HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ **Using mathematics and computational thinking** **Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.** • **Use mathematical and/or computational representations of phenomena or design solutions to support explanations.** ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Interdependent Relationships in Ecosystems:** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. • These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. • Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. • This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**HS-LS2-1** *Students who demonstrate understanding can:* **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** **Clarification Statement:** Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets. **Assessment Boundary:** Assessment does not include deriving mathematical equations to make comparisons.

Crosscutting Concepts: Scale, Proportion, and Quantity
• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data **❺ Using mathematics and computational thinking** **Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.** **• Use mathematical representations of phenomena or design solutions to support and revise explanations.** ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Interdependent Relationships in Ecosystems:** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. • These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. • Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. • This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **Ecosystem Dynamics, Functioning, and Resilience:** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. • If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. • Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**HS-LS2-2** *Students who demonstrate understanding can:* **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** **Clarification Statement:** Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. **Assessment Boundary:** The assessments should provide evidence of students' abilities to analyze and interpret the effect new information has on explanations (e.g., DDT effects on raptor populations, effects of water temperature below reservoirs on fish spawning, invasive species effects when spread to larger scale).

Crosscutting Concepts: Scale, Proportion, and Quantity
• Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data **❺ Using mathematics and computational thinking** **Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.** **• Use mathematical representations of phenomena or design solutions to support claims.** ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Cycles of Matter and Energy Transfer in Ecosystems:** • Plants or algae form the lowest level of the food web. • At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. • Given this inefficiency, there are generally fewer organisms at higher levels of a food web. • Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. • The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. • At each link in an ecosystem, matter and energy are conserved.	**HS-LS2-4** *Students who demonstrate understanding can:* **Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** **Clarification Statement:** Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. **Assessment Boundary:** The assessment should provide evidence of students' abilities to develop and use energy pyramids, food chains, food webs, and other models from data sets.

Crosscutting Concepts: Stability and Change

• Energy cannot be created or destroyed- it only moves between one place and another place, between objects and/or fields, or between systems.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
N/A	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) **❼ Engaging in argument from evidence** **Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.** **• Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.** ❽ Obtaining, evaluating, and communicating information	**Ecosystem Dynamics, Functioning, and Resilience:** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. • If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. • Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**HS-LS2-6** *Students who demonstrate understanding can:* **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** **Clarification Statement:** Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise. **Assessment Boundary:** The assessment should provide evidence of students' abilities to derive trends from graphical representations of population trends. Assessments should focus on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.

Crosscutting Concepts: Stability and Change

• Much of science deals with constructing explanations of how things change and how they remain stable.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	**MP.2** Reason abstractly and quantitatively. **HSS-ID.A.1** Represent data with plots on the real number line. **HSS-IC.A.1** Understand statistics as a process for making inferences about population parameters based on a random sample from that population. **HSS-IC.B.6** Evaluate reports based on data.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

ENVIRONMENTAL SCIENCE

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking **❻ Constructing explanations (for science) and designing solutions (for engineering)** **Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student- generated sources of evidence consistent with scientific ideas, principles, and theories.** • **Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Ecosystem Dynamics, Functioning, and Resilience:** • Anthropogenic changes (induced by human activity) in the environment can disrupt an ecosystem and threaten the survival of some species. **Biodiversity and Humans:** (secondary to HS-LS2-7) • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity. • Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. • Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **Developing Possible Solutions:** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	**HS-LS2-7** *Students who demonstrate understanding can:* **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment biodiversity.*** **Clarification Statement:** Examples of human activities can include urbanization, building dams, and dissemination of invasive species. **Assessment Boundary:** N/A

Crosscutting Concepts: Stability and Change

• Much of science deals with constructing explanations of how things change and how they remain stable.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	**MP.2** Reason abstractly and quantitatively. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-1 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ **Developing and using models** **Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.** • **Develop a model based on evidence to illustrate the relationships between systems or components of a system.** ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Earth Materials and Systems:** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **Plate Tectonics and Large-Scale System Interactions:** • Plate tectonics is the unifying theory that explains the past and current movements of rocks at Earth's surface and provides a framework for understanding its geologic history. • Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**HS-ESS2-1** *Students who demonstrate understanding can:* **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.** **Clarification Statement:** 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). **Assessment Boundary:** Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.

Crosscutting Concepts: Stability and Change

• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSF-IF.B.6** Calculate and interpret the average rate of change of function (presented symbolically or as a table) over specified interval. Estimate the rate of change from a graph.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-2 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations **❹ Analyzing and interpreting data** **Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.** **• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.** ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Earth Materials and Systems:** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **Weather and Climate:** • The foundation for Earth's global climate system is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	**HS-ESS2-2** *Students who demonstrate understanding can:* **Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks and interactions that cause changes to other Earth's systems.** **Clarification Statement:** Examples could be taken from system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion, which limits additional vegetation patterns; how dammed rivers increase ground-water recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent. Examples could also include climate feedbacks that increase surface temperatures through geologic time. **Assessment Boundary:** N/A

Crosscutting Concepts: Stability and Change

• Feedback (negative or positive) can stabilize or destabilize a system.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	**MP.2** Reason abstractly and quantitatively. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-3 Earth's Systems

Science & Engineering Practices

❶ Asking questions (for science) and defining problems (for engineering)
❷ **Developing and using models**
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
- **Develop a model based on evidence to illustrate the relationships between systems or components of a system.**

❸ Planning and carrying out investigations
❹ Analyzing and interpreting data
❺ Using mathematics and computational thinking
❻ Constructing explanations (for science) and designing solutions (for engineering)
❼ Engaging in argument from evidence
❽ Obtaining, evaluating, and communicating information

Disciplinary Core Ideas

Earth Materials and Systems:
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface features, its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust.
- Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

Plate Tectonics and Large-Scale System Interactions:
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection.
- Plate tectonics can be viewed as the surface expression of mantle convection.

Waves Properties:
(secondary to HS-ESS2-3)
- Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.

Performance Expectations

HS-ESS2-3
Students who demonstrate understanding can:

Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Clarification Statement:
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 the Earth's surface features as well as three-dimensional structure in the subsurface, 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.

Assessment Boundary:
N/A

Crosscutting Concepts: Energy and Matter
- Energy drives the cycling of matter within and between systems.

Oklahoma Academic Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-4 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations **❹ Analyzing and interpreting data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.** **• Analyze data using computational models in order to make valid and reliable scientific claims.** ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Earth and the Solar System:** (secondary to HS-ESS2-4) • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other changes in climate. **Earth Materials and Systems:** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **Weather and Climate:** • The foundation for Earth's global climate system is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	**HS-ESS2-4** *Students who demonstrate understanding can:* **Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate.** **Clarification Statement:** Changes differ by timescale, from sudden (large volcanic eruption, ocean circulation) to intermediate (ocean circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, and maps of global and regional temperatures, and atmospheric levels of gases. **Assessment Boundary:** N/A

Crosscutting Concepts: Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-5 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models **❸ Planning and carrying out investigations** **Planning and carrying out investigations in 9-12 builds on 6-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.** **• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.** ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**The Role of Water in Earth's Surface Processes:** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**HS-ESS2-5** *Students who demonstrate understanding can:* **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** **Clarification Statement:** Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for 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, or 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). **Assessment Boundary:** N/A

Crosscutting Concepts: Structure and Function

• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-6 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ **Developing and using models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.** • **Develop a model based on evidence to illustrate the relationships between systems or components of a system.** ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Biogeology:** • Organisms ranging from bacteria to human beings are a major driver of the global carbon and they influence global climate by modifying the chemical makeup of the atmosphere. • The abundance of carbon in the atmosphere is reduced through the ocean floor accumulation of marine sediments and the accumulation of plant biomass.	**HS-ESS2-6** *Students who demonstrate understanding can:* **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** **Clarification Statement:** 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. **Assessment Boundary:** N/A

Crosscutting Concepts: Energy and Matter

• The total amount of energy and matter in closed systems is conserved.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
N/A	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS2-7 Earth's Systems

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) **❼ Engaging in argument from evidence** **Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.** **• Construct an oral and written argument or counter- arguments based on data and evidence.** ❽ Obtaining, evaluating, and communicating information	**Weather and Climate:** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **Biogeology:** • The many dynamic and delicate feedback mechanisms between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.	**HS-ESS2-7** *Students who demonstrate understanding can:* **Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth.** **Clarification Statement:** Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors influence conditions for 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 affected animal life; how microbial life on land increased the formation of soil, which in turn allowed for the development of land plant species; or how the changes in coral species created reefs that altered patterns of erosion and deposition along coastlines and provided habitats to support biodiversity. Geologic timescale should be considered with the emphases above. **Assessment Boundary:** Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.

Crosscutting Concepts: Stability and Change
• Much of science deals with constructing explanations of how things change and how they remain stable.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
WHST.9-12.1 Write arguments focused on discipline-specific content.	**N/A**

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS3-1 Earth and Human Activities

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking **❻ Constructing explanations (for science) and designing solutions (for engineering)** **Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student- generated sources of evidence consistent with scientific ideas, principles, and theories.** • **Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.** ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Natural Resources:** • Resource availability has guided the development of human society. **Natural Hazards:** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.	**HS-ESS3-1** *Students who demonstrate understanding can:* **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** **Clarification Statement:** Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised. **Assessment Boundary:** N/A

Crosscutting Concepts: Cause and Effect

• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	**MP.2** Reason abstractly and quantitatively. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS3-2 Earth and Human Activities

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) **❼ Engaging in argument from evidence** **Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.** • **Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).** ❽ Obtaining, evaluating, and communicating information	**Natural Resources:** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **Developing Possible Solutions:** (secondary to HS-ESS3-2) • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**HS-ESS3-2** *Students who demonstrate understanding can:* **Evaluate competing design solutions for developing, managing, and utilizing natural resources based on cost-benefit ratios.*** **Clarification Statement:** Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). **Assessment Boundary:** N/A

Crosscutting Concepts:
• N/A

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	**MP.2** Reason abstractly and quantitatively.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS3-3 Earth and Human Activities

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data **❺ Using mathematics and computational thinking** **Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.** **• Create a computational model or simulation of a phenomenon, design device, process or system.** ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Human Impacts on Earth Systems:** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**HS-ESS3-3** *Students who demonstrate understanding can:* **Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.** **Clarification Statement:** Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of consumption, and urban planning. **Assessment Boundary:** Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

Crosscutting Concepts: Stability and Change
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
N/A	**MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-ESS3-4 Earth and Human Activities

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ Planning and carrying out investigations ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking **❻ Constructing explanations (for science) and designing solutions (for engineering)** **Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student- generated sources of evidence consistent with scientific ideas, principles, and theories.** **• Design or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations.** ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Human Impacts on Earth Systems:** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.	**HS-ESS3-4** *Students who demonstrate understanding can:* **Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.*** **Clarification Statement:** Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use. Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions. **Assessment Boundary:** N/A

Crosscutting Concepts: Stability and Change

• Feedback (negative or positive) can stabilize or destabilize a system.

Oklahoma Academic Standards Connections

ELA/Literacy	Mathematics
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	**MP.2** Reason abstractly and quantitatively. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.