Government of **Western Australia**
**School Curriculum and Standards Authority**

# EARTH AND ENVIRONMENTAL SCIENCE

ATAR COURSE

Year 11 syllabus

**Acknowledgement of Country**

Kaya. The School Curriculum and Standards Authority (the Authority) acknowledges that our offices are on Whadjuk Noongar boodjar and that we deliver our services on the country of many traditional custodians and language groups throughout Western Australia. The Authority acknowledges the traditional custodians throughout Western Australia and their continuing connection to land, waters and community. We offer our respect to Elders past and present.

**Important information**

This syllabus is effective from 1 January 2024.

Users of this syllabus are responsible for checking its currency.

Syllabuses are formally reviewed by the School Curriculum and Standards Authority (the Authority) on a cyclical basis, typically every five years.



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# Content

# Rationale

Earth and environmental science is a multifaceted field of inquiry that focuses on interactions between the Earth's geosphere, hydrosphere, atmosphere and biosphere, and on dynamic, interdependent relationships that have developed between these components. Earth and environmental scientists consider how these relationships produce environmental change over 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.

The Earth and Environmental Science ATAR course builds on the content in all science sub-strands of the Year 7–10 Science curriculum. In particular, the course 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 course, 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 an integrated approach, rather than with a particular ecological, biological, physical or chemical focus.

Studying senior secondary science provides students with a range of skills and understandings that are valuable to a wide range of further study pathways and careers. In the Earth and Environmental Science ATAR course, students develop their investigative, analytical and communication skills. They can 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 course 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.

# Aims

The Earth and Environmental Science ATAR course 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 interacting systems, including the geosphere, atmosphere, hydrosphere and biosphere
- 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 science concepts, interpretations, claims and conclusions with reference to evidence
- ability to communicate science understandings, findings, arguments and conclusions using appropriate representations and formats.

# Organisation

This course is organised into a Year 11 syllabus and a Year 12 syllabus. The cognitive complexity of the syllabus content increases from Year 11 to Year 12.

## Structure of the syllabus

The Year 11 syllabus is divided into two units, each of one semester duration, which are typically delivered as a pair. The notional time for each unit is 55 class contact hours.

### Unit 1 – Earth systems

In this unit, students examine the evidence underpinning theories of the development of the Earth systems, their interactions and their components.

### Unit 2 – Earth processes

In this unit, students investigate how Earth processes involve interactions of Earth systems that are interrelated through transfers and transformations of matter and energy.

Each unit includes:

- a unit description – a short description of the focus of the unit
- learning outcomes – a set of statements describing the learning expected as a result of studying the unit
- unit content – the content to be taught and learned.

## Organisation of content

### Science strand descriptions

The Science curriculum has three interrelated strands: Science Inquiry Skills, Science as a Human Endeavour and Science Understanding. In the Earth and Environmental Science ATAR course, the three strands build on students' learning in the Year 7–10 Science curriculum. The three strands of the Earth and Environmental Science course 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 focusses on evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions, and developing evidence-based arguments.

Investigations can involve a range of activities, including experimental testing, field work, sample analysis, locating and using information sources, conducting surveys, and using modelling and simulations.

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, cross-sections and stratigraphic columns, text, 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.

**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.

**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.

## 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 health and safety guidelines.

## 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* (www.nhmrc.gov.au).

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*, in addition to relevant State guidelines.

## Mathematical skills expected of students studying the Earth and Environmental Science ATAR course

The Earth and Environmental Science ATAR course requires students to use the mathematical skills they have developed through the Year 7–10 Mathematics curriculum, in addition to the numeracy skills they have developed through the Science Inquiry Skills strand of the Science curriculum.

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 using appropriate units to an appropriate degree of accuracy.

It is assumed that students will be able to:

- 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.

## Progression from the Year 7–10 curriculum

This syllabus continues to develop student understanding and skills from across the three strands of the Year 7–10 Science curriculum. In the Science Understanding strand, this course draws on knowledge and understanding from across the four sub-strands of Biological, Physical, Chemical, and Earth and Space Sciences.

In particular, this course 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.

## Representation of the general capabilities

The general capabilities encompass the knowledge, skills, behaviours and dispositions that will assist students to live and work successfully in the twenty-first century. Teachers may find opportunities to incorporate the capabilities into the teaching and learning program for Earth and Environmental Science ATAR course. The general capabilities are not assessed unless they are identified within the specified unit content.

### Literacy

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 formats 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

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 technology capability

Information and communication technology (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

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. 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

Personal and social capability is integral to a wide range of activities in the Earth and Environmental Science ATAR course, 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

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

Through intercultural understanding, 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 develop 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 the cross-curriculum priorities

The cross-curriculum priorities address contemporary issues which students face in a globalised world. Teachers may find opportunities to incorporate the priorities into the teaching and learning program for the Earth and Environmental Science ATAR course. The cross-curriculum priorities are not assessed unless they are identified within the specified unit content.

## Aboriginal and Torres Strait Islander histories and cultures

Contexts that draw on Aboriginal and Torres Strait Islander histories and cultures provide an opportunity for students investigate to the importance of Aboriginal and Torres Strait Islander Peoples' knowledge in developing a richer understanding of the Australian environment. Students could develop an appreciation of the unique Australian biota and its interactions, the impacts of Aboriginal and Torres Strait Islander Peoples on their environments and the ways in which the Australian landscape has changed over tens of thousands of years. They could examine the ways in which Aboriginal and Torres Strait Islander knowledge of ecosystems has developed over time, the spiritual significance of Country/Place, and their relationship with life-forms through totemic connections.

## Asia and Australia's engagement with Asia

Contexts that draw on Asian scientific research and development and collaborative endeavours in the Asia Pacific region provide an opportunity for students to investigate Asia and Australia's engagement with Asia. Students could develop an appreciation that interaction between human activity and the diverse environments of the Asia region continues to influence the region, including Australia, and has significance for the rest of the world. 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.

## Sustainability

The cross-curriculum priority of Sustainability is explicitly addressed in the Earth and Environmental Science course. 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.

Students appreciate that the Earth and Environmental Science ATAR course provides the basis for decision making in many areas of society and that these decisions can impact on 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.

# Unit 1 – Earth systems

## Unit description

The Earth consists of interacting systems, including the geosphere, atmosphere, hydrosphere and biosphere. A change in any one sphere can impact on 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, ice sheets and groundwater.

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 changes in Earth's systems influence the distribution and diversity of life on Earth.

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 to engage in a range of investigations that help them develop the field and research skills used 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 geosphere, 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 to communicate primary and secondary data using qualitative and quantitative representations in appropriate formats.

## Unit content

This unit includes the knowledge, understandings and skills described below.

### Science Inquiry Skills

- propose hypotheses; plan, and predict possible outcomes; and conduct investigations
- 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

- conduct laboratory and field investigations, including using map and field location techniques and environmental sampling and identification procedures, safely, competently and methodically for the collection of valid and reliable data
- identify the following sedimentary rocks from physical samples, diagrams and photographs – conglomerate, breccia, sandstone, limestone, siltstone, shale, mudstone
- 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
- 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
- interpret and use appropriate representations, including maps and cross-sections where the section line is perpendicular to strike, to describe and analyse spatial relationships and stratigraphy, and to communicate conceptual understanding, solve problems and make predictions
- communicate to specific audiences and for specific purposes using appropriate language and formats, including compilations of field data and research reports

## Science as a Human Endeavour

- early attempts to place Earth's past events in sequential order used a relative geological timescale based on stratigraphic principles, including superposition and cross-cutting relationships; subsequently radiometric dating techniques enabled these events to be assigned specific ages on an absolute timescale
- in recent decades advances in science (including microbiology) have provided new ways to analyse and interpret the evidence for evolution in the fossil record and to model the conditions for the origin of life
- improved understanding of complex events in Earth’s history (such as oxygenation of the atmosphere) requires integration of knowledge and concepts from multiple scientific disciplines (such as chemistry and palaeontology)

## 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
- a relative geological timescale can be constructed using stratigraphic principles, including original horizontality, faunal succession, superposition, cross-cutting relationships, inclusions, unconformities and correlation
- precise dates can be assigned to points on the relative geological timescale using data derived from the decay of radioisotopes in rocks and minerals; this establishes an absolute timescale and places the age of the Earth at approximately 4.5 billion years
- 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 theory

- rocks are composed of one or more minerals and are formed through igneous, sedimentary and metamorphic processes as part of the rock cycle
- minerals can be characterised by their colour, streak, lustre, transparency, cleavage, fracture, hardness (Moh's scale), magnetism, density
- simple sedimentary structures are used as evidence of past processes and are related to depositional environments, including the use of cross-bedding, graded bedding and mud cracks
- some sedimentary rocks can be identified according to their composition and texture, including conglomerate, breccia, sandstone, limestone, siltstone, shale, mudstone
- soil formation requires interaction between atmospheric, geological, hydrological and biotic processes; soil is composed of rock and mineral particles, organic material, water, gases and living organisms

**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
- the modern atmosphere has a layered structure characterised by changes in temperature: the troposphere, stratosphere, mesosphere and thermosphere
- 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
- the water cycle is an important component of Earth system processes

**Development of the biosphere**

- fossil evidence indicates that life first appeared on Earth approximately 4 billion years ago. Index fossils enable correlation of rock strata for relative dating
- current theories state that life emerged under anoxic atmospheric conditions in an aqueous mixture of inorganic compounds, either in a shallow water setting as a result of a lightning strike or in an ocean floor setting due to hydrothermal activity
- in any one location, the characteristics (including temperature, surface water, substrate, organisms, available light) and interactions of the atmosphere, geosphere, hydrosphere and biosphere, give rise to unique and dynamic communities
- the characteristics of past environments and communities (including presence of water, nature of the substrate, organism assemblages) can be inferred from the sequence and internal textures of sedimentary rocks and enclosed fossils, including banded iron formations and Ediacara fauna
- the diversification and proliferation of living organisms over time (including increases in marine animals in the Cambrian period), and the catastrophic collapse of ecosystems (including the mass extinction event at the end of the Cretaceous period) can be inferred from the fossil record

# Unit 2 – Earth processes

## 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 explore 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.

Students investigate how scientific knowledge is used to offer evidence-based explanations and reliable predictions, and the ways in which it interacts with social, economic and cultural factors.

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, tectonic and biogeochemical cycles
- understand how theories and models have developed based on evidence from multiple disciplines
- use science inquiry skills to collect, analyse and communicate primary and secondary data using qualitative and quantitative representations in appropriate formats.

## Unit content

This unit includes the knowledge, understandings and skills described below.

### Science Inquiry Skills

- propose hypotheses; plan, and predict possible outcomes; and conduct investigations
- 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

- conduct laboratory and field investigations, including using map and field location techniques and environmental sampling and identification procedures, safely, competently and methodically for the collection of valid and reliable data
- identify and classify igneous rocks based on texture and mineralogy in physical samples, diagrams and photographs, including basalt, dolerite, gabbro, andesite, diorite, rhyolite, pegmatite, granite, pumice, tuff and obsidian
- 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
- 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
- interpret and use appropriate representations, including maps and cross-sections where the section line is perpendicular to strike, to describe and analyse spatial relationships, and stratigraphy, to communicate conceptual understanding, solve problems and make predictions
- communicate to specific audiences and for specific purposes using appropriate language and formats, including compilations of field data and research reports

### Science as a Human Endeavour

- scientific study of the origin and maintenance of the Earth's internal heat has been important in developing many significant concepts in the Earth sciences, including the origin of igneous rocks and volcanoes, the age of the Earth and plate tectonics
- identification of cyclic changes in the atmosphere and hydrosphere, including El Niño and La Niña, requires systematic collection and analysis of data, such as air pressure and sea-surface temperature records, to reveal patterns that are not evident at small spatial or short temporal scales
- satellite technologies enable the estimation, comparison and monitoring of primary production (biomass production due to photosynthesis) globally and in a range of different ecosystems

### Science Understanding

- energy is neither created nor destroyed, but can be transformed from one form to another (for example, kinetic, gravitational, heat, light) and transferred between objects
- processes within and between Earth systems require energy that originates either from the Sun or the interior of Earth
- transfers and transformations of heat and gravitational energy in Earth's interior drive the movement of tectonic plates through processes, including mantle convection, plume formation and slab sinking
- igneous processes form different igneous rocks which can be identified based on texture and mineralogy, including basalt, dolerite, gabbro, andesite, diorite, rhyolite, pegmatite, granite, pumice, tuff and obsidian
- 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

- most of the thermal radiation emitted from Earth's surface passes back out into space, but some is reflected or scattered by greenhouse gases toward Earth; this additional surface warming produces a phenomenon known as the naturally occurring Greenhouse Effect
- 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
- the movement of atmospheric air masses due to heating and cooling, and Earth's rotation and revolution, cause systematic atmospheric circulation
- the interaction between Earth's atmosphere and oceans changes over time and can result in phenomena, including El Niño and La Niña
- thermal and light energy from the Sun drives important Earth processes, including evaporation and photosynthesis
- photosynthesis is the principal mechanism for the transformation of energy from the Sun into energy forms that are useful for living things
- energy and matter flow through the biotic and abiotic components of an ecosystem, and human activities influence this flow; applied to a Western Australian case study
- biogeochemical cycling of matter, including nitrogen, involves the transfer and transformation of energy between the biosphere, geosphere, atmosphere and hydrosphere
- energy is stored, transferred and transformed in the carbon cycle; biological elements, including living and dead organisms, store energy over relatively short time scales, and geological components store energy for extended periods

# School-based assessment

The *Western Australian Certificate of Education (WACE) Manual* contains essential information on principles, policies and procedures for school-based assessment that needs to be read in conjunction with this syllabus.

Teachers design school-based assessment tasks to meet the needs of students. The table below provides details of the assessment types for the Earth and Environmental Science ATAR Year 11 syllabus and the weighting for each assessment type.

## Assessment table – Year 11

| Type of assessment | Weighting |
| --- | --- |
| **Investigation**<br>Investigations are practical tasks or exercises designed to develop and assess a range of practical skills and conceptual understanding, and skills associated with processing data.<br>Investigations can be communicated in any appropriate format, including written, oral or graphic.<br>Tasks can take the form of a practical skills exercise, design and/or conduct of an investigation, a laboratory report, a descriptive field study or a short in-class test to validate the knowledge gained during the investigation. | 30% |
| **Extended task**<br>Tasks can take the form of: individual research assignments involving interpretation of a range of scientific and media texts; case studies; responses to discussions, presentations and questions; multimedia presentations.<br>Appropriate strategies should be used to authenticate student achievement that has been completed as a part of a group or as an out-of-class task. | 10% |
| **Test**<br>Tasks can involve comprehension and interpretation exercises; analysis and evaluation of qualitative and quantitative information; application of scientific principles to explain situations; use of reasoning to construct scientific arguments and problem solving. | 20% |
| **Examination**<br>Typically conducted at the end of each semester and/or unit. In preparation for Unit 3 and Unit 4, the examination should reflect the examination design brief included in the ATAR Year 12 syllabus for this course. | 40% |

Teachers are required to use the assessment table to develop an assessment outline for the pair of units (or for a single unit where only one is being studied).

The assessment outline must:

- include a set of assessment tasks
- include a general description of each task
- indicate the unit content to be assessed
- indicate a weighting for each task and each assessment type
- include the approximate timing of each task (for example, the week the task is conducted, or the issue and submission dates for an extended task).

In the assessment outline for the pair of units, each assessment type must be included at least once over the year/pair of units. In the assessment outline where a single unit is being studied, each assessment type must be included at least once.

The set of assessment tasks must provide a representative sampling of the content for Unit 1 and Unit 2.

Assessment tasks not administered under test/controlled conditions require appropriate validation/authentication processes.

## Grading

Schools report student achievement in terms of the following grades:

| Grade | Interpretation |
|---|---|
| **A** | Excellent achievement |
| **B** | High achievement |
| **C** | Satisfactory achievement |
| **D** | Limited achievement |
| **E** | Very low achievement |

The teacher prepares a ranked list and assigns the student a grade for the pair of units (or for a unit where only one unit is being studied). The grade is based on the student's overall performance as judged by reference to a set of pre-determined standards. These standards are defined by grade descriptions and annotated work samples. The grade descriptions for the Earth and Environmental Science ATAR Year 11 syllabus are provided in Appendix 1. They can also be accessed, together with annotated work samples, through the Guide to Grades link on the course page of the Authority website at www.scsa.wa.edu.au.

To be assigned a grade, a student must have had the opportunity to complete the education program, including the assessment program (unless the school accepts that there are exceptional and justifiable circumstances).

Refer to the *WACE Manual* for further information about the use of a ranked list in the process of assigning grades.

# Appendix 1 – Grade descriptions Year 11

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| **A** | **Understanding and applying concepts**<br>Applies models and principles to explain complex systems and processes accurately and in detail, illustrating with supporting examples and accurate diagrams where appropriate.<br>Clearly links multiple concepts to explain cycles and relationships in detail.<br>Accurately applies scientific knowledge to unfamiliar contexts or examples.<br>Interprets and evaluates scientific information from a variety of sources to solve problems and presents well-developed arguments which are supported by evidence. Uses past and present evidence to predict change. |
| | **Science inquiry skills**<br>Formulates a testable hypothesis that states the relationship between dependent and independent variables.<br>Plans investigations to identify and control appropriate variables, describes the experimental method in detail and accurately collects and interprets data.<br>Processes data accurately and presents it logically in a range of forms, including graphs, tables and diagrams to identify patterns and relationships.<br>Comprehensively explains trends using numerical data and uses evidence to draw conclusions that relate to the hypothesis.<br>Evaluates the experimental method and provides specific relevant suggestions to improve validity and reliability of the data collected.<br>Communicates detailed information and concepts logically and coherently, using appropriate terminology and conventions. |

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| **B** | **Understanding and applying concepts**<br>Applies models and principles to accurately explain simple, and some complex, systems and processes, illustrating with clear diagrams where appropriate.<br>Presents explanations of concepts logically, with some provision of supporting examples.<br>Applies scientific knowledge to unfamiliar contexts or examples, sometimes lacking detail.<br>Interprets and evaluates scientific information to solve problems or to support a point of view. |
| | **Science inquiry skills**<br>Formulates a testable hypothesis that states the relationship between dependent and independent variables.<br>Plans investigations to identify and control appropriate variables, clearly describes the experimental method and accurately collects data.<br>Processes data correctly and presents data in a range of forms, including graphs, tables and diagrams, and identifies patterns and relationships.<br>Explains trends and uses evidence to draw conclusions that relate to the hypothesis.<br>Evaluates the experimental method and provides general suggestions to improve validity and reliability of the data.<br>Describes relationships between data and concepts using appropriate terminology and conventions. |

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| **C** | **Understanding and applying concepts**<br>Applies models and principles to describe simple systems and processes.<br>Interprets information to describe trends or relationships and makes predictions.<br>Applies models to explain cycles and processes; using diagrams where appropriate.<br>Applies scientific knowledge to familiar contexts or examples.<br>Presents arguments or statements supported by some evidence. Responses lack detail and may include irrelevant information. |
| | **Science inquiry skills**<br>Formulates a testable hypothesis that links dependent and independent variables.<br>Plans investigations to identify and control some variables; briefly outlines the experimental method used and collects data.<br>Processes and presents data using basic tables and graphs.<br>Makes general suggestions for improving the validity and reliability of data.<br>Describes trends in data and draws simple conclusions that may not be linked back to the hypothesis.<br>Communicates information and concepts, without detail, using some appropriate terminology and conventions. |

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| **D** | **Understanding and applying concepts**<br>Incorrectly applies models and principles to describe systems and processes.<br>Presents statements of ideas with limited development of an argument and little use of evidence.<br>Inconsistently recalls facts and includes some irrelevant or confused information.<br>Provides limited cause and effect examples.<br>Inconsistently applies principles to unfamiliar contexts.<br>Describes the interdependence of systems in a general way. |
| | **Science inquiry skills**<br>Identifies one or more relevant variables without making links between them.<br>Identifies a limited number of controlled variables. Does not distinguish between the dependent, independent and controlled variables. Experimental method lacks sufficient detail.<br>Presents data that is unclear, insufficient and lacks appropriate processing.<br>Identifies trends in data incorrectly or overlooks trends.<br>Offers simple conclusions that are not supported by data or are not related to the hypothesis.<br>Provides trivial or irrelevant suggestions for improving the validity and reliability of the data.<br>Communicates information using everyday language with frequent errors in the use of conventions. |

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| **E** | Does not meet the requirements of a D grade and/or has completed insufficient assessment tasks to be assigned a higher grade. |