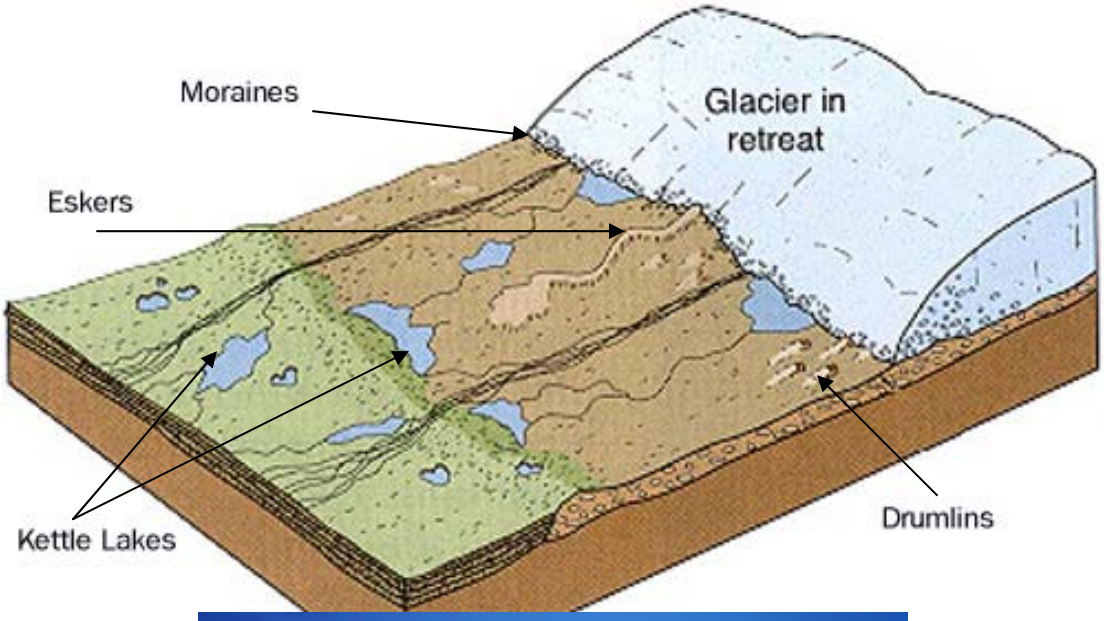
Continental Drainage Systems

The changing lithosphere affects the drainage patterns of the continents. The Continental Divide marks the division whereby the rivers drain west and east from the divide. Continental drainage systems were also created and are affected by the movement of ice.

Glaciers

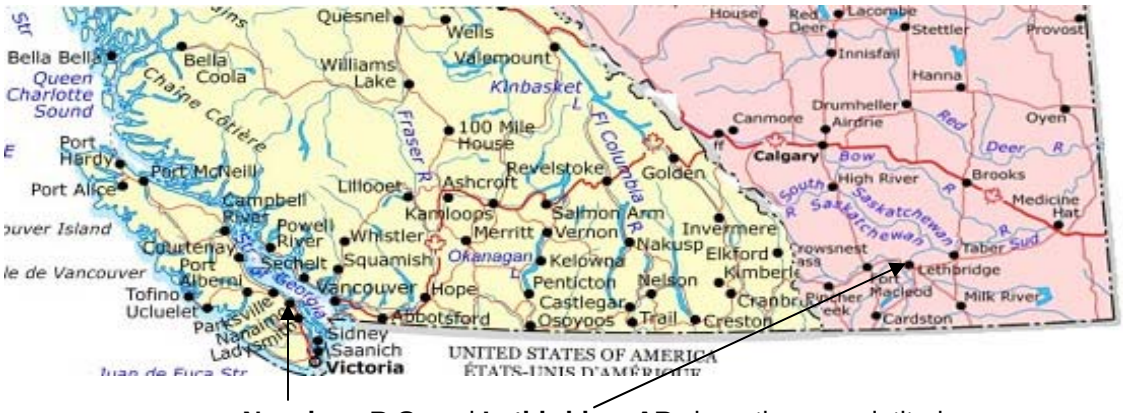
Large bodies of moving Ice are called **glaciers**.

Those covering large areas of land are called ***continental glaciers*** or ***icecaps***. Continental glaciers cover Antarctica and Greenland. Glaciers also form high in the mountains and move through valleys between mountain peaks. These are called ***valley glaciers***. As glaciers move, pieces of rock – embedded in the ice help to shape the landscape by gouging out chunks of the land as the glacier moves.
Glacial movement depends on the climate. In colder climates, little melting occurs and the glacier continues to grow or move forward (this is called an *advancing glacier*). If the climate is warmer, the glacier melts faster than it grows and leaves the rocks, soil and large boulders it once contained. These glaciers are called *retreating glaciers*.
As glaciers advance or retreat, they create specific **glacial features** across the landscape.
Both of these sites about **Glaciers** have actual photographs of the features that a glacier creates.
http://www.glacier.rice.edu/land/5_glaciallandforms.html
http://oz.plymouth.edu/~sci_ed/Turski/Courses/Earth_Science/chp5.html



This is another glacial feature, an **erratic** - and can be seen just outside Calgary, near Okotoks, AB.

2.4 Water and Climate



Nanaimo, B.C. and **Lethbridge, AB** share the same latitude, but their climates are very different. The primary reason for the difference is the fact that Nanaimo, BC is close to the Pacific Ocean, and Lethbridge, AB is not near a large body of water.

Climate

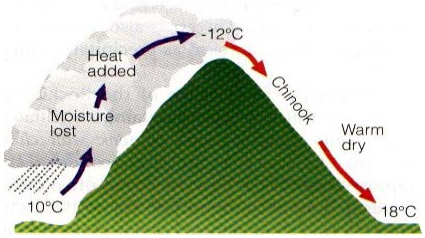
Climate is the average weather measured over a long period of time. The two cities have very different climates.

The Effect Of Large Bodies Of Water On Climate

Large bodies of water, like the ocean and the Great Lakes (in Ontario), influence the weather and the climate in their regions. Water holds the heat longer than most substances and so cities that are close to large bodies of water have warmer climates. The main effect that water has on climate is that *extreme temperatures are less likely to occur in cities near large bodies of water* (Nanaimo), because water heats up and cools down very slowly – whereas in places where there is not very much water (Lethbridge), the land heats up quickly and cools down quickly – and that is where the extremes are felt.

The Rocky Mountains have a major influence on Lethbridge's climate

The **rain shadow** that is created by the Rockies makes the climate very dry in Southern Alberta.



Current Events

Ocean currents can also affect climate. Currents are streams of water that move within a larger body of water. They can be caused by:

- Wind
- Temperature differences in the water
- Salinity differences in the water
- Earth's rotation

Currents and Climate

Currents cause water to move from place to place. Surface currents are caused by steady winds. The currents that affect Labrador and Scotland are surface currents. If they start near the equator (like the **North Atlantic Current** does), they are warm. If they start near the North Pole, they carry very cold water (like the **Labrador Current** does). When the current flow to their respective shores, they can influence the climate of the land.

Ocean Currents and Precipitation

The temperature of the ocean current not only affects the **air temperature**, but they also affect the **amount of precipitation** that an area receives. Warm air (warm currents) hold more moisture than cold air (cold currents).

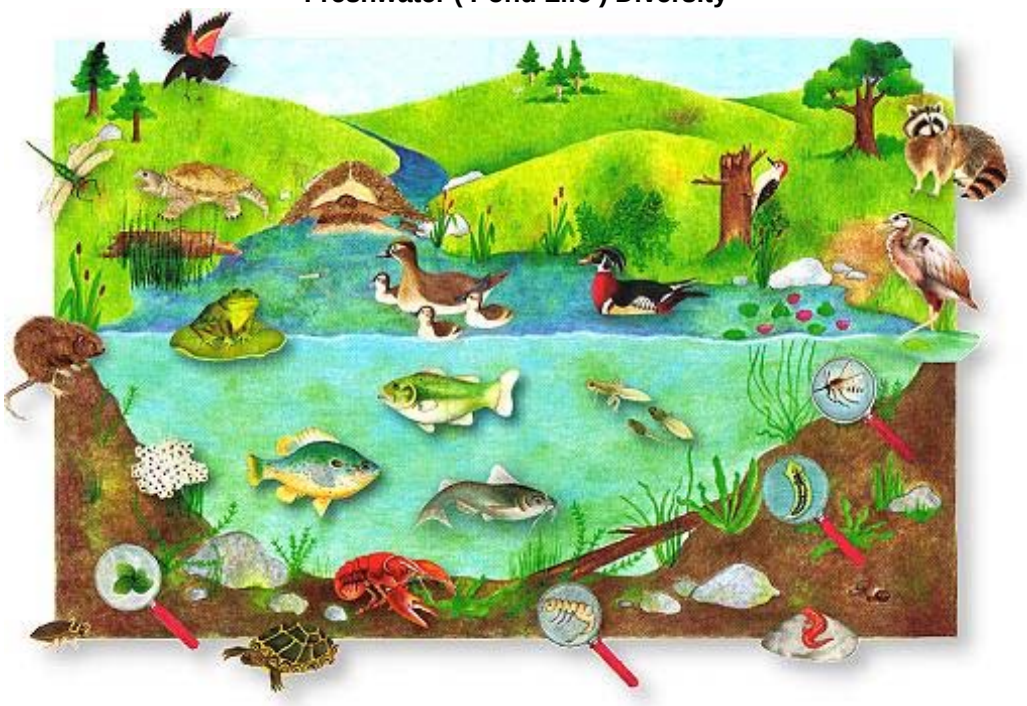
3.0 Living things in aquatic environments are affected by many factors.

A rich variety of organisms living and interacting within a water ecosystem indicates a healthy ecosystem. The more species you find, the more likely you will also find more oxygen, and less pollutants.

3.1 The Diversity of Organisms in Salt and Freshwater Systems

Diversity refers to the variety of different kinds of organism species (both plant and animal) living in a particular ecosystem or environment.

Freshwater (Pond Life) Diversity

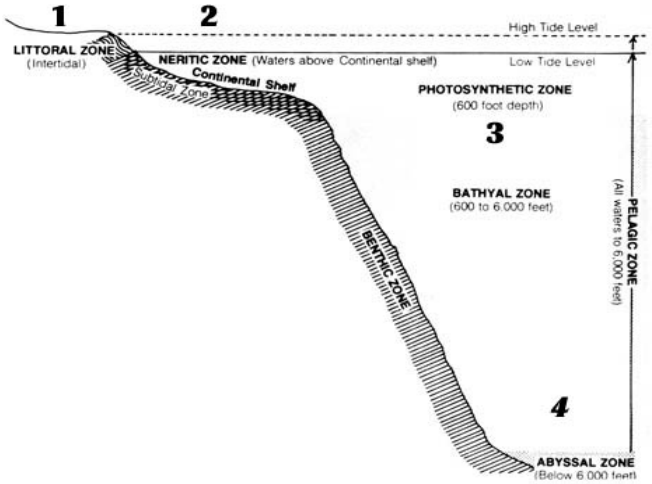


Saltwater (Coral Reef – 2nd most diverse ecosystem in the world **) Diversity**

Lake Diversity (see diagram in textbook SIA p. 375)
Large bodies of water like oceans and lakes have layers or **zones**. Some organisms live in only one or two zones, while other organisms can live in all three. In Canada lakes are affected by extreme changes in temperature. Organisms living in the freshwater ecosystem of a lake or pond must be able to adapt to these changes in order to survive.

Lake Zones	Species you might find in this zone
Upper Zone – is the area of a lake from the shore down to where the aquatic plants stop growing	Plants – bulrushes, water lilies Animals – small fish, clams, insects, snails, worms, leeches, and frogs
Middle Zone – is the open water area that still has light penetration.	***Phytoplankton*** are food for fish that live here. Some of the fish that live in this zone also travel to the deeper zone.
Lowest/Deep Zone – is where no light penetrates, so no plants grow there. Food for organisms living in this zone comes from the zones above, in the form of waste.	Deep water fish (large size species)

Ocean Diversity (also, see diagram in textbook SIA pgs. 376-377)
Oceans have similarities to lakes in terms of zones, but with greater differences in water motion, salinity and depth, diversity is much greater in the oceans.



Ocean Zones	Species you might find in this zone
Estuary – one of the most diverse and richest ecosystems. This is where freshwater and saltwater mix to form ***brackish*** water.	- Marshes grow here providing habitat for many different kinds of plants, insects and other animals that can tolerate the brackish water. - These ecosystems are also rich in bird life, because of all the food and shelter available
1 Intertidal Zone – is the shoreline of an ocean.	Plants and animals living in this zone must be able to withstand the pounding of the waves and the rise and fall of tides. Animals with special adaptations live in this zone.
2 Continental Self – is warmer water than out in the deep ocean and this area has full light penetration.	Many varieties of plants and animals live in this zone because of the rich nutrients available. ***Phytoplankton*** are food for fish that live here. Some of the fish that live in this zone also travel to the deeper zone.
3 Oceanic (Deep Ocean) Zone – is where very little light penetrates, so no plants grow there. Food for organisms living in this zone comes from the zones above, usually in the form of waste.	**4 Abyssal Zone -** Deep water fish (specialized adaptations for survival under extreme pressure and no light)

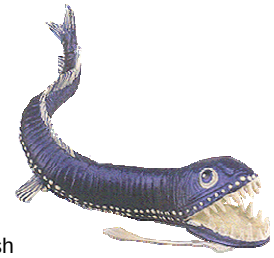
Adaptations Of Organisms In Aquatic Environments

An **adaptation** is a *physical characteristic* or *behaviour* of a species that increases that species' chances of survival in a particular environment. All living things are adapted to live in particular environments. As changes occur within their environment, those organisms that can adapt to the changes have a better chance of surviving than those organisms that cannot adapt to the changes.

There are **five factors** that have led to the development of adaptations by aquatic species.

Temperature

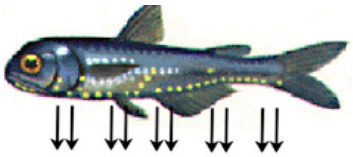
Fish that live in cold water have adapted to the temperature. Their body would overheat in warm water. Fish that live in extremely cold water (Arctic) have a natural anitfreeze that keeps their blood and tissues from freezing. In the very deep parts of the ocean, near volcanic vents, organisms can actually survive in extremely hot water.



viperfish

Light

Most organisms need light. Plants need light to photosynthesize (make food). In the deepest parts of the ocean some organisms have adapted to the absence of light by producing their own light from spots on their bodies called **photophores**.



Photophores - light emitting organs

Pressure

As you travel deeper in the ocean, the pressure increases. Those animals that have adapted to different regions of the ocean would perish in other regions because they would be unable to survive the pressure difference.

Salinity

The salt content of the ocean water can be very high. Those organisms that live in this ecosystem cannot survive in freshwater. Freshwater organisms cannot live in saltwater, because the salt makes fluid leave their bodies.

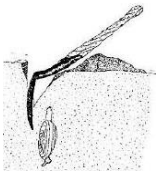
Salmon can survive in freshwater (where they are born) and saltwater (where they live most of their lives).

Water Movement

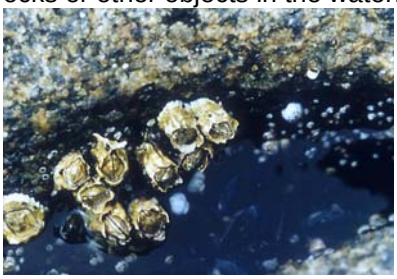
Some organisms are able to live in fast moving water.

Some organisms are adapted to dig themselves into the sand for protection. (Clams do this)

Clams show at the edge of the surf line when you pound the beach with a shovel handle or your foot. They may squirt sand and water out of the hole where they are located.



Barnacles attach themselves to rocks or other objects in the water.



3.2 Populations in Fresh and Salt Water

Natural changes in animal populations are not unusual, but the rapid decline in a species is a cause for concern. What caused the decline is important to know because it affects other species within the ecosystem as well.

Understanding Populations

The study of populations looks at groups within a particular species. A **population** is a group of organisms of the same species ***that live in a particular area***. .

Changes In Populations

A change in a population can mean an increase or a decrease in the number of individuals in that population. It can also mean the change in the number of males and females, or a change in the numbers of old and young individuals. A population within an ecosystem changes as a result of something happening in that ecosystem.

There are three types of changes: **seasonal**, **short-term** and **long-term**.

Seasonal Changes

There are dramatic changes in populations of freshwater organisms between the seasons in northern regions (Canada) because of extreme temperature changes. Because of these extreme shifts in temperature, populations swell in the summer and disappear in the winter. The disappearance of a population may mean only that surviving individuals are dormant, or hibernating in the winter months. Breeding cycles can also cause seasonal changes in populations.

Short-Term Changes

Short-term changes take place over a relatively short period of time and don't last very long. They happen irregularly and may be part of a natural event, or caused by human activities. **El NiÑo** is a natural event that might adversely affect fish populations. An oil spill can have short-term effects and long-term consequences if the clean-up is not done effectively.

Long-Term Changes

Long-term changes in populations also result from natural events or human activities. A landslide can change the course of a river or stream. Addition of a new species (zebra mussels introduced by accident) to an area (the Great Lakes) may result in overpopulation of that species because there are no natural enemies. These changes can cause ripple effects because of the interactions that occur within every ecosystem.

3.3 Water Quality and Living Things

When changes occur in the environment, the water supply can be affected. The quality can change when natural events or human activities affect what is being added or taken from the water.

Changes In Water Quality

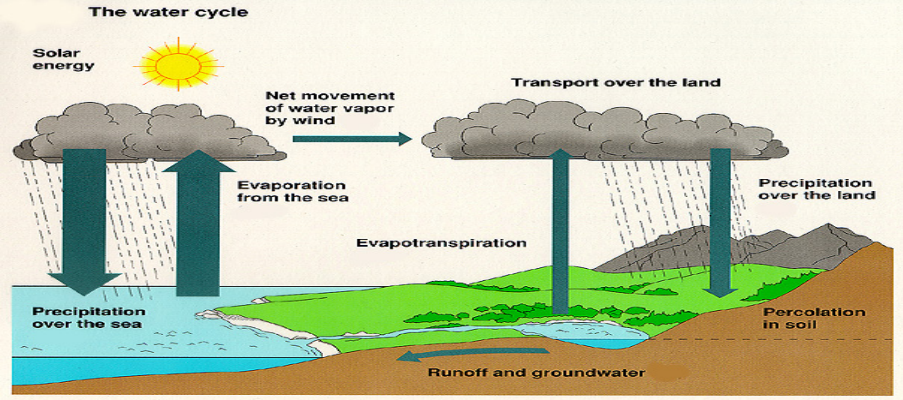
A wide range of species depends on the quality of the water for survival. Some species can tolerate certain changes because those changes are within their ***range of tolerance***. Other species may have a very different range of tolerance to certain conditions and will not be able to survive when the water quality changes.

Examples Of Water Quality Changes

Acid rain can kill a lake. The lake's death results from altering the conditions, which specific species can tolerate. When this happens, because of a higher than normal acid level, not only the species that cannot tolerate the increased acid level dies, but those species which depend on that species for survival (in the food chain) will also perish. Sometimes light is blocked by algae growing on the surface of the water. This increased growth can occur when fertilizer is added to the water supply by runoff. Even though the ***algal bloom*** grows rapidly, water plants, which produce oxygen for other

organisms in the water, die (because they don't get enough light). When there is not enough oxygen in the water, other organisms also perish, and soon, the lake cannot support any life at all (it dies).

4.0 Human activities affect aquatic environments.



Water is recycled around the world through the **water cycle**. This doesn't mean that any one area will always have the same amount of water. In fact, it means just the opposite. No one area can expect the same amount of water year after year. This is because of other natural cycles and human intervention (use) that can cause changes to occur.

4.1 How Humans Use Water

There are **direct** (*domestic* or *personal use*) and **indirect** (*industrial* and *agricultural*) ways that humans use water. Many indirect uses can have negative effects on Earth's water supply. Negative effects may include:

- Pollution of surface and groundwater
- Depletion of groundwater supply

There are benefits and costs to using water.

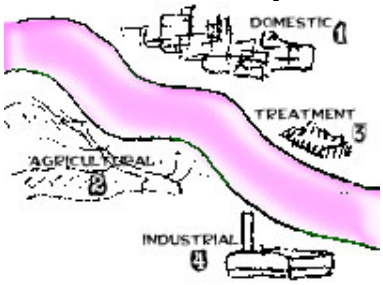
The Major Uses Of Water

Water Use	Direct/Indirect	Benefit (+)	Cost (-)
Agriculture (irrigation)	73% - indirect	Food Economy Jobs	Soil salinity Decreases vegetation Depletes groundwater supplies
Industry (coolant, solvent, washing, diluting pollutants)	22% - indirect	Jobs Consumer Products Services	Pollution contributor Depletes groundwater supplies
Domestic	5% - direct	Convenience Jobs	Cost

Practices And Technologies Affect Water Quality

Power stations – can discharge warm water into lakes or rivers (thermal pollution) killing organisms that cannot tolerate the increased temperature.

Runoff – from **farmland** contains fertilizers that can cause excessive plant growth. It may also contain toxic chemicals (pesticides and herbicides) that can kill living organisms.



Runoff – from **cities** contains large amounts of oil and salt, which can affect plants and animals in the water.

Factories – may add toxic chemicals (which can cause tumors, birth defects, sterility and even death) or, add to the thermal pollution problem.

Habitat destruction takes away the places where animals and plants can live and interact in an aquatic ecosystem.

Sewage – contains large amounts of nitrogen, which causes micro-organism populations to increase. These micro-organisms use up the oxygen in the water and may organisms can die as a result.

Oil Spills – from ships transporting oil from place to place can cause harm to plants and animals in, on or near the water.

4.2 Measuring Impacts

One way to help guard against problems with water quality is to monitor the water supply. To **monitor** means to observe, check, or keep track of something for a specific purpose

Town and city water supplies have to be monitored on a regular basis to ensure that the quality of the water remains high. Water technicians (***freshwater biologists***) regularly measure the level of chemicals in the water and the numbers and kinds of different species of organisms. They also make observations on how it looks and smells. In this way they can identify potential problems in the water supply and adjust the treatment of the water to eliminate them. Research scientists use monitoring techniques (evidence of toxins in the water and living organisms) to help them develop technologies to help protect the environment.

Ongoing Monitoring

Ongoing monitoring of a site helps scientists observe change. The information they gather is then interpreted and suggestions are made to help the ecosystem recover. This can be through regulations to limit human activities in this ecosystem or develop technologies, which can address the problem and protect the environment. The studies they undertake are long-term and all encompassing, so that as many of the interactions as possible that are affected, will be addressed.

Problem Solving Needs More Than Science And Technology

Problem solving requires a strong **commitment** from people. They need to decide what needs to be done and then commit themselves and others to get it done. In many cases the solutions will require money and a way to raise it so the solution can be implemented without delay.

A Success Story

The Thames River in England, used to be an open sewer. It was so polluted by the sewage, toxins, and dead animals it contained, that people decided something needed to be done because of *PUBLIC HEALTH* issues. It is now clean and clear, with some types of fish that use to live in it now returning.

People Working Together

Water systems everywhere need to be monitored and cleaned up if they are causing a problem. The solutions to many of the problems may already be available, or new technologies should be developed to address the concern. Most importantly people must work together to solve the problems, because our water supply is our life source and without it, we will all perish.