**HS-ESS2 Earth’s Systems**

**HS-ESS2-1 Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.**

Further explanation: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). An example could be to utilize Maine Geologic maps, including tectonic maps, as data to create a model to illustrate how Maine’s land features or oceanic features were formed. Consider looking to Maine’s glacial history, features formed and materials deposited by glaciers.

Developing and Using Models, Plate Tectonics and Large-Scale System Interactions, Earth Materials and Systems, Stability and Change

**HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.**

Further explanation: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth’s surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; and how the loss of wetlands causes a decrease in local humidity that further reduces the wetlands’ extent. An example could consider timber harvesting practices related to erosion and water runoff issues, river damming, or coastal erosion of Maine’s beaches and dunes.

Analyzing and Interpreting Data, Earth Materials and Systems, Stability and Change

**HS-ESS2-3 Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection.**

Further explanation: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth’s three-dimensional structure obtained from seismic waves, records of the rate of change of Earth’s magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth’s layers from high-pressure laboratory experiments.

Developing and Using Models, Earth Materials and Systems, Plate Tectonics and Large-Scale System Interactions, Wave Properties, Energy and Matter

**HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.**

Further explanation: Examples of the causes of climate change differ by timescale, over 1-10 years; large volcanic eruptions, ocean circulation; 10s to 100s of years: changes in human activity, ocean circulation, solar output; 10s a-100s of thousands of years: changes to Earth’s orbit and the orientation of its axis; and 10s-100s of millions of years: long-term changes in atmospheric composition. Consider the climatic impacts of the Gulf stream and the Labrador currents on the Gulf of Maine, e.g. water temperature changes and fishing industry disruptions.

Developing and Using Models, Earth and the Solar System, Earth Materials and Systems, Weather and Climate, Scale, Proportion, and Quantity

**HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**

Further explanation: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide evidence for the connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Draw connections to Maine phenomena such as ice jams, frost heaves and potholes.

Planning and Carrying Out Investigations, The Role of Water in Earth’s Surface Processes, Structure and Function

**HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.**

Further explanation: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

Developing and Using Models, Weather and Climate, Energy and Matter

**HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.**

Further explanation: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth’s other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth’s surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; and how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

Engaging in Argument from Evidence, Weather and Climate, Biogeology, Stability and Change