PISCATAWAY
TOWNSHIP SCHOOLS

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Environmental Science

Content Area: Science
Grade Span: 10-12
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COURSE OVERVIEW

Description

This is an elective course in Environmental Science for 2.5 credits, which is intended to provide students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them. Students explore connections between current infrastructure such as roads, power systems, tap water systems, and buildings to environmental issues such as water quality, biodiversity, natural resource use, and climate. Using a project-based approach, students analyze each topic through the lens of specific local, state, or national scenarios.

Goals

Students in this course will be introduced to the interrelationships of the natural world. They will be able to identify and analyze both natural and human-made environmental problems. They will work to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving or preventing them. The crosscutting concepts of Cause and Effect, Systems and System Models, and Stability and Change are called out as organizing concepts for this course's disciplinary core ideas. Students demonstrate proficiency in Developing and Using Models; Using Mathematical and Computational Thinking, and Constructing Explanations; and to use these practices to demonstrate understanding of the core ideas.

Scope and Sequence

Unit	Topic	Length
1	Energy, Water, and Natural Resources	17 blocks
2	Climate Change	12 blocks
3	Land Use	4 blocks
4	Natural Hazards	6 blocks

UNIT 1: ENERGY, WATER, AND NATURAL RESOURCES

Summary and Rationale

This unit focuses on natural resources and their use by humans. Students first explore the difference between renewable and non-renewable resources, and how human behavior and societal rules relate to resource use through the “tragedy of the commons” concept. Students will conduct a hands-on simulation of the extraction of a mineral resource from its ore. Next students focus on the natural resource of freshwater, learning about the distribution of Earth’s freshwater, the system of the Lower Raritan River watershed basin, and how the local tap water and wastewater systems function. Finally, students will learn about the power grid and the various ways that natural resources are used to generate electricity, including coal, natural gas, nuclear, solar, wind, hydroelectric, geothermal, and biomass. Pros and cons of each power source will be explored, and students will conduct design projects related to electricity generation. Students will investigate how electricity is produced in New Jersey and the United States in comparison to other state and country' power generation methods.

Recommended Pacing

17 blocks

State Standards

HS-ESS2-5 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).
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral 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). Science knowledge indicates what can happen in natural systems—not what should happen.
HS-ESS3-4 Evaluate or refine a technological solution that reduces 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 (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Structure and Function (HS-ESS2-5)
- Stability and Change (HS-ESS3-4)
- ***Connections to Engineering, Technology, and Applications of Science:*** Influence of Engineering, Technology, and Science on Society and the Natural World
- ***Connections to Nature of Science:*** Science Addresses Questions About the Natural and Material World

Unit Essential Questions

- How can humans use natural resources sustainably?
- How is electricity produced in New Jersey compared to other countries or states? What natural resources are used to produce electricity?
- Where does our tap water come from? Where does our water go after it goes down the drain?

Objectives

Students will know (DCIs):

- **The Roles 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.
- **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.
- **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.
- **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.
- **Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Students will be able to (SEPs):

- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence

UNIT 2: CLIMATE CHANGE

Summary and Rationale

This unit focuses on Earth's climate and climate change. Students first learn about the difference between weather and climate, and then analyze New Jersey state climate data to determine long term trends and changes. Next, various types of evidence of climate change will be explored through data-based student projects, with an emphasis on identifying positive and negative feedback loops. Examples of feedback include how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, thus reducing the amount of sunlight reflected from Earth's surface, which in turn increases surface temperatures and further reduces the amount of ice.Students will then go on to learn about causes of climate change on Earth, beginning with natural causes of long-term and short-term climate change, such as volcanic eruptions and changes in Earth's orbit, and then moving on to the greenhouse effect and the increase of atmospheric greenhouse gas levels. Students will investigate the connection between the carbon cycle, combustion of fossil fuels and deforestation, atmospheric carbon dioxide levels, and global temperatures through computer model simulations and experiments. Finally students will explore various adaptation and mitigation solutions to climate change, focusing on solutions that are currently being implemented or considered in New Jersey. Example mitigation solutions include technologies such as electric vehicles, hydrogen fuel cell vehicles, wind turbines, and advanced battery designs.

Recommended Pacing

12 blocks

State Standards

HS-LS2-4 Use mathematical representations 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	Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.
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.	
Clarification Statement	Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.
Assessment Boundary	Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.
HS-ESS3-4 Evaluate or refine a technological solution that reduces 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 (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	
Clarification Statement	Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).
Assessment Boundary	Assessment is limited to one example of a climate change and its associated impacts
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity	
Clarification Statement	Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.
Assessment Boundary	Assessment does not include running computational representations but is limited to using the published results of scientific computational models.
HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	
HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	
HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Energy and Matter (HS-LS2-4)
- Cause and Effect (HS-ESS2-4)
- Systems and System Models (HS-ETS1-4), (HS-ESS3-6)
- Stability and Change (HS-ESS3-5), (HS-ESS3-4)
- ***Connections to Engineering, Technology, and Applications of Science:*** Influence of Science, Engineering, and Technology on Society and the Natural World

Unit Essential Questions

- How is our climate changing?
- Why is our climate changing?
- How is New Jersey reducing and preparing for climate change?

Objectives

Students will know (DCIs):

- **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.
- **Weather and Climate** The foundation for Earth's global climate systems 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. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

- **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.
- **Global Climate Change** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.
- **Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
- **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. Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Students will be able to (SEPs):

- Asking Questions and Defining Problems
- Analyzing and Interpreting Data
- Developing and Using Models
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions

UNIT 3: LAND USE

Summary and Rationale

This unit focuses on land use decisions by humans and the impact of land use on surrounding ecosystems. Students develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface, and how humans impact those systems. Students will learn about the different ways that humans use lands, urban, suburban, and rural land use and the various methods of land management and conservation. The urban heat island effect, the environmental effects of deforestation, and the connection between land use and biodiversity will be discussed. Student projects will include creating land use models, soil experiments, and researching local land use issues.

Recommended Pacing

4 blocks

State Standards

HS-ESS3-3 Create a computational simulation to illustrate the relationships 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 conservation, and urban planning.
Assessment Boundary	Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

HS-ESS3-4 Evaluate or refine a technological solution that reduces 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 (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Stability and Change (HS-ESS3-3), (HS-ESS3-4)
- ***Connections to Engineering, Technology, and Applications of Science:*** Influence of Engineering, Technology, and Science on Society and the Natural World
- ***Connections to Nature of Science:*** Science is a Human Endeavor

Unit Essential Questions

- How is land used in Piscataway and around the globe?
- How does land use affect nearby ecosystems and global Earth systems?

Objectives

Students will know (DCIs):

- **Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
- **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.

Students will be able to (SEPs):

- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions

UNIT 4: NATURAL HAZARDS

Summary and Rationale

In this unit students construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards are connected to human activity. Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the significant environmental impacts of human activities. Additionally, while students are exploring this idea they apply scientific and engineering ideas to design, evaluate, and refine a device that can be used to minimize the impacts of natural hazards. Students will explore and compare how natural hazards have influenced human activity in specific states and countries.

Recommended Pacing

6 blocks

State Standards

HS-ESS3-1 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). 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.

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Cause and Effect (HS-ESS3-1)
- ***Connections to Engineering, Technology, and Applications of Science:*** Influence of Engineering, Technology, and Science on Society and the Natural World

Unit Essential Questions

- What are the impacts of natural hazards and other geologic events on the globe and the human population?
- What natural hazards are most common in New Jersey and how do these hazards affect humans?

Objectives

Students will know (DCIs):

- **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.

Students will be able to (SEPs):

- Constructing Explanations and Designing Solutions