Earth and Environmental Science

OFFICIAL

2024 Subject Outline | Stage 2

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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. They assess the evidence that informs public debate on social and environmental issues such as use of the Earth’s resources, and climate change. Students design a field investigation into an Earth or environmental initiative or issue that is linked to one of the topics in this course. They report on their findings in terms of the interactions of two or more Earth 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 2 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

Stage 2 Earth and Environmental Science is a 20-credit subject.

The topics in Stage 2 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 2 Earth and Environmental Science are:

* Topic 1: Earth systems
* Topic 2: Earth’s resources
* Topic 3: Earth’s sustainable future
* Topic 4: Climate change

Students study all four topics. The topics can be sequenced and structured to suit individual groups of students.

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:

|  |  |
| --- | --- |
| image shows an icon of three cogs | indicates a possible teaching and learning strategy for science understanding |
| image shows an icon of a question mark | indicates a possible science inquiry activity |
| image shows an icon of a human body | indicates a possible focus on science as a human endeavour. |

image shows an icon of a question mark 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.

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. |

image shows an icon of a human body 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: Earth system

This topic lays the foundation of scientific inquiry skills that students use in planning and implementing their Earth system study. Students examine in detail the interaction between and within the Earth’s spheres — the atmosphere, hydrosphere, geosphere, and biosphere — and apply their learning to investigating their local area, as well as considering wider implications.

Students participate in field trips and use technology to develop their observational, recording, and analytical skills in preparation for the main study. They consider how their findings may provide advice to appropriate groups for future action.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| The four Earth’s spheres are the geosphere, atmosphere, hydrosphere, and biosphere.   * Investigate the components of each of the four spheres. * Identify visible and ‘hidden’ components and processes of spheres. * Identify interactions between components of spheres. * Describe dynamic relations within and between spheres. * Organise components and processes into a web of interactions. | Discuss an infographic about the spheres of the Earth:  <http://visual.ly/fifty-unbelievable-facts-about-earth>  Examine an overview of the Earth spheres and their interconnections, including numerous teaching resources and student activities in EarthLabs, ‘Earth System Science’ unit and field study:  http://serc.carleton.edu/earthlabs/climate/index.html  Use ‘Planetary Boundaries’ from the Stockholm Resilience Institute with the movie ‘Breaking Boundaries’ by David Attenborough on Netflix as a discussion starter about the interconnections between spheres. | image shows an icon of three cogs |
| Investigate the interaction of the four Earth spheres in the local area and construct a table to show how the four Earth spheres can interact.  [www.ucmp.berkeley.edu/education/dynamic/session4/index.html](http://www.ucmp.berkeley.edu/education/dynamic/session4/index.html)  Investigate a case study, for example, cleaning up an oil spill:  https://response.restoration.noaa.gov/resources/education | image shows an icon of a question mark |
| Use an example such as the *Exxon Valdez* oil spill or the fire on a cargo ship in Sri Lanka, to examine the contribution of science to the public debate on suitable methods to stimulate ecological recovery after an oil spill or chemical spill. | image shows an icon of a human being |
| A change in any one sphere can impact others at a range of temporal and spatial scales.   * Explain how changes in spheres can be caused by natural or human-induced factors. * Describe that changes within a sphere and between spheres can occur over a variety of time-scales. * Identify patterns and changes over a variety of time-scales. * Discuss how a change in the Earth spheres can influence conditions at a range of spatial scales from local to global.   Explain that changes in spheres may have cyclic or unpredictable patterns. | Explore use of fieldwork apps, such as:   * FieldMove Clino — free app for field notes, photos, map of sites, and recording dip and strike measurements: [www.mve.com/digital-mapping](http://www.mve.com/digital-mapping) * Evernote Skitch — a sketching app to complement field notes and photos: <https://evernote.com/skitch/?var=c> Have we moved on with stylus enabled devices etc. | image shows an icon of three cogs |
| * Examine changes in interactions between Earth spheres that have occurred in the past.   Predict future changes within and between Earth spheres in a given area. | Conduct a field activity in which students participate in a whole-class Earth systems study to develop appropriate science inquiry skills and make connections with science as a human endeavour.   * Observe interactions among the systems in a local area. * Identify and record these interactions. * Analyse this primary data. * Identify an environmental issue, concern, initiative, or successful undertaking. * Hypothesise, control variables, predict, and gather new data. * Gather background information, such as from maps and satellite imagery, and/or research the outcomes of prior studies. | image shows an icon of a question mark |
| Provide recommendations for further work.  Investigate the many factors that limit predictions about the effects of combustion of fossil fuels on global warming. | image shows an icon of a human being |

Topic 2: Earth’s resources

Students study how, for thousands of years, humans have made use of the Earth’s resources to sustain life and provide infrastructure for living. They consider how new technologies have made possible the discovery of the larger quantities of resources needed in a technological society and have led to new extraction processes.

Students extend their personal and social capability and ethical understanding through discussing the environmental consequences of the extraction, processing, and use of non-renewable mineral and energy resources. They recognise how sustainability of resources is now a topic for public debate — a debate that can be informed by the work of scientists.

Students investigate the formation of non-renewable mineral and energy resources; techniques used for their discovery; identification and extraction, and effects of the extraction; and use of these resources on ecosystems. They use skills in selection, graphing, analysis, and evaluation of data to draw conclusions about the environmental impacts associated with the use of non-renewable resources and current extraction and processing practices.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| People use the geological resources of the Earth to help satisfy their needs and wants.   * Compare the use of geological resources in various lifestyles. * Discuss, using examples from a variety of cultures, ways in which geological resources are used. | Compile a list of all the resources that one person uses in a day.  Explore ways in which Indigenous Australians, or Indigenous peoples in other countries, used geological resources before colonisation. | image shows an icon of three cogs |
| Non-renewable mineral and energy resources are formed in various ways over geological time-scales, so are not readily replenished.   * Discuss the sustainability of reserves of fossil fuels, and metallic and non-metallic resources. | Collect data on global consumption and the rate of new discoveries of conventional petroleum during the 20th and early 21st centuries (e.g. ‘peak oil’). Construct graphs to illustrate the findings.  Construct a table to display non-renewable fuel resources, including uranium and unconventional petroleum, and the approximate known global reserves of each resource, and critically evaluate this information in terms of sustainability.  Collect and graph data on global reserves and current rate of use of a range of metallic resources, and critically evaluate this information in terms of sustainability. | image shows an icon of a question mark |
| The formation of non-renewable energy resources, including fossil fuels and unconventional gas, is related to their geological setting.   * Explain the processes by which coal is formed. * Describe the processes by which petroleum and coal-seam gas are formed and are trapped. * Describe structures within which petroleum may be trapped. | Explore the benefits and risks of the extraction and use of unconventional gas.  [www.csiro.au/en/Research/Energy/Hydraulic-fracturing/What-is-unconventional-gas](http://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/What-is-unconventional-gas)  Use diagrams to explain the formation of a placer deposit in a stream bed.  Draw labelled diagrams of common petroleum traps to help explain how petroleum and coal-seam gas are formed and are trapped. | image shows an icon of three cogs |
| Identify hand specimens of various ranks of coal. | image shows an icon of a question mark |
| The formation of non-renewable metallic mineral resources is related to their geological setting.   * Explain how metallic ores may be concentrated by gravity-settling and hydrothermal processes. * Explain how the processes of weathering, erosion, and deposition may concentrate metallic ores. * Explain how the formation of iron ore (banded iron formations) occurred in an anaerobic environment. * Identify metallic ores, using their physical and chemical properties. | Use step-by-step diagrams to explore the formation of ore bodies by the processes of gravity-settling in a magma chamber, and by hydrothermal vein formation associated with igneous activity. | image shows an icon of three cogs |
| Identify minerals such as chalcopyrite, haematite, magnetite, galena, sphalerite, rutile, gold, bauxite, graphite, and copper and uranium minerals. | image shows an icon of a question mark |
| A variety of techniques can be used to discover deposits of mineral and energy resources and identify the extent and quality of these resources.   * Discuss techniques for finding mineral resources, using magnetic and electromagnetic surveys, geochemical sampling, and drilling. * Explain how seismic and gravity surveys are used in petroleum exploration. * Discuss how the presence of a resource can affect the surrounding physical and chemical environment. | Evaluate discovery techniques such as satellite imaging, and geochemical and geophysical sampling to collect datasets, and direct sampling techniques such as drilling, and core, soil, and rock sampling.  [www.earthsciencewa.com.au/mod/resource/view.php?id=1149](http://www.earthsciencewa.com.au/mod/resource/view.php?id=1149) | image shows an icon of three cogs |
| Use a magnetometer (or a metal detector) over a measured grid to locate and map buried metal objects. | image shows an icon of a question mark |
| Investigate the impacts of various steps used in mineral exploration on the environment:  [www.earthsciencewa.com.au/mod/resource/view.php?id=1155](http://www.earthsciencewa.com.au/mod/resource/view.php?id=1155)  [www.earthsciencewa.com.au/mod/resource/view.php?id=1154](http://www.earthsciencewa.com.au/mod/resource/view.php?id=1154) | image shows an icon of a human being |
| The depth, extent, and location of mineral and energy resources determine the method of extraction.   * Describe the essential features of underground, open-cut, and in-situ leaching methods of extraction of mineral resources. * Explain how the size, shape, and depth of a mineral deposit influence the choice of extraction method. * Explain how petroleum, shale oil, coal, and coal-seam gas are extracted from the Earth in different locations. | Draw and label diagrams showing the essential features and environmental impact of each mining and extraction method.  Discuss reasons for using underground mining or open-cut mining in different scenarios.  Explore the life cycle of a mine. | image shows an icon of three cogs |
| The extraction and use of mineral and energy resources influences interactions between the abiotic and biotic components of ecosystems, including hydrologic systems.   * Describe potential environmental impacts that can be associated with the extraction, use, and processing of mineral and energy resources. | Compare the environmental impacts associated with the extraction and use of coal and uranium for electricity generation. | image shows an icon of three cogs |
| Investigate sources of methane (including natural sources such as bacterial action and methane hydrates, and anthropogenic sources such as livestock and fugitive emissions from coal-seam gas extraction), its use as a fuel, and its action as a greenhouse gas. | image shows an icon of a question mark |
| Investigate how the processing of sulfide minerals can lead to the formation of acid rain or acid mine drainage, and the environmental impact of this.  Use case histories and news reports to evaluate environmental impacts of mining. Examples include uranium and bauxite mining at Poços de Caldas in Brazil, and pyrite mining at Brukunga in South Australia.  Create a poster explaining the benefits of generating electricity from a floating solar power station, such as at Jamestown South Australia. | image shows an icon of a human being |

Topic 3: Earth’s sustainable future

In this topic, students explore how increases in human life span and greater use of scientific and technological knowledge have increased the global demand for energy, water, and soil resources. They recognise why provision of good-quality fresh water and groundwater at local and global levels will continue to be of high importance into the future.

Students investigate how effective use of resources is constrained by factors such as waste disposal, and the efficiency of energy technologies. They consider how the desire to use more renewable sources to increase supply has generated discussion about the advantages and disadvantages of renewable and non-renewable resources, and changes in practice that might lead to a more sustainable future.

Students explore the consequences of using various types of renewable energy resources, and factors affecting the sustainability of soil, water, and energy resources. They investigate a range of aspects of soil, water, and energy use, and use critical-thinking skills to evaluate data and develop logical solutions.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Renewable resources include some that are available regularly and others that are replenished at time scales from years to millennia.   * Discuss the need for, and limitations of, renewable sources of energy, including biofuels, solar, wind, and geothermal energy. * Determine whether a renewable resource is either diminished or sustained over time, given the abundance of the resource and how readily it can be replenished. * Investigate how the timescale required to replenish a large groundwater system, such as the Great Artesian Basin, is influenced by the rate of depletion of the system. * Discuss the sustainability of soil and water at local, regional, and global scales. | Research the development of wind farms in a chosen location (region, state, or territory) and/or arrange a local visit to report on current and proposed electricity generation, costs of construction, and ongoing maintenance needs.  [www.earthsciencewa.com.au/mod/resource/view.php?id=1104](http://www.earthsciencewa.com.au/mod/resource/view.php?id=1104)  Sketch or photograph examples of dryland salinity or erosion to illustrate a negative impact of human activity on sustainability of resources.  Investigate how stormwater run-off affects the sand budget at the coast. | image shows an icon of three cogs |
| Investigate the drains and bores in use in areas that recycle stormwater run-off.  [www.salisbury.sa.gov.au/Live/Environment\_and\_Sustainability/Wetlands\_and\_Water/Wetlands](http://www.salisbury.sa.gov.au/Live/Environment_and_Sustainability/Wetlands_and_Water/Wetlands)  <http://bhkcstormwater.com.au/>  Oaklands wetlands <https://www.marion.sa.gov.au/things-to-do/wetlands/oaklands-wetland>’?  Collect, sieve, and microscopically view soil samples to compare and report on two or more soil types in a local district. | image shows an icon of a question mark |
| Evaluate the economic, social, and environmental impacts of the use of hydrogen as an energy source.  <https://www.ga.gov.au/scientific-topics/energy/resources/hydrogen>  <https://www.oresomeresources.com/resource/hydrogen-fact-sheet/>  Is this an important renewable resource? | image shows an icon of a human being |
| The availability and quality of fresh water can be influenced by human activities, and natural processes at local and regional scales.   * Discuss how stormwater run-off in urban areas may be recycled for community use so that it is not wasted and does not pollute waterways. * Explain how overextraction of groundwater from near-coastal aquifers may cause inflow of sea water. * Explain how pollution of groundwater can result from a variety of rural, urban, and industrial activities. | Discuss how urbanisation, overextraction, pollution, siltation, drought, and algal blooms affect the availability and quality of fresh water.  [www.mdba.gov.au/managing-water/water-quality/blue-green-algae](http://www.mdba.gov.au/managing-water/water-quality/blue-green-algae) | image shows an icon of three cogs |
| Visit, or investigate online, a water desalination plant, to research and report on aspects of production, including the energy used and cost.  Undertake research to design a comparative table of soil types found across a local district or region, to compare soil fertilities, mineral source rock types, and past and current land use.  Investigate and report on the sources and costs of water for domestic use at students’ own locality, and how these may have changed over time. Obtain data to calculate and report on the volume of rainwater that falls annually on a typical house roof in a local district. | image shows an icon of a question mark |
| Evaluate the benefits and limitations of using desalination of sea water to provide a viable water resource. | image shows an icon of a human being |
| The effective use of energy resources is constrained by factors including waste disposal, and the efficiency of available technologies to collect, store, and transfer the energy.   * Compare the advantages and disadvantages of using renewable and non-renewable energy resources. | Use different carbon calculators to estimate individual carbon footprints and investigate why different calculators give different results. | image shows an icon of a question mark |
| Investigate how using the same scientific knowledge in different scenarios can have unexpected consequences by comparing the operations at the hydroelectricity plant in the Italian Alps, which is well-managed, with those at the plant in São Paulo, which has developed a black foam issue.  Investigate the cost and efficiency of solar panels over the past decade.  Explore the benefits of new technology for a local community — Jamestown solar/wind hybrid plant <https://www.iberdrola.com/about-us/lines-business/flagship-projects/port-augusta-project> | image shows an icon of a human being |

Topic 4: Climate change

In this topic, students explore how climate variables have changed over geological time, due to natural processes occurring in the Earth’s atmosphere, outside the atmosphere, and within the Earth. They recognise why significant variation in the Earth’s climate has the potential to produce a major effect on the Earth’s systems and on life on this planet.

Students analyse secondary data from geological, prehistorical, historical, and contemporary records to interpret trends that provide evidence of past changes in climate. They also explore the impact that human activities have had on recent changes in the Earth’s climate and how changes in oceanic circulation can affect weather systems.

Students use critical-thinking skills to consider different interpretations of the scientific evidence for climate-change models, and the validity and reliability of these models in predicting future climate change. They develop and extend their skills in communicating scientific information by analysing and presenting evidence, and drawing and justifying conclusions. They recognise how scientific knowledge from global collaboration can be used to consider the future health and well-being of the global population.

| Science Understanding | Possible contexts |  |
| --- | --- | --- |
| Natural processes in the Earth’s atmosphere affect climate change over geological time.   * Discuss the evolution of the Earth’s atmosphere. * Explain how the composition of the Earth’s atmosphere changes over time. * Discuss the greenhouse effect. * Explain how the lifespans of greenhouse gases and their ability to absorb infrared radiation contribute to their warming potentials. * Discuss how solar energy is absorbed, re-emitted, and reflected by atmospheric gases and the Earth’s surface, including the albedo effect. | Watch the SciShow YouTube video, ‘A History of Earth’s Climate’ (includes natural and anthropogenic factors).  <https://youtu.be/dC_2WXyORGA>  Watch and discuss Australia: The Time Traveller’s Guide about the evolution of the Australian continent. Search Clickview or go to:  <https://www.imdb.com/title/tt2380395/> | image shows an icon of three cogs |
| Investigate how the composition of the atmosphere has changed over time, including greenhouse gases, water vapour, carbon dioxide, ozone, methane, and nitrous oxide, using:   * Earthlearningidea, ‘Earth’s Atmosphere – A Step by Step Evolution’:   [www.earthlearningidea.com/PDF/103\_Evolution\_atmosphere.pdf](http://www.earthlearningidea.com/PDF/103_Evolution_atmosphere.pdf)   * PhET ‘The Greenhouse Effect’:   <https://phet.colorado.edu/en/simulation/greenhouse>  Explore the Earth’s energy budget with EarthLabs:  <http://serc.carleton.edu/eslabs/weather/2b.html>  Investigate the Earth’s energy budget through the EarthLabs activity:  <http://d32ogoqmya1dw8.cloudfront.net/files/eslabs/weather/energy_balance_instructions.pdf> | image shows an icon of a question mark |
| Natural processes outside of the Earth’s atmosphere affect climate change over geological time.   * Explain how astronomical cycles affect natural climate variability. * Explain how variations in solar energy due to sunspot activity can contribute to natural climate change. | Investigate how the Milankovitch cycles and solar cycles affect natural climate variability. | image shows an icon of three cogs |
| Natural processes within the Earth affect climate change over geological time.   * Explain how the plate-tectonic supercycle has contributed to global climatic changes throughout the Earth’s history. | Investigate how plate tectonics has influenced climate change over geological time. | image shows an icon of three cogs |
| Oceans absorb large amounts of solar radiation.   * Explain the effect of water’s large specific heat capacity on changes in ocean temperature. | Investigate the specific heat capacity of various substances including water. | image shows an icon of a question mark |
| Changes in oceanic circulation may impact on weather systems.   * Explain the difference between surface and deep-water ocean currents. * Explain the relationship between the world’s wind belts and the world’s surface ocean currents. * Explain the relationship between the thermohaline circulation and deep-water ocean currents. | Examine how continental distribution influences ocean currents.  Discuss the impact of mountain-building on elevation and hence climatic conditions.  Watch and discuss *Deep Time Walk*, which looks at Earth history and advocates for a regenerative Earth.  <https://www.deeptimewalk.org/> | image shows an icon of three cogs |
| Investigate ocean currents and how they influence climate.  <http://oceanservice.noaa.gov/education/tutorial_currents/welcome.html> | image shows an icon of a question mark |
| Anthropogenic activities affect climate conditions.   * Explain the enhanced greenhouse effect. * Describe anthropogenic activities that are changing the levels of greenhouse gases. * Compare how local, national, and global policies can affect the levels of these gases.   Explain how carbon is stored in Earth’s systems over a variety of time-scales. | Explore the global-warming potential (GWP) of carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons.  Explore how land clearing and fossil fuel consumption can increase levels of greenhouse gases.  Examine the storage of carbon in the carbonate–silicate geochemical cycle.  Investigate state, territory, and/or national government policies related to climate change.  <http://dfat.gov.au/international-relations/themes/climate-change/pages/climate-change.aspx> | image shows an icon of three cogs |
|  | Examine evidence of past glaciations, interglacial periods, and atmospheric parameters to find a period in Earth’s history that can be used as an analogue for a future with an enhanced greenhouse effect.  Watch and discuss a TED talk, such as ‘Climate Change is Happening. Here’s How We Adapt’:  [www.ted.com/talks/alice\_bows\_larkin\_we\_re\_too\_late\_to\_prevent\_climate\_change\_here\_s\_how\_we\_adapt/transcript?language=en](http://www.ted.com/talks/alice_bows_larkin_we_re_too_late_to_prevent_climate_change_here_s_how_we_adapt/transcript?language=en) | image shows an icon of three cogs |
| Explore how global policies concerning chlorofluorocarbon (CFC) use brought a change to the levels of these gases in the atmosphere through the No Zone of Ozone activity.  Examine how to evaluate scientific claims:  [http://www.exploratorium.edu/evidence/evidence.html?#/tester/](http://www.exploratorium.edu/evidence/evidence.html?%23/tester/) | image shows an icon of a human being |
| Climate change affects the Earth system.   * Discuss the effects of climate change on the Earth’s spheres. | Investigate clathrate deposits on the ocean floor.  <https://en.wikipedia.org/wiki/Methane_clathrate>  Discuss whether the melting of sea ice will raise sea levels in the same way as the melting of continental ice sheets.  Explore the impacts of climate change on:   * the biosphere, e.g. species distribution and crop productivity * atmosphere, e.g. rainfall patterns and surface air temperatures * hydrosphere, e.g. sea levels, ocean acidification, extent of ice sheets.   Explain how climate analogues can be used to explore the impact of climate change.  Explore the interactions between the spheres that occur during the melting of permafrost.  Explore the effects of fire on the interactions between the spheres  Discuss effects of climate change on natural carbon sequestration in the carbon cycle. | image shows an icon of three cogs |
| Explore the potential risks and benefits of using geosequestration to reduce atmospheric levels of carbon dioxide:  <http://australianmuseum.net.au/blogpost/lifelong-learning/geosequestration-sweeping-co2-under-the-rug> | image shows an icon of a human being |
| Geological, prehistorical, historical, and contemporary records provide evidence that climate change has affected different regions and species differently over time.   * Investigate how contemporary levels of CO2 and temperature are monitored, and provide evidence of contemporary climate change. * Explore how climate proxies are used to provide evidence of climate change. | Explore NOAA, ‘Paleo Proxy Data – What Is It?’:  [www.ncdc.noaa.gov/paleo/primer\_proxy.html](http://www.ncdc.noaa.gov/paleo/primer_proxy.html)  <http://serc.carleton.edu/microbelife/topics/proxies/paleoclimate.html>  Explore the evidence for the Medieval Warm Period. | image shows an icon of three cogs |
| Explore how historical and archaeological records, such as cave paintings, can be used to determine past climates.  Investigate climate change using foraminifera.  [www.ucmp.berkeley.edu/fosrec/Olson2.html](http://www.ucmp.berkeley.edu/fosrec/Olson2.html)  Investigate the evidence for ‘The Little Ice Age: Understanding Climate and Climate Change’ using this CLEAN activity:  <http://cleanet.org/resources/41810.html> | image shows an icon of a question mark |
| Investigate how evidence from proxy data, such as isotopic ratios, ice-core data, palaeobotany, and the fossil record, has contributed to the development of models of climate change:  <http://serc.carleton.edu/eslabs/climatedetectives/index.html>  <https://www.bas.ac.uk/data/our-data/publication/ice-cores-and-climate-change/> | image shows an icon of a human being |
| Models for predicting climate change are based on past climate data and are continually changing.   * Explain how general circulation models can be used to predict future climate change. | Explore how global climate models are used to predict future climate, through watching and discussing *‘*Modeling Our Climate’, Brown University:  <https://www.youtube.com/watch?v=SuZHnqxltKo>  Explain how the El Niño/La Niña events in the ocean–atmosphere system of the tropical Pacific Ocean can be predicted using climate models. Bureau of Meteorology, ‘What is El Nino and What Might It Mean for Australia?’:  <http://www.bom.gov.au/climate/> | image shows an icon of three cogs |
|  | Evaluate the usefulness of general circulation models:  [www.ipcc-data.org/guidelines/pages/ gcm\_guide.html](http://www.ipcc-data.org/guidelines/pages/gcm_guide.html)  Investigate NASA global climate modelling:  [www.giss.nasa.gov/projects/gcm/](http://www.giss.nasa.gov/projects/gcm/)  Discuss the effectiveness of international collaboration of scientists at the Intergovernmental Panel on Climate Change (IPCC) in determining achievable targets for the reduction of global warming. | image shows an icon of a human being |

Assessment scope and requirements

All Stage 2 subjects have a school assessment component and an external assessment component.

Evidence of learning

The following assessment types enable students to demonstrate their learning in Stage 2 Earth and Environmental Science:

School assessment (70%)

* Assessment Type 1: Investigations Folio (30%)
* Assessment Type 2: Skills and Applications Tasks (40%)

External assessment (30%)

* Assessment Type 3: Earth Systems Study (30%).

Students provide evidence of their learning through eight assessments, including the external assessment component. Students complete:

* at least two practical investigations
* one investigation with a focus on science as a human endeavour
* at least three skills and applications tasks
* one Earth systems study.

At least one investigation or skills and applications task 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
* teachers and assessors to design opportunities for the student to provide evidence of their learning at the highest possible level of achievement.

The assessment design criteria consist of specific features that:

* students should demonstrate in their learning
* teachers and assessors 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 (30%)

Students undertake at least two practical investigations, one of which involves field work, and one investigation with a focus on science as a human endeavour. Students may undertake more than two practical investigations within the maximum number of assessments allowed in the school assessment component. They 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, practical/field 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 2 Earth and Environmental Science
* individually deconstruct a problem to design their own method and justify their plan of action.

For each 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 1500 words if written, or a maximum of 10 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.

Students select and explore a recent discovery, innovation, issue, or advance linked to one of the topics in Stage 2 Earth and Environmental Science. They analyse and synthesise information from different sources to explain the science relevant to the focus of their investigation, show its connections to science as a human endeavour, and develop a conclusion.

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 an aspect of earth and environmental science
* an article from a scientific publication (e.g. *Cosmos*, *New Scientist*)
* public concern about an issue that has environmental, social, economic, or political implications
* changes in government funding for earth and environmental science-related purposes, e.g. for scientific research into aerial and satellite imagery to model resource distribution, suitable extraction methods, social impacts of resource extraction, environmental impacts on landscapes and aquifers, maximum sustainable yield in fisheries, economic value of ecosystem services, identification of reliable earthquake‑precursor phenomena, reduction of greenhouse gas emissions
* ‘green fields’ research leading to new technologies.

Based on their investigation, students prepare a scientific report, which must include the use of scientific terminology and:

* an introduction to identify the focus of the investigation and the key concept(s) of science as a human endeavour that it links to
* relevant earth and environmental science concepts or background
* an explanation of how the focus of the investigation illustrates the interaction between science and society, including a discussion of the potential impact of the focus of the investigation, e.g. further development, effect on quality of life, environmental implications, economic impact, intrinsic interest
* a conclusion
* citations and referencing.

The report should be a maximum of 1500 words if written or a maximum of 10 minutes for an oral presentation, or the equivalent in multimodal form.

This report could take the form of, for example:

* an article for a scientific publication
* a letter to the editor
* a talk.

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 (40%)

Students undertake at least three skills and applications tasks. Students may undertake more than three skills and applications tasks within the maximum number of assessments allowed in the school assessment component, but at least three should be under the direct supervision of the teacher. The supervised setting (e.g. classroom, laboratory, or field) should be appropriate to the task. Each supervised task should be a maximum of 90 minutes of class time, excluding reading time.

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 task design.

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 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:

* 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 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.

External assessment

Assessment Type 3: Earth System Study (30%)

Students undertake one fieldwork investigation into a particular local environmental issue, concern, initiative, or successful undertaking that can be linked to topics studied in Stage 2 Earth and Environmental Science. Students develop a research question, then design, plan, undertake, and report on a field-based extended investigation to answer the question. The investigation must include collection and analysis of both primary and secondary data. Students analyse the information gathered in terms of the interactions of two or more of the Earth’s spheres.

Each student designs an investigation proposal. Students may trial their methods to assist the design of their procedure. One draft of the proposal should be submitted for teacher feedback and approval. Students may modify their proposal in response to teacher feedback before they undertake their investigation.

Students submit their modified proposal with their report for assessment.

Students work individually in their data collection and field or laboratory analysis, and preparation of reports for external assessment. However, fieldwork excursions may be undertaken in class groups.

Proposal

The proposal should include:

* a statement of an investigable question or hypothesis
* a rationale for and an outline of the proposed research approach and method
* a list of equipment required
* the procedure to be followed
* the type of data that will be collected
* a risk assessment that addresses safety, ethical, and legal considerations.

Report

The report should use scientific terminology and include:

* an introduction to identify the purpose, and relevant background or previous research into the topic
* appropriate representation of data, e.g. tables, graphs, maps, charts, photographs, or other illustrations
* analysis of the information gathered in terms of the interactions of two or more of the Earth’s spheres
* evaluation of procedures and results to identify limitations of, and improvements to, the investigation
* a conclusion, which includes predictions or advice based on findings
* citations and referencing.

The combined word count for the proposal and the report should be a maximum of 2000 words, if written, or the equivalent in multimodal form.

The following specific features of the assessment design criteria for this subject are assessed in the Earth systems study:

* investigation, analysis, and evaluation — IAE1, IAE2, IAE3, and IAE4
* knowledge and application — KA1 and KA4.

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 and assessors 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 each school assessment type, the teacher makes a decision about the quality of the student’s learning by:

* referring to the performance standards
* assigning a grade between A+ and E for the assessment type.

The student’s school assessment and external assessment are combined for a final result, which is reported as a grade between A+ and E.

Performance Standards for Stage 2 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 both the school assessment and the external 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 2 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)).