SUBAREA I. SCIENTIFIC INQUIRY

COMPETENCY 1.0 Understand types and uses of natural resources, the effects of human activities on the environment, and the need to preserve the environmental integrity of the earth's ecosystems.

SKILL 1.1 Understand the classification, uses, and importance of natural resources and methods of locating and obtaining natural resources

Natural Resources: naturally created commodities critically important or necessary to human life and civilization. The term natural resource can also include the total quantity of a given resource commodity on Earth, discovered and undiscovered.

A major source of contention in our modern society centers on the proper use and conservation of our natural resources. Although most people automatically think of coal, oil, iron, and other minerals when they think of natural resources, the definition also includes other often overlooked resources such as forests, soil, water, air, and land.

Our natural resources are classified into two broad categories: **Renewable Resources** and **Nonrenewable Resources**.

Renewable Resource: a resource that is capable of replenishment or regeneration on a human time scale. Example: Forests and water.

Nonrenewable Resource: a resource that, once exhausted, is not capable of replenishment or regeneration on a human time scale. Example: Petroleum and minerals.

With the exception of certain commodities (gold, silver, and salt), humans have historically given little thought to the concept of managing resources. The supply of every conceivable resource seemed boundless. Vast forests covered large parts of the planet, ensuring a seemingly ample supply of wood for heating and construction. Ore deposits, although less accessible than the forests, were nonetheless plentiful.

At first, our natural **reserves**, the quantity of a resource material that has been discovered and is economically or technologically recoverable, kept pace with the increased demand. However, as the population increased and civilization advanced, becoming increasingly technologically dependent, the demand on our natural resources soared. More important, the per capita consumption of resources has dramatically increased. With an increased standard of living comes the specter of increased individual consumption and strong dependence on machinery and manufactured goods. **Renewable Resource Concerns**

We have a watery planet. Unfortunately, a large percentage (97%) of the water is not fit for human consumption or agricultural use due to high salinity.

Plants and animals (including humans) require water for survival. In fact, statistics show that every person in the United States uses 300 liters of water, and when industrial uses are included, that number soars to roughly 5,000 liters per day, per person.

Pollution poses the severest threat to the water supply. Organic wastes (sewage) are produced by both humans and animals. Left untreated, these wastes, and the wastes from food treatment plants, can enter the waterways and upset the ecological balance. As the wastes decay, they consume oxygen in the water, depriving aquatic life of oxygen, or causing algae blooms which further deplete the oxygen supply, eventually turning some water anoxic.

Another danger to ecology is the poisoning of the food chain through pesticides and fertilizers, or with high concentrations of heavy metals carried into the water supply through runoff from farmlands, factories, and mine tailings.

Pollution also affects our air. The uncontrolled burning of fossil fuel hydrocarbons and high-sulphur content coals pose severe health risks, especially to the very young and very old. Smog alerts are routine in many of the major metropolitan areas, and in Mexico City, air pollution is reaching a critical level.

Forestry management is another area of concern. As our population grows, the demand for lumber and wood products has grown exponentially. Increased urbanization has claimed once vast tracts of forests, replacing them with concrete paving and closely packed structures.

This same drive to urbanization also affects our soil. Arable farmland is shrinking as the press to develop home and commercial sites increases. Of the approximately 15 billion hectares of dry land on the Earth, only 2 billion is suitable for agriculture. If the same land is used year after year, there is a definite danger of soil exhaustion as vital nutrients are depleted.

Farmland is not the only victim of urbanization. Grazing lands for our cattle and other domesticated animals are also shrinking, and as a consequence many of the remaining areas are being overgrazed. The danger of overgrazing lays in the non-availability of sufficient pasturage for the animals and the loss of top cover for the soil, which is then left vulnerable to erosion.

Nonrenewable Resource Concerns

The key focus in nonrenewable resources is the increasing demand for energy. The concern with regard to nonrenewable resources is that once they are depleted, they are permanently gone.

Despite a finite supply of fossil fuels and radioactive fuels such as uranium, the demand for energy continues to increase at a high rate. At our present rate of consumption, there are only 28 years of petroleum reserves left, and uranium reserves are estimated at depletion in 40 years.

To try and alleviate this predictable energy gap, scientists are exploring new methods of recovering additional fuels from once economically unfeasible sites, and researching alternative energy sources.

Alternative Energy Resources

Research efforts into alternative energy sources are directed at producing viable renewable energy sources.

Hydroelectric Power: power produced from falling water. This is not a new idea as waterwheels have been in use for centuries. The drawback to this energy source lays in the availability of suitable locations for dams, and the expense of their construction.

Wind Power: Windmills are also another ancient technology being revisited by engineers. However, the **wind generators** produce very little electricity for the expense involved, and the suitable locations (steady, high winds) for **windfields** are limited.

Tidal Power: Another concept in use in some areas of the world is generating electricity by deflecting and diverting strong tidal currents through offshore turbines that drive electric generators. Again, the presence of proper conditions is necessary (strong tidal power), and suitable locations are limited.

Geothermal Energy: In some areas of the world, such as New Zealand, Iceland, and Italy, energy is produced from hot igneous rocks within the Earth. Rainwater percolates through porous strata near an active magma chamber and flashes into steam. Some of the steam returns to the surface through natural fissures or is extracted through drilled vents. The steam is captured and routed to turbine powered electrical generators to produce geothermal power.

An additional use of geothermal energy is that the steam may also be used to directly heat buildings. Example: Reykjavik, Iceland uses the captured steam to directly heat their buildings. The limitations of this alternative energy source are obvious; the majority of metropolitan locations are not situated near active magma chambers. However, New Zealand does manage to gather enough power to meet approximately 5% of their electrical needs.

Solar Energy: Solar power can be utilized directly as a source of heat or to produce electricity. The most common use is to heat water. An array of dark colored piping is placed on the roof of a structure and as water circulates through the piping it is heated by the Sun.

Solar cells produce electricity from solar radiation. Photons striking the junction between two semi-conductors (usually selenium) induce an electrical current that is stored in batteries. Although this source of power is pollution free, there are two main limitations; first the production of power is limited by the distribution and periods of insolation, and atmospheric conditions can easily interfere with collection efforts (i.e. winter months, cloud cover, pollution, and storms).

Secondly, the solar cells individually produce very small amounts of electricity (trickle charges) and must be arrayed in very large banks. Example: A solar power plant with a capacity of 100 MW would cover a surface area of approximately 4 km^2.

Solar cells have been used successfully in outer space where atmospheric conditions and cell size restraints are of less concern. Spacecraft and satellites use solar cells to charge batteries that provide electrical power for communications equipment and operating power.

Biomass: Plant and animal wastes (decaying or decayed) can be burned to produce heat for steam turbine electrical generators. In most highly developed countries, the biomass is first converted to either methane gas (given off by decaying biomass) or alcohol, but in some underdeveloped countries, the biomass is still burned directly as a fuel source. Example: For centuries, **Peat Bogs** were exploited as a traditional source of home heating and cooking fuel.

Fusion Power: Although the technology does not currently exist, researchers are actively pursuing the means to make fusion power a reality. Unlike ***Fission***, the other form of nuclear energy currently in use, ***Fusion*** does not rely on splitting the atoms of uranium or other potentially deadly radioactive elements. Instead, fusion energy mimics the same process that produces the energy of the Sun.

Energy is produced when small atomic nuclei fuse together to form new atoms. In a fusion reaction, two isotopes of hydrogen, deuterium, and tritium combine to make helium.

The most significant advantage offered by fusion power as compared to fission power is that no dangerous radioactive isotopes are produced. The reaction produces only harmless helium that easily diffuses into the atmosphere and escapes into outer space. Additionally, the elements required for a fusion reaction are abundant on Earth (i.e. deuterium and tritium are extracted from seawater), and readily renew themselves through natural processes.

SKILL 1.2 Identify the positive and negative effects of human activities on earth's environment (e.g., reclamation of strip mines, ocean dumping).

Positive Effects – Reclamation of Strip Mines

Mining is the process by which minerals are extracted from the Earth. These minerals may often include coal, limestone, gold, silver, and many other metals. Mining causes the disturbance of land and ecosystems. Mine reclamation is the process by which mined land is restored to a useful state, such as a productive ecosystem or industrial or municipal land. Mine reclamation has become a regular part of modern mining industry, and improves water and air quality in abandoned mine areas. Reclaimed sites may function as pasture areas, hayland, recreational areas, wild life habitat, and wetlands.

Mine reclamation techniques stabilize land surfaces against water and wind erosion using material placement and capping. The final step in mine reclamation is often the replacement of topsoil and its revegetation with suitable plant species. Revegetation techniques include hydroseeding, a process commonly used for large-scale or hillside properties in which grass seed is sown in a stream of water aimed at the ground, as well as native seed drilling techniques, through which seeds can be sown in well-spaced rows at specific depths. Tree planting is another important part of mine reclamation. Trees are generally planted in low densities to allow for natural propagation. Tree seeds can be pelletalized to prevent excessive movement by the wind. This method proves particularly effective on rocky, barren slopes.

Tailing basins are a common characteristic of mined areas. These depressed areas contain a finely ground concentrate that is the byproduct of smelting operations conducted at mine sites. As the content levels of these basins increase, wind erosion leads to contamination of electrometallurgical refining processes, problems for residents of nearby towns, and machinery wear. To revegetate such areas and decrease erosion, seeding is established on portions of the basin closest to prevailing winds in order to minimize damage of young plants by eroding soil. Agricultural limestone can be applied to soil approximately six weeks before seeding to raise pH, and nitrogenous fertilizers are often used to encourage growth of young plants. When planting grasses, companion crops can be employed to create shading and reduce the dry effect of wind. To deal with drainage problems found in tailing basins, wetlands are often constructed downstream of the basins. These wetlands are capable of filtering and removing contaminants through biological and chemical processes.

Negative Effects – Ocean Dumping

In 1972, the Marine Protection, Research, and Sanctuaries Act was issued to "prevent or strictly limit the dumping into ocean waters of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities." Prior to this act, the dumping of industrial, nuclear, and other waste products into the ocean was common practice. For example, a 1970 Report to the President from the Council on Environmental Quality concluded that 38 million tons of dredged material (34% of which was polluted), 4.5 million tons of industrial waste, 4.5 million tons of sewage sludge containing heavy metals, and 0.5 million tons of construction and demolition debris was disposed of in ocean waters in 1968.

Currently, illegal ocean dumping is widespread. The majority of material dumped at sea is generated by dredging and amounts to hundreds of millions of tons each year. Approximately 10% of this material contains pollutants from shipping, industrial and municipal discharges, and land run off. These pollutants include heavy metals, such as cadmium, mercury, and chromium, hydrocarbons such as oil, pesticides, and nutrients such as nitrogen and phosphorous.

Ocean dumping may result in the rapid and substantial degradation of marine water quality and ecosystems. Toxic materials disposed of at sea may cause acute or chronic toxic effects on marine organisms and potentially contaminate human food sources. Dumping may also cause drastic decreases in ocean water oxygen concentrations, resulting in dead zones. When one habitat or species is affected by ocean pollution, the survival of organisms that rely on that niche is compromised as well, resulting in massive loss of life and even extinction. For example, sea turtles, manatees, fish, shrimp and crabs rely on sea grass for survival. This plant is particularly sensitive to pollution, and its numbers are decreasing drastically. Loss of sea grass affects the survival of animals such as sea lions, which in turn causes sea urchins, the sea lions' prey, to increase in number, upsetting the delicate ecosystem of the ocean.

Another danger to ocean ecology is the poisoning of the food chain through pesticides and fertilizers, or with high concentrations of heavy metals carried into the water supply through runoff from farmlands, factories, and mine tailings.

Landfills: Landfill toxins that leech into soil and groundwater are the primary cause. However, this is preventable and new federal standards require landfills to have a protective plastic barrier to prevent leaching.

Leaking underground storage tanks: This used to be a major source of pollution, but the federal government required the removal of old tanks and replacement with double-hulled, leak alarmed tanks.

Pipelines: Not a major source of concern since new construction techniques generally preclude routine leakage.

Contaminated Wells: New methods of controlling contamination by hydrocarbons (oil, gas, old tires, etc.) have shown promise.

Biomediation combines bacteria and nutrients pumped into the groundwater to consume the contamination. However, it is a long, slow process of over 30 days.

Road de-icing chemicals: This mostly affects areas that receive a significant amount of snow and ice. The chemicals leach into the water table. The only method of dealing with this problem is to use improved chemicals and use less of them.

Fertilizers: Farm chemicals are not a major threat because they are designed to be biodegradable, and usually don't reach into the groundwater. Fertilizers are more of a threat to surface water due to runoff.

Forestry management is another area of concern. As our population grows, the demand for lumber and wood products has grown exponentially. The increased urbanization has claimed once vast tracts of forests, replacing them with concrete paving and closely packed structures.

This same drive to urbanization also affects our soil. Arable farmland is shrinking as the press to develop home and commercial sites increases. Of the approximately 15 billion hectares of dry land on the Earth, only 2 billion are suitable for agriculture. If the same land is used year after year, there is a definite danger of soil exhaustion as vital nutrients are depleted. Grazing lands for our cattle and other domesticated animals are also shrinking, and as a consequence, many of the remaining areas are being overgrazed. The danger of overgrazing lays in the non-availability of sufficient pasturage for the animals and the loss of top cover for the soil, which is then left vulnerable to erosion.

Air Pollution

Pollution: the chemical or physical changes that are natural or man-made (anthropomorphic), that result in quality degradation.

Air Pollution & History

1273 - London, England: King Edward recognizes an air pollution problem. He issues a proclamation banning the burning of sea coal. Sea coal was a particularly poor grade of coal that gave off voluminous amounts of smoke.

1873 - London, England: 700 people die of the effects of the thick smoke caused by industrial activities.

1911 - The term "Smog" is coined and used in periodicals of the time.

1952 - The smog problem reaches a peak. 1000 people die of its effects. Parliament responds by passing the "Clean Air Act."

1948 - In the United States, 20 people die in Nora, Pennsylvania, due to air pollution.

1970 - The U.S. Congress passes the "Clean Air Act." The act has subsequently been revised and updated, but the economic costs of implementing the act have been enormous.

Types of Pollutants

Primary Pollutants: chemicals released into the air in a harmful form.
Example: Smokestack exhaust is harmful if not properly scrubbed before release.

Secondary Pollutants: chemicals that are not harmful as released, but are modified in the atmosphere and become harmful.
Example: Exhaust emissions of Nitrous Oxide from automobiles. When exposed to sunlight they become harmful.

Fugitive Emissions: emissions released by mistake.
Example: Holes in automobile tail pipes, mufflers, catalytic converters, and failed industrial scrubber units.

Sources of Outdoor Pollutants

Although there are natural pollutants, the primary sources of outdoor air pollution are pollutants created by humans. Transportation sources alone account for nearly 50% of all outdoor air pollution.

The U.S. **Environmental Protection Agency** (EPA) recognizes seven substances as being harmful to the environment.

Sulfur Compounds: Some are naturally released. The primary natural sources are volcanoes. The man-made sources are from the combustion of coal and oil products. When released, the sulfur combines with the atmosphere and changes to an oxidizer, Sulfur Dioxide (SO_2). Further chemical modifications transform this into Sulfate, and when combined with water, it changes to Sulfuric Acid ($S0_4$). This acid precipitation is popularly known as Acid Rain. The solution to the problem is to use low sulfur content coal. Since the EPA mandated its use, there has been an 11% drop in the amount of acid rain.

Nitrogen Compounds: 5% of all Nitrogen compounds occur naturally via bacterial decay, rice paddies, wetlands, and swamp decay. 95% of the problem is caused by man-made, high temperature combustion. Auto exhaust is the primary offender. The nitrogen compounds oxidize and combine with H_20 (water) to form into SO_4 (acid rain).

Carbon Oxides: Carbon Monoxide (CO) is very deadly because it replaces oxygen molecules in the blood, causing Carbon Monoxide poisoning. Carbon Monoxide is produced by combustion of oil and gas, with auto exhaust as the primary offender.

Particulates: These are Aerosols: small bits of solids suspended in H_20 (water) drops. Aerosols block solar radiation and make the air look dirty. The source of the particulate (dust, soot, ash) can be either man-made or natural. 40% comes from industrial processes. 17% comes from vehicle emissions. 30% comes from natural sources: salt spray, dust, and volcanoes. 13% comes from other miscellaneous sources. The most dangerous of the particulates are <2.5 microns in size. These microscopic sized particles cause lung problems. Some sources are asbestos, cigarette smoke, and coal dust. Example: Long exposure to coal dust can cause "Black Lung" disease. The sulfur in the dust particulates literally burns holes in the lungs.

Metals: Metal substances are the byproducts of a variety of manufacturing processes. Some sources are sandblasting, leaded gasoline, and leaded paint. Example: Since the EPA banned the use of lead in gasoline and paint there has been a drop in the lead accumulation problem observed in the environment. The major problem with metals is that almost all of them are carcinogenic, and because the metals accumulate in the fatty tissues of the body, they also cause long-term problems with nervous system disruption. Example: The haberdashery (hat maker) trade of the past had a high rate of craftsmen going insane. The reason was that the trade used to use a large amount of mercury in the crafting process. The fumes from the mercury were breathed in by the workers, and eventually caused severe nervous system disruption. Thus comes the old phrase, "As Mad as a Hatter".

Photochemical Oxidants: The oxidation process can change normally harmless chemicals into more dangerous substances. Example: Oxygen (O_2), when exposed to ultra-violet radiation (UV), becomes Ozone (O_3). Although Ozone is necessary in the upper atmosphere, when the human body is exposed to it, it causes lung damage. Example: Nitrogen compounds under certain circumstances can transform into NO_3. This compound is a major component of smog that irritates the soft tissues and mucous membranes.

Volatile Organic Compounds (VOCs): These are organic chemical gases that occur both naturally and through man-made processes.

Natural sources: Plants, wetlands, rice paddies, and ruminant animals release Methane. Conifer trees release Terpene. Terpene forms a haze in the atmosphere. It is what forms the haze over the Great Smoky Mountains and the Azure Mountains.

Man-made Sources: Any synthetic organic chemical (such as Benzene, Toluene, and Formaldehyde). All hydrocarbons emissions such as gasoline fumes.

Controlling Air Pollution Outdoors

Cyclone Collectors: Utilizes an electrostatic precipitator. Small particulates are electronically attracted to a charged filter screen and destroyed.

Scrubber: Used to control SO_2 (Sulfur Dioxide) emissions. Limestone is crushed and mixed into a slurry. The slurry mixture chemically removes 95% of the SO_2 emissions. Use of scrubber units is a relatively inexpensive procedure. However, the United States is the only country to consistently use this method. In 1987, only 40% of German industries used this method, compared to 95% of U.S. industries.

Afterburners and **Converters**: Nitrogen compounds in auto exhaust can be removed by the use of afterburners. Afterburners rely on another stage in the combustion process to rechannel the exhaust back to the combustion source and re-burn it. Catalytic converters use platinum to act as a catalyst to remove CO_2 and CO compounds.

Indoor Air Pollutants

Indoor air pollution is on the rise due to urban lifestyles. New construction techniques cause better sealing of homes and buildings, trapping air inside of buildings. However, if the air filtration system isn't good or properly maintained, then the occupants end up re-breathing polluted air.

Carbon Monoxide: Produced by gas or oil burning stoves, water heaters, furnaces, fireplaces, etc., the gas is colorless, odorless, and deadly. Preventive safety measures include ensuring proper ventilation and the use of Carbon Monoxide (CO) detectors.

PAH (Polycyclic Aromatic Hydrocarbons): This gas is given off by new carpeting, flooring, fabrics, and padding made from polycarbonates. Long-term exposure to PAH causes eye tearing and aggravates asthma and bronchitis.

Radon: A naturally occurring radioactive gas. The source of the emission is the natural decay of radioactive elements from granite, uranium, and other metamorphic rocks that contain radioactive elements. As the rock material weathers or breaks down, the gas seeps into the foundations of buildings and homes. The gas can then be re-circulated through the air system. The gas is a carcinogenic and, in areas where this type of material forms the bedrock, the use of Radon detectors is advised.

Formaldehyde: This chemical is used extensively in the processing of fabric. The fumes from trace amounts left on the fabric cause teary eyes and skin rashes.

Asbestos: A naturally occurring mineral, asbestos was once extensively used as a fire retardant in homes, buildings, schools, and as lining for automobile brake shoes. In its natural state as a solid, it is harmless. However, if the fibers become airborne, they can collect in human lungs and eventually cause asbestosis. Long term exposure to airborne particulate asbestos fibers can be deadly. In the short term, it can cause severe respiratory problems. Its use is now banned by the EPA, and the rip out and replacement process is very time consuming and expensive.

Tobacco Smoke: The EPA has identified this as a major carcinogen. The EPA has also identified second hand tobacco smoke as a problem. The effects of tobacco smoke are lung cancer, emphysema, heart disease, asthma, bronchitis, and Brittle Lung Disease (lungs lose their elastic capacity). EPA data is the major source of material cited in the enactment of antismoking legislation.

SKILL 1.3 Describe strategies for dealing with environmental problems.

Addressing the Issues

Our increasing population, urbanization, and dependence on technology are the key factors that drive the rapid consumption of our resources. How long our natural resources will last depends on future demand and willingness on the part of governments to efficiently manage their energy needs and resources.

Likewise, industry must become more deeply involved by modifying their existing, or developing new, techniques and procedures to effectively utilize our natural materials.

Unfortunately, natural resources are not evenly distributed throughout the Earth, and political considerations have, to date, hampered cooperation of conservation efforts and development of alternative energy sources on a global scale.

As grim as the projected shortfalls may seem, there is some hope. There is a growing awareness of the problems we face and although not usually coordinated on a global scale, some countries are taking steps to address the issues.

Better agricultural techniques to prevent soil depletion, reclamation of waterways, banning the use of chemicals damaging to the atmosphere, recycling plastics and metals, and seeking alternative energy sources are all examples of ongoing initiatives to ensure resources for future generations.

Controlling Air Pollution Indoors

The vast majority of problems caused to humankind by indoor air pollutants are directly attributable to bad ventilation. Filter systems are not cleaned on a regular basis or replaced frequently enough. If improper ventilation systems are installed they may restrict airflow or have insufficient exchange capability.

Sick Building Syndrome: Sick building syndrome is the name given to the effects from pollutants being re-breathed. New construction techniques more effectively seal buildings, trapping the pollutants inside, and can cause cold-like symptoms of watery eyes, fatigue, and respiratory problems. Trapped pollutants can become deadly.

Legionnaires Disease: Named after the incident in which many attendees at an American Legion convention died. Mold in the air conditioning system caused the death of the attendees. Areas of water damage can promote the growth of black mold (Staphybaucus bacteria) which causes bleeding in the human lung.

Good ventilation and properly maintained ventilation systems are the key factors in controlling indoor air pollution.

Solutions to the Problems

Restoration of the Kissimee River & Everglades Wetlands: The Army Corps of Engineers (ACE) built a $30 million dollar canal project through the wetlands. Finished in 1971, the project has caused massive problems for the ecosystem. ACE is removing the canal and letting the land flood naturally. However, this is a slow and expensive process. The estimated cost is $600 million to acquire the 88,000 acres of land that had been developed.

The EPA is cracking down on the Orlando tourist complex. Addressing the problem of dumping of untreated wastewater, the city of Orlando was forced by the EPA to build a $200 million dollar sewage treatment plant. The plant treats and recycles 25-50 million gallons of wastewater per year. This treated water is used for irrigation.

Southern Florida instituted a Water Management District (WMD). The WMD determines water policy and monitors the use of water resources. Its policies are directed at preventing pollution, over use, etc.

Treating Contaminated Groundwater

Some treatments are available to reclaim polluted groundwater.

- Pump the water out, haul it away, and treat it. However, this surmises that the water taken out will be replaced naturally. Of course this is self-defeating if the source of the pollution isn't eliminated.

- Biomediation: Use of contaminant eating enzymes.

- Using plastic barriers under landfills to prevent leeching.

- Treatment Beds: The concept is to dig down and place a silt-sand layer between the contaminated area and clear water. The layer filters the water and is now being used to protect many cities' water supplies. However, this is a very expensive process and is generally only employed by affluent municipalities.

Sewage Treatment Sequence

lst Stage: Primary treatment. Skim off large objects by using screens and settle suspended solids. However, the waste is still rich in pathogens.

2nd Stage: Secondary treatment. Fine material in suspension is removed by trickling it over stones or activated sludge. Mixing the wastewater in a tank with active "friendly" bacteria forms activated sludge. The bacteria reduce the material by eating it.

3rd Stage: Chlorinate the water. Chlorination kills the bacteria and pathogens. However, non-biodegradable compounds are still in the water. Example: nitrogen and phosphorus from fertilizers, and oil and other hydrocarbons.

4th Stage: Tertiary treatment. Removes or binds up the heavy metals. This deals with fertilizer and hydrocarbon contamination. This is a very expensive stage and many communities do not use a tertiary treatment