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# Macomb Intermediate School District High School Science Power Standards Document

## Earth Science

The Michigan High School Science Content Expectations establish what every student is expected to know and be able to do by the end of high school. They also outline the parameters for receiving high school credit as dictated by state law.

To aid teachers and administrators in meeting these expectations the Macomb ISD has undertaken the task of identifying those content expectations which can be considered power standards. The critical characteristics<sup>1</sup> for selecting a **power standard** are:

- **Endurance** - knowledge and skills of value beyond a single test date.
- **Leverage** - knowledge and skills that will be of value in multiple disciplines.
- **Readiness** - knowledge and skills necessary for the next level of learning.

The selection of **power standards** is not intended to relieve teachers of the responsibility for teaching all content expectations. Rather, it gives the school district a common focus and acts as a safety net of standards that all students must learn prior to leaving their current level.

The following document utilizes the unit design including the big ideas and real world contexts, as developed in the science companion documents for the Michigan High School Science Content Expectations.

<sup>1</sup> Dr. Douglas Reeves, Center for Performance Assessment

## **Unit 1: Organizing Principles of Earth Science**

### **Big Idea**

Processes, events and features on Earth result from energy transfer and movement of matter through interconnected Earth systems.

### **Contextual Understandings**

Earth science is an umbrella term for the scientific disciplines of geology, meteorology, climatology, hydrology, oceanography, and astronomy.

Earth systems science has given an improved, interdisciplinary perspective to researchers in fields concerned with global change, such as climate change and geologic history.

Plate tectonics is the unifying theory of geology and helps explain all features and processes in the geosphere.

Large quantities of carbon dioxide can be taken in by the Earth's plants, algae, and remain dissolved in ocean water. The carbon cycle is a biogeochemical cycle that quantifies the movement of carbon through the four major Earth systems.

Carbon dioxide is a major greenhouse gas that makes Earth warm enough to sustain life as we know it. Human industrialization has dramatically increased the percentage of carbon dioxide in the atmosphere, making the Earth warmer and altering the climate system.

Foraminifer, corals, snails, and other marine organisms take in carbon forming calcium carbonate in shells and other hard structures. Upon their death some of these structures are deposited and lithified to become limestone, a major carbon reservoir.

Acidic water running over limestone can dissolve calcium carbonate and carry it into rivers, lakes, and groundwater.

Nitrogen exists in several organic and inorganic forms throughout the Earth systems and can be depicted as one of the biogeochemical cycles known as the "Nitrogen-Cycle." It is very important for ecosystems. Human actions such as burning of trees or fossil fuels, use of nitrogen fertilizer, impact the movement and storage of nitrogen. Detrimental results include nitrogen loading in waterways and increased nitrogen based pollutants including nitrous oxide, a greenhouse gas.

At black smokers, heat energy is transferred from the interior of the Earth to the ocean. The hot water carries dissolved minerals. These minerals and heat energy are utilized by bacteria as the basis of an ecosystem which is not based on photosynthesis.

	<b>Additional Standards</b>
<p>E2.1B - Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.</p> <p>E2.1C - Explain, using specific examples, how a change in one system affects other Earth systems.</p> <p>E3.3B - Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that results from their increased density.</p>	<p>E2.3A - Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life within Earth systems) and how those forms can be beneficial or harmful to humans.</p> <p>E2.3c - Explain how the nitrogen cycle is part of the Earth system.</p> <p>E2.3d – Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society.</p>

## Unit 2: Earthquakes and Earth's Interior

### Big Idea

A model of the structure and dynamics of Earth's interior where the transfer of heat from the interior towards the surface causes slow movement of Earth's tectonic plates is based largely on recordings of seismic waves.

### Contextual Understandings

Moderate, shallow earthquakes are well characterized by the Richter scale, a logarithmic scale that measures magnitude of a seismic wave.

Larger magnitude earthquakes are better characterized by the Moment Magnitude scale that is determined from seismographs and quantifies released energy.

Modified Mercalli Scale expresses the intensity of an earthquake's effects with a scale from I to XII based on descriptions of damage. Intensity zones are mapped to show patterns of earthquake damage.

A global network of seismometers has become more dense in recent decades allowing geophysicists to model the Earth's interior with more accuracy.

Earthquake risk is quantified by considering geologic surface material, building design and material, the condition of infrastructure, and population patterns. Unconsolidated sediment is a dominant surface material in the Midwest and is vulnerable to liquefaction during seismic shaking.

	<b>Additional Standards</b>
<p>E2.2C - Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.</p> <p>E3.2A - Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.</p> <p>E3.2B - Explain how scientists infer that the Earth has internal layers with discernable properties using patterns of primary (P) and secondary (S) seismic wave arrivals</p> <p>E3.2C - Describe the differences between oceanic and continental crust (including density, age, composition).</p> <p>E3.4B - Describe how the sizes of earthquakes and volcanoes are measured or characterized.</p> <p>E3.4C - Describe the effects of earthquakes and volcanic eruptions on humans.</p>	<p>E3.4f - Explain why fences are offset after an earthquake using the elastic rebound theory.</p> <p>E3.2d - Explain the uncertainties associated with models of the interior of the Earth and how these models are validated.</p>

### Unit 3: Plate Tectonics and Volcanoes

#### Big Idea

Plate tectonics is the central organizing theory of geology and is part of the explanation of every phenomena and process observable in the Geosphere. Plate tectonics influence phenomena in the atmosphere, hydrosphere and biosphere.

#### Contextual Understandings

A cooling limb of a convection cell is associated with subducting plates. Rising heat is associated with spreading centers. Aging ocean crust cools by conduction eventually causing the lithosphere to become more dense than the underlying asthenosphere.

The plate tectonic context is a necessary consideration in the interpretation of ancient and modern geologic features and materials.

Modern plate motions are determined through the use of geodetic and satellite technology. Plate motions of the past are deduced from offsets of geologic features including landforms, rock formations and magnetic signatures recorded in rocks that can be correlated to a paleomagnetic time scale.

Composite (or strata) volcanoes develop in a general line (called a volcanic arc) parallel to a convergent plate boundary, built upon the overriding plate.

Intraplate volcanoes are developed over hotspots and produce a variety of volcanic landforms. Hotspots under oceanic lithosphere produce shield volcanoes that develop a linear chain of ocean islands if the plate has moved over the hotspots (e.g., Hawaii). Hotspots under continental lithosphere may produce a plateau of layered volcanic rocks, such as the Columbia River flood basalts which emerged as fluid, low viscosity lava. In other instances they may produce highly explosive volcanic events and related landforms (e.g., Yellowstone).

	<b>Additional Standards</b>
E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.	E3.3C Describe the motion history of geologic features (e.g., plates, Hawaii) using equations relating rate, time, and distance.
E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.	E3.4e Explain how volcanoes change the atmosphere, hydrosphere, and other Earth systems.
E2.2A Describe the Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).	E3.3d Distinguish plate boundaries by the pattern of depth and magnitude of earthquakes.
E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	E3.4d Explain how the chemical composition of magmas relates to plate tectonics and affects the geometry, structure, and explosivity of volcanoes.
E3.3A Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.	

E3.3B Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that result from their increased density.

E3.4A Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries.

E3.4B Describe how the sizes of earthquakes and volcanoes are measured or characterized.

E3.4C Describe the effects of earthquakes and volcanic eruptions on humans.

## Unit 4: Rock Forming Processes

### Big Idea

Understanding natural processes and Earth materials allows Earth history to be discerned.

### Contextual Understandings

Rock forming processes create large-scale forms and structures that assist in the interpretation of geologic history and the plate tectonic context.

Regions of the continental crust that expose (at the surface) deep crustal igneous and metamorphic rocks are remnants of mountain ranges and must have experienced dramatic uplift due to the compression typical of a convergent plate boundary.

The percentage of silica in igneous rocks is an influential variable that relates to the origin and history of magma in a plate tectonic context. The silica content influences the viscosity of magma, temperature of crystallization of minerals, the types of intrusive and extrusive igneous bodies and the byproducts of weathering and erosion.

Basalt is the most common surface or near surface crustal rock because it is the main product of ocean spreading centers which formed all the of the ocean crust.

An ancient volcanic arc can be inferred from deposits of andesite (fine grained, with intermediate percentage of silica) and pyroclastic rocks such as tuff and understood to be a product of a composite (or strata) volcano.

The composition and sorting of sedimentary grains provides clues to the sediment source region, transport history and environment of deposition.

Sedimentary rocks that are comprised of volcanic rock fragments indicate a volcanic source region, and if sub-rounded to angular a short travel history, such as that of an ocean trench next to a volcanic arc. Well rounded, quartz rich sandstones may represent a beach environment at a passive continental margin.

Chemically precipitated rocks that have formed due to evaporation (e.g., rock salt, rock gypsum) are possibly remnants of shallow seas in warm arid climates.

Biochemical sedimentary rocks (e.g., chert, fossiliferous limestone) originate in ocean environments when the hard remains of marine organisms collect as sediment. Great ocean depth can be inferred from chert because calcium carbonate has high solubility in colder high pressure environments, typical of the deep oceans.

Metamorphic rocks can record a history of changing pressure and/or temperature that can be associated with specific plate tectonic settings. For example, blueschist represent the high pressure low temperature environment of a subduction zone. Gneiss is produced from a number of rock types exposed to extremely high pressure and temperature that occur deep in the crust where mountain building occurs. These examples all have foliation due to high pressure. Marble and quartzite are non-foliated and may have formed from contact metamorphism caused by extreme heat provided by igneous intrusions. However, because marble and quartzite are dominated by equant minerals, regional metamorphism would not produce foliation either.

Some important rock forming processes concentrate strategic minerals in economically viable deposits.

	<b>Additional Standards</b>
<p>E3.1A Discriminate between igneous, metamorphic, and sedimentary rocks and describe the processes that change one kind of rock into another.</p> <p>E3.1B Explain the relationship between the rock cycle and plate tectonics theory in regard to the origins of igneous, sedimentary, and metamorphic rocks.</p> <p>E3.1d Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.</p>	<p>E3.1c Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.</p> <p>E3.1e Explain how the texture (foliated, non-foliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.</p>



## Unit 5: Discerning Earth's History

### Big Idea

The application of age dating techniques provides evidence for an ancient Earth and allows for the interpretation of Earth history which has been the basis of the design and refinement of the geologic time scale.

### Contextual Understandings

Determining sequences of events in geologic time couples what is known about index fossils with insights on rock origin, rock layers and the evolution of life.

A relative geologic time scale was constructed in the 18th and 19th century using index fossils in conjunction with relative age dating principles such as the law of superposition, the principle of original horizontality, crosscutting relationships, inclusions and unconformities.

Uniformitarianism is the fundamental principle of geology that relates to the interpretation of Earth History. It says that geologic processes occurring today are generally the same as those that shaped Earth in the past, and can be used to interpret Earth history. A short hand phrase is “the present is the key to the past.”

Early scientific research on the nature and behavior of the atom led to an understanding of how radiometric decay could be used for age dating of geologic materials. Radiometric dating techniques put absolute ages on geologic and paleontologic events some of which are the basis of divisions in the geologic time scale.

The techniques of radioactive dating are valid and understandable. Misrepresentation of the processes and level of validity has occurred in the non-scientific publications.

	<b>Additional Standards</b>
E5.3B Describe the process of radioactive decay and explain how radioactive elements are used to date the rocks that contain them.  E5.3D Describe how index fossils can be used to determine time sequence.	E5.3C Relate major events in the history of the Earth to the geologic time scale, including formation of the Earth, formation of an oxygen atmosphere, rise of life, Cretaceous-Tertiary (K-T) and Permian extinctions, and Pleistocene ice age.  E5.3e Determine the approximate age of a sample, when given the half-life of a radioactive substance (in graph or tabular form) along with the ratio of daughter to parent substances present in the sample.  E5.3f Explain why C-14 can be used to date a 40,000 year old tree but U-Pb cannot.  E5.3g Identify a sequence of geologic events using relative-age dating principles.

## Unit 6: Severe Weather

### Big Idea

Protecting the human interests of health, safety and resource management depends upon an understanding of natural hazards and human impact on Earth systems.

### Contextual Understandings

Mid-latitude cyclones form between 30° and 60° North Latitude. Because of the location of the United States mid-latitude cyclones have a tremendous impact on our weather.

Hurricane risk in the United States is both seasonal and regional.

Where and when hurricanes form is due to the temperature of ocean water. What direction they move is mostly a function of the direction of prevailing winds and the Coriolis Effect.

Much of the energy that empowers hurricanes comes from the latent heat as water evaporates from the ocean and later condenses into rain.

The United States Gulf Coast is among the world's most at-risk regions in terms of human mortality and economic loss due to hurricanes.

Improved ability to predict severe weather has led to reduced risk of injury and death.

Some lifting mechanisms include frontal boundaries such as cold fronts or warm fronts, upper level disturbances, orographic lifting (upslope flow associated with higher elevations), low level warm air or moisture advection (the transport of warmer temperature or higher amounts of moisture by the wind), and low pressure systems.

Tornado formation is possible when significant directional wind shear exists in the atmosphere ahead of a cold front in the presence of a strong upper level jet stream. Thunderstorms and tornadoes can develop anytime during the year in North America, however there is some times that are more conducive to their formation.

Storm prediction uses measurements of air pressure, wind speed, wind direction, temperature, cloudiness and precipitation.

	<b>Additional Standards</b>
E2.2A Describe the Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).	E2.2D Identify the main sources of energy to the climate system.
E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	E4.3F Describe how mountains, frontal wedging (including dry lines), convection, and convergence form clouds and precipitation.
E4.3A Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).	E4.3g Explain the process of adiabatic cooling and adiabatic temperature changes to the formation of clouds.
E4.3B Describe the damage resulting from and the social impact of thunderstorms, tornadoes, hurricanes, and floods.	

E4.3C Describe severe weather and flood safety and mitigation.

E4.3D Describe the seasonal variations in severe weather.

E4.3E Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).

## Unit 7: Oceans and Climates

### **Big Idea**

Local, regional, and global climates are patterns of atmospheric circulation driven by temperature differences in water, land and the atmosphere which involves the exchange of matter and energy between the ocean and atmosphere.

### **Contextual Understandings**

Warm ocean water heats air above it to produce strong convection currents and high annual rain fall.

The warm Gulf Stream current causes Great Britain and northwestern Europe to be much warmer than would be predicted based on their latitude. The Labrador Current in a similar way cools the east coast of Canada.

Distinct layers in the Atlantic Ocean can be identified as to where they originated (e.g., North Atlantic, Mediterranean Sea, etc.). Their unique characteristics (and the order of their position in the water column) is due to their temperatures and salt concentrations.

El Nino events increase the frequency of drought and fires in northern Australia and Indonesia, and flooding in Ecuador and Peru. Our increased ability to predict El Nino events allow farmers to change what crops they plant for the upcoming season.

Argo floats are used to measure temperature, salinity and currents in the ocean at depth which allows the construction of vertical profiles of these variables.

	<b>Additional Standards</b>
<p>E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.</p> <p>E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.</p> <p>E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.</p> <p>E4.2A Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the Earth, changes in water temperature and salinity in high latitudes, and basin shape.</p> <p>E4.2B Explain how the interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climate zones, and the ocean as a major carbon dioxide reservoir.</p>	<p>E2.2e Explain how energy changes form through Earth system</p> <p>E4.2c Explain the dynamics (including ocean-atmosphere interactions) of the El Nino Southern Oscillation (ENSO) and its effect on continental climate.</p> <p>E4.2d Identify factors affecting seawater density and salinity and describe how density affects oceanic layering and currents.</p> <p>E4.2e Explain the differences between maritime and continental climates with regard to oceanic currents.</p> <p>E4.2f Explain how the Coriolis Effect controls oceanic circulation.</p>

## Unit 8: Climate Change

### Big Idea

Predicting and mitigating the potential impact of global climate change requires an understanding of the mechanisms of Earth's climate, involving studies of past climates, measurements of current interactions of Earth's systems and the construction of climate change models.

### Contextual Understandings

The Intergovernmental Panel on Climate Change (IPCC) assesses scientific, technical and socio-economic information related to climate change and produces comprehensive reports on the potential impacts and options for adaptation and mitigation.

The endeavor to predict the consequences of global warming depends greatly on the Earth system science perspective. Researchers interpret observations in light of the connections of systems and subsystems.

Burning of fossil fuels releases carbon once stored in ancient biomass. This carbon can exist in several main forms and reside in different reservoirs of the Earth system. Releases of carbon dioxide into the atmosphere promotes greater plant growth, moving carbon from the atmosphere into plants. More carbon dioxide in the atmosphere also results in more of it dissolving in water of the oceans, lakes, and rain.

The burning of biomass both releases more carbon dioxide into the air and reduces the biosphere's capacity to remove carbon dioxide through photosynthesis.

The current warming trend is resulting in the melting of glacial ice. Other possible effects include the melting of permafrost (releasing methane) and warming oceans which melts methane hydrates of the ocean floor.

Melting of glacial ice effects Earth systems in many ways. The effects of sea level rise are most profound when ice is land based. Increasing water density drives the thermohaline current (initiating the North Atlantic Deep Water) and plays a major role distributing Earth's heat. Increased fresh water in the North Atlantic Ocean due to melting ice decreases sea water salinity and therefore water density. Resulting changes in global heat distribution would impact climate on land regionally, a hypothesis supported by studies of ancient climates. The melting of ice reduces Earth's average albedo (the reflectivity of Earth surface materials) and therefore increases the amount of energy absorbed by the Earth.

Volcanic eruptions can release more greenhouse gases (carbon dioxide and water vapor) into the air. It also releases sulfur dioxide which combines with rain to form acid rain, which increases the weathering of limestone and puts more carbon dioxide from the limestone into the air.

Aerosols in the upper atmosphere that form by the interaction of the sulfur dioxide and water act to cause a temporary cooling of global temperatures when there is a major eruption

Multiple lines of evidence (including foram fossils, dust deposits in ocean sediments, pollen deposits, tree ring measurements, and ice core testing) all lead to very similar conclusions about the historical patterns of temperature changes in the Earth system. Data derived from ice cores strongly suggests a relationship between atmospheric carbon dioxide levels and temperature.

	<b>Additional Standards</b>
E2.3A Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.	E5.4D Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity

E2.1A Explain why the Earth is essentially a closed system in terms of matter.

E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.

E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.

E5.4C Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.

E2.2e Explain how energy changes form through Earth systems.

E2.2f Explain how elements exist in different compounds and states as they move from one reservoir to another.

E2.3d Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society.

E5.4A Explain the natural mechanism of the greenhouse effect including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).

E5.4B Describe natural mechanisms that could result in significant changes in climate (e.g., major volcanic eruptions, changes in sunlight received by the Earth, and meteorite impacts).

E5.4e Based on evidence from historical climate research (e.g., fossils, varves, ice core data) and climate change models, explain how the current melting of polar ice caps can impact the climate system.

E5.4f Describe geologic evidence that implies climates were significantly colder at times in the geologic record (e.g., geomorphology, striations, and fossils).

E5.4g Compare and contrast the heat trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat trapping capacity of the biosphere).

## Unit 9: Hydrogeology

### Big Idea

Finding solutions to problems related to water resources requires an understanding of the dynamics and interconnectedness of the components of the hydrosphere and the impact created by human activity.

### Contextual Understandings

Watersheds are the main organizing concept for elements and process of surface hydrology, ground water and land use.

Depletion of ground water can impact streams and biological viability. Landscapes can establish equilibrium inconsistent with emerging climatic patterns. Changes in climatic patterns or human diversions of water will shift equilibrium and produce changes in the characteristics of streams, ground water and landscapes.

Wetlands store water and recharge rivers during dry spells. They also absorb water during large storm events. A reduction of wetlands due to development or urbanization make flooding more likely as well as low stream discharge during drier months.

While water quality can be reduced by land use in many ways, the effects of agricultural practices are perhaps most profound.

Loss of soil not only diminishes the agricultural viability of land, but may greatly increase stream water turbidity which increases absorption of thermal energy and therefore water temperature. Dissolved oxygen levels drop as water temperature rises.

Organic and synthetic fertilizer from surface run off adds nitrates to stream water which can cause algal blooms. Algae are eventually broken down by aerobic bacteria that consume great quantities of dissolved oxygen. Such occurrences can be inferred from a high biochemical oxygen demand (B.O.D.) and lower percent saturation of dissolved oxygen.

The “dead zone” in the Gulf of Mexico is one of many off shore areas on Earth where coastal ecosystems suffer from extremely low amounts of dissolved oxygen. The depletion of oxygen begins in the spring, swells to a maximum size in summer and disappears in the fall. A major cause is excessive nutrients from agriculture in the Mississippi watershed.

Ground water systems are sustainable when input is equal to or exceeds out put. Major sections of the Midwest are practicing unsustainable agriculture due to excessive down draw of the Ogallala aquifer. Some areas experience topographic subsidence due to excessive and continuous ground water withdrawal.

Ground water quality suffers from industrial chemicals and saline infiltration. The United States superfund sites are prioritized locations suffering from dangerous levels of ground water pollution.

Urbanization increases the proportion of impermeable surfaces that accelerate water runoff, reduce infiltration and recharge of wetlands and aquifers.

Water quality measured by physical, chemical and biological parameters reflect land use practices.

	<b>Additional Standards</b>
E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.	E2.3b Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities (e.g., dead zone in the Gulf of Mexico, Lake Nyos in Africa, fluoride in water).

E4.1A Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).

E4.1B Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g., the past 100 years) qualitatively using the concepts of recharge, residence time, inputs and outputs.

E4.1C Explain how water quality in both groundwater and surface systems is impacted by land use decisions.

E2.3c Explain how the nitrogen cycle is part of the Earth system.



## Unit 10: Resources and Environmental Challenges

### Big Idea

Protecting the human interests of health, safety and resource management depends upon an understanding of natural hazards and human impact on earth systems.

### Contextual Understandings

Decisions on policy and investment in energy systems for human consumption take into account many factors such as cost and access of natural resources, carbon emissions, technology, impact on society and the challenges of pollution.

Convection currents in the Earth's atmosphere produces winds which drive the surface currents of the oceans. Both can be utilized as alternative sources of energy.

The development of automobiles that run on alternative fuels (hydrogen, electricity) will reduce carbon dioxide emissions but involve other environmental trade offs.

Coral reefs are threatened around the world due to long term stresses resulting from a variety of sources. Changing ocean chemistry and temperature has an impact as well as the composition of runoff from land.

Deforestation can result in less humidity in the air, more carbon dioxide in the air, greater soil erosion, which in turn can change the chemical and physical conditions of streams, lakes, and groundwater.

The choice of paper or plastic bag in the grocery store is not simple if all the steps in making and disposing of it are considered. Paper has often been touted as the better choice environmentally, but understanding the trade-offs should require one to consider a number of issues such as how well the paper manufacturing plant is operated and what bleaching agents are used in making the paper.

	<b>Additional Standards</b>
E2.2B Identify differences in the origin and use of renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear [U-235]) sources of energy.	E2.2e Explain how energy changes form through Earth systems.
E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	E2.2f Explain how elements exist in different compounds and states as they move from one reservoir to another.
E2.4A Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits.	E2.4c Explain ozone depletion in the stratosphere and methods to slow human activities to reduce ozone depletion.
E2.4B Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.	E2.4d Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal, and pollution.

## Unit 11: Cosmology and Earth's Place in the Universe

### Big Idea

Extraterrestrial energy and materials influence Earth's systems and the position and motion of the Earth within an evolving solar system, galaxy, and universe.

### Contextual Understandings

Evolution of universe: major feature of "big bang" theory.

The Doppler Redshift results from the relative motion of the light emitting object and an observer. If the source of light is moving away from an observer the wavelength of the light is shifted towards the red due to an apparent increase in wavelength from that perspective. If the source of light is moving toward an observer, the wavelength of the light is shifted toward the blue due to an apparent shortening of wavelength. These effects, called the redshift and the blueshift, respectively are together known as doppler shifts.

The Cosmological Redshift (or Hubble Redshift) is a redshift caused by the expansion of space. The wavelength of light increases as it traverses the expanding universe between its point of emission and its point of detection proportional to the expansion of space during the crossing time.

Cosmic background radiation is considered a remnant of the big bang.

Structure of universe: Location of our galaxy among others and role of gravitation in galaxy formation.

	<b>Additional Standards</b>
E5.1A Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.	E5.1c Explain how observations of the cosmic background radiation have helped determine the age of the universe.
E5.3A Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga (billion years ago).	E5.1d Differentiate between the cosmological and Doppler red shift.
E5.1b Describe how the Big Bang theory accounts for the formation of the universe.	

## Unit 12: The Sun and Other Stars

### Big Idea

Extraterrestrial energy and materials influence Earth's systems and the position and motion Earth within an evolving solar system, galaxy, and universe.

### Contextual Understandings

There is evidence that Earth's climate is effected by the solar activity cycle.

Three dimensional images of the sun by space crafts such as the STEREO, have greatly enhanced our ability to follow solar storms and forecast arrival time to Earth.

The origin of elements involves the formation of Hydrogen and Helium in the early universe followed by the formation of heavier elements.

	<b>Additional Standards</b>
E5.2B Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances.  E5.2C Describe how nuclear fusion produces energy in the Sun.	E5.2A Identify patterns in solar activities (sunspot cycle, solar flares, solar wind).  E5.2D Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements.  E5.2e Explain how the Hertzsprung-Russell (H-R) diagram can be used to deduce other parameters (distance).  E5.2f Explain how you can infer the temperature, life span, and mass of a star from its color. Use the H-R diagram to explain the life cycles of stars.  E5.2g Explain how the balance between fusion and gravity controls the evolution of a star (equilibrium).  E5.2h Compare the evolution paths of low, moderate and high mass stars using the H-R diagram.