# Crosscutting Concepts Matrix for PESTL – Secondary

1. ***Patterns, Similarity, and Diversity*** – Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying the patterns.

| *Identify and Describe* | *Model and Predict* | *Explanations and Solutions* | *Compare, Analyze, and Apply* |
|---|---|---|---|
| ▪ Identify and describe patterns in the natural world.<br>▪ Identify and describe patterns of symmetry in nature.<br>▪ Identify and describe the purpose for patterns in engineered objects. | ▪ Use models to investigate patterns in phenomena.<br>▪ Use patterns to make predictions.<br>▪ Use patterns to identify and classify objects, mechanism, and organism.<br>▪ Develop warranted inferences from patterns observed in data.<br>▪ Use patterns in rates of change and mathematical relationships to develop information about how natural and human designed systems operate. | ▪ Use patterns as evidence to support science explanations.<br>▪ Use patterns as evidence to support arguments.<br>▪ Use patterns of performance to analyze design solutions.<br>▪ Use patterns to explain cause and effect relationships. | ▪ Analyze phenomena for evidence of patterns.<br>▪ Analyze data to determine patterns.<br>▪ Analyze patterns that are related to time.<br>▪ Use graphs and charts to investigate and analyze patterns in data.<br>▪ Relate macroscopic patterns to the nature of microscopic and atomic-level structure.<br>▪ Use mathematical representations to analyze patterns. |

2. ***Cause and Effect: Mechanism and Prediction*** – Events have causes, sometimes simple, sometime multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science.

| *Identify and Describe* | *Model and Predict* | *Explanations and Solutions* | *Compare, Analyze, and Apply* |
|---|---|---|---|
| ▪ Identify and describe the causes of phenomena.<br>▪ Describe the conditions necessary for phenomena to occur (e.g., temperature necessary for seeds to germinate, temperature for a chemical reaction to occur).<br>▪ Identify the causes of observed patterns in natural systems.<br>▪ Describe the likelihood of a cause and effect relationship occurring in terms of probability. | ▪ Use patterns to determine the causes of observed phenomena.<br>▪ Examine small-scale systems to predict cause and effect relationships of larger scale phenomena.<br>▪ Use cause and effect relationships to predict the frequency of phenomena.<br>▪ Justify predictions using cause and effect relationships. | ▪ Use evidence to support explanations for the causes of phenomena.<br>▪ Explain order of events necessary to cause a phenomenon to occur.<br>▪ Design and build machines capable of performing specified tasks.<br>▪ Design and/or analyze systems that cause a desired effect. | ▪ Compare multiple causes contributing to one phenomenon.<br>▪ Analyze the relative impacts of various causes contributing to a change.<br>▪ Analyze the scale of the effect of changes in systems.<br>▪ Use empirical evidence to distinguish between causal and correlational relationships.<br>▪ Analyze data to determine if relationships are causal or correlational. |

3. ***Scale, Proportion, and Quantity*** – In considering phenomena, it is critical to recognize what is relevant at different size, time and energy scales and to recognize proportional relationships between different quantities as scales change.

| *Identify and Describe* | *Model and Predict* | *Explanations and Solutions* | *Compare, Analyze, and Apply* |
|---|---|---|---|
| ▪ Describe phenomena that can be observed at one scale; but may not be observable at another scale.<br>▪ Use measurement to compare objects.<br>▪ Use mathematical relationships to describe objects.<br>▪ Describe the movement of objects specific to time scales (e.g., orbit of planets, movement of tectonic plates).<br>▪ Use algebraic thinking to examine data and predict the effect of one variable on another (e.g., linear growth, exponential growth). | ▪ Use scale, proportion, and quantity to model systems.<br>▪ Predict changes over time.<br>▪ Use measurement to compare phenomena represented by models.<br>▪ Develop models of events using accurate time scales.<br>▪ Use mathematical algebraic expressions and equations to explain scientific relationships.<br>▪ Use models to examine systems that are too small, too large, too fast, or too slow to observe directly.<br>▪ Use models at one scale to understand phenomena at a different order of magnitude. | ▪ Use patterns that can be observed at one scale to explain phenomena at another scale.<br>▪ Use ratio to support explanations (e.g., more dense objects sink, force of a moving object increases as speed and mass increases).<br>▪ Use proportion and quantity to support explanations.<br>▪ Use quantitative reasoning to compare solutions to problems. | ▪ Use proportional relationships (e.g., density, speed, concentration) to analyze the components of a system.<br>▪ Compare objects and systems that are at the same scale.<br>▪ Compare microscopic organisms to macroscopic scales.<br>▪ Compare distances at various scales.<br>▪ Compare the motion of objects across various distances.<br>▪ Use geologic time lines and scales to compare events in the past. |

4. ***Systems and System Models –*** Delimiting and defining the system under study and making a model of it are tools used throughout science and engineering for developing understanding.

| ***Identify and Describe*** | ***Model and Predict*** | ***Explanations and Solutions*** | ***Compare, Analyze, and Apply*** |
|---|---|---|---|
| ▪ Describe the interactions of specific components of systems.<br>▪ Describe energy inputs to systems that cause changes.<br>▪ Describe systems in terms of interactions and components.<br>▪ Describe systems that interact with other systems and are part of larger, more complex systems.<br>▪ Describe the limitations of models in terms of precision and reliability for predictions. | ▪ Use diagrams and representations to model systems.<br>▪ Use conceptual models to represent systems.<br>▪ Use models to represent the inputs, outputs, cycling, and flow of matter and energy in systems.<br>▪ Use models to predict the behavior of a system. | ▪ Explain interactions across multiple systems.<br>▪ Explain the inputs and outputs of matter, energy, and forces in a system.<br>▪ Develop explanations for the role of various components of systems.<br>▪ Design systems to do specific tasks. | ▪ Analyze interactions within a system and across multiple systems.<br>▪ Analyze the limitations of models that are used to represent specific aspects of systems.<br>▪ Evaluate limitations of an investigation of complex systems.<br>▪ Evaluate the degree to which an investigation defines the boundaries of a system. |

5. ***Energy and Matter: Flows, Cycles and Conservation*** – Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

| ***Identify and Describe*** | ***Model and Predict*** | ***Explanations and Solutions*** | ***Compare, Analyze, and Apply*** |
|---|---|---|---|
| ▪ Distinguish between the common use of the word *energy* and the way science uses the word.<br>▪ Describe the transfer of energy.<br>▪ Describe the role of energy in causing changes (e.g., heat evaporates water, energy lifting an object).<br>▪ Account for the conservation of energy in a system.<br>▪ Account for the conservation of matter in a system. | ▪ Use principles of conservation of matter and energy to predict changes in systems.<br>▪ Use models to describe the flow of energy.<br>▪ Use the particle model to describe matter cycling.<br>▪ Use models to trace the flow of energy in systems. | ▪ Use energy flow to explain changes in systems.<br>▪ Use matter cycles to explain cycles in systems.<br>▪ Explain matter cycles in terms of the flow of energy in systems.<br>▪ Explain the relationship of energy to changes in matter.<br>▪ Explain how energy is involved when matter changes.<br>▪ Explain the transformation of energy in systems. | ▪ Analyze the conservation of energy and matter in complex systems.<br>▪ Analyze the flow of energy and cycling of matter into, out of, and within a system.<br>▪ Analyze nuclear processes in terms of the conservation of the total number of protons and neutrons. |

6. ***Structure and Function*** – The way an object is shaped or structured determines many of its properties and functions.

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|---|---|---|---|
| ▪ Identify the attributes of a structure that contribute to stability (e.g., diagonal bracing, spherical share).<br>▪ Relate the structure to the mechanical functioning of a machine or organism.<br>▪ Investigate phenomena and describe the structure/function relationships. | ▪ Describe how the materials that objects are constructed from affect the function of the object.<br>▪ Investigate or design new systems or structures for the properties of material and the structure of different components to revel function.<br>▪ Use models to visualize and describe how a system's function depends on the shapes, composition, and relationships among parts. | ▪ Explain the function of microscopic structures on organisms.<br>▪ Develop explanations for phenomena based on structure and function relationships.<br>▪ Design structures that utilize specific properties of materials to best serve a specific function. | ▪ Analyze the design of mechanical systems in terms of structure and function.<br>▪ Infer the properties and function of a natural or designed system based on overall structure, components, and molecular properties.<br>▪ Compare the structure of substances in various phases to the way they function.<br>▪ Analyze complex and microscopic structures and systems by using models to determine how they operate. |

7. ***Stability and Change*** – For both designed and natural systems, conditions of stability, and factors that control rates of change are critical elements to consider and understand.

| ***Identify and Describe*** | ***Model and Predict*** | ***Explanations and Solutions*** | ***Compare, Analyze, and Apply*** |
|---|---|---|---|
| ▪ Distinguish between events that are changing and ones that are stable.<br>▪ Describe stability and change in terms of time scales.<br>▪ Describe systems in terms of stability and change.<br>▪ Identify things that trigger changes to a system that was previously stable.<br>▪ Describe changes to stability in terms of sudden events or gradual changes over time.<br>▪ Describe systems that are stable over very long periods of time. | ▪ Use models to predict changes in stable systems to changes in unstable systems.<br>▪ Use models to describe opposing forces that result in stability.<br>▪ Model systems in dynamic equilibrium.<br>▪ Use mathematical relationships to model change and rates of change over short and very long periods. | ▪ Explain changes in a system in terms of inputs and outputs.<br>▪ Explain the necessary attributes of stable systems.<br>▪ Explain patterns of change overtime.<br>▪ Explain phenomena in terms of equilibrium.<br>▪ Explain the stability and change in natural systems over time and at multiple scales.<br>▪ Explain how feedback mechanisms keep systems in equilibrium.<br>▪ Design systems for greater or lesser stability. | ▪ Compare systems that are stable at one scale and not stable on another scale.<br>▪ Analyze patterns of change and stability.<br>▪ Analyze the attributes of systems engineered for stability or controlled change.<br>▪ Analyze how small changes in a system may lead to large changes parts of the system.<br>▪ Evaluate systems in terms of how specific components of the system change and/or remain stable. |