



Statewide Framework Document for:

**011201 Soil Chemistry**

Standards may be added to this document prior to submission but may not be removed from the framework to meet state credit equivalency requirements. Performance assessments and leadership alignment may be developed at the local level. In order to earn state approval, performance assessments must be submitted within this framework. **This course is eligible for one credit of lab science.** The Washington State Science Standards performance expectations for high school blend core ideas (Disciplinary Core Ideas, or DCIs) with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs) to support students in developing usable knowledge that can be applied across the science disciplines. These courses are to be taught in a three-dimensional manner. The details about each performance expectation can be found at Next Generation Science Standards, and the supporting evidence statements can be found under Resources.

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| **School District Name** |
| **Course Title:** Soil Chemistry | **Total Framework Hours:** 180 |
| **CIP Code:** 011201 | **[x]** Exploratory **[ ]** Preparatory | **Date Last Modified:** March 31, 2021 |
| **Career Cluster:** Agriculture, Food and Natural Resources | **Cluster Pathway:** Plant Systems  |
| **Course Summary**: Soil Chemistry is a course that focuses on the scientific principles of chemistry that underlie the cultivation and production of agricultural plants through soil. Students will also learn about the production, processing, and distribution of nutrients through soil for plant products. Student will get the chance to address the soil and environmental impacts of wildfires. Instruction in the soil sciences includes crop cultivation, nutrient availability and uptake. As with all agriculture courses, instruction, and assessment in the Supervised Agriculture Experience (SAE) is a requirement. The Supervised Agriculture Experience includes placing a student in a position where he or she will learn the practices of entrepreneurship and the fundamentals of research and experimentation in the agricultural field. Participants in the SAE will conduct exploratory projects with the purpose of learning about and improving practices in their surroundings.SAE.01. This course will include instruction and Student involvement in Supervised Agriculture Experience Projects (SAE). |
| **Eligible for Equivalent Credit in:** Science | **Total Number of Units:** 7 |
| **Course Resources:** <http://www.piercecountyscd.org/uploads/8/9/0/7/89072058/0046_001.pdf><http://www.piercecountyscd.org/uploads/8/9/0/7/89072058/healthysoilsarewellstructured.pdf><http://www.piercecountyscd.org/uploads/8/9/0/7/89072058/healthysoilsarehighinorganicmatter.pdf><http://www.piercecountyscd.org/uploads/8/9/0/7/89072058/5principlesofsoilhealth.pdf>Unit 2: <https://cropwatch.uni.edu/tillage>Unit 4: Atrazine research: Atrazine Use and Weed Management Strategies to Protect Surface Water Quality<https://ppp.purdue.edu/wp-content/uploads/2016/08/PPP-67.pdf> Eating at You: Food and Chernobyl<https://origins.osu.edu/milestones/april-2016-eating-you-food-and-chernobyl> [Chemistry of pH and soils metals and how they affect Hydrangea coloration](https://opentextbc.ca/introductorychemistry/chapter/shifting-equilibria-le-chateliers-principle-2/) |
| **Unit 1:** What is Soil? | **Total Learning Hours for Unit:** 20 |
| **Unit Summary**: This unit will be assessed throughout the school year and culminate with the students designing and implementing a scientific investigation related to soil chemistry within agriculture. Students learn about soil structure by conducting investigations to discover what elements make up soil and at what proportions. Students discover the different types of soil (sand, clay, silt, peat, chalk, loam) through observations and investigation and understand how the different soil types relate to agriculture. Students plan and conduct investigations to discover the effect of different soils on the growth of plant or crop varieties. Students explore soil maps in Washington state to discover the range of soil types in the state. They compare soil maps with agricultural/crop maps to determine what soils are best suited for growing which crops, and what lands are best suited for agricultural use in Washington. Students will understand the role of photosynthesis in cycling carbon. Students will explore how carbon is stored in and moves through soil. Students understand the role of water in the carbon cycle and soil related processes, including soil chemistry. Students understand the significant role of water and water availability in the carbon cycle, soil structure, and agricultural management practices. Students learn about jobs involved in the unit-specific areas of agriculture focus (agronomists, hydrologists, climatologists etc.) Students cover lab safety in this unit. |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Classify soil structure by observing, interacting with, and constructing explanations of the different soil types and their makeup.
* Model soil structure and label the different types of soil with the percentages of different components
* Students map their own region and classify the soil types in their community, along with the agricultural crops grown in the region, or what crops might grow well, based on the soil type.
* Conduct a field investigation to classify the soil in three different places: at school, at home, and in one other location in their community.
* Model the carbon cycle, with an emphasis on the role of photosynthesis, and how carbon is stored in and moves through soil.
* Investigate and construct explanations based on the concepts of soil texture and structure and its impact on functions of soil.
* Design and implement a crop test plot to investigate the effect of different soil fertility/amendment practices on crop fertility across the unit. Iterate on the practices to determine an optimal design solution.
* Research unit-related agriculture career opportunities that interest them.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Examples:*Through team-based activities relating to soil chemistry careers, students:* Accurately determine soil texture and structure for a given field location.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.)
* Make judgments and decisions through the land evaluation (soil judging) career development events.

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies**:**Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>PS.01.02.01.b. Describe the physical and chemical characteristics of growing media and explain the influence they have on plant growth. PS.01.03.06.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.). PS.01.03.06.b. Assess and describe the impact environmental factors have on a crop.ESS.03.03.01.a. Examine and summarize how chemistry affects soil structure and function (e.g., pH, cation-exchange capacity, filtration capability, flooding likelihood, etc.). ESS.03.03.01.b. Analyze the soil chemistry of sample. ESS.05.02.02.b. Assess different measurements of soil quality (e.g., soil horizons, soil texture, organic matter, soil respiration, etc.) to determine their effectiveness and limitations. ESS.05.02.02.c. Evaluate a sample of soil to determine its quality and if it has been contaminated.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Developing and Using Models |
| Planning and Carrying Out Investigations |
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| PS3.D: Energy in Chemical Processes and Everyday Life  |
| LS2.B:  Cycles of Matter and Energy Transfer in EcosystemsESS2.C:  The Roles of Water in Earth’s Surface Processes |

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| Structure and Function |

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|  Systems and System Models |
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| **Unit 2:** Matters, Elements and Structures in Soil | **Total Learning Hours for Unit:** 20 |
| **Unit Summary**: In this unit, students deepen their journey into the world of soil chemistry at the atomic level. They understand that matter is made up of atoms composed of specific subsystems and structures. They understand how atoms interact to build molecules and larger elements that make up living and nonliving elements of soil, such as water, plants, animals, and rocks.  Students are introduced to the periodic table and its structure. Students understand the properties of elements, especially those in soil that are used by plants. Students understand that certain elements of the periodic table are commonly found in soil and that these elements are highly relevant to agriculture. Students return to the concept of carbon in the soil and build their understanding of carbon as an element in the periodic table, then expand their exploration of the periodic table to other elements and their applications in soil science.Students understand the implications of till versus no till agricultural systems on soil structure, and the role of mycorrhizae in the soil as well as the effects of synthetic pesticide use on these systems. They use discourse to understand the complexity of agricultural management practices and their impacts on soil health. Students research cost-benefit ratios of till versus no-till agriculture, the equipment and materials required for each, and feedback loops caused by the different systems.  Students learn about jobs involved in the unit-specific areas of agriculture focus.  |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Develop a model of soil, with attention to the living and nonliving parts of soil and the molecular structure of different elements in the soil.
* Construct an explanation about the relationship between atomic properties and the impacts of the uses of different elements’ in agriculture.
* Model on a periodic table the elements that are most important in agriculture.  Which are commonly found in soil? Which are found on Earth but not used in agriculture, and why?
* Model the role of water in soil chemistry, with a focus on its ability to dissolve and transport materials and how that impacts soil chemistry or best practices for managing soil in agricultural systems.
* Construct an argument for or against tilling and/or synthetic inputs (e.g. pesticides or synthetic fertilizer) given different agricultural situations and soils and their effects on plants and agriculture,
* Model to compare the effect of tilling and not tilling and/or synthetic inputs (e.g. pesticides or synthetic fertilizer) on soil elements and structures and the resulting effects on plants and agriculture.
* Investigate the effects of tilling and not tilling on soil and its makeup/proportions and the resulting effects on plants and agriculture.
* Research unit-related agriculture career opportunities that interest them.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Use reasoning skills to determine different type of chemical reactions and how they are used in soil science.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.)

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies**:**Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>PS.01.02.01.b. Describe the physical and chemical characteristics of growing media and explain the influence they have on plant growth. PS.01.02.02.b. Discuss how soil drainage and water-holding capacity can be improved. ESS.03.02.02.a. Research and describe the process of soil formation through weathering ESS.03.02.02.b. Differentiate rock types and relate the chemical composition of mineral matter in soils to the parent material. ESS.03.02.03.a. Examine and explain how the physical qualities of the soil influence the infiltration and percolation of water. ESS.03.02.03.b. Assess the physical qualities of the soil that determine its potential for filtration of groundwater supplies and likelihood for flooding. ESS.03.03.01.a. Examine and summarize how chemistry affects soil structure and function (e.g., pH, cation-exchange capacity, filtration capability, flooding likelihood, etc.). ESS.03.03.01.b. Analyze the soil chemistry of sample. ESS.03.03.01.c. Evaluate a sample’s soil chemistry and assess how the results may impact considerations in environmental service systems. ESS.05.02.02.b. Assess different measurements of soil quality (e.g., soil horizons, soil texture, organic matter, soil respiration, etc.) to determine their effectiveness and limitations. ESS.05.02.02.c. Evaluate a sample of soil to determine its quality and if it has been contaminated.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outer most energy levels of atomsHS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.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. |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Developing and Using Models |  |
| Constructing Explanations and Designing Solutions |  |

 Analyzing and Interpreting Data |

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| PS1.A: Structure and Properties of Matter  |
| PS1.B: Chemical ReactionsPS3.D:  Energy in Chemical Processes and Everyday LifeLS2.B:  Cycles of Matter and Energy Transfer in EcosystemsESS2.A:  Earth Materials and Systems |
| PS2.B: Types of Interactions |

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| Patterns |  |
| Systems and System Models |  |

 Stability and Change |

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| **Unit 3:** Molecular Structures and Properties of Soil | **Total Learning Hours for Unit:** 25 |
| **Unit Summary**: Students identify and quantify the presence of carbon in the lithosphere, biosphere, hydrosphere and the processes by which it cycles throughout the parts of a system. Students understand the molecular flow of matter between soil, plants, and other ecosystem components. Students write and balance chemical equations to represent the chemical reactions occurring in soil and in plants. Students understand that matter is neither created nor destroyed in the process of chemical reactions. Students understand the functions of molecules in making proteins for soil and plant structures.They learn about jobs involved in the unit-specific areas of agriculture focus. |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Model the components of a system using an example provided in class.
* Construct an explanation based on evidence that identifies boundaries and conditions of the system.
* Provide an explanation that defines the system’s inputs and outputs.
* Create models of molecular formulas and use them to display the molecular structures of soil and soil amendments.
* Construct an explanation of the relationship between a molecule or chemical compound and a structural formula (graphic representation of the molecular structure) in the soil.
* Given a molecule or compound, students build a structural formula (graphic representation of the molecule) to articulate the atomic structure and bonds of the molecule or compound in the soil.
* Develop a model that shows how elements brought from the soil are made into stronger double and triple bonded molecules.
* Evaluate different types of chemical reactions and explain where they are used in soil science.
* Be able to write and properly balance chemical equations to demonstrate the understanding of conservation of matter and energy during chemical reactions.
* Develop a model that shows the movement of energy during photosynthesis and its impact on energy in a soil system.
* Research unit-related agriculture career opportunities that interest them.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Communicate the pros and cons of forms of fertilizers used in plant production.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.).
* Analyze different media resources.

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies:****Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>PS.01.02.01.b. Describe the physical and chemical characteristics of growing media and explain the influence they have on plant growth. PS.01.02.02.a. Identify the categories of soil water. PS.01.02.02.b. Discuss how soil drainage and water-holding capacity can be improved. PS.01.03.01.a. Identify the essential nutrients for plant growth and development and their major functions (e.g., nitrogen, phosphorous, potassium, etc.). PS.01.03.04.a. Identify fertilizer sources of essential plant nutrients; explain fertilizer formulations, including organic and inorganic; and describe different methods of fertilizer application. PS.01.03.04.b. Calculate the amount of fertilizer to be applied based on nutrient recommendation and fertilizer analysis. PS.01.03.06.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.). PS.01.03.06.b. Assess and describe the impact environmental factors have on a crop.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and Biosphere.HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Developing and Using Models |
| Constructing Explanations and Designing Solutions |
| Using Mathematics and Computational Thinking |

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|  ESS2.D: Weather and Climate |

 PS1.B:  Chemical Reactions LS1.C:  Organization for Matter and Energy Flow I in Organisms |

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| Systems and System Models |  |
| Energy and Matter |  |

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| **Unit 4:** Understanding Chemical Reactions Common in Soil | **Total Learning Hours for Unit:** 35 |
| **Unit Summary**: Students understand solutions, types of solutions, and solution concentrations as a means to understand soil amendments and their properties. Students identify and understand phases and phase changes and their impacts on soil amendments such as fertilizers (liquid, granular, and gas). Students understand the effects of agriculture on the soil and how soil amendments and fertilizer impact and/or change soil chemistry and affect food production. Students distinguish between different nutrient toxicity and deficiency symptoms. Students use moles and calculate the Cation and Anion exchange capacities of ~~a~~ soil. Students learn about pH, the pH scale and how pH affects soil and plant production, as well as how to neutralize pH in soil.Students understand isotopes and how those can impact plant production through soil, as well as how electron movement, transition metals, and bonds affect element uptake by plants from the soil. Students learn about jobs involved in the unit-specific areas of agriculture focus. |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Compare and contrast using models how liquid and solid soil amendments act and function at the molecular level to impact soil chemistry and fertility.
* Use computational thinking to construct an explanation for how gas pressure, density, and different gas laws impact gaseous fertilizers and amendments.
* Using evidence, argue the pros and cons of each of the different forms of fertilizers used in plant production (e.g. gas, liquid, or solid).
* Analyze chemical reaction data and interpret the results to describe the impact of those reactions on soil nutrients and fertility.
* Use mole ratios and discuss excess and limiting factors related to soil nutrients.
* Read and interpret a variety of fertilizer labels and use them as evidence to explain desired trace elements and their ratios in different agricultural soils and/or systems.
* Given novel scenarios, develop and explain multiple strategies to address soil imbalances in different situations (e.g. soil deficiencies or soil toxicity).
* Communicate the role of solutions, types of solutions, and solution concentrates, to articulate their role as soil amendments in soil chemistry.
* Plan an investigation to identify the pH of given soil, soil amendments, and other factors used in plant production.
* Use titrations as a means of carrying out an investigation of soil.
* Solve stoichiometry problems as they relate to soil chemical reactions.
* Investigate and analyze the effects of changes to soil chemistry on microbial activity.
* Construct a model that shows cation and anion exchange capacities in a soil.
* Obtain information about the different types of chemical bonding and develop an argument describing how those bonds have an effect on molecular/compound use in agricultural production and conservation.
* Design a biological or non-synthetic approach to increasing nutrient availability and/or crop yield in a farm system and include a cost-benefit ratio analysis of this practice.
* Research unit-related agriculture career opportunities that interest them.
* Research and explain how the eruption of Mt. St. Helens affected soil chemistry and created a new agricultural industry in Eastern Washington.
* Research and explain why Walla Walla onions have their distinctive flavor and quality.  Use examples and evidence to explain how soil chemistry and environmental factors work together to create this specific crop product?
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Make decisions to adjust the PH for specific plants or crops.
* Analyze how poor soil impacts farmers unable to improve soil nutrients due to costs.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.).

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies:****Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>ESS.05.02.02.b. Assess different measurements of soil quality (e.g., soil horizons, soil texture, organic matter, soil respiration, etc.) to determine their effectiveness and limitations. ESS.05.02.02.c. Evaluate a sample of soil to determine its quality and if it has been contaminated. PS.01.03.04.a. Identify fertilizer sources of essential plant nutrients; explain fertilizer formulations, including organic and inorganic; and describe different methods of fertilizer application. PS.01.03.04.b. Calculate the amount of fertilizer to be applied based on nutrient recommendation and fertilizer analysis. PS.01.03.06.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.). PS.01.03.02.a. Discuss the influence of pH and cation exchange capacity on the availability of nutrients. PS.01.03.02.b. Contrast pH and cation exchange capacity between mineral soil and soilless growing media.PS.01.03.02.c. Adjust the pH of growing media for specific plants or crops. PS.01.03.03.a. Collect soil and plant tissue samples using generally accepted procedures and explain how incorrect sample collection will affect the results of a laboratory analysis. PS.01.03.03.b. Interpret laboratory analyses of soil samples. PS.01.03.03.c. Prescribe fertilizer applications based on the results of a laboratory analysis of soil and plant tissue samples.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.HS-PS-1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios (engineering). |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Engaging in Argument from Evidence |  |
| Constructing Explanations and Designing Solutions |  |
| Using Mathematics and Computational Thinking |  |
| Planning and Carrying Out Investigations |  |
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| PS1.A: Structure and Properties of Matter  |
| PS2.B: Types of Interactions |

PS1.B:  Chemical ReactionsLS1.A:  Structure and FunctionESS3.A:  Natural ResourcesETS1.B:  Developing Possible Solutions |

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| Patterns |  |
| Influence of Engineering, Technology, and Science on Society and the Natural World |  |
| Science Addresses Questions About the Natural and Material World |  |
| Energy and Matter |  |
| Stability and Change |  |

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| **Unit 5:** Energy and Matter Flow through Soil  | **Total Learning Hours for Unit:** 30 |
| **Unit Summary**: Students explore the concept of energy flow and its effect on soil and agricultural systems.Students investigate the effects of slash-and-burn agricultural practices, and wildfire, on soil and soil chemistry. Add burning of ag fields specifically. They understand the laws of thermodynamics, endothermic and exothermic reactions in soils, heat capacity and the heat curve of water. Students understand the different reactions dealing with energy- especially combustion and oxidation-reduction in soils. Students investigate reaction rates and the assistance of catalysts in rates of the reactions. Students discover how soil is related to feedback mechanisms and homeostasis in crop and/or soil systems. Students understand the role of soil chemical influences on food production. Students learn about jobs involved in the unit-specific areas of agriculture focus.  |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Ask questions abou~~t~~ energy and the function of its different forms in agricultural systems different forms.
* Communicate the role of heat transfer in soil chemistry
* Plan and carry out investigations on calorimetry within different agronomic~~al~~ crops.
* Communicate how reaction rates are measured in soil.
* Argue that catalysts have a cause and effect relationship on reaction rates within a soil system.
* Construct an explanation and/or model to explain and show oxidation-reduction reactions and how they impact iron or other metal resources in our soil.
* Create a computational model to demonstrate that energy is neither created nor destroyed when it flows into and/or out of systems.
* Plan and conduct an investigation to demonstrate that feedback mechanisms maintain homeostasis in crop and/or soil systems.
* Engage in an argument, based on evidence, of the pros and cons of slash-and-burn as it pertains to the plant or animal production industry. What are the costs and benefits of this approach?
* Evaluate and communicate the soil benefits and agricultural impacts of wildfires.
* Research unit-related agriculture career opportunities that interest them.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Develop a sense of global awareness by researching both controlled burns and wildfires and how they impact countries around the world.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.).

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information  |
| **Industry Standards and/or Competencies:****Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>NRS.04.04.01.a. Differentiate between desirable and undesirable fires and research the role fire plays in a healthy ecosystem. NRS.04.04.01.b. Assess and apply techniques used to fight wild fires, manage prescribed fires and ensure human safety. NRS.04.04.01.c. Develop a prevention plan for harmful fires for a particular region. NRS.04.04.02.a. Research and summarize how fire management techniques have evolved. NRS.04.04.02.b. Assess the effectiveness of techniques previously and currently used to prevent harmful fires. NRS.04.04.02.c. Anticipate and predict how fire management techniques will evolve in the future. PS.01.03.06.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.). PS.02.03.01.b. Apply knowledge of photosynthesis to analyze how various environmental factors will affect the rate of photosynthesis. PS.02.03.01.c. Evaluate the impact of photosynthesis and the factors that affect it on plant management, culture and production problems. PS.02.03.02.b. Analyze the factors that affect cellular respiration processes and rate in a crop production setting. PS.02.03.02.c. Evaluate the impact of plant respiration on plant growth, crop management and post-harvest handling decisions.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.HS- PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Developing and Using Models |
| Using Mathematics and Computational Thinking |
| Planning and Carrying Out Investigations |
| Scientific Investigations Use a Variety of Methods |

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| Constructing Explanations and Designing Solutions |
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| PS1.A: Structure and Properties of Matter |
| PS1.B: Chemical ReactionsPS3.A:  Definitions of EnergyPS3.B:  Conservation of Energy and Energy TransferLS1.A:  Structure and Function |
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| Stability and Change |  |
| Scientific Knowledge Assumes an Order and Consistency in Natural SystemsPatterns |  |
| Energy and Matter |  |
| System and System Models |  |
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| **Unit 6:** Understanding Chemical Equilibrium in Soil | **Total Learning Hours for Unit:** 30 |
| **Unit Summary**: Students understand reversible reactions and their role in soil chemistry and plant production. Students understand ion exchange in soil as a reversible reaction. They also investigate chemical equilibrium and how this impacts nutrient uptake from soil during plant production. Students investigate stressing chemical equilibrium through variables such as states of matter, temperature, soil metals, and pH, and discover the effects on plant appearance and growth (e.g. Hydrangea coloration.) Students model cation and anion exchange in soil, as well as how that impacts fertility in soils around the world. Students research and develop an agricultural management plan for ~~a~~ different soil types in order to achieve and maximize successful crop production.Students learn about jobs involved in the unit-specific areas of agriculture focus.  |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** Develop a model that shows reversible processes and explains their role in maintaining homeostasis within a soil ecosystem.
* Construct an explanation for soil fertility/nutrient availability in soil based on reversible processes.
* Construct an explanation of chemical equilibrium and how it impacts soil fertility and crop yield.
* Analyze and interpret how changing conditions can impact chemical equilibrium.
* Research and communicate how a soil in a given soil system scenario can be amended properly to have success in crop production in a culminating project.
* Calibrate fertilizer system(s) in a greenhouse environment.
* Design and implement a crop test plot to investigate the effect of different soil fertility/amendment practices on crop fertility. Iterate on the practices to determine an optimal soil fertility design solution that maximizes crop health and yield. Identify trade-offs and include cost-benefit analysis in your analysis,
* Use mathematical representations of chemical formulas to demonstrate that atoms, and mass, are conserved during a chemical reaction.
* Research unit-related agriculture career opportunities that interests them.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Research and communicate how a soil in a given soil system scenario can be amended properly to have success in crop production.
* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.).

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies**:**Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>NRS.01.05.04.c. Devise a soil management plan to minimize erosion and maximize biodiversity, plant productivity, and the formation of topsoil. PS.01.02.01.c. Formulate and prepare growing media for specific plants or crops. PS.01.03.03.c. Prescribe fertilizer applications based on the results of a laboratory analysis of soil and plant tissue samples. PS.01.03.04.c. Calibrate application equipment to meet plant nutrient needs. PS.01.03.05.c. Devise a plan for soil management for a selected production method. PS.01.03.06.c. Devise a plan to meet plant nutrient needs based on environmental factors present.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-PS-1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Using Mathematics and Computational Thinking |
| Constructing Explanations and Designing Solutions |
| Scientific Investigations Use a Variety of Methods |
| Planning and Carrying Out Investigations |

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| PS1.B: Chemical Reactions |
| LS1.A: Structure and Function |
| ETS1.C: Optimizing the Design Solution |

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| Energy and Matter |  |
| Stability and Change |  |
| Scientific Knowledge Assumes an Orderand Consistency in Natural Systems |  |
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| **Unit 7:** Scientific Culminating Project | **Total Learning Hours for Unit:** 20 (Throughout the course) |
| **Unit Summary**: Students will demonstrate the complex interactions in soil systems and the challenge of managing soil and land in Washington State. They will consider and address possible soil system elements (weather, soil, budget, crops/livestock etc.) and design their own scientific investigation to address an agricultural issue and describe possible solutions by analyzing, interpreting, and presenting their findings. This unit will be assessed throughout the school year and culminate with the students designing and implementing a scientific investigation related to chemistry within agriculture. This project will culminate with presenting at a science fair/contest of the schools choosing local/regional or state level. |
| **Performance Assessments**:(Districts to complete for each unit)*Example assessments for this unit include:** + Plan and carry out a soil/crop inquiry-based scientific investigation and revise the hypothesis based on new evidence.
	+ Design their own scientific investigation to address an agricultural issue and describe possible solutions by analyzing data.
	+ Construct an explanation and design a solution based on their scientific findings from their investigations.
	+ Conduct Supervised Agricultural Experience project (SAE).
	+ Present, through a mode of choice (e.g. essay, slide deck, video production), a potential career path of interest that is related to soil chemistry. Explain why it interests you and provide details about your investigation of this career path.  include evidence of interviewing at least one professional in the field.
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| **Leadership Alignment**: (Districts to complete for each unit)*Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.* *Example:* Through team-based activities relating to soil chemistry careers, students:* Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts.
* Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions.
* Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade).
* Utilize multiple media and technologies and know how to judge their effectiveness a priority as well as assess their impact.
* Communicate effectively in diverse environments, including technical-based language (schematic, pictorial, diagrammatic, etc.).
* Produce results for the scientific culminating project.

Leadership Skills:1.A Think Creatively.1.B Work Creatively with Others 2.A Reason Effectively2.B Use Systems Thinking2.C Make Judgments and Decisions 2.D Solve Problems.4.A Access and Evaluate Information |
| **Industry Standards and/or Competencies:****Agriculture, Food and Natural Resources (AFNR) standards**<https://www.k12.wa.us/sites/default/files/public/careerteched/clusters/agriculture/afnrstandards.pdf>Standards depending upon Scientific Culminating Project.CS.03.04.01.a. Identify and differentiate the appropriate protective equipment for the safe use and operation of specific tools and equipment (e.g. PPE, etc.). CS.03.04.01.b. Analyze and demonstrate adherence to protective equipment requirements when using various AFNR tools and equipment.  |
| **Aligned Washington State Academic Standards** |
| **Science** | HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios (engineering)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. 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.  |
| **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
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| Constructing Explanations and Designing SolutionsEngaging in Argument from Evidence |

 |  SS3.A:  Natural Resources

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| ETS1.B: Developing Possible Solutions |
| ETS1.C: Optimizing the Design Solution |

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| Connections to Engineering, Technology, and Applications of Science |
| Influence of Science, Engineering, and Technology on Society and the Natural WorldScience Addresses Questions About he Natural and Material World |

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