Earth and Environmental Science

OFFICIAL

2023 Subject Outline | Stage 1

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contents

Introduction 1

Subject description 1

Capabilities 2

Aboriginal and Torres Strait Islander knowledge, cultures, and perspectives 4

Health and safety 5

Learning scope and requirements 6

Learning requirements 6

Content 6

Assessment scope and requirements 34

Evidence of learning 34

Assessment design criteria 34

School assessment 35

Performance standards 39

Assessment integrity 41

Support materials 42

Subject-specific advice 42

Advice on ethical study and research 42

Introduction

Subject description

Earth and Environmental Science is a 10-credit subject or a 20-credit subject at Stage 1 and a 20-credit subject at Stage 2.

The Earth system involves four interacting systems: the geosphere, atmosphere, hydrosphere, and biosphere. A change in any one ‘sphere’ can affect others on a range of temporal and spatial scales. In this subject, the term ‘environment’ encompasses terrestrial, marine, and atmospheric settings and includes the Earth’s interior. Environments are described and characterised with a focus on systems thinking and a multidisciplinary approach, including ecological, geological, biological, physical, and chemical aspects.

This subject emphasises ways in which Earth materials and processes generate environments, including habitats, where organisms live; the natural processes and human influences that induce changes in physical environments; and ways in which organisms respond to those changes.

Through their study of Earth and Environmental Science, students develop and extend their inquiry skills, including in designing and undertaking investigations, and collecting and analysing primary and secondary data. They interpret and evaluate information, and synthesise and use evidence to construct and justify conclusions.

Students apply their understanding of the interaction of the four Earth systems to investigate, evaluate, and make predictions about the impact of human activities on the environment and vice versa.

At Stage 1, students consider a range of the Earth hazards that illustrate the dynamic nature of the Earth’s systems. Students critically examine the scientific evidence for the origin of life, linking this with their understanding of the evolution of the Earth’s hydrosphere and atmosphere. Students review evidence from the fossil record that demonstrates the interrelationships between major changes in the 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, the Earth’s systems.

At Stage 2, students consider how human beings use the Earth’s resources and the impact of human activities on the environment. They assess the evidence that informs public debate on social and environmental issues such as use of the Earth’s resources, and climate change. They conduct a detailed investigation into an aspect of human activity that impacts on two or more of the Earth’s systems.

In their study of Earth and Environmental Science, students integrate and apply a range of understanding and inquiry skills that encourage and inspire them in thinking scientifically, contributing their own solutions to current and future problems and challenges, and pursuing scientific pathways, including in environmental science, geology, meteorology, oceanography, seismology, metallurgy, and scientific research.

Capabilities

The capabilities connect student learning within and across subjects in a range of contexts. They include essential knowledge and skills that enable people to act in effective and successful ways.

The SACE identifies seven capabilities. They are:

* literacy
* numeracy
* information and communication technology (ICT) capability
* critical and creative thinking
* personal and social capability
* ethical understanding
* intercultural understanding.

Literacy

In this subject students extend and apply their literacy capability by, for example:

* interpreting the work of scientists across disciplines, using earth and environmental science knowledge
* critically analysing and evaluating primary and secondary data
* extracting earth and environmental science information presented in a variety of modes
* using a range of communication formats to express ideas logically and fluently, incorporating the terminology and conventions of earth and environmental science
* synthesising evidence-based arguments
* communicating appropriately for specific purposes and audiences.

Numeracy

In this subject students extend and apply their numeracy capability by, for example:

* solving problems using calculations and critical thinking skills
* measuring with appropriate instruments
* recording, collating, representing, and analysing primary data
* accessing and interpreting secondary data
* identifying and interpreting trends and relationships
* calculating and predicting values by manipulating data and using appropriate scientific conventions.

Information and communication technology (ICT) capability

In this subject students extend and apply their ICT capability by, for example:

* locating and accessing information
* collecting, analysing, and representing data electronically
* modelling concepts and relationships
* using technologies to create new ways of thinking about science
* communicating earth and environmental science ideas, processes, and information
* understanding the impact of ICT on the development of earth and environmental science and its application in society
* evaluating the application of ICT to advance understanding and investigations in earth and environmental science.

Critical and creative thinking

In this subject students extend and apply critical and creative thinking by, for example:

* analysing and interpreting problems from different perspectives
* deconstructing a problem to determine the most appropriate method for investigation
* constructing, reviewing, and revising hypotheses to design investigations
* interpreting and evaluating data and procedures to develop logical conclusions
* analysing interpretations and claims, for validity and reliability
* devising imaginative solutions and making reasonable predictions
* envisaging consequences and speculating on possible outcomes
* recognising the significance of creative thinking on the development of earth and environmental science knowledge and applications.

Personal and social capability

In this subject students extend and apply their personal and social capability by, for example:

* understanding the importance of earth and environmental science knowledge on health and well-being, both personally and globally
* making decisions and taking initiative while working independently and collaboratively
* planning effectively, managing time, following procedures effectively, and working safely
* sharing and discussing ideas about earth and environmental science issues and developments, while respecting the perspectives of others
* recognising the role of their own beliefs and attitudes in gauging the impact of earth and environmental science in society
* seeking, valuing, and acting on feedback.

Ethical understanding

In this subject students extend and apply their ethical understanding by, for example:

* considering the implications of their investigations on organisms and the environment
* making ethical decisions based on an understanding of earth and environmental science principles
* using data and reporting the outcomes of investigations accurately and fairly
* acknowledging the need to plan for the future and to protect and sustain the biosphere
* recognising the importance of their responsible participation in social, political, economic, and legal decision-making.

Intercultural understanding

In this subject students extend and apply their intercultural understanding by, for example:

* recognising that science is a global endeavour with significant contributions from diverse cultures
* respecting and engaging with different cultural views and customs and exploring their interaction with scientific research and practices
* being open-minded and receptive to change in the light of scientific thinking based on new information
* understanding that the progress of earth and environmental science influences and is influenced by cultural factors.

Aboriginal and Torres Strait Islander knowledge, cultures, and perspectives

In partnership with Aboriginal and Torres Strait Islander communities, and schools and school sectors, the SACE Board of South Australia supports the development of high-quality learning and assessment design that respects the diverse knowledge, cultures, and perspectives of Indigenous Australians.

The SACE Board encourages teachers to include Aboriginal and Torres Strait Islander knowledge and perspectives in the design, delivery, and assessment of teaching and learning programs by:

* providing opportunities in SACE subjects for students to learn about Aboriginal and Torres Strait Islander histories, cultures, and contemporary experiences
* recognising and respecting the significant contribution of Aboriginal and Torres Strait Islander peoples to Australian society
* drawing students’ attention to the value of Aboriginal and Torres Strait Islander knowledge and perspectives from the past and the present
* promoting the use of culturally appropriate protocols when engaging with and learning from Aboriginal and Torres Strait Islander peoples and communities.

Health and safety

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 2012, in addition to relevant state, territory, or national health and safety guidelines. Information about these procedures is available from the school sectors.

The following safety practices must be observed in all laboratory work:

* Use equipment only under the direction and supervision of a teacher or other qualified person.
* Follow safety procedures when preparing or manipulating apparatus.
* Use appropriate safety gear when preparing or manipulating apparatus.

The following ethical and safety practices must be observed in all fieldwork:

* Obtain permission if conducting fieldwork on private land and Indigenous lands.
* Be environmentally sensitive in deciding where to collect samples and the amount of samples needed.
* Do not collect specimens or cause damage when visiting conservation sites.
* Follow appropriate safety procedures.
* Use appropriate safety gear when visiting quarries and collecting samples.
* Observe care when visiting coastal areas to minimise the risk posed by freak waves.

Learning scope and requirements

Learning requirements

The learning requirements summarise the knowledge, skills, and understanding that students are expected to develop and demonstrate through their learning in Stage 1 Earth and Environmental Science.

In this subject, students are expected to:

1. apply science inquiry skills to deconstruct a problem and design and conduct earth and environmental science investigations, using appropriate procedures and safe, ethical working practices

2. obtain, record, represent, analyse, and interpret the results of earth and environmental science investigations

3. evaluate procedures and results, and analyse evidence to formulate and justify conclusions

4. develop and apply knowledge and understanding of earth and environmental science concepts in new and familiar contexts

5. explore and understand science as a human endeavour

6. communicate knowledge and understanding of earth and environmental science concepts, using appropriate terms, conventions, and representations.

Content

Earth and Environmental Science is a 10-credit or a 20-credit subject at Stage 1.

The topics in Stage 1 Earth and Environmental Science provide the framework for developing integrated programs of learning through which students extend their skills, knowledge, and understanding of the three strands of science.

The three strands of science to be integrated throughout student learning are:

* science inquiry skills
* science as a human endeavour
* science understanding.

The topics for Stage 1 Earth and Environmental Science are:

* Topic 1: Turbulent Earth
* Topic 2: Composition of the geosphere
* Topic 3: Processes in the geosphere
* Topic 4: The Earth’s atmosphere
* Topic 5: Importance of the hydrosphere
* Topic 6: Biosphere

For a 10-credit subject, students study a selection of concepts from at least two topics.

For a 20-credit subject, students study a selection of concepts from at least four topics.

The topics selected can be sequenced and structured to suit individual groups of students. Topics can be studied in their entirety or in part, taking into account student interests, and preparation for pathways into future study of earth and environmental science.

The following pages describe in more detail:

* science inquiry skills
* science as a human endeavour
* the topics for science understanding.

The descriptions of the science inquiry skills and the topics are structured in two columns: the left-hand column sets out the science inquiry skills or science understanding and the right-hand column sets out possible contexts.

Together with science as a human endeavour, the science inquiry skills and science understanding form the basis of teaching, learning, and assessment in this subject.

The possible contexts are suggestions for potential approaches, and are neither comprehensive nor exclusive. Teachers may select from these and are encouraged to consider other approaches according to local needs and interests.

Within the topic descriptions, the following symbols are used in the possible contexts to show how a strand of science can be integrated:

|  |  |
| --- | --- |
|  | indicates a possible teaching and learning strategy for science understanding |
|  | indicates a possible science inquiry activity |
|  | indicates a possible focus on science as a human endeavour. |

 Science Inquiry Skills

In Earth and Environmental Science, investigation is an integral part of the learning and understanding of concepts, using the scientific method to test ideas and develop new knowledge.

Practical investigations must involve a range of both individual and collaborative activities, during which students extend the science inquiry skills described in the table that follows.

Practical activities may take a range of forms, such as developing or using models and simulations that enable students to develop a better understanding of particular concepts. The activities include laboratory and field studies during which students develop investigable questions and/or testable hypotheses, and select and use equipment appropriately to collect data. The data may be observations, measurements, or other information obtained during the investigation. Students represent and analyse the data they have collected; evaluate procedures, and describe the limitations of the data and procedures; consider explanations for their observations; and present and justify conclusions appropriate to the initial question or hypothesis.

For a 10-credit subject, it is recommended that a minimum of 8–10 hours of class time involves practical activities.

For a 20-credit subject, it is recommended that a minimum of 16–20 hours of class time involves practical activities.

Science inquiry skills are fundamental to students investigating the social, ethical, and environmental impacts and influences of the development of scientific understanding and the applications, possibilities, and limitations of science. These skills enable students to critically consider the evidence they obtain so that they can present and justify a conclusion.

| Science Inquiry Skills | Possible contexts |
| --- | --- |
| Scientific methods enable systematic investigation to obtain measurable evidence.   * Deconstruct a problem to determine and justify the most appropriate method for investigation. * Design investigations, including: * a hypothesis or inquiry question * types of variables * dependent * independent * factors held constant (how and why they are controlled) * factors that may not be able to be controlled (and why not) * materials required * the method to be followed * the type and amount of data to be collected * identification of ethical and safety considerations. | Develop inquiry skills by, for example:   * designing investigations that require investigable questions and imaginative solutions (with or without implementation) * critiquing proposed investigations * using the conclusion of one investigation to propose subsequent experiments * changing an independent variable in a given procedure and adapting the method * researching, developing, and trialling a method * improving an existing procedure * identifying options for measuring the dependent variable * researching hazards related to the use and disposal of chemicals and/or earth and environmental science materials * developing safety audits * identifying relevant ethical and/or legal considerations, including accessibility of investigation sites, in different contexts. |
| Obtaining meaningful data depends on conducting investigations using appropriate procedures and safe, ethical working practices.   * Conduct investigations, including: * selection and safe use of appropriate materials, apparatus, and equipment * collection of appropriate primary and/or secondary data (numerical, visual, descriptive) * individual and collaborative work. | Develop inquiry skills by, for example:   * identifying equipment, materials, or instruments fit for purpose * practising techniques and safe use of apparatus * comparing resolution of different measuring tools * distinguishing between, and using, primary and secondary data. |
| Results of investigations are represented in a well-organised way to allow them to be interpreted.   * Represent results of investigations in appropriate ways, including: * use of appropriate SI units, symbols * use of field notes * construction of appropriately labelled tables * drawing of graphs, including lines or curves of best fit as appropriate * use of significant figures. | Develop inquiry skills by, for example:   * practising constructing field notes (e.g. use the FieldMove Clino or FieldMove apps). * practising constructing tables to tabulate data, including column and row labels with units * identifying the appropriate representations to graph different data sets * selecting appropriate axes and scales to graph data * clarifying understanding of significant figures, e.g. using:   [www.astro.yale.edu/astro120/SigFig.pdf](http://www.astro.yale.edu/astro120/SigFig.pdf)   * comparing data from different sources to describe as quantitative or qualitative. |
| Scientific information can be presented using different types of symbols and representations.   * Select, use, and interpret appropriate representations, including: * mathematical relationships, such as ratios * diagrams * equations   to explain concepts, solve problems, and make predictions. | Develop inquiry skills by, for example:   * drawing and labelling diagrams * constructing flow diagrams * recording images * writing chemical formulae and equations * interpreting satellite images * constructing maps and cross-sections. |
| Analysis of the results of investigations allows them to be interpreted in a meaningful way.   * Analyse data, including: * identification and discussion of trends, patterns, and relationships * interpolation or extrapolation where appropriate. | Develop inquiry skills by, for example:   * analysing data sets to identify trends and patterns * determining relationships between independent and dependent variables * using graphs from different sources (e.g. CSIRO, the Bureau of Meteorology (BOM), or the Australian Bureau of Statistics (ABS)), to predict values other than plotted points * calculating mean values, where appropriate. |
| Critical evaluation of procedures and data can determine the meaningfulness of the results.   * Identify sources of uncertainty, including: * random and systematic errors * uncontrolled factors. * Evaluate reliability, accuracy, and validity of results, by discussing factors including: * sample size * precision * resolution of equipment * random error * systematic error * factors that cannot be controlled. | Develop inquiry skills by, for example:   * discussing how the repeating of an investigation with different materials/equipment may detect a systematic error * using an example of an investigation report to develop report-writing skills.   Useful website:  [www.biologyjunction.com/ap\_sample\_lab\_12\_dissolved\_oxyge.htm](http://www.biologyjunction.com/ap_sample_lab_12_dissolved_oxyge.htm) |
| Conclusions can be formulated that relate to the hypothesis or inquiry question.   * Select and use evidence and scientific understanding to make and justify conclusions. * Recognise the limitations of conclusions. * Recognise that the results of some investigations may not lead to definitive conclusions. | Develop inquiry skills by, for example:   * evaluating procedures and data sets provided by the teacher to determine and hence comment on the limitations of possible conclusions * using data sets to discuss the limitations of the data in relation to the range of possible conclusions that could be made. |
| Effective scientific communication is clear and concise.   * Communicate to specific audiences and for specific purposes using: * appropriate language * terminology * conventions. | Develop inquiry skills by, for example:   * reviewing scientific articles or presentations to recognise conventions * developing skills in referencing and/or footnoting * distinguishing between reference lists and bibliographies * practising scientific communication in written, oral, and multimodal formats. |

 Science as a Human Endeavour

The science as a human endeavour strand highlights science as a way of knowing and doing, and explores the purpose, use, and influence of science in society.

By exploring science as a human endeavour, students develop and apply their understanding of the complex ways in which science interacts with society, and investigate the dynamic nature of earth and environmental science. They explore how earth and environmental scientists develop new understanding and insights, and produce innovative solutions to everyday and complex problems and challenges in local, national, and global contexts. In this way, students are encouraged to think scientifically and make connections between the work of others and their own learning. This enables them to explore their own solutions to current and future problems and challenges.

Students understand that the development of science concepts, models, and theories is a dynamic process that involves analysis of evidence and sometimes produces ambiguity and uncertainty. They consider how and why science concepts, models, and theories are continually reviewed and reassessed as new evidence is obtained and as emerging technologies enable new avenues of investigation. They understand that scientific advancement involves a diverse range of individual scientists and teams of scientists working within an increasingly global community of practice.

Students explore how scientific progress and discoveries are influenced and shaped by a wide range of social, economic, ethical, and cultural factors. They investigate ways in which the application of science may provide great benefits to individuals, the community, and the environment, but may also pose risks and have unexpected outcomes. They understand how decision-making about socio-scientific issues often involves consideration of multiple lines of evidence and a range of needs and values. As critical thinkers, they appreciate science as an ever-evolving body of knowledge that frequently informs public debate, but is not always able to provide definitive answers.

The key concepts of science as a human endeavour underpin the contexts, approaches, and activities in this subject, and must be integrated into all teaching and learning programs.

The key concepts of science as a human endeavour, with elaborations that are neither comprehensive nor exclusive, in the study of Earth and Environmental Science are:

Communication and Collaboration

* Science is a global enterprise that relies on clear communication, international conventions, and review and verification of results.
* Collaboration between scientists, governments, and other agencies is often required in scientific research and enterprise.

Development

* Development of complex scientific models and/or theories often requires a wide range of evidence from many sources and across disciplines.
* New technologies improve the efficiency of scientific procedures and data collection and analysis. This can reveal new evidence that may modify or replace models, theories, and processes.

Influence

* Advances in scientific understanding in one field can influence and be influenced by other areas of science, technology, engineering, and mathematics.
* The acceptance and use of scientific knowledge can be influenced by social, economic, cultural, and ethical considerations.

Application and Limitation

* Scientific knowledge, understanding, and inquiry can enable scientists to develop solutions, make discoveries, design action for sustainability, evaluate economic, social, cultural, and environmental impacts, offer valid explanations, and make reliable predictions.
* The use of scientific knowledge may have beneficial or unexpected consequences; this requires monitoring, assessment, and evaluation of risk, and provides opportunities for innovation.
* Science informs public debate and is in turn influenced by public debate; at times, there may be complex, unanticipated variables or insufficient data that may limit possible conclusions.

Topic 1: Turbulent Earth

Natural hazards such as earthquakes, tsunamis, and volcanic eruptions affect life on Earth. In this topic students 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.

Students explore how the interactions of Earth systems may result in Earth hazards. They investigate ways in which scientific data are used to predict and mitigate the damage caused by these hazards, recognising their social responsibility and the need to plan for the future to protect the biosphere.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Interactions of Earth systems may result in Earth hazards.   * Describe different types of Earth hazards. * Describe how Earth hazards affect life, health, poverty, and the environment. * Explain how occurrence of Earth hazards in one sphere can affect Earth processes in other spheres. * Investigate how human activity influences the frequency and intensity of some hazards. * Discuss different strategies that have helped lessen the severity of Earth hazards. | Explore Earth hazards, such as earthquakes, tsunamis, volcanic eruptions, hurricanes, floods, droughts, landslides, extreme weather, lightning-induced fires, sinkholes, coastal erosion, and comet/asteroid impacts.  Useful websites:  https://www.ga.gov.au/education/classroom-resources/student-activities  [www.bom.gov.au/climate/change/](http://www.bom.gov.au/climate/change/)  Examine examples of life affected by Earth hazards:   * 1986 Lake Nyos (volcanic crater lake and CO2) * Cyclone Tracy (Darwin), Cyclones Yasi and Larry (destruction of banana crops) * Christchurch 2011 earthquake, Tohuku 2011 earthquake, Nepal 2015 earthquake. |  |
| Investigate examples of sphere interaction, such as how ash clouds influence global weather, earthquakes that occur under the ocean affect the hydrosphere by forming tsunamis, lightning strikes in the atmosphere affect the biosphere by starting fires, and bushfires affect atmospheric conditions. |  |
| Explore and evaluate the construction of tsunami barriers in Japan, design of earthquake-resistant buildings, and monitoring of volcanic and seismic activity. |  |
| Processes within the geosphere generate Earth hazards.   * Describe how plate tectonics generate earthquakes, volcanic eruptions, and tsunamis. * Discuss how earthquakes, volcanic eruptions, and tsunamis affect other Earth systems processes. | Explore how:   * earthquakes, volcanic eruptions, and tsunamis can be related * volcanoes can cause ash clouds that may influence global weather * an eruption can cause flash flooding * Hawaiian volcanic fog forms * volcanic activity at the East Pacific Rise may affect El Niño cycles.   Watch video of Sakurajima volcano in Japan erupting, e.g. at: [www.sciencephoto.com/media/246259/view](http://www.sciencephoto.com/media/246259/view) |  |
|  | Compare the different types of volcanism <https://www.usgs.gov/faq/natural-hazards>  Investigate factors causing earthquakes using the QuakeCaster apparatus, see: Geoscience Pathways Project newsletter. |  |
| The impact of extraterrestrial bodies can affect Earth systems.   * Describe an extraterrestrial impact and how it affects Earth systems. | Explore how extraterrestrial impacts can:   * cause a tsunami if the impact is on water * cause an earthquake * affect global climate * cause the extinction of species. |  |
| Earthquake and volcanic eruption data can be used to map hazardous zones and to predict future events.   * Describe how Earth hazards are monitored by measuring various factors. * Discuss how data can contribute to future predictions of Earth hazards. | Compare the effectiveness of various tsunami early-warning systems.  Use changes in size and shape of the volcano cone, chemistry of volatiles, and Earth tremors to predict eruptions.  Use the QuakeCaster apparatus to explore why earthquakes are very difficult to predict. |  |
| Investigate how international collaboration of scientists and use of modern technology allows scientists to better model potential tsunami impacts produced by an expected underwater earthquake, using resources from the Schmidt Ocean Institute website at:  <http://schmidtocean.org/about/our-story/> |  |

Topic 2: Composition of the Geosphere

This topic introduces students to the geosphere, the solid part of the Earth. Students investigate how minerals are classified and used according to their properties, while rocks are classified according to their origins through igneous, sedimentary, and metamorphic processes, as well as according to their compositions and textures. Students also investigate the formation of soil resulting from interactions between the spheres, and how the development of the geological time-scale based on fossil evidence and geological principles has led to revisions of the age of the Earth.

Students explore the multidisciplinary nature of earth and environmental science, with physical, chemical, and geological aspects relevant in concepts such as radioactive decay, the formulae of minerals, and the evidence of fossils. Students develop their numeracy skills by representing the half-life of radioactive elements graphically and identifying the trend in radioactivity levels as elements decay.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Minerals are constituents of the geosphere and are classified according to their chemical composition.   * Discuss the limitations of using criteria to categorise substances as minerals. * Minerals may be identified by their characteristic properties. * Identify common rock-forming minerals by observing their properties. * Discuss how the uses of minerals are related to their properties. | Examine some of the resources at ESWA (Earth Science Western Australia).  Revise chemical symbols for elements that are commonly found in minerals. |  |
| Investigate properties such as colour, streak, cleavage, hardness, lustre, density, magnetism, and reaction to dilute hydrochloric acid.  <https://artsandculture.google.com/exhibit/identifying-minerals-geoscience-australia/XQLi9pyyxhIYKQ?hl=en>  Identify minerals such as quartz, feldspar, biotite, muscovite, calcite, augite, and clay minerals (kaolinite).  Identify hand specimens of minerals and metallic ores, e.g. see:  <https://geology.com/minerals/> |  |
| Explore how use of minerals such as diamonds has improved the efficiency of industrial processes. |  |
| 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.   * Classify rocks as one of igneous, sedimentary, or metamorphic by identification of their characteristic minerals and texture. * Describe the processes that form igneous, sedimentary, and metamorphic rocks. | Use a simple diagram when explaining the interactions within the rock cycle. |  |
| Classify rocks found in the local area.  Classify rocks using the interactive site: <https://geology.com/rocks/>  or Virtual Rock kit at:  <https://www.earthlearningidea.com/virtual_rock_kit/index.html>  Organise a cemetery field trip to observe rocks used as headstones. |  |
| Interactions between the geosphere, atmosphere, hydrosphere, and biosphere lead to the formation of soil.   * Describe the composition of soil as rock and mineral particles, organic material, water, gases, and living organisms * Discuss the relationship between a soil, its origin, and its possible uses. | Prepare a presentation that describes the life of a grain of quartz. |  |
| Observe some examples of physical and chemical weathering in a local area.  Test soil samples from students’ backyards and predict the suitability of these sites for various activities such as construction of houses or growing plants. |  |
| Radioisotopes have been used to establish an absolute time-scale and place the age of the Earth at 4.5 billion years old.   * Explain how the half-life of radioactive elements is used to date Earth materials.   Radioisotopes have been used to date organic remains.   * Describe how carbon-14 is used to date middens and megafauna up to 50 000 years old.   The relative geological time-scale has been constructed using fossils and geological principles.   * Explain, with the aid of diagrams, how the relative ages of rock strata can be determined using fossil evidence and the principles of superposition, cross-cutting relationships, inclusions, and correlation. | Explain why older time spans that predate the reliable fossil record (before the Ediacaran Period) are defined by absolute age.  Investigate how radioisotopic dating of artefacts has provided evidence of Aboriginal and Torres Strait Islander communities in certain areas.  Locate on a map of the world some of the oldest and youngest rocks known.  Interpret radioactive decay curves from a half-life simulation practical. |  |
| Use  and emitters to collect data for graphing.  Conduct a field investigation in the local area. Determine the relative ages of rocks found in the field. |  |
| Explore how the development of dating techniques has altered the estimated age of the Earth.  Explore how the development of the geographical time-scale requires international collaboration of geologists. |  |

Topic 3: Processes in the Geosphere

In this topic students explore how some of the Earth’s most spectacular events are due to energy transformations in the geosphere. They analyse how energy from the Earth’s interior drives movements of tectonic plates in the geosphere, which causes volcanic and earthquake activity.

Students investigate evidence that provides information about the structure of the Earth, and learn how scientists analyse this evidence to develop models that describe changes to the Earth’s structure. Students use the principle of uniformitarianism to develop their creative thinking by making reasonable predictions based on evidence.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Observation of present-day processes can be used to infer past events and processes, by applying the principle of uniformitarianism.   * Explain how features of sedimentary rocks can provide information about their history. | Use the principle of uniformitarianism to interpret the surface of other objects in the solar system, such as Pluto. |  |
| Conduct a field investigation in the local area. Apply the principle of uniformitarianism to interpret geological features seen in the field, e.g. volcanic landforms in south-east SA. |  |
| Discuss limitations of the use of the principle of uniformitarianism to formulate reliable conclusions. |  |
| The study of seismic waves and meteorites provides evidence for the layered structure of the Earth.   * Explain how the presence of shadow zones provides information about the layered structure of the Earth. * Explain how the composition of a meteorite can provide evidence of the internal composition, of the Earth. * Describe the structure, relative thickness, composition and state of each layer of the Earth’s interior. * Describe how continental crust is different from oceanic crust. | Illustrate different types of crust using a clay-ball model of the Earth. |  |
| Some processes within and between Earth systems require energy that originates from the interior of the Earth.   * Interpret graphs of the Earth’s geothermal gradient. * Describe the transfer of geothermal energy from the decay of naturally occurring radioactive elements to rocks.   Transfers and transformations of energy in the Earth’s interior cause plume formation and drive the movement of tectonic plates, through processes such as mantle convection, slab pull, and ridge push.   * Describe how plumes from the mantle can transfer heat energy from the Earth’s interior to produce ‘hot-spot’ volcanic activity and form an island chain. * Explain why new crust is pushed away from mid-ocean ridges. * Explain why an oceanic plate is subducted in collisions with a continental plate. | Discuss how radioactive decay produces heat.  Demonstrate simple convection cells in the laboratory using coloured dye in a heated beaker.  Visit, or investigate online, the Centre for Tectonics Resources and Exploration at the University of Adelaide.  Watch and discuss a video of Marum lava lake in Vanuatu:  [www.sciencephoto.com/media/247789/view](http://www.sciencephoto.com/media/247789/view)  View and discuss some animations describing aspects of plate tectonics, including the occurrence of hot-spot volcanoes.  Demonstrate plate movement using this method:  <https://www.earthlearningidea.com/PDF/318_Rock_cycle_plates_def_met.pdf>  <https://www.earthlearningidea.com/PDF/Earth_plate_tectonics1.pdf>  Explore the relationship between the ages of the Hawaiian Islands and plate movement.  Modelling hotspot volcanism.  <https://www.earthlearningidea.com/PDF/208_Hotspots.pdf> |  |
| Investigate seafloor spreading of tectonic plates, e.g. see:  <https://www.earthlearningidea.com/PDF/Earth_plate_tectonics1.pdf>  Demonstrate slab pull simply by sliding a blanket from a bench top. |  |
| Explore the contributions from different types of scientists during the last 100 years to the ideas of the modern theory of plate tectonics. |  |

Topic 4: The Earth’s atmosphere

The composition of gases in the Earth’s atmosphere has varied over time. Students examine different theories to explain how the atmosphere was derived, and explore reasons for its changing composition. They examine effects of atmospheric ozone in protecting the environment and albedo on the climate, and use the mechanisms that cause atmospheric circulation to explain wind direction.

Students investigate how the movement of atmospheric air masses influences local ecosystems and weather patterns. They recognise how climate models are continually evolving as new evidence becomes available.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Different theories exist that describe how the Earth’s atmosphere was derived.   * Discuss theories, such as volcanic outgassing, about the derivation of the Earth’s atmosphere. * Compare the approximate proportion of nitrogen, oxygen, argon, and carbon dioxide in the Earth’s atmosphere at different times in its history. * Explain why nitrogen is essential for life.   The composition of the Earth’s atmosphere has been significantly modified by photosynthesising organisms.   * Describe fluctuations in the proportion of oxygen in the Earth’s atmosphere over geological time. | Investigate recent research that identifies the source of the Earth’s nitrogen during the early history of its development.  Investigate the gases that are typically released during modern volcanic activity, and the range of their relative proportions.  Investigate the critical importance of cyanobacteria found in stromatolites to oxygen production in the atmosphere and to the evolution of life on Earth.  <https://www.earthlearningidea.com/PDF/103_Evolution_atmosphere.pdf>  Watch Crude — the Incredible Journey of Oil, at [www.abc.net.au/science/crude/](http://www.abc.net.au/science/crude)  Compare the effects on past periods of a carbon rich atmosphere with the current levels of atmospheric carbon. |  |
| The modern atmosphere has a layered structure: the troposphere, mesosphere, stratosphere, and thermosphere.   * Discuss the key features that characterise the four main layers of the atmosphere. * Describe the variation of temperature with altitude in the layers of the atmosphere. | Investigate the structure of the Earth’s atmosphere, e.g. at:  <https://www.nasa.gov/mission_pages/sunearth/science/atmosphere-layers2.html> |  |
| Construct a scaled drawing (on a very large piece of paper) of a part of the Earth’s cross-section, including the layers of the atmosphere. Include, for example, the highest mountain, the deepest ocean trench, and the altitudes of the highest-flying aircraft and Earth-orbiting satellites.  Construct a scaled drawing of the layers of the atmosphere that includes a plot of temperature vs height. |  |
| The net transfer of solar energy through the atmosphere to Earth’s surface is influenced by the interaction of ultraviolet radiation with atmospheric ozone, and albedo.   * Explain the importance of the ozone layer in protecting living organisms from damaging UV radiation. * Describe how albedo affects the Earth’s climate. | Discuss whether the Earth is an energy absorber or reflector.  Investigate the development of the ozone layer over time. |  |
| Investigate how the monitoring of stratospheric ozone led to the discovery of the hole in the ozone layer and how continued monitoring informs current knowledge about the repair of the hole. |  |

|  |  |  |
| --- | --- | --- |
| Certain gases in the Earth’s atmosphere (known as ‘greenhouse gases’) produce a phenomenon known as the ‘greenhouse effect’.   * Explain how greenhouse gases absorb and reradiate some of the thermal radiation emitted from Earth’s surface to warm the atmosphere. | Use examples of atmospheric gases that act as greenhouse gases, such as water vapour, nitrous oxide, methane, and carbon dioxide, to explain the greenhouse effect. |  |
| Describe how new technologies have informed us about the runaway greenhouse effect on Venus and the absence of a greenhouse effect on Mars. |  |
| The movement of atmospheric air masses, due to heating, cooling, and the Earth’s rotation, causes systematic atmospheric circulation; this is the dominant mechanism for the transfer of thermal energy around the Earth’s surface.   * Explain how convection currents promote atmospheric circulation. * Explain how convection cells promote atmospheric circulation in each hemisphere. * Explain how the Coriolis effect influences wind direction around the Earth. * Explain how the movement of atmospheric air masses influences local ecosystems. | Explore atmospheric (convection) cells such as polar cells, the Ferrel Cell and the Hadley Cell.  Compare the climates of different regions at similar latitudes.  Explore the NOAA resource ‘Toasty Wind’.  <https://www.noaa.gov/education/resource-collections/weather-atmosphere/weather-systems-patterns> |  |
| Conduct practical activities from the Weather Experiments website:  [www.hometrainingtools.com/a/weather-experiments-project](http://www.hometrainingtools.com/a/weather-experiments-project) |  |
| The interaction between the Earth’s atmosphere and oceans changes over time and can result in anomalous global weather patterns.   * Discuss the causes and effects of ENSO (El Niño–Southern Oscillation). | Make predictions about phenomena such as El Niño and La Niña, based on previous data from BOM ENSO resources.  <http://www.bom.gov.au/climate/about/australian-climate-influences.shtml> |  |
| Investigate how atmospheric climate models could be used to predict extreme weather events in countries dependent on agriculture and fishing. |  |

Topic 5: Importance of the hydrosphere

Water exists in three phases on the Earth and plays an important part in the interactions between the Earth’s systems. Students investigate evidence that gives rise to different theories about the origins of water on the Earth. They study the properties of water and how these affect its role in biotic and abiotic environments.

Students explore how the action of oceans, as heat sinks, leads to formation of ocean currents and how the global-ocean conveyer belt influences climate in regions around the world. They use specific terminology in discussions of interactions between the hydrosphere and the other Earth systems.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Water is present on the Earth as a result of volcanic outgassing and the impact of icy extraterrestrial bodies.   * Discuss theories of the origin of the Earth’s water. | Research estimates of the total volume of water that is believed to exist on Earth.  Research recent data about the composition of comets.  Discuss how the densely cratered surface of the moon indicates the frequency of impacts in the early history of the solar system. |  |
| Water occurs in three phases on the Earth, solid, liquid, and gas.   * Describe examples of the occurrence of the three phases of water in each of the Earth’s spheres. * Describe the hydrological cycle. * Explain why evaporation from large bodies of water, e.g. the ocean and rivers, is important for atmospheric moisture. * Explain how changes to the hydrological cycle impact on ecosystems and people’s use of resources. * Discuss global water distribution. * Explain the importance of water’s unique properties in sustaining life on Earth and in shaping Earth processes. | Use T and P phase diagrams to explain why and where water naturally occurs on Earth.  Use data from the water cycle to compare relative quantities of water existing as salt water, fresh water, ice, and biological water, and in rivers, lakes, streams, and groundwater systems, e.g. see:  USGS website [https://www.usgs.gov/special-topic/water-science-school/science/water-cycle-adults-and-advanced-students?qt-science\_center\_objects=0#qt-science\_center\_objects](https://www.usgs.gov/special-topic/water-science-school/science/water-cycle-adults-and-advanced-students?qt-science_center_objects=0%23qt-science_center_objects)  Describe glaciation, weathering, and erosion.  Use properties such as boiling point, density in solid and liquid phases, surface tension, and solvent properties to explain the importance of water.  Consider the essential roles of water in photosynthesis and as a transport agent providing food and oxygen and eliminating waste in organisms.  Investigate how climate change advantages some species while threatening others. |  |
| Discuss the sustainability of local sources of water used for various purposes, and identify measures that could be used to save or recycle water locally. |  |
| The global-ocean conveyor belt is a constantly moving system of deep-ocean circulation caused by a combination of thermohaline currents in the deep ocean and wind-driven currents on the surface.   * Explain how differences in temperature and salinity produce movement of water deep in the ocean. * Explain the role of the global-ocean conveyor belt in regulating temperatures in Europe. * Explain the role of the global-ocean conveyor belt in global-ocean nutrient and carbon dioxide cycles. | Explore the relationship between the Earth’s prevailing winds and the direction of ocean currents.  Research for evidence of past interruptions to the global-ocean conveyor belt and the impacts on climate.  Investigate how global warming could lead to drastic temperature changes in Europe. |  |
| Investigate the thermohaline gradient using salt solutions of different concentrations. |  |
| Investigate how ocean currents are measured and how the data collected affects people’s lives. Discuss the implications of a change to the ocean conveyor belt for future societies. |  |

Topic 6: Biosphere

The fossil record provides evidence of the diverse life forms that have existed over time. Students interpret and evaluate different types of fossil evidence and explore the connections of fossils to past environments.

Students explore how interactions among the spheres affect the communities of organisms in different ecosystems. They investigate the importance of processes such as photosynthesis and the cycling of nutrients and energy for sustaining life on Earth.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Evidence indicates that life first appeared on Earth approximately 3.7 billion years ago.   * Discuss the significance of prokaryotes as the first life on Earth in the Archaean Eon. * Explain how life then evolved into eukaryotes. | Link the appearance of photosynthetic organisms in stromatolites to the changes in oxygen production discussed in Topic 4: The Earth’s atmosphere.  Visit, or investigate online, a museum exhibiting Ediacaran fossils.  Identify and explain the importance of Ediacaran fauna.  Observe preserved specimens of stromatolites in rocks.  Watch and discuss David Attenborough’s First Life DVD.  Use the Deep Time Walk app to explore Earth history <https://www.deeptimewalk.org/> |  |
| Laboratory experimentation has informed theories about how life emerged.   * Explain how scientists use systematic investigation to replicate primeval conditions on Earth that could possibly produce chemicals that are essential for life to begin. * Describe the atmospheric and oceanic conditions that are thought to have existed in the Archaean Eon. | Explain how the Miller–Urey experiment is used to replicate primeval conditions on Earth that could possibly produce chemicals that are essential for life to begin.  Describe possible environmental settings and conditions in which this could occur.  Describe the limitations of the Miller–Urey experiment.  Watch an animation of primordial Earth.  Research evidence for the origin of life on Earth. |  |
| Use a physical model to show the development of our current atmosphere using ‘Earth’s Atmosphere – Step by Step Evolution’.  <https://www.earthlearningidea.com/PDF/103_Evolution_atmosphere.pdf>  Explore modelling the Earth’s early atmosphere. |  |
| In any one location, the characteristics and interactions of the geosphere, atmosphere, hydrosphere, and biosphere give rise to unique and dynamic communities.   * Describe the difference between biotic and abiotic features of an ecosystem. * Explain how a change in these features can create different environments. * Identify, measure, and record the appropriate characteristics in a field location. | Conduct a field investigation focused on an environmental monitoring and ecosystem study.  Conduct a field trip to a local ecosystem (e.g. national park, beach, river system) to investigate biotic and abiotic features and how changing these would affect the communities of living organisms in the ecosystem. Select appropriate biotic and abiotic characteristics for the field study location, such as temperature, available water, nature of the substrate, organisms present, available light, UV, and wind. |  |
| * Describe how these factors may affect the distribution and abundance of organisms found in a particular location. | Use online sites for modelling ecosystems. |  |
| Investigate how scientists design action for sustainability, using a TED talk such as ‘How Can We Make Crops Survive Without Water?’ as a starting point:  [www.ted.com/talks/jill\_farrant\_how\_we\_can\_make\_crops\_survive\_without\_water](http://www.ted.com/talks/jill_farrant_how_we_can_make_crops_survive_without_water) |  |
| The characteristics of past environments and communities can be inferred from the sequence and internal textures of sedimentary rocks, and from enclosed fossils and trace fossils.   * Explain ways in which fossils form. * Relate the present environment of living organisms to the past environment of fossils of similar organisms. * Describe the formation of sedimentary structures that are used to determine the facing of beds. | Investigate various aspects of past environments using numerous activities at the Earth Learning Ideas website.  Examine how factors such as the presence of water, nature of the substrate, atmospheric temperature, and water temperature impact on the organism assemblages in a past environment.  Investigate sedimentary structures that are used to determine the facing of beds, including cross-bedding and way up, graded bedding, and ripple marks.  Useful websites:  <https://www.earthlearningidea.com/PDF/Crime_scene.pdf>  [www.earthlearningidea.com/English/Evolution\_of\_Life.html](http://www.earthlearningidea.com/English/Evolution_of_Life.html)  [www.earthlearningidea.com/PDF/194\_Cross\_bedding\_1.pdf](http://www.earthlearningidea.com/PDF/194_Cross_bedding_1.pdf)  [www.earthlearningidea.com/PDF/195\_Cross\_bedding\_2.pdf](http://www.earthlearningidea.com/PDF/195_Cross_bedding_2.pdf)  <http://www.earthlearningidea.com/PDF/Symmetrical_Ripple_Marks.pdf> |  |
| The diversification and proliferation of living organisms over time and the catastrophic collapse of ecosystems can be inferred from the fossil record.   * Explain the relationship between the fossil record and the eras in the geological time-scale. * Explain why some fossils are useful as index fossils. * Explain why the fossil record is inevitably incomplete, especially for organisms that lived more than 600 million years ago. | Investigate the Ediacaran fauna at the palaeontology exhibit at a state, territory, or national museum.  Model the geological time-scale using ‘A Time-line in Your Own Backyard’ from Earth Learning Idea.  Conduct a field investigation to examine the stratigraphy and observe fossils (e.g. at Maslin Bay or Port Willunga). |  |
| * Explain the significance of fossils within the geological time-scale and as indicators of past environments. * Describe the Cambrian Explosion and its significance. * Discuss possible theories about the extinction of dinosaurs at the end of the Cretaceous Period.   Scientists recognise six waves of extinction in the past half billion years.   * Explain how past mass extinctions were caused by events like asteroid strikes, volcanic eruptions, and natural climate shifts. * Explain why current biodiversity loss is almost entirely caused by humans. | Identify specimens of each of the following and describe the time and environment in which they lived:  Ediacaran fauna, trilobites, dinosaurs, ammonites, archaeocyatha, graptolites, megafauna (e.g. diprotodonts). |  |
| Investigate the limitations of the available fossil evidence in determining the cause of the death of the megafauna.  Debate current geological time being named the Anthropocene.  <https://www.earthlearningidea.com/PDF/339_Anthropocene.pdf>  Watch the movie – *Anthropocene: The Human Epoch*  or *Breaking Boundaries: The Science of Our Planet.* |  |
| Energy from the sun is converted into chemical energy in the form of biomass.   * Explain the importance of photosynthesis in converting light energy into chemical energy that is stored in glucose. * Explain that net primary production (NPP) is the rate at which plants in an ecosystem produce net useful chemical energy. | Choose from a large number of ideas for activities on photosynthesis at:  <https://www.biologycorner.com/2020/11/07/photosynthesis-virtual-lab-2/>  [www.juliantrubin.com/fairprojects/botany/photosynthesis.html](http://www.juliantrubin.com/fairprojects/botany/photosynthesis.html) |  |
| Observe and discuss a very simple activity on manipulating factors that affect photosynthesis.  Obtain, tabulate, and graph data on photosynthesis.  Design practical investigations, individually or in groups, on factors affecting the rate of photosynthesis. |  |
| The availability of energy and matter are one of the main determinants of ecosystem carrying capacity.   * Explain how biotic and abiotic factors affect carrying capacity.   Processes occurring in ecosystems that achieve major transformations of resources that benefit humans are known as ecosystem services.   * Discuss the benefits of ecosystem services. | Use interactive resources to model carrying capacity, such as:  rabbits vs wolves online modelling, at:  [www.shodor.org/interactivate/activities/RabbitsAndWolves](http://www.shodor.org/interactivate/activities/RabbitsAndWolves)  student activity ‘Musky Fish’, at:  <http://intotheoutdoors.org/wp-content/uploads/2013/06/BioCarryCapacity_Lesson.final_.pdf>  simple population introductory graphing activity, at:  [www.populationeducation.org/sites/default/files/pop\_ecology\_files.pdf](http://www.populationeducation.org/sites/default/files/pop_ecology_files.pdf) |  |
|  | Choose one example to describe the interaction between humans and natural ecosystems services.  Explore the importance of biodiversity in the provision of ecosystem services. |  |
| Explore how increased scientific understanding of ecosystem services influences decisions made in agricultural production. |  |
| Energy is stored, transferred, and transformed in the carbon cycle.   * Describe the key processes and the role they play in the carbon cycle, including photosynthesis, respiration, decomposition, and combustion. * Identify the main carbon sinks. * Describe the differences between the fast and slow carbon cycle. * Identify where these processes occur in the carbon cycle. * Explain the interactions between the forms of carbon and each of the spheres. | Discuss how the Amazon basin acts as a carbon sink.  Explore fast and slow carbon cycles. |  |
| Investigate the carbon cycle in an interactive activity, e.g. at:  [www.learner.org/courses/envsci/interactives/carbon/](http://www.learner.org/courses/envsci/interactives/carbon/) |  |
| Biogeochemical cycling of nitrogen and phosphorus in matter occurs between the geosphere, atmosphere, hydrosphere, and biosphere.   * Describe the key processes in the nitrogen cycle, including nitrification, denitrification, nitrogen fixation, ammonification, eutrophication. * Identify where these processes occur in the nitrogen cycle. * Explain the interactions between the forms of nitrogen and each of the spheres. * Discuss the key processes in the phosphorus cycle including the conversion of inorganic phosphate to organic phosphate and the role of earth and environmental science processes. * Explain why the atmosphere does not play a significant role in the phosphorus cycle but does in the nitrogen cycle. | Explore the nitrogen cycle on a virtual farm environment.  Explore how nutrient levels in water used for aquaculture are monitored to ensure that fist and microbes have available sources of oxygen for aerobic processes to be maintained. |  |

Assessment scope and requirements

Assessment at Stage 1 is school based.

Evidence of learning

The following assessment types enable students to demonstrate their learning in Stage 1 Earth and Environmental Science:

* Assessment Type 1: Investigations Folio
* Assessment Type 2: Skills and Applications Tasks.

For a 10-credit subject, students provide evidence of their learning through four assessments. Each assessment type should have a weighting of at least 20%.

Students complete:

* at least one practical investigation, either in the laboratory or in the field
* one investigation with a focus on science as a human endeavour
* at least one skills and applications task.

For a 20-credit subject, students provide evidence of their learning through eight assessments. Each assessment type should have a weighting of at least 20%.

Students complete:

* at least two practical investigations, either in the laboratory or in the field
* two investigations with a focus on science as a human endeavour
* at least two skills and applications tasks.

For both the 10-credit and 20-credit subjects, at least one assessment should involve collaborative work.

Assessment design criteria

The assessment design criteria are based on the learning requirements and are used by teachers to:

* clarify for the student what they need to learn
* design opportunities for the student to provide evidence of their learning at the highest level of achievement.

The assessment design criteria are the specific features that:

* students should demonstrate in their learning
* teachers look for as evidence that students have met the learning requirements.

For this subject, the assessment design criteria are:

* investigation, analysis, and evaluation
* knowledge and application.

The specific features of these criteria are described below.

The set of assessments, as a whole, must give students opportunities to demonstrate each of the specific features by the completion of study of the subject.

Investigation, Analysis, and Evaluation

The specific features are as follows:

IAE1 Deconstruction of a problem and design of an earth and environmental science investigation.

IAE2 Obtaining, recording, and representation of data, using appropriate conventions and formats.

IAE3 Analysis and interpretation of data and other evidence to formulate and justify conclusions.

IAE4 Evaluation of procedures and their effect on data.

Knowledge and Application

The specific features are as follows:

KA1 Demonstration of knowledge and understanding of earth and environmental science concepts.

KA2 Application of earth and environmental science concepts in new and familiar contexts.

KA3 Exploration and understanding of the interaction between science and society.

KA4 Communication of knowledge and understanding of earth and environmental science concepts and information, using appropriate terms, conventions, and representations.

School assessment

Assessment Type 1: Investigations Folio

For a 10-credit subject, students undertake at least one practical investigation, either in the laboratory or in the field, and one investigation with a focus on science as a human endeavour. Students may undertake more than one practical investigation within the maximum number of assessments allowed.

For a 20-credit subject, students undertake at least two practical investigations, either in the laboratory or in the field, and two investigations with a focus on science as a human endeavour. Students may undertake more than two practical investigations within the maximum number of assessments allowed.

Students inquire into aspects of earth and environmental science through practical discovery and data analysis, and/or by selecting, analysing, and interpreting information.

Practical/Field Investigations

As students design and safely carry out investigations, they demonstrate their science inquiry skills by:

* deconstructing a problem to determine the most appropriate method for investigation
* formulating investigable questions and hypotheses
* selecting and using appropriate equipment, apparatus, and techniques
* identifying variables
* collecting, representing, analysing, and interpreting data
* evaluating procedures and considering their impact on results
* drawing conclusions
* communicating knowledge and understanding of concepts.

As a set, practica/fieldl investigations should enable students to:

* work both individually or collaboratively.
* investigate a question or hypothesis for which the outcome is uncertain.
* investigate a question or hypothesis linked to one of the topics in Stage 1 Earth and Environmental Science
* individually deconstruct a problem to design their own method and justify their plan of action.

For each practical/field investigation, students present an individual report.

Evidence of deconstruction (where applicable) should outline the deconstruction process, the method designed as most appropriate, and a justification of the plan of action, to a maximum of 4 sides of an A4 page. This evidence must be attached to the practical report.

Suggested formats for this evidence include flow charts, concept maps, tables, or notes.

In order to manage the implementation of an investigation efficiently, students could individually design investigations and then conduct one of these as a group, or design hypothetical investigations at the end of a practical activity.

A practical report must include:

* introduction with relevant earth and environmental science concepts, and either a hypothesis and variables, or an investigable question
* materials/apparatus
* the method that was implemented
* identification and management of safety and/or ethical risks
* results, including table(s) and/or graph(s)
* analysis of results, including identifying trends and linking results to concepts
* evaluation of procedures and their effect on data, and identifying sources of uncertainty
* conclusion, with justification.

The report should be a maximum of 1000 words if written, or a maximum of 6 minutes for an oral presentation, or the equivalent in multimodal form.

Only the following sections of the report are included in the word count:

* introduction
* analysis of results
* evaluation of procedures
* conclusion and justification.

Suggested formats for presentation of a practical investigation report include:

* a written report
* an oral presentation
* a multimodal product.

Science as a Human Endeavour Investigation

Students investigate a contemporary example of how science interacts with society. This may focus on one or more of the key concepts of science as a human endeavour described on pages 11 and 12, and may draw on a context suggested in the topics or relate to a new context.

Student could consider, for example, how:

* humans seek to improve their understanding and explanation of the natural world
* working scientifically is a way of obtaining knowledge that allows for testing scientific claims
* scientific theory can change in the light of new evidence
* technological advances change ways of working scientifically
* links between advances in science impact and influence society
* society influences scientific research
* emerging earth and environmental science-related careers and pathways involve science
* ‘green fields’ research leads to new technologies.

Students access information from different sources, select relevant information, analyse their findings, and explain the connection to science as a human endeavour.

Possible starting points for the investigation could include, for example:

* the announcement of a discovery in the field of earth and environmental science
* an expert’s point of view on a controversial innovation in earth and environmental science
* a TED talk based on a development in earth and environmental science
* an article from a scientific publication, e.g. Cosmos
* public concern about an issue that has environmental, social, economic, or political implications.

Based on their investigation, students prepare a scientific communication, which must include the use of scientific terminology.

The communication should be a maximum of 1000 words if written, or a maximum of 6 minutes for an oral presentation, or the equivalent in multimodal form.

For this assessment type, students provide evidence of their learning in relation to the following assessment design criteria:

* investigation, analysis, and evaluation
* knowledge and application.

Assessment Type 2: Skills and Applications Tasks

For a 10-credit subject, students undertake at least one skills and applications task. Students may undertake more than one skills and applications task within the maximum number of assessments allowed, but at least one should be under the direct supervision of the teacher. The supervised setting (e.g. classroom, laboratory, or field) should be appropriate to the task.

For a 20-credit subject, students undertake at least two skills and applications tasks. Students may undertake more than two skills and applications tasks within the maximum number of assessments allowed, but at least two should be under the direct supervision of the teacher. The supervised setting (e.g. classroom, laboratory, or field) should be appropriate to the task.

Skills and applications tasks allow students to provide evidence of their learning in tasks that may:

* be applied, analytical, and/or interpretative
* pose problems in new and familiar contexts
* involve individual or collaborative assessments, depending on the design of the assessment.

A skills and applications task may involve, for example:

* solving problems
* designing an investigation to test a hypothesis or investigable question
* considering different scenarios in which to apply knowledge and understanding
* graphing, tabulating, and/or analysing data
* evaluating procedures and identifying their limitations
* formulating and justifying conclusions
* representing information diagrammatically or graphically
* using earth and environmental science terms, conventions, and notations.

As a set, skills and applications tasks should be designed to enable students to apply their science inquiry skills, demonstrate knowledge and understanding of key earth and environmental science concepts and learning, and explain connections with science as a human endeavour. Problems and scenarios should be set in a relevant context, which may be practical, social, or environmental.

Skills and applications tasks may include, for example:

* modelling or representing concepts
* developing simulations
* practical and/or graphical skills
* a multimodal product
* an oral presentation
* participation in a debate
* an extended response
* responses to short-answer questions
* a structured interview
* an excursion report
* a response to science in the media.

For this assessment type, students provide evidence of their learning in relation to the following assessment design criteria:

* investigation, analysis, and evaluation
* knowledge and application.

Performance standards

The performance standards describe five levels of achievement, A to E.

Each level of achievement describes the knowledge, skills and understanding that teachers refer to in deciding how well students have demonstrated their learning on the basis of the evidence provided.

During the teaching and learning program the teacher gives students feedback on their learning, with reference to the performance standards.

At the student’s completion of study of a subject, the teacher makes a decision about the quality of the student’s learning by:

* referring to the performance standards
* taking into account the weighting of each assessment type
* assigning a subject grade between A and E.

Performance Standards for Stage 1 Earth and Environmental Science

| - | Investigation, Analysis, and Evaluation | Knowledge and Application |
| --- | --- | --- |
| A | Critically deconstructs a problem and designs a logical, coherent, and detailed earth and environmental science investigation.  Obtains, records, and represents data, using appropriate conventions and formats accurately and highly effectively.  Systematically analyses and interprets data and evidence to formulate logical conclusions with detailed justification.  Critically and logically evaluates procedures and their effect on data. | Demonstrates deep and broad knowledge and understanding of a range of earth and environmental science concepts.  Applies earth and environmental science concepts highly effectively in new and familiar contexts.  Critically explores and understands in depth the interaction between science and society.  Communicates knowledge and understanding of earth and environmental science coherently, with highly effective use of appropriate terms, conventions, and representations. |
| B | Logically deconstructs a problem and designs a well-considered and clear earth and environmental science investigation.  Obtains, records, and represents data, using appropriate conventions and formats mostly accurately and effectively.  Logically analyses and interprets data and evidence to formulate suitable conclusions with reasonable justification.  Logically evaluates procedures and their effect on data. | Demonstrates some depth and breadth of knowledge and understanding of a range of earth and environmental science concepts.  Applies earth and environmental science concepts mostly effectively in new and familiar contexts.  Logically explores and understands in some depth the interaction between science and society.  Communicates knowledge and understanding of earth and environmental science mostly coherently, with effective use of appropriate terms, conventions, and representations. |
| C | Deconstructs a problem and designs a considered and generally clear earth and environmental science investigation.  Obtains, records, and represents data, using generally appropriate conventions and formats, with some errors but generally accurately and effectively.  Undertakes some analysis and interpretation of data and evidence to formulate generally appropriate conclusions with some justification.  Evaluates procedures and some of their effect on data. | Demonstrates knowledge and understanding of a general range of earth and environmental science concepts.  Applies earth and environmental science concepts generally effectively in new or familiar contexts.  Explores and understands aspects of the interaction between science and society.  Communicates knowledge and understanding of earth and environmental science generally effectively, using some appropriate terms, conventions, and representations. |
| D | Prepares a basic deconstruction of a problem and an outline of an earth and environmental science investigation.  Obtains, records, and represents data, using conventions and formats inconsistently, with occasional accuracy and effectiveness.  Describes data and undertakes some basic interpretation to formulate a basic conclusion.  Attempts to evaluate procedures or suggest an effect on data. | Demonstrates some basic knowledge and partial understanding of earth and environmental science concepts.  Applies some earth and environmental science concepts in familiar contexts.  Partially explores and recognises aspects of the interaction between science and society.  Communicates basic earth and environmental science information, using some appropriate terms, conventions, and/or representations. |
| E | Attempts a simple deconstruction of a problem and a procedure for an earth and environmental science investigation.  Attempts to record and represent some data, with limited accuracy or effectiveness.  Attempts to describe results and/or interpret data to formulate a basic conclusion.  Acknowledges that procedures affect data. | Demonstrates limited recognition and awareness of earth and environmental science concepts.  Attempts to apply earth and environmental science concepts in familiar contexts.  Attempts to explore and identify an aspect of the interaction between science and society.  Attempts to communicate information about earth and environmental science. |

Assessment integrity

The SACE Assuring Assessment Integrity Policy outlines the principles and processes that teachers and assessors follow to assure the integrity of student assessments. This policy is available on the SACE website ([www.sace.sa.edu.au](file:///C:\Users\Ekwomr01\Objective\edrms.saceboard.sa.gov.au-8008-ekwomr01\Objects\www.sace.sa.edu.au)) as part of the SACE Policy Framework.

The SACE Board uses a range of quality assurance processes so that the grades awarded for student achievement in the school assessment are applied consistently and fairly against the performance standards for a subject, and are comparable across all schools.

Information and guidelines on quality assurance in assessment at Stage 1 are available on the SACE website ([www.sace.sa.edu.au](file:///C:\Users\Ekwomr01\Objective\edrms.saceboard.sa.gov.au-8008-ekwomr01\Objects\www.sace.sa.edu.au)).

Support materials

Subject-specific advice

Online support materials are provided for each subject and updated regularly on the SACE website ([www.sace.sa.edu.au](file:///C:\Users\Ekwomr01\Objective\edrms.saceboard.sa.gov.au-8008-ekwomr01\Objects\www.sace.sa.edu.au)). Examples of support materials are sample learning and assessment plans, annotated assessment tasks, annotated student responses, and recommended resource materials.

Advice on ethical study and research

Advice for students and teachers on ethical study and research practices is available in the guidelines on the ethical conduct of research in the SACE on the SACE website ([www.sace.sa.edu.au](file:///C:\Users\Ekwomr01\Objective\edrms.saceboard.sa.gov.au-8008-ekwomr01\Objects\www.sace.sa.edu.au)).