**NEXT GENERATION SCIENCE STANDARDS – EARTH SYSTEMS**

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| **4.PSE Processes that Shape the Earth** |
| Students who demonstrate understanding can:  **a. Ask testable questions about the effects of moving water on the rate of erosion under various conditions and plan and carryout investigations to observe and document the effects.** [Clarification Statement: Examples of variables to test could be angle of slope, amount of vegetation, or volume of flow.] [Assessment Boundary: Ratios should not be included in quantitative analysis.]  **b. Obtain and communicate information about how patterns in tree rings and ice cores are used as evidence to describe the recent history of Earth’s climate.** [Assessment Boundary: Students not to be assessed on their understanding of deep time.]  **c. Use evidence to explain how the physical characteristics of local areas are affected by the processes of weathering and erosion, including the activities of living organisms.** [Clarification Statement: Examples of activities of living organisms could be tree planting, beaver dams, or human-built dams and waterways.]  **d. Use evidence to construct an explanation that some rocks and minerals are formed from the remains of organisms.**  **e. Use evidence from the fossil record to construct an explanation for the relationship between types of organisms living today and types of organisms that lived in the past.**  **f. Use evidence to construct explanations for how environments today may be different from past environments in which fossilized organisms once lived.** [Clarification Statement: Examples of evidence of environments that have changed could be seashell fossils found on mountains or petrified wood found in deserts.]  **g. Obtain information about the locations of a variety of Earth’s features and map the geographic patterns that emerge.** [Clarification Statement: Examples of features could be volcanoes and earthquakes that are often found at the boundaries of continents and the ocean floor or major mountain chains that often form near the edges of continents.]  **h. Analyze maps and other data to determine the likelihood of geological hazards occurring in an area and evaluate the possible effects on landforms and organisms.** [Assessment Boundary: Results of analysis and evaluation are qualitative.]  **i. Construct models, based on research, to test and refine various design solutions for reducing the impacts of geological hazards.** |

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| **5.ESI Earth Systems and Their Interactions** |
| Students who demonstrate understanding can:  **a. Obtain and communicate information about the various forms of water on Earth.** [Clarification Statement: The forms of water on Earth that students will address include vapor, fog or clouds in the atmosphere; rain or snow falling from clouds; ice, snow, and running water on land; moisture in soil and salt water in the ocean; and groundwater beneath the surface.] [Assessment Boundary: Focus is on the existence of different forms of water, not the cycling.]  **b. Use mathematical thinking to compare the relative abundance of salt water to fresh water and analyze data to identify the major locations of fresh water.**  **c. Construct models to describe systems interactions for the geosphere, hydrosphere, atmosphere, and biosphere and identify the limitations of the models.**  **d. Obtain and share information on the role of the ocean in supporting a variety of ecosystems and organisms, shaping landforms, and influencing climate.**  **e. Construct models to describe weather and climate patterns which are produced by the interactions among the atmosphere, the ocean, and landforms.**  **f. Obtain, evaluate, and communicate information describing the impacts human activities has on Earth’s systems and generate examples of actions individuals and communities have taken to conserve Earth’s resources and environments.**  **g. Design and evaluate a process or product to minimize unwanted outcomes of human activities on Earth’s systems, while increasing benefits and meeting societal demands.** [Clarification Statement: Examples of processes or products could be designing a cost-effective water filtration system that reduces pollutants in a river; or conducting an energy audit and developing a plan to reduce energy use.]  **h. Provide evidence to explain how increases in Earth’s temperature can affect humans and other organisms.** [Clarification Statement: Examples of effects on humans and other organisms can include changes in crop growing seasons, changes in coral reefs, and loss of habitat for penguins.] [Assessment Boundary: The Greenhouse effect and details of climate change are not included here.] |

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| **MS.ESS-HE The History of Earth** |
| Students who demonstrate understanding can:  **a. Construct explanations for patterns in geologic evidence to determine the relative ages of a sequence of events that have occurred in Earth’s past.** [Clarification Statement: Evidence can be field evidence or representations (e.g., model of geologic cross-sections). Events may include sedimentary layering, fossilization, folding, faulting, igneous intrusion, and/or erosion.]  **b. Use models of the geologic time scale in order to organize major events in Earth’s history.** [Clarification Statement: Models may be temporal (e.g., clock) or spatial (e.g., football field).] [Assessment Boundary: Memorization of specific periods or epochs of the geologic timescale is not intended.]  **c. Construct explanations from evidence for how different geologic processes shape Earth’s evolution over widely varying scales of space and time.** [Clarification Statement: Chemical erosion of a mountain occurs at molecular scales while mountain building can occur through large-scale tectonic processes; meteor impacts are nearly instantaneous, mountain building can take many millions of years. It is appropriate to use regional geographical features familiar to students.]  **d. Use empirical evidence from the rock and fossil records to investigate how past geologic events have caused major extinctions of life forms on Earth and how these extinctions have subsequently allowed other life forms to flourish.**  **e. Use models of the geosphere and biosphere that highlight system interactions to explain how the geosphere and biosphere coevolve over geologic time.** [Assessment Boundary: Use examples of weathering and erosion of land surfaces, composition of soils and atmosphere, and distribution of water in the hydrosphere.] |

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| **MS.ESS-EIP Earth’s Interior Processes** |
| Students who demonstrate understanding can:  **a. Use models to explain how the flow of energy drives a cycling of matter between Earth’s surface and deep interior.** [Assessment Boundary: The thermodynamic processes that drive convection are not required, only a description of those motions. Explanations should include mid-ocean ridges and ocean trenches.]  **b. Develop and use models of ancient land and ocean basin patterns to explain past plate motions.** [Assessment Boundary: Explanations should be based on fossil evidence, evidence from rock formations, continent shapes, and seafloor structures.]  **c. Use representations of current plate motions, based on data from modern techniques like GPS, to predict future continent locations.** [Clarification Statement: Representations may include maps.]  **d. Plan and carry out investigations that demonstrate the chemical and physical processes that form rocks and cycle Earth materials.** [Assessment Boundary: Students should use various materials to replicate, simulate, and demonstrate the processes of crystallization, heating and cooling, weathering, deformation, and sedimentation involved. Investigations should focus on connecting, correlating, and identifying parts of the rock cycle.]  **e. Construct explanations for how the uneven distribution of Earth’s mineral and energy resources, which are limited and often non-renewable, are a result of past and current geologic processes, including plate motions.**  **f. Analyze and interpret data sets to describe the history of natural hazards in a region to identify the patterns of hazards that allow for forecasts of the locations and likelihood of future events.** [Assessment Boundary: Hazards are limited to those resulting from Earth’s interior processes (e.g., volcanoes, earthquakes, tsunamis).] |

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| **MS.ESS-ESP Earth’s Surface Processes** |
| Students who demonstrate understanding can:  **a. Use models to explain how weathering, erosion, and deposition of Earth materials, by the movement of water, shape landscapes and create underground formations.** [Clarification Statement: Models may include maps.]  **b. Model multiple pathways for the cycling of water through the atmosphere, geosphere, and hydrosphere as it changes phase and moves in response to energy from the sun and the force of gravity.** [Assessment Boundary: Heat of vaporization and heat of condensation are not to be addressed.]  **c. Plan and conduct investigations to explain how temperature and salinity cause changes in density which affect the separation and movement of water masses within the ocean.** [Assessment Boundary: Complex system interactions such as the Coriolis Effect are not required.]  **d. Plan and carry out investigations of the variables that affect how water causes the erosion, transportation, and deposition of surface and subsurface materials as evidence of how matter cycles through Earth’s systems.**  **e. Apply scientific knowledge to design engineered solutions to natural hazards that result from surface geologic and hydrologic processes.** [Clarification Statement: Examples of natural hazards are flooding, avalanches, and landslides. Direct methods engineers use to control flooding include building artificial levees and dams.]  **f. Generate and revise causal explanations for how physical and chemical interactions among rocks, sediments, water, air, and organisms contribute to the weathering and erosion of rocks and the formation of soil.** |

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| **HS.ESS-HE History of Earth** |
| Students who demonstrate understanding can:  **a. Analyze determined or hypothetical isotope ratios within Earth materials to make valid and reliable scientific claims about the planet’s age, the ages of Earth events and rocks, and the overall time scale of Earth’s history.** [Assessment Boundary: Radiometric dating techniques using complex methods such as multiple isotope ratios are not included.]  **b. Construct an explanation, using plate tectonic theory, for the general trends of the ages of continental and oceanic crust and the patterns of topographic features.** [Clarification Statement: Trends of crustal ages involve the youngest seafloor rocks located at mid-ocean ridges and the oldest ocean rocks often located near continental boundaries, with age bands of rocks parallel across mid-ocean ridges. Major topographic features are ocean ridges, trenches, and hot spot islands.]  **c. Construct explanations about changes that occurred to Earth during the Hadean Eon based on data from Earth materials, planetary surfaces, and meteorites.** [Clarification Statement: Dynamic Earth processes have destroyed most of Earth’s very early rock record; however, lunar rocks, asteroids, and meteorites have remained relatively unchanged and provide evidence for conditions during Earth’s earliest time periods.]  **d. Construct scientific arguments to support the claim that dynamic causes, effects, and feedbacks among Earth’s systems result in a continual coevolution of Earth and the life that exists on it.** [Assessment Boundary: Students examine examples of feedbacks between Earth’s different systems to understand how life has coevolved with Earth’s surface (e.g., the atmosphere and biosphere affect the conditions for life, which in turn affects the composition of the atmosphere.] |

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| **HS.ESS-ES Earth’s Systems** |
| Students who demonstrate understanding can:  **a. Apply scientific reasoning to explain how geophysical, geochemical, and geothermal evidence was used to develop the current model of Earth’s interior.** [Clarification Statement: Evidence should include drill cores, gravity, seismic waves, and laboratory experiments on Earth materials.]  **b. Use a model of Earth’s interior and the mechanisms of thermal convection to explain the cycling of matter and the impact of plate tectonics on Earth’s surface.** [Assessment Boundary: Convection mechanisms should include heat from radioactive decay and gravity acting on materials of different densities as the drivers of convection and tectonic activity.]  **c. Analyze the impact of water on the flow of energy and the cycling of matter within and among Earth systems.** [Assessment Boundary: Should explore the unique physical and chemical properties of water, such as the polar nature of the molecule and water’s ability to absorb/store/release energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.]  **d. Use Earth system models to explain how Earth’s internal and surface processes work together at different spatial and temporal scales to form landscapes and sea floor features.**  **e. Construct an evidence-based claim about how a change to one part of an Earth system creates feedbacks that causes changes in other systems (e.g., coastal dynamics, watersheds and reservoirs, stream flow and erosion rates, changes in ecosystems).**  **f. Use mathematical expressions of phenomena to simulate how temperature, relative humidity, air pressure, and the dew point vary from the windward to the leeward side of a mountain range.** [Clarification Statement: The phenomena include latent heat, adiabatic heating/cooling, absolute/relative humidity, and dew point.]  **g. Use models to analyze data to make claims about how energy from the sun is redistributed throughout the atmosphere.** [Clarification Statement: Unequal heating of the atmosphere results in high and low pressure systems; air moves from areas of high pressure to low pressure; clockwise and counter-clockwise atmospheric circulations develop in response to Earth’s rotation (the Coriolis Effect).] |