The Australian **Curriculum**

Subjects	Earth and Environmental Science
Units	Unit 1, Unit 2, Unit 3 and Unit 4
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AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

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Earth and Environmental Science

Earth and Environmental Science

Rationale and Aims

Rationale

Earth and Environmental Science is a multifaceted field of inquiry that focuses on interactions between the solid Earth, its water, its air and its living organisms, and on dynamic, interdependent relationships that have developed between these four components. Earth and environmental scientists consider how these interrelationships produce environmental change at a variety of timescales. To do this, they integrate knowledge, concepts, models and methods drawn from geology, biology, physics and chemistry in the study of Earth's ancient and modern environments. Earth and environmental scientists strive to understand past and present processes so that reliable and scientifically-defensible predictions can be made about the future.

Earth and Environmental Science builds on the content in the Biological and Earth and Space Sciences sub-strands of the Foundation to Year 10 Australian Curriculum: Science. In particular, the subject provides students with opportunities to explore the theories and evidence that frame our understanding of Earth's origins and history; the dynamic and interdependent nature of Earth's processes, environments and resources; and the ways in which these processes, environments and resources respond to change across a range of temporal and spatial scales.

In this subject, the term 'environment' encompasses terrestrial, marine and atmospheric settings and includes Earth's interior. Environments are described and characterised with a focus on systems thinking and multidisciplinarity rather than with a particular ecological, biological, physical or chemical focus. This subject emphasises the way Earth materials and processes generate environments including habitats where organisms live; the natural processes and human influences which induce changes in physical environments; and the ways in which organisms respond to those changes.

Studying senior secondary Science provides students with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. In this subject, students develop their investigative, analytical and communication skills and apply these to their understanding of science issues in order to engage in public debate, solve problems and make evidence-based decisions about contemporary issues. The knowledge, understanding and skills introduced in this subject will encourage students to become confident, active citizens who can competently use diverse methods of inquiry, and will provide a foundation for further studies or employment in Earth and environmental science-related fields.

Aims

Earth and Environmental Science aims to develop students':

- interest in Earth and environmental science and their appreciation of how this multidisciplinary knowledge can be used to understand contemporary issues
- understanding of Earth as a dynamic planet consisting of four interacting systems: the geosphere, atmosphere, hydrosphere and lithosphere
- appreciation of the complex interactions, involving multiple parallel processes, that continually change Earth systems over a range of timescales
- understanding that Earth and environmental science knowledge has developed over time; is used in a variety of contexts; and influences, and is influenced by, social, economic, cultural and ethical considerations
- ability to conduct a variety of field, research and laboratory investigations involving collection and analysis of qualitative and quantitative data, and interpretation of evidence
- ability to critically evaluate Earth and environmental science concepts, interpretations, claims and conclusions with reference to evidence
- ability to communicate Earth and environmental understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

Earth and Environmental Science

Organisation

Overview of the senior secondary Australian Curriculum

ACARA has developed senior secondary Australian Curriculum for English, Mathematics, Science and History according to a set of design specifications. The ACARA Board approved these specifications following consultation with state and territory curriculum, assessment and certification authorities.

The senior secondary Australian Curriculum specifies content and achievement standards for each senior secondary subject. Content refers to the knowledge, understanding and skills to be taught and learned within a given subject. Achievement standards refer to descriptions of the quality of learning (the depth of understanding, extent of knowledge and sophistication of skill) expected of students who have studied the content for the subject.

The senior secondary Australian Curriculum for each subject has been organised into four units. The last two units are cognitively more challenging than the first two units. Each unit is designed to be taught in about half a 'school year' of senior secondary studies (approximately 50–60 hours duration including assessment and examinations). However, the senior secondary units have also been designed so that they may be studied singly, in pairs (that is, year-long), or as four units over two years.

State and territory curriculum, assessment and certification authorities are responsible for the structure and organisation of their senior secondary courses and will determine how they will integrate the Australian Curriculum content and achievement standards into their courses. They will continue to be responsible for implementation of the senior secondary curriculum, including assessment, certification and the attendant quality assurance mechanisms. Each of these authorities acts in accordance with its respective legislation and the policy framework of its state government and Board. They will determine the assessment and certification specifications for their local courses that integrate the Australian Curriculum content and achievement standards and any additional information, guidelines and rules to satisfy local requirements including advice on entry and exit points and credit for completed study.

The senior secondary Australian Curriculum for each subject should not, therefore, be read as a course of study. Rather, it is presented as content and achievement standards for integration into state and territory courses.

Senior secondary Science subjects

The Australian Curriculum senior secondary Science subjects build on student learning in the Foundation to Year 10 Science curriculum and include:

- Biology
- Chemistry
- Earth and Environmental Science
- Physics.

Structure of Earth and Environmental Science

Units

In Earth and Environmental Science, students develop their understanding of the ways in which interactions between Earth systems influence Earth processes, environments and resources. There are four units:

- Unit 1: Introduction to Earth systems
- Unit 2: Earth processes - energy transfers and transformations
- Unit 3: Living on Earth - extracting, using and managing Earth resources
- Unit 4: The changing Earth - the cause and impact of Earth hazards.

In Units 1 and 2, students are introduced to the Earth system model and to the ways in which the Earth spheres interact and are related by transfers and transformations of energy. In Unit 1, students examine the evidence underpinning theories of the development of the Earth systems, their interactions and their components. In Unit 2, students investigate how Earth processes involve interactions of Earth systems and are inter-related through transfers and transformations of energy.

In Units 3 and 4, students use the Earth system model and an understanding of Earth processes, to examine Earth resources and environments, as well as the factors that impact the Earth system at a range of spatial and temporal scales. In Unit 3, students examine renewable and non-renewable resources, the implications of extracting, using and consuming these resources, and associated management approaches. In Unit 4, students consider how Earth processes and human activity can contribute to Earth hazards, and the ways in which these hazards can be predicted, managed and mitigated to reduce their impact on Earth environments.

Each unit includes:

- Unit descriptions – short descriptions of the purpose of and rationale for each unit
- Learning outcomes – six to eight statements describing the learning expected as a result of studying the unit
- Content descriptions – descriptions of the core content to be taught and learned, organised into three strands:
  - *Science Inquiry Skills*
  - *Science as a Human Endeavour*
  - *Science Understanding (organised in sub-units).*

Organisation of content

Science strand descriptions

The Australian Curriculum: Science has three interrelated strands: *Science Inquiry Skills, Science as a Human Endeavour* and *Science Understanding*. These strands are used to organise the Science learning area from Foundation to Year 12. In the senior secondary Science subjects, the three strands build on students' learning in the F-10 Australian Curriculum: Science.

In the practice of science, the three strands are closely integrated: the work of scientists reflects the nature and development of science, is built around scientific inquiry, and seeks to respond to and influence society. Students' experiences of school science should mirror this multifaceted view of science. To achieve this, the three strands of the Australian Curriculum: Science should be taught in an integrated way. The content descriptions for *Science Inquiry Skills*, *Science as a Human Endeavour* and *Science Understanding* have been written so that this integration is possible in each unit.

Science Inquiry Skills

Science inquiry involves identifying and posing questions; planning, conducting and reflecting on investigations; processing, analysing and interpreting data; and communicating findings. This strand is concerned with evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions, and developing evidence-based arguments.

Science investigations are activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem. Investigations can involve a range of activities, including experimental testing, field work, locating and using information sources, conducting surveys, and using modelling and simulations. The investigation design will depend on the context and subject of the investigation.

In science investigations, the collection and analysis of data to provide evidence plays a major role. This can involve collecting or extracting information and reorganising data in the form of tables, graphs, flow charts, diagrams, prose, keys, spreadsheets and databases. The analysis of data to identify and select evidence, and the communication of findings, involve the selection, construction and use of specific representations, including mathematical relationships, symbols and diagrams.

Through the senior secondary Science subjects, students will continue to develop generic science inquiry skills, building on the skills acquired in the F-10 Australian Curriculum: Science. These generic skills are described below and will be explicitly taught and assessed in each unit. In addition, each unit provides more specific skills to be taught within the generic science inquiry skills; these specific skills align with the *Science Understanding* and *Science as a Human Endeavour* content of the unit.

The generic science inquiry skills are:

- Identifying, researching and constructing questions for investigation; proposing hypotheses; and predicting possible outcomes
- Designing investigations, including the procedure/s to be followed, the materials required and the type and amount of primary and/or secondary data to be collected; conducting risk assessments; and considering ethical research
- Conducting investigations, including using equipment and techniques safely, competently and methodically for the collection of valid and reliable data
- Representing data in meaningful and useful ways; organising and analysing data to identify trends, patterns and relationships; recognising error, uncertainty and limitations in data; and selecting, synthesising and using evidence to construct and justify conclusions
- Interpreting scientific and media texts and evaluating processes, claims and conclusions by considering the quality of available evidence; and using reasoning to construct scientific arguments
- Selecting, constructing and using appropriate representations to communicate understanding, solve problems and make predictions
- Communicating to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes.

The senior secondary Science subjects have been designed to accommodate, if appropriate, an extended scientific investigation within each pair of units. States and territories will determine whether there are any requirements related to an extended scientific investigation as part of their course materials.

Science as a Human Endeavour

Through science, we seek to improve our understanding and explanations of the natural world. The *Science as a Human Endeavour* strand highlights the development of science as a unique way of knowing and doing, and explores the use and influence of science in society.

As science involves the construction of explanations based on evidence, the development of science concepts, models and theories is dynamic and involves critique and uncertainty. Science concepts, models and theories are reviewed as their predictions and explanations are continually re-assessed through new evidence, often through the application of new technologies. This review process involves a diverse range of scientists working within an increasingly global community of practice and can involve the use of international conventions and activities such as peer review.

The use and influence of science are shaped by interactions between science and a wide range of social, economic, ethical and cultural factors. The application of science may provide great benefits to individuals, the community and the environment, but may also pose risks and have unintended consequences. As a result, decision making about socio-scientific issues often involves consideration of multiple lines of evidence and a range of stakeholder needs and values. As an ever-evolving body of knowledge, science frequently informs public debate, but is not always able to provide definitive answers.

Across the senior secondary Science subjects, the same set of *Science as a Human Endeavour* content descriptions is used for Units 1 and 2 of the subjects; and another set for Units 3 and 4. This consistent approach enables students to develop a rich appreciation of the complex ways in which science interacts with society, through the exploration of *Science as a Human Endeavour* concepts across the subjects and in multiple contexts.

'*Examples in context*' will be developed to illustrate possible contexts related to *Science Understanding* content, in which students could explore *Science as a Human Endeavour* concepts. These will be made available to complement the final online curriculum. Each *Example in context* will be aligned to the relevant sub-unit in Science Understanding and will include links to the relevant *Science as a Human Endeavour* content descriptions.

Science Understanding

Science understanding is evident when a person selects and integrates appropriate science concepts, models and theories to explain and predict phenomena, and applies those concepts, models and theories to new situations. Models in science can include diagrams, physical replicas, mathematical representations, word-based analogies (including laws and principles) and computer simulations. Development of models involves selection of the aspects of the system/s to be included in the model, and thus models have inherent approximations, assumptions and limitations.

The *Science Understanding* content in each unit develops students' understanding of the key concepts, models and theories that underpin the subject, and of the strengths and limitations of different models and theories for explaining and predicting complex phenomena.

Science understanding can be developed through the selection of contexts that have relevance to and are engaging for students. The Australian Curriculum: Science has been designed to provide jurisdictions, schools and teachers with the flexibility to select contexts that meet the social, geographic and learning needs of their students.

Organisation of achievement standards

The Earth and Environmental Science achievement standards are organised by two dimensions: 'Earth and Environmental Science Concepts, Models and Applications' and 'Earth and Environmental Science Inquiry Skills'. They describe five levels of student achievement.

'Earth and Environmental Science Concepts, Models and Applications' describes the knowledge and understanding students demonstrate with reference to the content of the *Science Understanding* and *Science as a Human Endeavour* strands of the curriculum. 'Earth and Environmental Science Inquiry Skills' describes the skills students demonstrate when investigating the content developed through the strands of *Science Understanding* and *Science as a Human Endeavour*.

Senior secondary achievement standards have been written for each Australian Curriculum senior secondary subject. The achievement standards provide an indication of typical performance at five different levels (corresponding to grades A to E) following the completion of study of senior secondary Australian Curriculum content for a pair of units. They are broad statements of understanding and skills that are best read and understood in conjunction with the relevant unit content. They are structured to reflect key dimensions of the content of the relevant learning area. They will be eventually accompanied by illustrative and annotated samples of student work/ performance/ responses.

The achievement standards will be refined empirically through an analysis of samples of student work and responses to assessment tasks: they cannot be maintained *a priori* without reference to actual student performance. Inferences can be drawn about the quality of student learning on the basis of observable differences in the extent, complexity, sophistication and generality of the understanding and skills typically demonstrated by students in response to well-designed assessment activities and tasks.

In the short term, achievement standards will inform assessment processes used by curriculum, assessment and certifying authorities for course offerings based on senior secondary Australian Curriculum content.

ACARA has made reference to a common syntax (as a guide, not a rule) in constructing the achievement standards across the learning areas. The common syntax that has guided development is as follows:

- Given a specified context (as described in the curriculum content)
- With a defined level of consistency/accuracy (the assumption that each level describes what the student does well, competently, independently, consistently)
- Students perform a specified action (described through a verb)
- In relation to what is valued in the curriculum (specified as the object or subject)
- With a defined degree of sophistication, difficulty, complexity (described as an indication of quality)

Terms such as ‘analyse’ and ‘describe’ have been used to specify particular action but these can have everyday meanings that are quite general. ACARA has therefore associated these terms with specific meanings that are defined in the senior secondary achievement standards glossary and used precisely and consistently across subject areas.

Links to Foundation to Year 10

Progression from the F-10 Australian Curriculum: Science

The Earth and Environmental Science curriculum continues to develop student understanding and skills from across the three strands of the F-10 Australian Curriculum: Science.

In the *Science Understanding* strand, the Earth and Environmental Science curriculum draws on knowledge and understanding from across the four sub-strands of Biological, Physical, Chemical and Earth and Space Sciences. In particular, the Earth and Environmental Science curriculum continues to develop the key concepts introduced in the Biological Sciences and Earth and Space Sciences sub-strands, that is, that a diverse range of living things have evolved on Earth over hundreds of millions of years; that living things are interdependent and interact with each other and with their environment; and that the Earth is subject to change within and on its surface, over a range of timescales as a result of natural processes and human use of resources.

Mathematical skills expected of students studying Earth and Environmental Science

The Earth and Environmental Science curriculum requires students to use the mathematical skills they have developed through the F-10 Australian Curriculum: Mathematics, in addition to the numeracy skills they have developed through the Science Inquiry Skills strand of the Australian Curriculum: Science.

Within the Science Inquiry Skills strand, students are required to gather, represent and analyse numerical data to identify the evidence that forms the basis of their scientific arguments, claims or conclusions.. In gathering and recording numerical data, students are required to make measurements with an appropriate degree of accuracy and to represent measurements using appropriate units.

Students may need to be taught to recognise when it is appropriate to join points on a graph and when it is appropriate to use a line of best fit. They may also need to be taught how to construct a straight line that will serve as the line of best fit for a set of data presented graphically.

It is assumed that students will be able to competently:

- perform calculations involving addition, subtraction, multiplication and division of quantities
- perform approximate evaluations of numerical expressions
- express fractions as percentages, and percentages as fractions
- calculate percentages

- recognise and use ratios
- transform decimal notation to power of ten notation
- substitute physical quantities into an equation using consistent units so as to calculate one quantity and check the dimensional consistency of such calculations
- solve simple algebraic equations
- comprehend and use the symbols/notations $<, >, \Delta, \approx$
- translate information between graphical, numerical and algebraic forms
- distinguish between discrete and continuous data and then select appropriate forms, variables and scales for constructing graphs
- construct and interpret frequency tables and diagrams, pie charts and histograms
- describe and compare data sets using mean, median and inter-quartile range
- interpret the slope of a linear graph.

Representation of General capabilities

Literacy is important in students' development of *Science Inquiry Skills* and their understanding of content presented through the *Science Understanding* and *Science as a Human Endeavour* strands. Students gather, interpret, synthesise and critically analyse information presented in a wide range of genres, modes and representations (including text, flow diagrams, symbols, graphs and tables). They evaluate information sources and compare and contrast ideas, information and opinions presented within and between texts. They communicate processes and ideas logically and fluently and structure evidence-based arguments, selecting genres and employing appropriate structures and features to communicate for specific purposes and audiences.

Numeracy is key to students' ability to apply a wide range of *Science Inquiry Skills*, including making and recording observations; ordering, representing and analysing data; and interpreting trends and relationships. They employ numeracy skills to interpret complex spatial and graphic representations, and to appreciate the ways in which Earth systems are structured, interact and change across spatial and temporal scales. They engage in analysis of data, including issues relating to reliability and probability, and they interpret and manipulate mathematical relationships to calculate and predict values.

*Information and Communication Technolog*y *(ICT) capability* is a key part of *Science Inquiry Skills*. Students use a range of strategies to locate, access and evaluate information from multiple digital sources; to collect, analyse and represent data; to model and interpret concepts and relationships; and to communicate and share science ideas, processes and information. Through exploration of *Science as a Human Endeavour* concepts, students assess the impact of ICT on the development of science and the application of science in society, particularly with regard to collating, storing, managing and analysing large data sets.

Critical and creative thinking is particularly important in the science inquiry process. Science inquiry requires the ability to construct, review and revise questions and hypotheses about increasingly complex and abstract scenarios and to design related investigation methods. Students interpret and evaluate data; interrogate, select and cross-reference evidence; and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their own processes and conclusions. Science is a creative endeavour and students devise innovative solutions to problems, predict possibilities, envisage consequences and speculate on possible outcomes as they develop *Science Understanding* and *Science Inquiry Skills.* They also appreciate the role of critical and creative individuals and the central importance of critique and review in the development and innovative application of science.

Personal and social capability is integral to a wide range of activities in Earth and Environmental Science, as students develop and practise skills of communication, teamwork, decision-making, initiative-taking and self-discipline with increasing confidence and sophistication. In particular, students develop skills in both independent and collaborative investigation; they employ self-management skills to plan effectively, follow procedures efficiently and work safely; and they use collaboration skills to conduct investigations, share research and discuss ideas. In considering aspects of *Science as a Human Endeavour,* students also recognise the role of their own beliefs and attitudes in their response to science issues and applications, consider the perspectives of others, and gauge how science can affect people's lives.

Ethical understanding is a vital part of science inquiry. Students evaluate the ethics of experimental science, codes of practice, and the use of scientific information and science applications. They explore what integrity means in science, and they understand, critically analyse and apply ethical guidelines in their investigations. They consider the implications of their investigations on others, the environment and living organisms. They use scientific information to evaluate the claims and actions of others and to inform ethical decisions about a range of social, environmental and personal issues and applications of science.

Intercultural understanding is fundamental to understanding aspects of *Science as a Human Endeavour*, as students appreciate the contributions of diverse cultures to developing science understanding and the challenges of working in culturally diverse collaborations. They develop awareness that raising some debates within culturally diverse groups requires cultural sensitivity, and they demonstrate open-mindedness to the positions of others. Students also develop an understanding that cultural factors affect the ways in which science influences and is influenced by society.

Representation of Cross-curriculum priorities

While the significance of the cross-curriculum priorities for Earth and Environmental Science varies, there are opportunities for teachers to select contexts that incorporate the key concepts from each priority.

The Earth and Environmental Science curriculum provides an opportunity for students to engage with *Aboriginal and Torres Strait Islander histories and cultures*. It acknowledges that Aboriginal and Torres Strait Islander people have longstanding scientific knowledge traditions that inform understanding of the Australian environment and the ways in which it has changed over time. In exploring scientific knowledge and decision making about Earth processes, environments and resources, students could develop an understanding that Aboriginal and Torres Strait Islander people have particular ways of knowing the world and continue to be innovative in providing significant contributions to development in science. Students could investigate examples of Aboriginal and Torres Strait Islander science and the ways traditional knowledge and Western scientific knowledge can be complementary.

Students could investigate a wide range of contexts that draw *on Asia and Australia's engagement with Asia* through Earth and Environmental Science. Students could explore the diverse environments of the Asia region and develop an appreciation that interaction between human activity and these environments continues to influence the region, including Australia, and has significance for the rest of the world. Through an examination of developments in Earth and Environmental Science, students could appreciate that the Asia region plays an important role in scientific research and development, including through collaboration with Australian scientists, in such areas as natural hazard prediction and management, natural resource management, energy security and food security.

The *Sustainability* priority is explicitly addressed in Earth and Environmental Science. The Earth system model that frames the curriculum requires students to understand the interconnectedness of Earth's biosphere, geosphere, hydrosphere and atmosphere and how these systems operate and interact across a range of spatial and temporal scales. Relationships including cycles and cause and effect are explored, and students develop skills of observation and analysis to examine these relationships in the world around them now and into the future.

In Earth and Environmental Science, students appreciate that Earth and environmental science provides the basis for decision making in many areas of society and that these decisions can impact the Earth system, its environments and its resources. They understand the importance of using science to predict possible effects of human and other activity, and to develop management plans or alternative technologies that minimise these effects and provide for a more sustainable future.

Safety

Science learning experiences may involve the use of potentially hazardous substances and/or hazardous equipment. It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students and that school practices meet the requirements of the Work Health and Safety Act 2011, in addition to relevant state or territory health and safety guidelines.

When state and territory curriculum authorities integrate the Australian Curriculum into local courses, they will include more specific advice on safety.

For further information about relevant guidelines, contact your state or territory curriculum authority.

Animal ethics

Through a consideration of research ethics as part of *Science Inquiry Skills*, students will examine their own ethical position, draw on ethical perspectives when designing investigation methods, and ensure that any activities that impact on living organisms comply with the *Australian code of practice for the care and use of animals for scientific purposes 7th edition* (2004) (http://www.nhmrc.gov.au/guidelines/publications/ea16) .

Any teaching activities that involve the care and use of, or interaction with, animals must comply with the *Australian code of practice for the care and use of animals for scientific purposes 7th edition*, in addition to relevant state or territory guidelines.

When state and territory curriculum authorities integrate the Australian Curriculum into local courses, they will include more specific advice on the care and use of, or interaction with, animals.

For further information about relevant guidelines or to access your local Animal Ethics Committee, contact your state or territory curriculum authority.

Unit 1: Introduction to Earth systems

Unit Description

The Earth system involves four interacting systems: the geosphere, atmosphere, hydrosphere and biosphere. A change in any one ‘sphere’ can impact others at a range of temporal and spatial scales. In this unit, students build on their existing knowledge of Earth by exploring the development of understanding of Earth's formation and its internal and surface structure. Students study the processes that formed the oceans and atmosphere. They review the origin and significance of water at Earth’s surface, how water moves through the hydrological cycle, and the environments influenced by water, in particular the oceans, the cryosphere and groundwater. Students will examine the formation of soils at Earth’s surface (the pedosphere) as a process that involves the interaction of all Earth systems.

Students critically examine the scientific evidence for the origin of life, linking this with their understanding of the evolution of Earth’s hydrosphere and atmosphere. They review evidence from the fossil record that demonstrates the interrelationships between major changes in Earth’s systems and the evolution and extinction of organisms. They investigate how the distribution and viability of life on Earth influences, and is influenced by, Earth systems.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from multiple disciplines and individuals and the development of ICT and other technologies have contributed to developing understanding of Earth systems. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic and cultural factors.

Students use science inquiry skills that mirror the types of inquiry conducted to establish our contemporary understanding of Earth systems: they engage in a range of investigations that help them develop the field and research skills used by geoscientists, soil scientists, atmospheric scientists, hydrologists, ecologists and environmental chemists to interpret geological, historical and real-time scientific information.

Learning Outcomes

By the end of this unit, students:

- understand the key features of Earth systems, how they are interrelated, and their collective 4.5 billion year history
- understand scientific models and evidence for the structure and development of the solid Earth, the hydrosphere, the atmosphere and the biosphere
- understand how theories and models have developed based on evidence from multiple disciplines; and the uses and limitations of Earth and environmental science knowledge in a range of contexts
- use science inquiry skills to collect, analyse and communicate primary and secondary data on Earth and environmental phenomena; and use these as analogues to deduce and analyse events that occurred in the past
- evaluate, with reference to empirical evidence, claims about the structure, interactions and evolution of Earth systems
- communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills (Earth and Environmental Science Unit 1)

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSES001)

Design investigations including the procedure/s to be followed, the information required and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSES002)

Conduct investigations, including using map and field location techniques and rock and soil sampling and identification procedures, safely, competently and methodically for the collection of valid and reliable data (ACSES003)

Represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; qualitatively describe sources of measurement error, and uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions (ACSES004)

Interpret a range of scientific and media texts and evaluate processes, claims and conclusions by considering the quality of available evidence; use reasoning to construct scientific arguments (ACSES005)

Select, construct and use appropriate representations, including maps and cross sections to describe and analyse spatial relationships, and stratigraphy and isotopic half-life data to infer the age of rocks and fossils, to communicate conceptual understanding, solve problems and make predictions (ACSES006)

Communicate to specific audiences and for specific purposes using appropriate language, genres and modes, including compilations of field data and research reports (ACSES007)

Science as a Human Endeavour (Units 1 & 2)

Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility (ACSES008)

Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines (ACSES009)

Advances in science understanding in one field can influence other areas of science, technology and engineering (ACSES010)

The use of scientific knowledge is influenced by social, economic, cultural and ethical considerations (ACSES011)

The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences (ACSES012)

Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions (ACSES013)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSES014)

Science Understanding

Development of the geosphere

Observation of present day processes can be used to infer past events and processes by applying the Principle of Uniformitarianism (ACSES015)

A relative geological time scale can be constructed using stratigraphic principles including superposition, cross cutting relationships, inclusions and correlation (ACSES016)

Precise dates can be assigned to points on the relative geological time scale using data derived from the decay of radioisotopes in rocks and minerals; this establishes an absolute time scale and places the age of the Earth at 4.5 billion years (ACSES017)

Earth has internally differentiated into a layered structure: a solid metallic inner core, a liquid metallic outer core and a silicate mantle and crust; the study of seismic waves and meteorites provides evidence for this structure (ACSES018)

Rocks are composed of characteristic assemblages of mineral crystals or grains that are formed through igneous, sedimentary and metamorphic processes, as part of the rock cycle (ACSES019)

Soil formation requires interaction between atmospheric, geologic, hydrologic and biotic processes; soil is composed of rock and mineral particles, organic material, water, gases and living organisms (ACSES020)

Development of the atmosphere and hydrosphere

The atmosphere was derived from volcanic outgassing during cooling and differentiation of Earth and its composition has been significantly modified by the actions of photosynthesising organisms (ACSES021)

The modern atmosphere has a layered structure characterised by changes in temperature: the troposphere, mesosphere, stratosphere and thermosphere (ACSES022)

Water is present on the surface of Earth as a result of volcanic outgassing and impact by icy bodies from space; water occurs in three phases (solid, liquid, gas) on Earth's surface (ACSES023)

Water's unique properties, including its boiling point, density in solid and liquid phase, surface tension and its ability to act a solvent, and its abundance at the surface of Earth make it an important component of Earth system processes (for example, precipitation, ice sheet formation, evapotranspiration, solution of salts) (ACSES024)

Development of the biosphere

Fossil evidence indicates that life first appeared on Earth approximately 4 billion years ago (ACSES025)

Laboratory experimentation has informed theories that life emerged under anoxic atmospheric conditions in an aqueous mixture of inorganic compounds, either in a shallow water setting as a result of lightning strike or in an ocean floor setting due to hydrothermal activity (ACSES026)

In any one location, the characteristics (for example, temperature, surface water, substrate, organisms, available light) and interactions of the atmosphere, geosphere, hydrosphere and biosphere give rise to unique and dynamic communities (ACSES027)

The characteristics of past environments and communities (for example, presence of water, nature of the substrate, organism assemblages) can be inferred from the sequence and internal textures of sedimentary rocks and enclosed fossils (ACSES028)

The diversification and proliferation of living organisms over time (for example, increases in marine animals in the Cambrian), and the catastrophic collapse of ecosystems (for example, the mass extinction event at the end of the Cretaceous) can be inferred from the fossil record (ACSES029)

Earth and Environmental Science

Unit 2: Earth processes – energy transfers and transformations

Unit Description

Earth system processes require energy. In this unit, students explore how the transfer and transformation of energy from the sun and Earth's interior enable and control processes within and between the geosphere, atmosphere, hydrosphere and biosphere. Students examine how the transfer and transformation of heat and gravitational energy in Earth's interior drive movements of Earth's tectonic plates. They analyse how the transfer of solar energy to Earth is influenced by the structure of the atmosphere; how air masses and ocean water move as a result of solar energy transfer and transformation to cause global weather patterns; and how changes in these atmospheric and oceanic processes can result in anomalous weather patterns.

Students use their knowledge of the photosynthetic process to understand the transformation of sunlight into other energy forms that are useful for living things. They study how energy transfer and transformation in ecosystems are modelled and they review how biogeochemical cycling of matter in environmental systems involves energy use and energy storage.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from multiple disciplines and individuals and the development of ICT and other technologies have contributed to developing understanding of the energy transfers and transformations within and between Earth systems. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic and cultural factors, including the design of action for sustainability.

Students use inquiry skills to collect, analyse and interpret data relating to energy transfers and transformations and cycling of matter and make inferences about the factors causing changes to movements of energy and matter in Earth systems.

Learning Outcomes

By the end of this unit, students:

- understand how energy is transferred and transformed in Earth systems, the factors that influence these processes, and the dynamics of energy loss and gain
- understand how energy transfers and transformations influence oceanic, atmospheric and biogeochemical cycling
- understand how theories and models have developed based on evidence from multiple disciplines; and the uses and limitations of Earth and environmental science knowledge in a range of contexts
- use science inquiry skills to collect, analyse and communicate primary and secondary data on energy transfers and transformations between and within Earth systems
- evaluate, with reference to empirical evidence, claims about energy transfers and transformations between and within Earth systems
- communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills (Earth and Environmental Science Unit 2)

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSES030)

Design investigations including the procedure/s to be followed, the information required and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSES031)

Conduct investigations, including using map and field location techniques and environmental sampling procedures, safely, competently and methodically for the collection of valid and reliable data (ACSES032)

Represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; qualitatively describe sources of measurement error, and uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions (ACSES033)

Interpret a range of scientific and media texts and evaluate processes, claims and conclusions by considering the quality of available evidence; use reasoning to construct scientific arguments (ACSES034)

Select, construct and use appropriate representations, including maps and other spatial representations, diagrams and flow charts, to communicate conceptual understanding, solve problems and make predictions (ACSES035)

Communicate to specific audiences and for specific purposes using appropriate language, genres and modes, including compilations of field data and research reports (ACSES036)

Science as a Human Endeavour (Units 1 & 2)

Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility (ACSES037)

Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines (ACSES038)

Advances in science understanding in one field can influence other areas of science, technology and engineering (ACSES039)

The use of scientific knowledge is influenced by social, economic, cultural and ethical considerations (ACSES040)

The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences (ACSES041)

Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions (ACSES042)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSES043)

Science Understanding

Energy for Earth processes

Energy is neither created nor destroyed, but can be transformed from one form to another (for example, kinetic, gravitational, thermal, light) and transferred between objects (ACSES044)

Processes within and between Earth systems require energy that originates either from the sun or the interior of Earth (ACSES045)

Thermal and light energy from the Sun drives important Earth processes including evaporation and photosynthesis (ACSES046)

Transfers and transformations of heat and gravitational energy in Earth's interior drives the movement of tectonic plates through processes including mantle convection, plume formation and slab sinking (ACSES047)

Energy for atmospheric and hydrologic processes

The net transfer of solar energy to Earth’s surface is influenced by its passage through the atmosphere, including impeded transfer of ultraviolet radiation to Earth’s surface due to its interaction with atmospheric ozone, and by the physical characteristics of Earth’s surface, including albedo (ACSES048)

Most of the thermal radiation emitted from Earth’s surface passes back out into space but some is reflected or scattered by greenhouse gases back toward Earth; this additional surface warming produces a phenomenon known as the greenhouse effect (ACSES049)

The movement of atmospheric air masses due to heating and cooling, and Earth’s rotation and revolution, cause systematic atmospheric circulation; this is the dominant mechanism for the transfer of thermal energy around Earth’s surface (ACSES050)

The behaviour of the global oceans as a heat sink, and Earth’s rotation and revolution, cause systematic ocean currents; these are described by the global ocean conveyer model (ACSES051)

The interaction between Earth’s atmosphere and oceans changes over time and can result in anomalous global weather patterns, including El Nino and La Nina (ACSES052)

Energy for biogeochemical processes

Photosynthesis is the principal mechanism for the transformation of energy from the sun into energy forms that are useful for living things; net primary production is a description of the rate at which new biomass is generated, mainly through photosynthesis (ACSES053)

The availability of energy and matter are one of the main determinants of ecosystem carrying capacity; that is, the number of organisms that can be supported in an ecosystem (ACSES054)

Biogeochemical cycling of matter, including nitrogen and phosphorus, involves the transfer and transformation of energy between the biosphere, geosphere, atmosphere and hydrosphere (ACSES055)

Energy is stored, transferred and transformed in the carbon cycle; biological elements, including living and dead organisms, store energy over relatively short timescales, and geological elements (for example, hydrocarbons, coal and kerogens) store energy for extended periods (ACSES056)

Units 1 and 2 Achievement Standards

Earth and Environmental Science concepts, models and applications

A	B	C	D	E
For the Earth systems studied, the student:	*For the Earth systems studied, the student:*	*For the Earth systems studied, the student:*	*For the Earth systems studied, the student:*	*For the Earth systems studied, the*

Earth and Environmental Science concepts, models and applications

				student:

Earth and Environmental Science concepts, models and applications

• analyses how Earth systems and their components are inter-related across a range of spatial scales, and how they have changed over time • analyses how cycling of matter and transfers and transformations of energy are interrelated within and between Earth systems across a range of temporal and spatial scales • explains the theories and model/s used to explain the system and the aspects of the system they include • applies theories and models of systems and processes to explain phenomena, interpret complex problems and make reasoned, plausible predictions in unfamiliar contexts *For the Earth and environmental contexts*	• explains how Earth system components are inter-related and how they have changed over time • explains how cycling of matter and transfers and transformations of energy occur between and within Earth systems • describes the theories and model/s used to explain the system • applies theories and models of systems and processes to explain phenomena, interpret problems and make plausible predictions in unfamiliar contexts *For the Earth and environmental contexts studied, the student:*	• describes Earth system components and how they have changed over time • describes the ways in which matter and energy move within and between Earth systems • describes a theory or model used to explain the system • applies theories or models of systems and processes to explain phenomena, interpret problems and make plausible predictions in familiar contexts *For the Earth and environmental contexts studied, the student:* • describes the role of collaboration and review, and	• identifies Earth system components • identifies processes that cause change in Earth systems • identifies aspects of a theory or model related to the system • describes phenomena, interprets simple problems and makes simple predictions in familiar contexts *For the Earth and environmental contexts studied, the student:* • describes the role of communication and new evidence in the development of Earth and environmental knowledge • describes	• identifies some parts of the Earth system • describes some observable Earth processes • identifies aspects of a theory or model related to parts of the system • describes phenomena and makes simple predictions in familiar, simple contexts *For the Earth and environmental contexts studied, the student:* • identifies that Earth and environmental knowledge has changed over time • identifies

Earth and Environmental Science concepts, models and applications

studied, the student: • analyses the role of collaboration, debate and review, and technologies, in the development of Earth and environmental theories and models • evaluates how Earth and environmental science has been used in concert with other sciences to meet diverse needs and inform decision making; and how these applications are influenced by interacting social, economic and ethical factors	• explains the role of collaboration, debate and review, and technologies, in the development of Earth and environmental theories and models • explains how Earth and environmental science has been used to meet diverse needs and inform decision making; and how these applications are influenced by social, economic and ethical factors	and review, and technologies, in the development of Earth and environmental theories or models • discusses how Earth and environmental science has been used to meet needs and inform decision making, and some social, economic or ethical implications of these applications	• describes ways in which Earth and environmental science has been used in society to meet needs and identifies some implications of these applications	• identifies ways in which Earth and environmental science has been used in society to meet needs

Earth and Environmental Science inquiry skills

A	B	C	D	E
For the Earth and environmental contexts studied, the student:	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*

Earth and Environmental Science inquiry skills

• designs, conducts and improves safe, ethical investigations that efficiently collect valid, reliable data in response to a complex question or problem • analyses data sets to explain causal and correlational relationships, the reliability of the data and sources of error • justifies their selection of data as evidence, analyses evidence with reference to models and/or theories and develops evidence-based conclusions that identify limitations • evaluates processes and claims; provides an evidence-based critique and discussion of improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve complex and unfamiliar problems • communicates effectively and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs, conducts and improves safe, ethical investigations that collect valid, reliable data in response to a question or problem • analyses data sets to identify causal and correlational relationships, anomalies and sources of error • selects appropriate data as evidence, interprets evidence with reference to models and/or theories and provides evidence for conclusions • evaluates processes and claims; provides a critique with reference to evidence and identifies possible improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve unfamiliar problems • communicates clearly and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs and conducts safe, ethical investigations that collect valid data in response to a question or problem • analyses data to identify relationships, anomalies and sources of error • selects data to demonstrate relationships linked to Earth and environmental knowledge and provides conclusions based on data • evaluates processes and claims and suggests improvements or alternatives • selects, constructs and uses appropriate representations to describe relationships and solve problems • communicates clearly in a range of modes, styles and genres for specific purposes	• plans and conducts safe, ethical investigations to collect data in response to a question or problem • analyses data to identify trends and anomalies • selects data to demonstrate trends and presents simple conclusions based on data • considers processes and claims from a personal perspective • constructs and uses simple representations to describe relationships and solve simple problems • communicates in a range of modes and genres	• follows a procedure to conduct safe, ethical investigations to collect data • identifies trends in data • selects data to demonstrate trends • considers claims from a personal perspective • constructs and uses simple representations to describe phenomena • communicates in a range of modes

Unit 3: Living on Earth - extracting, using and managing Earth resources

Unit Description

Earth resources are required to sustain life and provide infrastructure for living (for example, food, shelter, medicines, transport, and communication), driving ongoing demand for biotic, mineral and energy resources. In this unit, students explore renewable and non-renewable resources and analyse the effects that resource extraction, use and consumption and associated waste removal have on Earth systems and human communities.

Students examine the occurrence of non-renewable mineral and energy resources and review how an understanding of Earth and environmental science processes guides resource exploration and extraction. They investigate how the rate of extraction and other environmental factors impact on the quality and availability of renewable resources, including water, energy resources and biota, and the importance of monitoring and modelling to manage these resources at local, regional and global scales. Students learn about ecosystem services and how natural and human-mediated changes of the biosphere, hydrosphere, atmosphere and geosphere, including the pedosphere, influence resource availability and sustainable management.

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to resource extraction, use and management have developed over time and through interactions with social, economic, cultural and ethical considerations. They investigate the ways in which science contributes to contemporary debate regarding local, regional and international resource use, evaluation of risk and action for sustainability, and recognise the limitations of science in providing definitive answers in different contexts.

Students use science inquiry skills to collect, analyse and interpret data relating to the extraction, use, consumption and waste management of renewable and non-renewable resources. They critically analyse the range of factors that determine management of renewable and non-renewable resources.

Learning Outcomes

By the end of this unit, students:

- understand the difference between renewable and non-renewable Earth resources and how their extraction, use, consumption and disposal impact Earth systems
- understand how renewable resources can be sustainably extracted, used and consumed at local, regional and global scales
- understand how models and theories have developed over time; and the ways in which Earth and environmental science knowledge interacts with social, economic, cultural and ethical considerations in a range of contexts
- use science inquiry skills to collect, analyse and communicate primary and secondary data on resource extraction and related impacts on Earth systems
- evaluate, with reference to empirical evidence, claims about resource extraction and related impacts on Earth systems and justify evaluations
- communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills (Earth and Environmental Science Unit 3)

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSES057)

Design investigations including the procedure/s to be followed, the information required and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSES058)

Conduct investigations, including using spatial analysis to complement map and field location techniques and environmental sampling procedures, safely, competently and methodically for the collection of valid and reliable data (ACSES059)

Represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; discuss the ways in which measurement error and instrumental accuracy and the nature of the procedure and sample size may influence uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions (ACSES060)

Interpret a range of scientific and media texts and evaluate processes, claims and conclusions by considering the quality of available evidence, including interpreting confidence intervals in secondary data; use reasoning to construct scientific arguments (ACSES061)

Select, construct and use appropriate representations, including maps and other spatial representations, to communicate conceptual understanding, solve problems and make predictions (ACSES062)

Communicate to specific audiences and for specific purposes using appropriate language, genres and modes, including compilations of field data and research reports (ACSES063)

Science as a Human Endeavour (Units 3 & 4)

ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of data sets with which scientists work (ACSES064)

Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power (ACSES065)

The acceptance of scientific knowledge can be influenced by the social, economic and cultural context in which it is considered (ACSES066)

People can use scientific knowledge to inform the monitoring, assessment and evaluation of risk (ACSES067)

Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question (ACSES068)

International collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region (ACSES069)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSES070)

Science Understanding

Use of non-renewable Earth resources

Non-renewable mineral and energy resources are formed over geological time scales so are not readily replenished (ACSES071)

The location of non-renewable mineral and energy resources, including fossil fuels, iron ore and gold, is related to their geological setting (for example, sedimentary basins, igneous terrains) (ACSES072)

Mineral and energy resources are discovered using a variety of remote sensing techniques (for example, satellite images, aerial photographs and geophysical datasets) and direct sampling techniques (for example, drilling, core sampling, soil and rock sampling) to identify the spatial extent of the deposit and quality of the resource (ACSES073)

The type, volume and location of mineral and energy resources influences the methods of extraction (for example, underground, open pit, onshore and offshore drilling and completion) (ACSES074)

Extraction of mineral and energy resources influences interactions between the abiotic and biotic components of ecosystems, including hydrologic systems (ACSES075)

Use of renewable Earth resources

Renewable resources are those that are typically replenished at time scales of years to decades and include harvestable resources (for example, water, biota and some energy resources) and services (for example, ecosystem services) (ACSES076)

Ecosystems provide a range of renewable resources, including provisioning services (for example, food, water, pharmaceuticals), regulating services (for example, carbon sequestration, climate control), supporting services (for example, soil formation, nutrient and water cycling, air and water purification) and cultural services (for example, aesthetics, knowledge systems) (ACSES077)

The abundance of a renewable resource and how readily it can be replenished influence the rate at which it can be sustainably used at local, regional and global scales (ACSES078)

The cost-effective use of renewable energy resources is constrained by the efficiency of available technologies to collect, store and transfer the energy (ACSES079)

The availability and quality of fresh water can be influenced by human activities (for example, urbanisation, over-extraction, pollution) and natural processes (for example, siltation, drought, algal blooms) at local and regional scales (ACSES080)

Any human activities that affect ecosystems (for example, species removal, habitat destruction, pest introduction, dryland salinity) can directly or indirectly reduce populations to beneath the threshold of population viability at local, regional and global scales and impact ecosystem services (ACSES081)

Overharvesting can directly reduce populations of biota to beneath the threshold of population viability; the concept of maximum sustainable yield aims to enable sustainable harvesting (ACSES082)

Producing, harvesting, transporting and processing of resources for consumption, and assimilating the associated wastes, involves the use of resources; the concept of an ‘ecological footprint’ is used to measure the magnitude of this demand (ACSES083)

Earth and Environmental Science

Unit 4: The changing Earth - the cause and impact of Earth hazards

Unit Description

Earth hazards occur over a range of time scales and have significant impacts on Earth systems across a wide range of spatial scales. Investigation of naturally occurring and human-influenced Earth hazards enables prediction of their impacts, and the development of management and mitigation strategies. In this unit, students examine the cause and effects of naturally occurring Earth hazards including volcanic eruptions, earthquakes and tsunami. They examine ways in which human activities can contribute to the frequency, magnitude and intensity of Earth hazards such as fire and drought. This unit focuses on the timescales at which the effects of natural and human-induced change are apparent and the ways in which scientific data are used to provide strategic direction for the mitigation of Earth hazards and environmental management decisions.

Students review the scientific evidence for climate change models, including the examination of evidence from the geological record, and explore the tensions associated with differing interpretations of the same evidence. They consider the reliability of these models for predicting climate change, and the implications of future climate change events, including changing weather patterns, globally and in Australia (for example, changes in flooding patterns or aridity, and changes to vegetation distribution, river structure and groundwater recharge).

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to monitoring and managing Earth hazards and climate change have developed over time and through interactions with social, economic, cultural, and ethical considerations. They investigate the ways in which science contributes to contemporary debate regarding local, regional and international management of Earth hazards, evaluation of risk and action for sustainability, and recognise the limitations of science in providing definitive answers in different contexts.

Students use inquiry skills to collect, analyse and interpret data relating to the cause and impact of Earth hazards. They critically analyse the range of factors that influence the magnitude, frequency, intensity and management of Earth hazards at local, regional and global levels.

Learning Outcomes

By the end of this unit, students:

- understand the causes of Earth hazards and the ways in which they impact, and are impacted by, Earth systems
- understand how environmental change is modelled, and how the reliability of these models influences predictions of future events and changes
- understand how models and theories have developed over time; and the ways in which Earth and environmental science knowledge interacts with social, economic, cultural and ethical considerations in a range of contexts
- use science inquiry skills to collect, analyse and communicate primary and secondary data on Earth hazards and related impacts on Earth systems
- evaluate, with reference to empirical evidence, claims about Earth hazards and related impacts on Earth systems and justify evaluations
- communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills (Earth and Environmental Science Unit 4)

Identify, research and construct questions for investigation, propose hypotheses and predict possible outcomes (ACSES084)

Design investigations including the procedure/s to be followed, the information required and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSES085)

Conduct investigations, including using spatial analysis to complement map and field location techniques, environmental sampling procedures and field metering equipment, safely, competently and methodically for the collection of valid and reliable data (ACSES086)

Represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; discuss the ways in which measurement error and instrumental accuracy, the nature of the procedure and sample size may influence uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions (ACSES087)

Interpret a range of scientific and media texts and evaluate processes, claims and conclusions by considering the quality of available evidence, including interpreting confidence intervals in secondary data; use reasoning to construct scientific arguments (ACSES088)

Select, construct and use appropriate representations, including maps and other spatial representations, to communicate conceptual understanding, make predictions and solve problems (ACSES089)

Communicate to specific audiences and for specific purposes using appropriate language, genres and modes, including compilations of field data and research reports (ACSES090)

Science as a Human Endeavour (Units 3 & 4)

ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of data sets with which scientists work (ACSES091)

Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power (ACSES092)

The acceptance of scientific knowledge can be influenced by the social, economic and cultural context in which it is considered (ACSES093)

People can use scientific knowledge to inform the monitoring, assessment and evaluation of risk (ACSES094)

Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question (ACSES095)

International collaboration is often required when investing in large scale science projects or addressing issues for the Asia-Pacific region (ACSES096)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSES097)

Science Understanding

The cause and impact of Earth hazards

Earth hazards result from the interactions of Earth systems and can threaten life, health, property, or the environment; their occurrence may not be prevented but their effect can be mitigated (ACSES098)

Plate tectonic processes generate earthquakes, volcanic eruptions and tsunamis; the occurrence of these events affects other Earth processes and interactions (for example, ash clouds influence global weather) (ACSES099)

Monitoring and analysis of data, including earthquake location and frequency data and ground motion monitoring, allows the mapping of potentially hazardous zones, and contributes to the future prediction of the location and probability of repeat occurrences of hazardous Earth events, including volcanic eruptions, earthquakes and tsunamis (ACSES100)

Major weather systems generate cyclones, flood events and droughts; the occurrence of these events affects other Earth processes and interactions (for example, habitat destruction, ecosystem regeneration) (ACSES101)

Human activities, including land clearing, can contribute to the frequency, magnitude and intensity of some natural hazards (for example, drought, flood, bushfire, landslides) at local and regional scales (ACSES102)

The impact of natural hazards on organisms, including humans, and ecosystems depends on the location, magnitude and intensity of the hazard, and the configuration of Earth materials influencing the hazard (for example, biomass, substrate) (ACSES103)

The cause and impact of global climate change

Natural processes (for example, oceanic circulation, orbitally-induced solar radiation fluctuations, the plate tectonic supercycle) and human activities contribute to global climate changes that are evident at a variety of time scales (ACSES104)

Human activities, particularly land-clearing and fossil fuel consumption, produce gases (including carbon dioxide, methane, nitrous oxide and hydrofluorocarbons) and particulate materials that change the composition of the atmosphere and climatic conditions (for example, the enhanced greenhouse effect) (ACSES105)

Climate change affects the biosphere, atmosphere, geosphere and hydrosphere; climate change has been linked to changes in species distribution, crop productivity, sea level, rainfall patterns, surface temperature and extent of ice sheets (ACSES106)

Geological, prehistorical and historical records provide evidence (for example, fossils, pollen grains, ice core data, isotopic ratios, indigenous art sites) that climate change has affected different regions and species differently over time (ACSES107)

Climate change models (for example, general circulation models, models of El Nino and La Nina) describe the behaviour and interactions of the oceans and atmosphere; these models are developed through the analysis of past and current climate data, with the aim of predicting the response of global climate to changes in the contributing components (for example, changes in global ice cover and atmospheric composition) (ACSES108)

Units 3 and 4 Achievement Standards

Earth and Environmental Science concepts, models and applications

A	B	C	D	E
For the Earth systems studied, the student:	*For the Earth systems studied, the student:*	*For the Earth systems studied, the student:*	*For the Earth systems studied, the student:*	*For the Earth systems studied, the*

Earth and Environmental Science concepts, models and applications

				student:

Earth and Environmental Science concepts, models and applications

• analyses how human activities and Earth processes affect components of, and interactions between, Earth systems across a range of temporal and spatial scales • analyses how interactions between Earth systems change, and how these changes are monitored and managed across a range of temporal and spatial scales • explains the theories and model/s used to explain the systems, the supporting evidence and their limitations and assumptions • applies theories and models of systems and processes to explain phenomena and critically analyse complex problems and make reasoned, plausible predictions in unfamiliar contexts *For the Earth and environmental contexts studied, the student:*	• explains how human activities and Earth processes affect components of, and interactions between, Earth systems • explains how interactions between Earth systems change, and how these changes are monitored and managed • describes the theories and model/s used to explain the systems, some supporting evidence, and their limitations • applies theories and models of systems and processes to explain phenomena, analyse problems and make plausible predictions in unfamiliar contexts *For the Earth and environmental contexts*	• explains how human activities and Earth processes affect components of Earth systems • explains how components of Earth systems change, and how these changes are managed • describes key aspects of a theory or model used to explain system processes and the phenomena to which they can be applied • applies theories or models of systems and processes to explain phenomena, interpret problems and make plausible predictions in some unfamiliar contexts *For the Earth and environmental contexts studied, the student:*	• describes how human activities and Earth processes affect components of Earth systems • describes changes to components of Earth systems and some management responses • describes key aspects of a theory or model used to explain a system process • describes phenomena, interprets simple problems and makes predictions in familiar contexts *For the Earth and environmental contexts studied, the student:* • describes the role of communication	• identifies some human activities and Earth processes that impact components of Earth systems • describes some changes to components of Earth systems, and a related management response • identifies aspects of a theory or model related to a system process • describes phenomena and makes simple predictions in familiar contexts *For the Earth and environmental contexts studied, the student:* • identifies that Earth and

Earth and Environmental Science concepts, models and applications

• analyses the role of collaboration, debate and review, and technologies, in the development of Earth and environmental theories and models • evaluates how Earth and environmental science has been used in concert with other sciences to meet diverse needs and inform decision making; and how these applications are influenced by interacting social, economic and ethical factors	*studied, the student:* • explains the role of collaboration, debate and review, and technologies, in the development of Earth and environmental theories and models • explains how Earth and environmental science has been used to meet diverse needs and inform decision making; and how these applications are influenced by social, economic and ethical factors	• describes the role of collaboration and review, and technologies, in the development of Earth and environmental theories or models • discusses how Earth and environmental science has been used to meet needs and inform decision making, and some social, economic or ethical implications of these applications	and new evidence in developing Earth and environmental knowledge • describes ways in which Earth and environmental science has been used in society to meet needs and identifies some implications of these applications	Earth and environmental knowledge has changed over time • identifies ways in which Earth and environmental science has been used in society to meet needs

Earth and Environmental Science inquiry skills

A	B	C	D	E
For the Earth and environmental contexts studied, the student:	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*	*For the Earth and environmental contexts studied, the student:*

Earth and Environmental Science inquiry skills

• designs, conducts and improves safe, ethical investigations that efficiently collect valid, reliable data in response to a complex question or problem • analyses data sets to explain causal and correlational relationships, the reliability of the data and sources of error • justifies their selection of data as evidence, analyses evidence with reference to models and/or theories and develops evidence-based conclusions that identify limitations • evaluates processes and claims; provides an evidence-based critique and discussion of improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve complex and unfamiliar problems • communicates effectively and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs, conducts and improves safe, ethical investigations that collect valid, reliable data in response to a question or problem • analyses data sets to identify causal and correlational relationships, anomalies and sources of error • selects appropriate data as evidence, interprets evidence with reference to models and/or theories and provides evidence for conclusions • evaluates processes and claims; provides a critique with reference to evidence and identifies possible improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve unfamiliar problems • communicates clearly and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs and conducts safe, ethical investigations that collect valid data in response to a question or problem • analyses data to identify relationships, anomalies and sources of error • selects data to demonstrate relationships linked to Earth and environmental knowledge and provides conclusions based on data • evaluates processes and claims and suggests improvements or alternatives • selects, constructs and uses appropriate representations to describe relationships and solve problems • communicates clearly in a range of modes, styles and genres for specific purposes	• plans and conducts safe, ethical investigations to collect data in response to a question or problem • analyses data to identify trends and anomalies • selects data to demonstrate trends and presents simple conclusions based on data • considers processes and claims from a personal perspective • constructs and uses simple representations to describe relationships and solve simple problems • communicates in a range of modes and genres	• follows a procedure to conduct safe, ethical investigations to collect data • identifies trends in data • selects data to demonstrate trends • considers claims from a personal perspective • constructs and uses simple representations to describe phenomena • communicates in a range of modes

Earth and Environmental Science Glossary

Accuracy

The extent to which a measurement result represents the quantity it purports to measure; an accurate measurement result includes an estimate of the true value and an estimate of the uncertainty.

Animal ethics

Animal ethics involves consideration of respectful, fair and just treatment of animals. The use of animals in science involves consideration of replacement (substitution of insentient materials for conscious living animals), reduction (using only the minimum number of animals to satisfy research statistical requirements) and refinement (decrease in the incidence or severity of ‘inhumane’ procedures applied to those animals that still have to be used).

Biogeochemical cycles

Pathways by which chemical substances move through the biosphere, lithosphere, atmosphere, and hydrosphere.

Biomass

The mass of living matter (microbial, plant and animal) in a given environmental area.

Biomass pyramid

A representation of the total biomass at each trophic level within a system.

Biophysical interactions

Interaction between the biotic and abiotic elements of the atmosphere, hydrosphere, lithosphere and biosphere.

Carrying capacity

The largest number of individuals (within populations) that can be supported by the ecosystem.

Data

The plural of datum; the measurement of an attribute, for example, the volume of gas or the type of rubber. This does not necessarily mean a single measurement: it may be the result of averaging several repeated measurements. Data may be quantitative or qualitative and be from primary or secondary sources.

Environmental sampling techniques

Techniques used to survey, measure, quantify, assess and monitor biotic and abiotic components of the environment and their interactions; techniques used depend on the subject and purpose of the study and may include: random quadrats, transects, grid arrays, netting, trapping, aerial surveys and rock, soil, air and water sampling.

Evidence

In science, evidence is data that is considered reliable and valid and which can be used to support a particular idea, conclusion or decision. Evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness.

Field metering equipment

Tools used in the field to measure and record environmental parameters including light meters, weather stations, electromagnetic induction (EMI) meters, magnetometers and radioactivity sensors.

Field work
Observational research undertaken in the normal environment of the subject of the study.

Genre
The categories into which texts are grouped; genre distinguishes texts on the basis of their subject matter, form and structure (for example, scientific reports, field guides, explanations, procedures, biographies, media articles, persuasive texts, narratives).

Hypothesis
A tentative explanation for an observed phenomenon, expressed as a precise and unambiguous statement that can be supported or refuted by experiment.

Investigation
A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities. Investigations can include observation, research, field work, laboratory experimentation and manipulation of simulations.

Law
A statement describing invariable relationships between phenomena in specified conditions, frequently expressed mathematically.

Mapping and field location techniques
Techniques used in the field to describe the field location and to measure and record data and field observations, including use of maps, global positioning system (GPS), magnetic compasses and electronic devices with geopositioning capacity (for example, cameras).

Measurement error
The difference between the measurement result and a currently accepted or standard value of a quantity.

Media texts
Spoken, print, graphic or electronic communications with a public audience. Media texts can be found in newspapers, magazines and on television, film, radio, computer software and the internet.

Mode
The various processes of communication – listening, speaking, reading/viewing and writing/creating.

Model
A representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea.

Population
A group of organisms of one species that interbreed and live in the same place at the same time.

Primary data
Data collected directly by a person or group.

Primary source
Report of data created by the person or persons directly involved in observations of one or more events, experiments, investigations or projects.

Principle of Uniformitarianism

The principle that all geologic phenomena may be explained as the result of existing forces having operated similarly from the origin of Earth to the present time.

Reliability

The degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Reliable data

Data that has been judged to have a high level of reliability; reliability is the degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Representation

A verbal, visual, physical or mathematical demonstration of understanding of a science concept or concepts. A concept can be represented in a range of ways and using multiple modes.

Research

To locate, gather, record, attribute and analyse information in order to develop understanding.

Research ethics

Norms of conduct that determine ethical research behaviour; research ethics are governed by principles such as honesty, objectivity, integrity, openness and respect for intellectual property and include consideration of animal ethics.

Risk assessment

Evaluations performed to identify, assess and control hazards in a systematic way that is consistent, relevant and applicable to all school activities. Requirements for risk assessments related to particular activities will be determined by jurisdictions, schools or teachers as appropriate.

Rock and soil sampling and identification procedures

Procedures used in the field to enable rock and soil sampling and identification, including use of classification charts, geological hammer, hand lens, soil auger, soil pH kit and other soil testing chemicals (for example, dilute acid).

Secondary data

Data collected by a person or group other than the person or group using the data.

Secondary source

Information that has been compiled from records of primary sources by a person or persons not directly involved in the primary event.

Simulation

A representation of a process, event or system which imitates a real or idealised situation.

Spatial analysis

The range of techniques used to examine imagery and datasets covering large spatial areas and commonly compiled in geographical information systems (GIS) including maps, satellite imagery, aerial photographs, geophysical data sets, water or rock samples and other directly sensed data.

Stratigraphy

Study of rock layers and layering of materials such as sediments including ash, meteoritic impact ejecta layers, and soils.

System

A group of interacting objects, materials or processes that form an integrated whole. Systems can be open or closed.

Tectonic plate supercycle

The cycling of Earth over a period of 400 to 600 million years from a single continent and ocean with an inferred icehouse climate to many continents and oceans with a moderate to warm climate.

Theory

A set of concepts, claims and/or laws that can be used to explain and predict a wide range of related observed or observable phenomena. Theories are typically founded on clearly identified assumptions, are testable, produce reproducible results and have explanatory power.

Uncertainty

Range of values for a measurement result, taking account of the likely values that could be attributed to the measurement result given the measurement equipment, procedure and environment.

Validity

The extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate.

Glossary

Abstract

Abstract scenario: a scenario for which there is no concrete referent provided.

Account

Account for: provide reasons for (something).

Give an account of: report or describe an event or experience.

Taking into account: considering other information or aspects.

Analyse

Consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences.

Apply

Use, utilise or employ in a particular situation.

Assess

Determine the value, significance or extent of (something).

Coherent

Orderly, logical, and internally consistent relation of parts.

Communicates

Conveys knowledge and/or understandings to others.

Compare

Estimate, measure or note how things are similar or dissimilar.

Complex

Consisting of multiple interconnected parts or factors.

Considered

Formed after careful thought.

Critically analyse

Examine the component parts of an issue or information, for example the premise of an argument and its plausibility, illogical reasoning or faulty conclusions

Critically evaluate

Evaluation of an issue or information that includes considering important factors and available evidence in making critical judgement that can be justified.

Deduce

Arrive at a conclusion by reasoning.

Demonstrate

Give a practical exhibition as an explanation.

Describe

Give an account of characteristics or features.

Design

Plan and evaluate the construction of a product or process.

Develop

In history: to construct, elaborate or expand.

In English: begin to build an opinion or idea.

Discuss

Talk or write about a topic, taking into account different issues and ideas.

Distinguish

Recognise point/s of difference.

Evaluate

Provide a detailed examination and substantiated judgement concerning the merit, significance or value of something.

In mathematics: calculate the value of a function at a particular value of its independent variables.

Explain

Provide additional information that demonstrates understanding of reasoning and/or application.

Familiar

Previously encountered in prior learning activities.

Identify

Establish or indicate who or what someone or something is.

Integrate

Combine elements.

Investigate

Plan, collect and interpret data/information and draw conclusions about.

Justify

Show how an argument or conclusion is right or reasonable.

Locate

Identify where something is found.

Manipulate

Adapt or change.

Non-routine

Non-routine problems: Problems solved using procedures not previously encountered in prior learning activities.

Reasonableness

Reasonableness of conclusions or judgements: the extent to which a conclusion or judgement is sound and makes sense

Reasoned

Reasoned argument/conclusion: one that is sound, well-grounded, considered and thought out.

Recognise

Be aware of or acknowledge.

Relate

Tell or report about happenings, events or circumstances.

Represent

Use words, images, symbols or signs to convey meaning.

Reproduce

Copy or make close imitation.

Responding

In English: When students listen to, read or view texts they interact with those texts to make meaning. Responding involves students identifying, selecting, describing, comprehending, imagining, interpreting, analysing and evaluating.

Routine problems

Routine problems: Problems solved using procedures encountered in prior learning activities.

Select

Choose in preference to another or others.

Sequence

Arrange in order.

Solve

Work out a correct solution to a problem.

Structured

Arranged in a given organised sequence.

In Mathematics: When students provide a structured solution, the solution follows an organised sequence provided by a third party.

Substantiate

Establish proof using evidence.

Succinct

Written briefly and clearly expressed.

Sustained

Consistency maintained throughout.

Synthesise

Combine elements (information/ideas/components) into a coherent whole.

Understand

Perceive what is meant, grasp an idea, and to be thoroughly familiar with.

Unfamiliar

Not previously encountered in prior learning activities.