Earth and Environmental Science
Stage 6

Syllabus

With changes tracked

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1 The Higher School Certificate Program of Study

The purpose of the Higher School Certificate program of study is to:

• provide a curriculum structure which encourages students to complete secondary education;

• foster the intellectual, social and moral development of students, in particular developing their:
  – knowledge, skills, understanding and attitudes in the fields of study they choose
  – capacity to manage their own learning
  – desire to continue learning in formal or informal settings after school
  – capacity to work together with others
  – respect for the cultural diversity of Australian society;

• provide a flexible structure within which students can prepare for:
  – further education and training
  – employment
  – full and active participation as citizens;

• provide formal assessment and certification of students’ achievements;

• provide a context within which schools also have the opportunity to foster students’ physical and spiritual development.
2 Rationale for Earth and Environmental Science in Stage 6 Curriculum

Earth and Environmental Science in Stage 6 Science is the study of the Earth and its processes. The course aims to provide an understanding of systems and processes in both aquatic and terrestrial environments. It seeks to explore changes that have occurred during Earth’s history, including changes in the lithosphere, atmosphere, hydrosphere, cryosphere and biosphere, and the evolution of organisms since the origin of life on Earth.

The study of planet Earth and its environments recognises that while humans are part of nature they continue to have a greater influence on the environment than any other species. Earth and Environmental Science is built on the premise that the natural environment is the host to all local environments and that, therefore, an understanding of the natural environment is fundamental to any analysis of more specific local environments.

The common factor in all of the environmental hazards that humanity faces is that they are derived from peoples’ lack of awareness that society is part of an environment that is composed of the interactions of the sub-systems: water, land, air, ice and living things. The history and philosophy of science as it relates to the development of the understanding, utilisation and manipulation of sub-systems by humans is an integral part of the study of contemporary Earth and Environmental Science.

Earth and Environmental Science is not isolated from the other science disciplines and the multi-disciplinary nature of many aspects of the subject is recognised. Earth and Environmental Science in Stage 6 draws upon and builds onto the knowledge and understanding, skills and values and attitudes developed in Stages 4–5 Science. It further develops students’ understanding of science as a continually developing body of knowledge, the role of experiment in deciding between competing theories, the provisional nature of scientific explanations, the interdisciplinary nature of science, the complex relationship between evidence and ideas, and the impact of science on society.

The study of planet Earth and its environments involves students working individually and with others in practical work, fieldwork and interactive media experiences, that are related to the theoretical concepts considered in the course. It is expected that students studying Earth and Environmental Science will apply investigative and problem-solving skills, effectively communicate information and appreciate the contribution that a study of planet Earth and its environments makes to our understanding of the world. The course aims to assist students to recognise and understand our responsibility to conserve, protect and maintain the quality of all environments for future generations.

The Earth and Environmental Science Stage 6 course is designed for those students who have a substantial achievement level based on the Science Stages 4–5 course performance descriptions. The subject matter of the Earth and Environmental Science course recognises the different needs and interests of students by providing a structure that builds upon the foundations laid in Stage 5 yet recognises that students entering Stage 6 have a wide range of abilities, circumstances and expectations.
Experience in learning about the natural and made environment, exploring phenomena and patterns of events, acquiring scientific skills and relating science to everyday life.
4 Aim

The aim of the Earth and Environmental Science Stage 6 Syllabus is to provide learning experiences through which students will:

- acquire knowledge and understanding about fundamental concepts related to planet Earth and its environments, the historical development of these concepts and their application to personal, social, economic, technological and environmental situations
- progress from the consideration of specific data and knowledge to the understanding of models and concepts and the explanation of generalised Earth and Environmental Science terms; from the collection and organisation of information to problem-solving and from the use of simple communication skills to those which are more sophisticated
- develop positive attitudes towards the study of planet Earth and its environments, and towards the opinions held by others, recognising the importance of evidence and critically evaluating differing scientific opinions related to various aspects of Earth and Environmental Science.

5 Objectives

Students will develop knowledge and understanding of:

1. the history of Earth and Environmental Science
2. the nature and practice of Earth and Environmental Science
3. applications and uses of Earth and Environmental Science
4. the implications of Earth and Environmental Science for society and the environment
5. current issues, research and developments in Earth and Environmental Science
6. the resources of the Earth, particularly air, soil, water, minerals, their distribution and their role in supporting living systems
7. the abiotic features of the environment
8. models to explain structures and processes of change affecting the Earth and its environments
9. Australian resources
10. biotic impacts on the environment.

Students will develop further skills in:

11. planning investigations
12. conducting investigations
13. communicating information and understanding
14. developing scientific thinking and problem-solving techniques
15. working individually and in teams.

Students will develop positive attitudes about and values towards:

16. themselves, others, learning as a lifelong process, Earth and the environment.
6 Course Structure

The Earth and Environmental Science Stage 6 Syllabus has a Preliminary course and a HSC course. The Preliminary and HSC courses are organised into a number of modules. The Preliminary modules consist of core content that would be covered in 120 indicative hours.

The HSC course consists of core and options organised into a number of modules. The core content covers 90 indicative hours with one option covering 30 indicative hours. Students are required to cover one of the options.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete 80 indicative hours of practical/field work during both the Preliminary and HSC courses with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences must include at least one integrated open-ended investigation in both the Preliminary and HSC courses.

Practical experiences should emphasise hands-on activities, including:

- undertaking laboratory experiments, including the use of appropriate computer-based technologies
- fieldwork
- research using the library, the Internet and digital technologies
- using computer simulations for modelling or manipulating data
- using and reorganising secondary data
- extracting and reorganising information in the form of flow charts, tables, graphs, diagrams, prose and keys
- using animation, video and film resources to capture/obtain information not available in other forms.

6.1 Preliminary Course (120 indicative hours)

The Preliminary course incorporates the study of:

- Planet Earth and Its Environment – A Five Thousand Million Year Journey (30 indicative hours)
- The Local Environment (30 indicative hours)
- Water Issues (30 indicative hours)
- Dynamic Earth (30 indicative hours).

6.2 HSC Course (120 indicative hours)

The HSC course builds upon the Preliminary course. The Preliminary course contains content that is considered assumed knowledge for the HSC course.
The HSC course incorporates the study of:

a) the core, which constitutes 90 indicative hours and includes:
   • Tectonic Impacts (30 indicative hours)
   • Environments Through Time (30 indicative hours)
   • Caring for the Country (30 indicative hours)

b) ONE option, which constitutes 30 indicative hours and may comprise any one of the following:
   • Introduced Species and the Australian Environment
   • Organic Geology – A Non-renewable Resource
   • Mining and the Australian Environment
   • Oceanography.
6.3 Overview

The following diagram summarises the relationship between the various elements of the course:

- **Aim**
  states the overall purpose of the syllabus

- **Objectives**
  define in broad terms the knowledge and understandings, skills and values and attitudes

- **Outcomes**
  define the intended results of teaching

- **Content of each module**

  - **Contexts**
    chosen to increase motivation, conceptual meaning, relevance, literacy and/or confidence

  - **Prescribed Focus Areas**
    identify emphases that are applied to what is being learned

  - **Domain**
    contains knowledge and understanding, skills and values and attitudes to be learned

- **set within a background of ongoing assessment aimed at assisting students to learn**

- **An independent learner**
  creative, responsible, scientifically literate, confident, ready to take their place as a member of society
Context

Contexts are frameworks devised to assist students to make meaning of the Prescribed Focus Areas and Domain. Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined. Contexts draw on the framework of society in all aspects of everyday life. The contexts for each module encourage students to recognise and use their current understanding to further develop and apply more specialised scientific understanding and knowledge.

Prescribed Focus Areas

The Prescribed Focus Areas are different curriculum emphases or purposes designed to increase students’ understanding of: Earth and Environmental Science as an ever-developing body of knowledge, the provisional nature of scientific explanations in Earth and Environmental Science, the complex relationship between evidence and ideas in Earth and Environmental Science and the impact Earth and Environmental Science has on society.

The following Prescribed Focus Areas are developed across the modules of the syllabus:

History of Earth and Environmental Science

Knowledge of the historical background of Earth and Environmental Science is important for an adequate understanding of the functioning, origins and evolution of the planet and its environment.

Students should develop knowledge of:

- the developmental nature of knowledge about the Earth and its environments
- the part that an understanding of the Earth and its environments plays in shaping society
- how our understanding of the Earth and its environments is influenced by society.

Nature and practice of Earth and Environmental Science

A study of Earth and Environmental Science should enable students to participate in scientific activities and develop knowledge of the practice of Earth and Environmental Science. Students should develop knowledge of the provisional nature of explanations and the complex relationship between:

- existing Earth and Environmental Science views and the evidence supporting these
- the process and methods of exploring, generating, testing and relating ideas
- the stimulation provided by technological advances in understanding Earth and Environmental Science
- the constraints imposed on understanding Earth and Environmental Science by the limitations of current technology and the stimulation this provides for the development of the required technology and technological advances.
Applications and uses of Earth and Environmental Science

Setting the study of Earth and Environmental Science into broader contexts allows students to deal with real problems and applications. The study of Earth and Environmental Science should increase students’ knowledge of:

- the relevance, usefulness and applicability of concepts and principles related to Earth and Environmental Science
- how increases in our understanding of Earth and Environmental Science have led to the development of useful technologies and systems
- the contributions Earth and Environmental Science has made to society, with particular emphasis on Australian achievements.

Implications for society and the environment

Earth and Environmental Science has an impact on our society and the environment. Students need to develop knowledge of the importance of positive values and practices in relation to society and the environment. The study of Earth and Environmental Science should enable students to develop:

- understanding about the interrelatedness among people and their surroundings
- skills in decision-making about issues concerning society and the environment
- an awareness of the social and environmental responsibility of a scientist
- an awareness of areas of Earth and Environmental Science that relate to distinctively Australian environments.

Current issues, research and developments in Earth and Environmental Science

Current issues, research and developments in Earth and Environmental Science are more readily known, and more information is available to students than ever before. The Earth and Environmental Science Syllabus should develop students’ knowledge of:

- areas currently being researched in Earth and Environmental Science
- career opportunities in Earth and Environmental Science and related fields
- events reported in the media that require an understanding of some aspect of Earth and Environmental Science.

Domain

Knowledge and understanding

As a course that focuses on a major discipline of science, Earth and Environmental Science presents a particular way of thinking about the world. It encourages students to use inference, deductive and inductive reasoning and creativity. It presumes that the interactions within Earth processes, between the atmosphere, hydrosphere and lithosphere, and between the abiotic and biotic features of the environment occur in consistent patterns that can be understood through careful, systematic study.
The Stage 6 courses extend the study developed in the Science Stages 4–5 course, particularly in relation to students’ knowledge and understanding of the big bang theory, plate tectonics and models for the rock cycle. It assumes some elementary knowledge and understanding of processes of evolution of the universe, solar system and Earth as well as Earth systems and structures and interactions involving the hydrosphere, lithosphere and atmosphere. The interactions between living things, including humans and their environment and the fundamentals of the classification, properties and uses of common substances, are assumed knowledge at a fundamental level.

**Skills**

The Earth and Environmental Science course involves the further development of the skills students have developed in the Science Stages 4–5 course through a range of practical experiences in both the Preliminary and HSC courses.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete 80 indicative hours of practical/field work across both the Preliminary and HSC courses with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences have been designed to utilise and further develop students’ expertise in each of the following skill areas:

- **planning investigations**
  This involves increasing students’ skills in planning and organising activities, effectively using time and resources, selecting appropriate techniques, materials, specimens and equipment to complete activities, establishing priorities between tasks and identifying ways of reducing risks when using laboratory and field equipment.

- **conducting investigations**
  This involves increasing students’ skills in locating and gathering information for a planned investigation. It includes increasing students’ skills in performing first-hand investigations, gathering first-hand data and accessing and collecting information relevant to Earth and Environmental Science from secondary sources using a variety of technologies.

- **communicating information and understanding**
  This involves increasing students’ skills in processing and presenting information. It includes increasing students’ skills in speaking, writing and using nonverbal communication, such as diagrams, graphs and symbols, to convey information and understanding. Throughout the course, students become increasingly efficient and competent in the use of both technical terminology and the form and style required for written and oral communication in Earth and Environmental Science.

- **developing scientific thinking and problem-solving techniques**
  This involves further increasing students’ skills in clarifying issues and problems relevant to Earth and Environmental Science, framing a possible problem-solving process, developing creative solutions, anticipating issues that may arise and devising appropriate strategies to deal with those issues and working through the issues in a logical and coherent way.

- **working individually and in teams**
  This involves further increasing students’ skills in identifying a collective goal, defining and allocating roles and assuming an increasing variety of roles in working as an effective member of a team within the agreed time frame to achieve the goal. Throughout the course, students are provided with further opportunities to improve their ability to communicate and relate effectively to each other in a team.
Values and attitudes

By reflecting about past, present and future involvement of Earth and Environmental Science with society, students are encouraged to develop positive values and informed critical attitudes. These include a responsible regard for both the living and non-living components of the environment, ethical behaviour, a desire for critical evaluation of the consequences of the applications of science, and recognising their responsibility to conserve, protect and maintain the quality of all environments for future generations. Students are encouraged to develop attitudes on which scientific investigations depend such as curiosity, honesty, flexibility, persistence, critical thinking, willingness to suspend judgement, tolerance of uncertainty and an acceptance of the provisional status of scientific knowledge. Students should balance commitment, tenacity and, at times, inflexibility with a willingness to take risks and make informed judgements. As well as knowing something of and/or about Earth and Environmental Science, students need to value and appreciate Earth and Environmental Science if they are to become scientifically literate persons.

6.4 Other Considerations

Safety Issues

Schools have a legal obligation in relation to safety. Teachers will need to ensure that they comply with the Occupational Health and Safety Act 1983-2000 (NSW), the Occupational Health and Safety Regulation 2001, the Dangerous Goods Act 1975, the Dangerous Goods Regulation 1978 (NSW) and the Hazardous Substances Regulation 1996 (NSW), as well as system and school requirements in relation to safety when implementing their programs.

Schools should refer to the resource package Chemical Safety in Schools (DET, 1999) to assist them in meeting their legislative obligations.

Animal Research Act

Schools have a legal responsibility in relation to the welfare of animals. All practical activities involving animals must comply with the Animal Research Act 1985 (NSW) as described in Animals in Schools: Animal Welfare Guidelines for Teachers (2002) produced on behalf of the Schools Animal Care and Ethics Committee (SACEC) by the NSW Department of the Education and Training, available through 3A Smalls Road, Ryde.
# 7 Objectives and Outcomes

## 7.1 Table of Objectives and Outcomes

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Preliminary Course Outcomes</th>
<th>HSC Course Outcomes</th>
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</thead>
<tbody>
<tr>
<td>Students will develop knowledge and understanding of:</td>
<td>A student:</td>
<td>A student:</td>
</tr>
<tr>
<td><strong>1</strong> the history of Earth and Environmental Science</td>
<td>P1 outlines the historical development of major Earth and Environmental Science principles, concepts and ideas</td>
<td>H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking</td>
</tr>
<tr>
<td><strong>2</strong> the nature and practice of Earth and Environmental Science</td>
<td>P2 applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in Earth and Environmental Science</td>
<td>H2 analyses the ways in which models, theories and laws in Earth and Environmental Science have been tested and validated</td>
</tr>
<tr>
<td><strong>3</strong> applications and uses of Earth and Environmental Science</td>
<td>P3 assesses the impact of particular technological advances on understanding in Earth and Environmental Science</td>
<td>H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies</td>
</tr>
<tr>
<td><strong>4</strong> implications for society and the environment</td>
<td>P4 describes applications of Earth and Environmental Science which affect society or the environment</td>
<td>H4 assesses the impact of applications of Earth and Environmental Science on society and the environment</td>
</tr>
<tr>
<td><strong>5</strong> current issues, research and developments</td>
<td>P5 describes the scientific principles employed in particular areas of Earth and Environmental Science research</td>
<td>H5 identifies possible future directions of Earth and Environmental Science research</td>
</tr>
<tr>
<td><strong>6</strong> the resources of Earth</td>
<td>P6 identifies the origins of Earth’s resources</td>
<td>H6 evaluates the use of Earth’s resources</td>
</tr>
<tr>
<td><strong>7</strong> the abiotic features of the environment</td>
<td>P7 identifies and describes the physical and chemical features of the environment</td>
<td>H7 discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments</td>
</tr>
<tr>
<td><strong>8</strong> models to explain structures and processes of change</td>
<td>P8 discusses the interplay between the internal and external forces which constantly reshape the Earth’s surface</td>
<td>H8 describes models which can be used to explain changing environmental conditions during the evolution of Australia and other continents</td>
</tr>
<tr>
<td><strong>9</strong> Australian resources</td>
<td>P9 describes and locates available resources in Australian environments</td>
<td>H9 evaluates the impact of resources utilisation on the Australian environment</td>
</tr>
<tr>
<td><strong>10</strong> biotic impacts on the environment</td>
<td>P10 describes human impact on the local environment</td>
<td>H10 assesses the effects of current pressures on the Australian environment</td>
</tr>
<tr>
<td>Domain: Skills</td>
<td>Objectives</td>
<td>Preliminary Course Outcomes</td>
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<tr>
<td></td>
<td>Students will develop knowledge and understanding of:</td>
<td>A student:</td>
</tr>
<tr>
<td>11 planning investigations</td>
<td>P11 identifies and implements improvements to investigation plans</td>
<td>H11 justifies the appropriateness of a particular investigation plan</td>
</tr>
<tr>
<td>12 conducting investigations</td>
<td>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</td>
<td>H12 evaluates ways in which accuracy and reliability could be improved in investigations</td>
</tr>
<tr>
<td>13 communicating information and understanding</td>
<td>P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science</td>
<td>H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding</td>
</tr>
<tr>
<td>14 developing scientific thinking and problem-solving skills</td>
<td>P14 draws valid conclusions from gathered data and information</td>
<td>H14 assesses the validity of conclusions drawn from gathered data and information</td>
</tr>
<tr>
<td>15 working individually and in teams</td>
<td>P15 implements strategies to work effectively as an individual or as a member of a team</td>
<td>H15 explains why an investigation is best undertaken individually or by a team</td>
</tr>
<tr>
<td>Domain: Values &amp; Attitudes</td>
<td>16 themselves, others, learning as a lifelong process, Earth and Environmental Science and the environment</td>
<td>P16 demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science</td>
</tr>
</tbody>
</table>
8 Content: Earth and Environmental Science Stage 6 Preliminary Course

8.1 Earth and Environmental Science Skills

During the Preliminary course, it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

<table>
<thead>
<tr>
<th>Preliminary Course Outcomes</th>
<th>Content</th>
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<tbody>
<tr>
<td>A student:</td>
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<tr>
<td>P11 identifies and implements improvements to investigation plans</td>
<td>Students:</td>
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<tr>
<td></td>
<td><strong>11.1 identify data sources to:</strong></td>
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<tr>
<td></td>
<td>a) analyse complex problems to determine appropriate ways in which each aspect may be researched</td>
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<td></td>
<td>b) determine the type of data that needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful</td>
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<td></td>
<td>c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data</td>
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<td></td>
<td>d) identify and use correct units for data that will be collected</td>
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<td></td>
<td>e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis</td>
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</tbody>
</table>

|                             | **11.2 plan first-hand investigations to:** |
|                             | a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation |
|                             | b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control |
|                             | c) design investigations that allow valid and reliable data and information to be collected |
|                             | d) describe and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures, or the repetition of procedures is appropriate |
|                             | e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary |

|                             | **11.3 choose equipment or resources by:** |
|                             | a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation |
|                             | b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards |
| P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources | 12.1 **perform first-hand investigations by:**  
   a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments  
   b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources  
   c) carefully and safely disposing of any waste materials produced during the investigation  
   d) identifying and using safe work practices during investigations  

| 12.2 **gather first-hand information by:**  
   a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors  
   b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate  

| 12.3 **gather information from secondary sources by:**  
   a) accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet  
   b) practising efficient data collection techniques to identify useful information in secondary sources  
   c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms  
   d) summarising and collating information from a range of sources  
   e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research  

| 12.4 **process information to:**  
   a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered  
   b) identify and apply relevant mathematical formulae and concepts  
   c) illustrate trends and patterns by organising data through the selection and use of appropriate methods, including computer assisted analysis  
   d) evaluate the validity of first-hand and secondary information and data in relation to the area of investigation  
   e) assess the reliability of first-hand and secondary information and data by considering information from various sources  
   f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals |
<table>
<thead>
<tr>
<th>P13</th>
<th>13.1 present information by:</th>
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<tbody>
<tr>
<td></td>
<td>a) selecting and using appropriate text types or combinations thereof, for oral and written presentations</td>
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<td>b) selecting and using appropriate media to present data and information</td>
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<td>c) selecting and using appropriate methods to acknowledge sources of information</td>
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<td>d) using symbols and formulae to express relationships and using appropriate units for physical quantities</td>
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<td>e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly</td>
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<td>f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately</td>
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<td>g) identifying situations where use of a curve of best fit is appropriate to present graphical information</td>
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<thead>
<tr>
<th>P14</th>
<th>14.1 analyse information to:</th>
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<tbody>
<tr>
<td></td>
<td>a) identify trends, patterns and relationships as well as contradictions in data and information</td>
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<td></td>
<td>b) justify inferences and conclusions</td>
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<td></td>
<td>c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem</td>
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<td></td>
<td>d) predict outcomes and generate plausible explanations related to the observations</td>
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<td></td>
<td>e) make and justify generalisations</td>
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<td></td>
<td>f) use models, including mathematical ones, to explain phenomena and/or make predictions</td>
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<td></td>
<td>g) use cause and effect relationships to explain phenomena</td>
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<td>h) identify examples of the interconnectedness of ideas or scientific principles</td>
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<thead>
<tr>
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<th>14.2 solve problems by:</th>
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<tbody>
<tr>
<td></td>
<td>a) identifying and explaining the nature of a problem</td>
</tr>
<tr>
<td></td>
<td>b) describing and selecting from different strategies those which could be used to solve a problem</td>
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<td></td>
<td>c) using identified strategies to develop a range of possible solutions to a particular problem</td>
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<tr>
<td></td>
<td>d) evaluating the appropriateness of different strategies for solving an identified problem</td>
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<tr>
<th></th>
<th>14.3 use available evidence to:</th>
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<tbody>
<tr>
<td></td>
<td>a) design and produce creative solutions to problems</td>
</tr>
<tr>
<td></td>
<td>b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas</td>
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<tr>
<td></td>
<td>c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations</td>
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<tr>
<td></td>
<td>d) formulate cause and effect relationships</td>
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8.2 Planet Earth and Its Environment – A Five Thousand Million Year Journey

Contextual Outline

According to currently accepted theory, the Sun formed about $4.7 \times 10^9$ years ago from a cloud of gas and dust whose collapse was triggered by a supernova explosion. The condensing gas and dust that went to form the Sun contained all its original elements plus the elements formed during the supernova explosion. Those elements heavier than uranium, from plutonium to californium and beyond, rapidly split into light elements or decayed into uranium and thorium whose half-lives are so long that they have survived in considerable amounts to the present day.

In addition to the different elements in the collapsing cloud of gas and dust, there would have been the many and various types of molecules like those found in interstellar space. As the young terrestrial planets formed, they would have consisted of a chaotic mixture of silicates, metals, liquids and gases. The metals then sank to the centre of the planets leaving while the silicates floated above. This raised the core temperature and forced out the gases that had been trapped inside earlier. These gases formed the early planetary atmosphere.

In time, Earth had a surface temperature sufficiently low for liquid water to exist and accumulate in natural depressions, forming the primitive oceans. The hydrologic and lithologic cycles removed methane, ammonia, hydrogen and carbon dioxide from the atmosphere, leaving nitrogen as the dominant gas. The evolution of life and the innovation of photosynthesis produced changes in the atmosphere that have prevailed to the present time.

The Earth’s atmosphere, lithosphere and hydrosphere have experienced cyclic episodes of cooling and heating and during this time, the biosphere has been slowly evolving. The present cycles have been established for many millions of years. But in the last few hundred years, humans have had an increasingly significant impact on the composition of the atmosphere and hydrosphere as they have extracted resources that have been locked up in the lithosphere for millions of years. The impact of increased resource use is now becoming obvious in the rapid degradation of some aspects of the environment.

This module increases students understanding of the historical background and the nature and practice of Earth and Environmental Science.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.9.1a discuss current scientific thinking about the origin of the universe
5.9.1b identify that some kinds of electromagnetic radiation are used to provide information about the universe
5.9.3a relate some major features of the universe to theories about the formation of the universe
Outcomes

The main course outcomes to which this module contributes are:

A student:
P1 — outlines the historical development of major Earth and Environmental Science principles, concepts and ideas
P2 — applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in Earth and Environmental Science
P6 — identifies the origins of the Earth’s resources
P7 — identifies and describes the physical and chemical features of the environment
P12 — discusses the validity and reliability of data gathered from first-hand investigations and secondary sources
P13 — identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science
P14 — draws valid conclusions from gathered data and information
P15 — implements strategies to work effectively as an individual or as a member of a team
P16 — demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science

Students learn to:

1. The solar system has evolved from a ball of gases released from a supernova explosion

   • recall the relationship between some major features of the universe and current thinking about the formation of the universe
   • recall current scientific thinking about the origin of the universe
   • compare two hypotheses developed using current scientific ideas to explain the existence of matter in the universe and describe the process of accretion of such matter to form stars and planets
   • discuss inferences about the relationship between some major features of the universe and theories about the formation of the universe
   • identify the sequence of events described by scientists to outline the formation of the solar system
   • identify that some types of electromagnetic radiation are used to provide information about the universe
   • discuss inferences about the relationship between emission spectra of elements and spectral analysis and the composition of stars

Students:

• gather, process and present information that outlines the sequence of events that led to the formation of the solar system
• identify data and perform first-hand investigations using a spectroscope and appropriate light sources to observe the spectral lines of some elements
• gather, process and analyse information from secondary sources to match the spectral signature of elements with emission spectra of a star, in order to determine the elements present in that star
2. The early Earth and its evolution

- compare cultural beliefs with those of astronomers and other scientists that may arise in discussion of the origins of the Earth
- recall the explanation of density using a simple particle model
- explain the role of gravity in the formation of the Earth
- recall the explanation of density using a simple particle model
- describe the relationship between the density of Earth materials and the layered structure of the Earth
- describe the composition of the early (pre-oxygen) atmosphere and compare it with the composition of the present atmosphere
- gather and process information that compares a cultural explanation with an astronomical or scientific model of the origin of the Earth
- plan and choose equipment or resources to perform a first-hand investigation to measure the density of a selection of earth materials representative of core, mantle and crust, and
- perform first-hand investigations and gather data to demonstrate the behaviour of a mixture of liquids of different densities during separation and use the available evidence to develop a hypothesis about how the Earth’s layered structure may have developed
- identify data sources, process and present information from secondary sources to use available evidence to compare the Earth’s earliest atmosphere and compare it with the present atmosphere

3. Living cells originated at a time when the atmosphere and environment were different to those presently found on Earth

- summarise the experiments of Urey and Miller and consider the importance of their findings to developing an understanding of how amino acids may have originated on Earth
- outline the evidence that indicates how the first cellular organisms (archaeobacteria Archaea) may have developed and describe their mode of respiration (anaerobic fermentation)
- discuss the impact of photolysis on the composition of the early (pre-oxygen) atmosphere
- outline the role of chemosynthesis in providing a suitable energy source for early organisms
- explain how the existence of archaeobacteria Archaea near fumaroles and submarine vents can be used to support ideas on early development of life
- gather and process information from secondary sources about the synthesis of amino acids caused by discharging an electric spark in mixtures of methane, ammonia, hydrogen and water
- plan, choose equipment or resources and perform a first-hand investigation to demonstrate fermentation of sugar by yeast and use an appropriate chemical test to identify the produced gas as carbon dioxide
- gather and process second-hand information about both ancient archaeobacteria Archaea and present day archaeobacteria Archaea that live near fumaroles and submarine vents known as black smokers
4. The evolution of photosynthesis shifted the balance of gases in the atmosphere

- identify photosynthetic bacteria as the first organisms to release oxygen into the environment
- discuss the roles of precipitation and photosynthesis in the removal of carbon dioxide from the early atmosphere
- identify that the reaction between methane and oxygen to form carbon dioxide could have been a means by which methane was removed from the atmosphere
- predict and explain the differences in composition of the oceans before and after the evolution of photosynthesis
- explain that reactions between oxygen and other elements would readily occur producing oxide minerals and thus moderate the release of oxygen into the oceans and atmosphere
- describe the forms in which carbon is now ‘locked up’ in the lithosphere and biosphere
- plan, choose equipment or resources and perform a first-hand investigation to gather information about the conditions under which iron reacts with oxygen to form iron oxides
- perform a first-hand investigation to demonstrate model the precipitation of carbonate minerals in solution by bubbling carbon dioxide through limewater
- gather and process information from secondary sources and use available evidence to analyse differences in the composition of the oceans before and after the evolution of photosynthesis
- process and present information from secondary sources to list and describe the forms in which carbon is now ‘locked up’ in the lithosphere and biosphere

5. The evidence provided by geological records suggests that there have been climatic variations over Earth’s history

- outline explain the links between the concentration of atmospheric carbon dioxide and average global temperature over geological time
- identify that evidence from marine and lake sediments, ice cores and sea level changes suggests average global temperatures have decreased over the last sixty million years
- identify data, process and analyse information from secondary sources and use available evidence to assess claims of a relationship between changing carbon dioxide concentrations and changes in average global temperatures
- gather, process and analyse information from secondary sources on the varying climate of the Earth since the end of the Cretaceous, sixty million years ago
8.3 The Local Environment

Contextual Outline

The immediate environment has an impact on all people in ways that an Earth and Environmental Science student will learn to recognise and explain. This module allows students to draw on existing knowledge of their own local area and expand on their understanding of geological and climatic concepts through careful analysis of the area. Study of this module must include field experience in the investigation of landforms, rock and soil types as well as biological factors and how all of these interact to form the local environment.

Students will be able to identify the physical and chemical features of their local environment and relate those features to the hydrologic, lithologic and atmospheric cycles in operation. They need to be able to identify and relate landforms, rock types and soils to the resultant natural environments in which they, the plants and other animals of the area, live. In order to judge the impact of human settlement in the area, students will need to investigate the history of the local environment as evident in the rocks, soils and fossils of the area. Where practicable, they could also seek the assistance of local Indigenous people in tracing the history of the area before the advent of European settlement.

Finally, students should be encouraged to analyse those aspects of the local environment that have been affected by people, describe the impacts, identify the causes of these impacts and propose realistic solutions to any problems that exist by emphasising ecologically sustainable development strategies. At least one field study will be necessary to identify the geographical features of the landscape. The report on any field study should include: a statement of purpose, a clear and detailed definition of the area studied, any background material collected on the area, appropriate presentation of data collected, analysis of data, suggestions of the relationships that exist in the area and an assessment of human impact on the area.

This module increases students understanding of the nature and practice of science, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.10a distinguish between biotic and abiotic features of the local environment
5.10c describe some impacts of human activities on ecosystems
5.10d discuss strategies used to balance human activities and needs in ecosystems with conserving, protecting and maintaining the quality of the environment
Outcomes

The main course outcomes to which this module contributes are:

A student:
P2 applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in Earth and Environmental Science
P4 describes applications of Earth and Environmental Science which affect society or the environment
P5 describes the scientific principles employed in particular areas of Earth and Environmental Science research
P6 identifies the origins of the Earth’s resources
P7 identifies and describes the physical and chemical features of the environment
P8 discusses the interplay between the internal and external forces which constantly reshape the Earth’s surface
P9 describes and locates available resources in Australian environments
P10 describes human impact on the local environment
P11 identifies and implements improvements to investigation plans
P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources
P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environment Science
P14 draws valid conclusions from gathered data and information
P15 implements strategies to work effectively as an individual or as a member of a team
P16 demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. Rocks are formed from different materials

Students learn to:

- identify common rock forming minerals
- distinguish between igneous, sedimentary and metamorphic rock groups in terms of their origins and common mineral composition
- identify and describe the geological features of the local environment that determine its natural landforms

Students:

- perform a first-hand investigation and use second hand data to classify several common igneous, sedimentary and metamorphic rocks using a key, with particular reference to those rocks in the local environment
- identify data, gather, process and present information as a report that identifies and describes:
  - the purpose of the report
  - the geological features of the local landscape
  - the past geological history of the area that can be deduced from evidence in the local rocks, soils or fossils

- choose equipment, plan and perform first-hand investigations during a local field study to:
  - identify the main parent rock types (if present)
  - analyse the soil in each area for:
    - organic content
    - pH
    - moisture content
    - presence of salts (chlorides, sulfate, phosphates, nitrate) by solution chemistry, test tape colour reactions or indicator solutions

- identify, gather and process first-hand or secondary data to identify the dominant types of plants and animals in the area studied and, where possible, solve problems related to the soil types

2. The properties of local soils affect the local biological environment

Students:

- recall the difference between biotic and abiotic features of the local environment
- outline the characteristics of a local soil
- summarise the processes that produce soil
- examine a soil and describe it in terms of:
  - the horizons present
  - the characteristics of each horizon
- analyse the ways in which the vegetation of an area can be influenced by the soil composition and climate/microclimate of a region
- relate the presence of particular animals in the local environment to their requirements within the local environment

Students:

- perform a first-hand investigation and use second hand data to classify several common igneous, sedimentary and metamorphic rocks using a key, with particular reference to those rocks in the local environment
- identify data, gather, process and present information as a report that identifies and describes:
  - the purpose of the report
  - the geological features of the local landscape
  - the past geological history of the area that can be deduced from evidence in the local rocks, soils or fossils

- choose equipment, plan and perform first-hand investigations during a local field study to:
  - identify the main parent rock types (if present)
  - analyse the soil in each area for:
    - organic content
    - pH
    - moisture content
    - presence of salts (chlorides, sulfate, phosphates, nitrate) by solution chemistry, test tape colour reactions or indicator solutions

- identify, gather and process first-hand or secondary data to identify the dominant types of plants and animals in the area studied and, where possible, solve problems related to the soil types
3. The impact of humans on local aquatic and terrestrial environments will differ with locality

- summarise and assess the changes in the local environment in the last fifty years in terms of:
  - vegetation cover and diversity
  - animal diversity and abundance
  - water flow and quality
- explain why different groups in the local society have different views of the impact of human activity on the local environment

4. The need for governments and local councils to design and enact laws to protect the biotic and abiotic environment

- identify one environmental issue that requires some government regulation or management, such as:
  - sustainable development
  - exploration
  - mining
  - environmental planning
  - air and water quality management
  - land use and rehabilitation
- identify an appropriate local environmental document that aims to address one of the issues above (e.g., environmental impact study, catchment management plan)

- gather and process information from secondary sources to describe changing vegetation cover, plant and animal diversity and abundance, and water flow and quality in the local environment over the last fifty years
- identify data, gather, process and analyse first-hand information and use available evidence to assess current human impact on the local biotic and abiotic environment
- gather, process and analyse information from secondary sources to identify and discuss the scientific basis of the issues in the chosen local environmental document
- gather information from secondary sources to discuss one government regulation based on ecologically sustainable development principles on land use
5. The activities of humans can cause systematic habitat alteration

- recall strategies used to balance human activities and needs in ecosystems with conserving, protecting and maintaining the quality of the environment
- assess the impact of human alterations to the environment, including land clearing, in terms of some specific consequences, such as increased runoff, increased soil erosion, changes in river flows, in-stream sedimentation
- describe, using examples from the local environment if possible, ways in which artificial structures can disrupt natural surface processes
- explain how habitat disturbance from soil degradation can advantage introduced species of plants and lead to the reduction or elimination of native flora and fauna species in affected areas
- use examples to describe and explain what is meant by biodiversity
- outline the potential effects of a loss of biodiversity in destabilised ecosystems
- discuss the importance of refugia in conserving biodiversity
- gather, process and present information about the consequences of land clearing in a particular catchment
- process and analyse secondary information to prepare a case study on the impact of an artificial structure on natural surface processes
- gather, process and present information from secondary sources on two Australian species that have been declared endangered and use available evidence to outline the reasons why the species have become endangered and the measures taken to ensure their survival

6. Biodiversity assists in keeping a dynamic balance in the biosphere

- gather information from a secondary source, including the Register of the National Estate (ERIN) or other databases to identify significant sites of biodiversity or places of environmental importance in the local area
- gather and process information from secondary sources to discuss issues associated with allowing public access to refugia
- gather information from secondary sources to identify and describe an example of a Biosphere Reserve and the aim(s) of this reserve
8.4 Water Issues

Contextual Outline

Planet Earth has been called ‘Planet Ocean’, ‘Planet Water’ or the ‘Blue Planet’, because of the abundant water on its surface. Liquid water, which is taken for granted on Earth, is a rare commodity in the cosmos. Abundant liquid water can only be found on a planet of the right mass and chemical composition and the right distance from a neighbouring star/sun.

On Earth, water can be obtained in an essentially pure form from the atmosphere with less than one percent dissolved salts, seawater with a few percent dissolved salts, and brines that are saturated solutions. Surface and groundwaters on Earth can range from essentially pure to highly saline. These different waters are found in different geological environments. It has taken over four thousand million years to form our current interacting subsystems comprising the atmosphere, hydrosphere, lithosphere and biosphere that together form the biome of planet Earth. The intimate relationship between these subsystems generates global climatic conditions that promote such diverse environments on the planet as deserts and rainforests and that can produce the extremes of wind and rain, ice and snow. As water moves between these spheres it acts as an agent of change and transportation.

The Australian environment has its own subsystems that have evolved over millions of years. For most of this time, Australian ecosystems evolved without humans. By the time Aboriginal people arrived, much of the continent was dry and water was the limiting factor on the distribution of both plants and animals.

Water is important in maintaining Australian environments. The protection of water quality against the potential effects of contamination is important in guarding the integrity of those environments.

This module increases students understanding of the applications and uses of and the implications for society and the environment of Earth and Environmental Science.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.9.4f explain some impacts of natural events including cyclones, volcanic eruptions – and earthquakes on the atmosphere, hydrosphere, lithosphere and/or biosphere
5.10a distinguish between biotic and abiotic features of the local environment
5.10c describe some impacts of human activities on ecosystems
5.11.2a relate pollution to contamination by unwanted substances

Outcomes

The main course outcomes to which this module contributes are:

A student:
P3 assesses the impact of particular technological advances on understanding in Earth and Environmental Science
P4 describes applications of Earth and Environmental Science which affect society or the environment
P7 identifies and describes the physical and chemical features of the environment
P9 describes and locates available resources in Australian environments
P10 describes human impact on the local environment
P11 identifies and implements improvements to investigation plans
P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources
P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science
P14 draws valid conclusions from gathered data and information
P15 implements strategies to work effectively as an individual or as a member of a team
P16 demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. Interacting sub-systems of the Earth that together produce a unique biome

Students learn to:

- recall some impacts of natural events including cyclones, volcanic eruptions and earthquakes on the atmosphere, hydrosphere, lithosphere and/or biosphere
- recall the distribution of the atmosphere, hydrosphere, lithosphere and biosphere on planet Earth
- outline an estimate of Earth’s total water budget and the percentage available for terrestrial organisms
- identify factors, including geographic position, climate and topography, that determine the present distribution of water on the planet

Students:

- identify data and gather information from secondary sources to construct diagrams representing:
  - the distribution of the atmosphere, hydrosphere, lithosphere and biosphere
  - the distribution of Earth’s total water budget

2. Water is an important ingredient in the maintenance of Australian environment

Students:

- explain the importance of water as a solvent in biological systems
- compare the relative solubility of oxygen and carbon dioxide in water and how the solubility of each changes with temperature
- predict the potential impact of excessive water evaporation and subsequent increase in salinity on common terrestrial and inland aquatic organisms
- identify common water pollutants that can affect the growth of plankton

Students:

- choose equipment and perform first-hand investigations to gather information about the presence of dissolved oxygen in water at different temperatures using indicators or appropriate technology
- plan and perform first-hand investigations to gather information that demonstrates the effect of varying salt concentrations on plant growth
- gather and analyse information from secondary sources to evaluate the effect of common pollutants, including detergents and fertilisers, on growth of algae in ponds
3. **Water plays an important part in weathering and the subsequent production of soils**

- describe the water cycle in terms of the physical processes involved
- distinguish between chemical and mechanical weathering
- identify the role that water plays in breaking down rocks by:
  - abrasion
  - changes in volume of water during freezing
  - dissolving substances
  - acid attack

4. **Water resources: past and present**

- describe evidence in rocks confirming the past presence of large bodies of water in inland Australia (eg, limestone, marine fossils, shallow-marine and lacustrine sediments) and for each type of evidence, a place (in NSW or Australia) where this evidence may be found
- recall pollution as contamination by unwanted substances
- discuss methods used to conserve water including the re-use of water after treatment
- assess examine efficiency of water usage both locally and in Australia and locally
- outline problems that may occur in ground water systems, such as pollution, salt water intrusion and ground salinity, and give examples of these problems occurring in Australian environments
- outline one State or Federal government policy related to the use of ground water and possible scientific solutions to identified environmental problems associated with the use of ground water
- identify data, plan and perform an investigation to demonstrate gather information from using local field examples to investigate the effects of one form of chemical weathering and one form of mechanical weathering the effects of:
  - abrasion
  - changes of volume of water during freezing
  - dissolving substances and analyse information about the impact of these effects on the environment
- gather information from secondary sources to summarise landscape features that may identify past aquatic environments
- gather, process and present information as a case study, and use available evidence to illustrate the impact on one or more ecosystems of a change in climate, including a change in water availability to illustrate the effect on an ecosystem of a change in water availability
- gather information and analyse one method of waste water management and outline the scientific principles involved that allow the re-use of the water
- gather information from secondary sources and use available evidence to present an outline of one environmental problem identified in NSW that has arisen from the use of ground water in the past
8.5 Dynamic Earth

Contextual Outline

The Earth’s landscapes result from the interplay of forces, internal and external, that continually reshape the Earth’s surface. These landscapes often show the effect of the most dramatic of the forces such as — those internal tectonic forces responsible for the movement of the crustal plates over the surface of the Earth.

The impact of crustal movements through earthquakes and volcanoes has been regularly recorded throughout human history. Although the Australian continent is now relatively stable, the geological record provides insight into its sometimes violent history.

This module examines the evidence of present Earth structures resulting from tectonic forces and compares this evidence with the features of the Australian landscape with a view to understanding how the Australian continent came to its present shape and form.

This module increases students understanding of the historical background, the nature and practice of, the applications and uses and the current issues, research and developments in Earth and Environmental Science.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.7.1d describe an appropriate model that has been developed to describe atomic structure

5.9.2a discuss the evidence that suggests crustal plates move over time

5.9.4d relate movements of Earth’s plates to convection currents in the asthenosphere — and to gravitational forces

5.9.4e explain how earthquakes, volcanic activity and new landforms result from the interactions at plate boundaries
Outcomes

The main course outcomes to which this module contributes are:

A student:

P1 outlines the historical development of major Earth and Environmental Science principles, concepts and ideas
P2 applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in Earth and Environmental Science
P3 assesses the impact of particular technological advances on understanding in Earth and Environmental Science
P5 describes the scientific principles employed in particular areas of Earth and Environmental Science research
P7 identifies and describes the physical and chemical features of the environment
P8 discusses the interplay between the internal and external forces which constantly reshape the Earth’s surface
P11 identifies and implements improvements to investigation plans
P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources
P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science
P14 draws valid conclusions from gathered data and information
P15 implements strategies to work effectively as an individual or as a member of a team
P16 demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. Evidence that the Australian continental land mass began developing 4.1 thousand million years ago

- Students learn to:
  - recall an appropriate model that has been developed to describe atomic structure
  - outline the process of radioactive decay of conditions under which an atomic nucleus is unstable and decomposes
  - explain radioactivity in terms of the decomposition of atomic nuclei
  - explain how the relative percentage of remnant radio-isotopes can be used to measure absolute ages of materials, including rocks
  - identify the age and explain the significance of the oldest mineral grains in Australia (Mt Narryer zircons of the Pilbara) evidence for the age of the oldest rocks in Australia

- Students:
  - gather, process and analyse information from secondary sources to determine the age of rocks and crystals based on data from radiometric (isotopic) methods
  - gather, process and analyse information from second-hand data to evaluate the significance of zircon grains found in the Mt Narryer complex
2. Geological evidence provides information about patterns of continental movement. Crustal plates move and their edges are marked by tectonic activity.

- recall evidence that crustal (lithospheric) plates move over time
- recall the relationship between plate movements, convection currents in the asthenosphere and gravitational forces
- describe similarities and outline differences between oceanic and continental crust
- summarise the evidence found in the Australian-Indian plate that support hypotheses of crustal movements (ie plate tectonics and sea floor spreading)
- explain how the alignment of magnetic fields of minerals in cooling igneous rocks is an indication of the rock’s position relative to the magnetic poles
- assess the significance of apparent polar wandering paths as evidence of continental mobility
- explain the significance of the discovery of magnetic field reversals on the development of a time scale
- analyse the assistance that palaeomagnetism has provided in understanding the process of sea floor spreading and the movement of continents
- identify regions where sea floor spreading is now occurring and describe the composition of igneous rocks formed at mid-ocean ridges
- describe the characteristics of volcanic activity associated with sea floor spreading
- describe the plate tectonic model and use it to explain the distribution and age of continents and oceans
- identify continents and subcontinents that formed part of Gondwana and describe evidence inferring their origins in Gondwana
- process and analyse information from secondary sources about the changing nature of ideas and models proposed about the movement of continents
- gather information from secondary sources, including maps, to solve problems about areas of sea floor spreading
- gather, process and present information from secondary sources on the use of magnetism in minerals as an indicator of crustal movement
- gather information from secondary sources to identify and describe the main features of igneous rocks associated with effusive volcanic activity
- gather information from secondary sources to identify the major world plates, their positions and boundaries, on a map
- process and analyse information from secondary sources to model a reconstruction of Gondwana from its component landmasses and use available evidence to discuss its relationship with Pangea
3. Magnetic patterns and volcanic activity provide further evidence of plate divergence

- explain how the alignment of magnetic fields of minerals in cooling igneous rocks provides an indication of the rocks position relative to the magnetic poles recall how earthquakes, volcanic activity and new landforms result from the interactions at plate boundaries
- assess the significance of apparent polar wandering paths as evidence of continental mobility describe the processes that may occur when two plates collide
- explain the significance of the discovery of magnetic field reversals on the development of a time scale define the term ‘subduction zone’ and identify the geological features that are characteristic of a subduction zone
- explain how the palaeomagnetic time scale provides evidence for sea floor spreading describe the characteristics of igneous rocks and volcanic activity associated with subduction zones
- identify regions where sea floor spreading is now occurring and describe the composition of igneous rocks formed at mid-ocean ridges analyse the inferences about processes occurring at subduction zones with data collected from earthquakes
- describe the characteristics of volcanic activity associated with sea floor spreading outline differences between plutonic and volcanic igneous rocks explain how granites, basalts and andesites are formed
- identify regions of Australia that provide evidence of past plate movements and assess the impact of plate movements on past environments of Australia
- gather, process and present information from secondary sources on the use of magnetism in minerals as an indicator of crustal movement identify data plan, choose resources, perform a first-hand investigation and gather information from secondary sources to identify, describe and explain the features of:
  — plutonic igneous rocks, such as granite
  — igneous rocks associated with explosive volcanic activity
- gather information from secondary sources to identify and describe the main features of igneous rocks associated with effusive volcanic activity process information to plot the occurrence of explosive volcanic activity around the world and relate the pattern produced to crustal movements
- gather and process information from secondary sources and use available evidence to develop a timeline that traces the movements and main events in the formation of the Australian continent to the present time
34. The interaction of plates during subduction, collision and breakup

- describe the processes that may occur when two plates collide
- define the term ‘subduction zone’ and identify the geological features that are characteristic of a subduction zone
- describe the characteristics of igneous rocks and volcanic activity associated with subduction zones
- analyse the inferences about processes occurring at subduction zones using data collected from earthquakes
- explain how granites and andesites are formed.

- describe the plate tectonic model and use it to explain the distribution and age of continents and oceans
- summarise the evidence found on the Australian-Indian plate that support hypotheses of crustal movements (ie plate tectonics and sea floor spreading)
- identify continents and subcontinents that formed part of Gondwana and describe evidence inferring their origins in Gondwana

- process information to plot the occurrence of explosive volcanic activity around the world and relate the pattern produced to crustal movements

5. Australia has been separated from other continents by plate tectonic motion

- process and analyse information from secondary sources that shows the historical development of theories to explain the movement of continents
- process and analyse information from secondary sources to model a reconstruction of Gondwana from its component landmasses and use available evidence to discuss its relationship with Pangaea
9 Content: Earth and Environmental Science Stage 6
HSC Course

9.1 Earth and Environmental Science Skills

During the HSC course, it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

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<th>HSC Course Outcomes</th>
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<td>A student:</td>
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<td>H11</td>
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<td>justifies the</td>
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<td>11.1 identify data sources to:</td>
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<tr>
<td>a) analyse complex problems to determine appropriate ways in which each aspect may be researched</td>
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<tr>
<td>b) determine the type of data which needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful</td>
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<tr>
<td>c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data</td>
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<tr>
<td>d) identify and use correct units for data that will be collected</td>
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<tr>
<td>e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis</td>
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<tr>
<td>11.2 plan first-hand investigations to:</td>
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<tr>
<td>a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation</td>
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<tr>
<td>b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control</td>
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<tr>
<td>c) design investigations that allow valid and reliable data and information to be collected</td>
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<tr>
<td>d) describe and trial procedures to undertake investigations and explain why a procedure or a sequence of procedures or the repetition of procedures is appropriate</td>
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<tr>
<td>e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary</td>
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<tr>
<td>11.3 choose equipment or resources by:</td>
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<tr>
<td>a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation</td>
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<tr>
<td>b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards</td>
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<tr>
<td>c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations</td>
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</tbody>
</table>
| H12 | 12.1 **perform first-hand investigations by:**  
|     | a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments  
|     | b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources  
|     | c) carefully and safely disposing of any waste materials produced during the investigation  
|     | d) identifying and using safe work practices during investigations  
|     |  
|     | 12.2 **gather first-hand information by:**  
|     | a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors  
|     | b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate  
|     |  
|     | 12.3 **gather information from secondary sources by:**  
|     | a) accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet  
|     | b) practising efficient data collection techniques to identify useful information in secondary sources  
|     | c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms  
|     | d) summarising and collating information from a range of sources  
|     | e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research  
|     |  
|     | 12.4 **process information to:**  
|     | a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered  
|     | b) identify and apply relevant mathematical formulae and concepts  
|     | c) illustrate trends and patterns by organising data through the selection and use of appropriate methods, including computer assisted analysis  
|     | d) evaluate the validity of first-hand and secondary information and data in relation to the area of investigation  
|     | e) assess the reliability of first-hand and secondary information and data by considering information from various sources  
|     | f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals  
| d) | recognising the difference between destructive and non-destructive testing of material and analysing potentially different results of these two procedures  

H12 evaluates ways in which accuracy and reliability could be improved in investigations.
**H13**

<table>
<thead>
<tr>
<th>13.1 present information by:</th>
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<tbody>
<tr>
<td>a) selecting and using appropriate text types or combinations thereof, for oral and written presentations</td>
</tr>
<tr>
<td>b) selecting and using appropriate media to present data and information</td>
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<tr>
<td>c) selecting and using appropriate methods to acknowledge sources of information</td>
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<tr>
<td>d) using symbols and formulae to express relationships and using appropriate units for physical quantities</td>
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<tr>
<td>e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly</td>
</tr>
<tr>
<td>f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately</td>
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<tr>
<td>g) identifying situations where use of a curve of best fit is appropriate to present graphical information</td>
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**H14**

<table>
<thead>
<tr>
<th>14.1 analyse information to:</th>
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<tbody>
<tr>
<td>a) identify trends, patterns and relationships as well as contradictions in data and information</td>
</tr>
<tr>
<td>b) justify inferences and conclusions</td>
</tr>
<tr>
<td>c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem</td>
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<tr>
<td>d) predict outcomes and generate plausible explanations related to the observations</td>
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<tr>
<td>e) make and justify generalisations</td>
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<tr>
<td>f) use models, including mathematical ones, to explain phenomena and/or make predictions</td>
</tr>
<tr>
<td>g) use cause and effect relationships to explain phenomena</td>
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<tr>
<td>h) identify examples of the interconnectedness of ideas or scientific principles</td>
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</table>

<table>
<thead>
<tr>
<th>14.2 solve problems by:</th>
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<tbody>
<tr>
<td>a) identifying and explaining the nature of a problem</td>
</tr>
<tr>
<td>b) describing and selecting from different strategies those that could be used to solve a problem</td>
</tr>
<tr>
<td>c) using identified strategies to develop a range of possible solutions to a particular problem</td>
</tr>
<tr>
<td>d) evaluating the appropriateness of different strategies for solving an identified problem</td>
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</table>

<table>
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<tr>
<th>14.3 use available evidence to:</th>
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<tbody>
<tr>
<td>a) design and produce creative solutions to problems</td>
</tr>
<tr>
<td>b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas</td>
</tr>
<tr>
<td>c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations</td>
</tr>
<tr>
<td>d) formulate cause and effect relationships</td>
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</table>
9.2 Tectonic Impacts

Contextual Outline

Throughout the history of the Earth, the movement of plates has resulted in continual global environmental change. This unit allows students to examine the scale of change by gathering and analysing information that indicates past tectonic activity and by considering the effects of earthquakes and volcanic eruptions. The impact of plate tectonics can be considered on two levels.

Current research suggests that throughout Earth history, global tectonics has followed a cyclic pattern resulting in the formation and breakup of supercontinents. The processes of continental agglomeration and sea floor spreading have resulted in the development of mountain belts characterised by distinctive geological features including lithologies and geological structures. Interpretation of the broad geological patterns on the Australian continent indicate how Australia has evolved.

The long-term Earth history indicates significant impacts due to the agglomeration of landmasses into larger landmasses and the subsequent changes in temperatures that these landmasses experienced. The splitting of landmasses, together with the changes in global water circulation that followed, also caused considerable change in environmental conditions, both in the oceans and on land.

On a smaller time scale, the impacts of earthquakes and volcanic eruptions that have occurred in the recorded history of humans provide insight into the slow but inexorable change brought upon land masses by tectonic activity. Students have the opportunity to examine how new technologies are facilitating the prediction of earthquakes and volcanic eruptions. This unit allows students to examine the scale of change caused by both earthquakes and volcanoes while gathering and analysing the information that indicates past tectonic activity.

This module increases the students understanding of the historical background, the nature and practice of, the applications and uses, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H2 analyses ways in which models, theories and laws in Earth and Environmental Science have been tested and validated
H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
H4 assesses the impact of applications of Earth and Environmental Sciences on society and the environment
H5 identifies possible future directions of Earth and Environmental Science research
H7 discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments
H8 describes models which can be used to explain changing environmental conditions during the evolution of Australia and other continents
H11 justifies the appropriateness of a particular investigation plan
H12 evaluates ways in which accuracy and reliability could be improved in investigations
H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
1. Lithospheric plates and their motion

- describe the characteristics of lithospheric plates
- identify the relationship between the general composition of igneous rocks and plate boundary type
- outline the motion of plates and distinguish between the three types of plate boundaries (convergent, divergent and conservative)
- assess-describe current hypotheses used to explain how convection currents and subduction drive plate motion

2. The movement of plates results in mountain building

- distinguish between mountain belts formed at divergent and convergent plate boundaries in terms of general rock types and structures, including folding and/or faulting

3. Continents evolve as plate boundaries move and change

- outline how the main stages involved in the growth of the Australian continent have grown over geological time as a result of plate tectonic processes
- summarise the plate tectonic super-cycle

Students learn to:

- gather and analyse information from secondary sources about the cause of forces driving plate motion
- gather, process and present information from secondary sources which compares formation, general rock type and structure of mountain belts formed as a result of thermal uplift and rifting with those resulting from different types of plate convergence
- analyse information from a geological or tectonic map of Australia in terms of age and/or structure of rocks and the pattern of growth of the continent
- gather, process and present information from secondary sources that present information as draw a sequence of diagrams to describe the plate tectonic super-cycle concept
4. Natural disasters are often associated with tectonic activity and environmental conditions caused by this activity may contribute to the problems experienced by people.

- **predict-identify-recall** where earthquakes and volcanoes are currently likely to occur based on the plate tectonic model
- describe methods used for the prediction of volcanic eruptions and earthquakes
- describe the general physical, chemical and biotic characteristics of a volcanic region and explain why people would inhabit such regions despite the risk
- describe hazards associated with earthquakes, including ground motion, tsunamis and collapse of structures
- describe hazards associated with volcanoes, including poisonous gas emissions, ash flows, lahars and lava flows and examine the impact of these hazards on the environment, on people and other living things
- justify continued research into reliable prediction of volcanic activity and earthquakes
- describe and explain the impacts of shock waves (earthquakes) on natural and built environments with reference to specific examples
- distinguish between plate margin and intra-plate earthquakes with reference to the origins of specific earthquakes recorded on the Australian continent
- gather, process and present information from secondary sources to chart the location of natural disasters worldwide associated with tectonic activity and use available evidence to assess the patterns in terms of plate tectonics
- identify data, plan an investigation and gather information from secondary sources to identify the technology used to measure crustal movements at collision boundaries and describe how this is used
- gather, process and present information from secondary sources to chart the location of natural disasters worldwide associated with tectonic activity and use available evidence to assess the patterns in terms of plate tectonics
- gather information from secondary sources to present a case study of a recent natural disaster associated with tectonic activity that includes:
  - an analysis of the tectonic movement or process involved
  - its distance from the area of disaster
  - predictions on the likely recurrence of the tectonic movement or process
  - technology available to assist prediction of future events
  - analysis of the accuracy of predictions of future events and potential improvements in this technology
  - using available evidence to give an investigation of possible solutions to minimise the disastrous effects of future events
5. **Plate tectonics and climate**

- predict the possible effects of explosive volcanic activity on global and local climates
- describe and explain the potential and observed impacts of volcanic eruptions on global temperature and agriculture
- outline the relationship between the plate tectonic super-cycle and the occurrence of ice ages (the icehouse/greenhouse cycle)

- identify data, choose resources, gather and analyse secondary data on recent volcanic activity to determine the relationship between the eruption of ash and gas from a recent explosive volcanic eruption and the subsequent decrease in global temperature
9.3 Environments Through Time

Contextual Outline
There is little direct evidence about the inception of life but from the available evidence, much of which has been gained from Australian rocks, geologists have been able to piece together an increasingly detailed description of the emergence of life. With the descriptions of fossil plants and animals, people can visualise the world as it was.

Palaeoecologists are able to describe past climates by the chemical and physical evidence from that time. When the information from the geological record about plants, animals, landforms and climates is combined, it is possible to describe the past environments of Australia.

The geological record provides evidence of periods of mass extinction often followed by periods when life forms have proliferated explosively. Some modern theories that attempt to explain the mass extinctions evident in the fossil record follow a neo-catastrophist model and evidence to support this model will be examined. This module allows the relationship between habitat alteration and the impact on life forms to be assessed and considers how much change leads to mass extinctions. Rapid adaptations and radiations of new species are a consequence of mass extinction events and the reasons for these will be considered.

When scientists are able to relate past changes in life forms to changing environmental conditions, they are then able to better predict the potential impact of human assisted environmental change and habitat destruction on modern life forms. When this is achieved, they may be better able to prevent more species from becoming endangered or extinct. This module will allow students to examine and discuss measures taken by law-makers and scientists in attempting to prevent the loss of further biodiversity from the biosphere.

This module increases the students understanding of the historical background, the nature and practice of, and the implications for society and the environment of Earth and Environmental Science.

Outcomes
The main course outcomes to which this module contributes are:

A student:
H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H2 analyses the ways in which models, theories and laws in Earth and Environmental Science have been tested and validated
H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
H7 discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments
H8 describes models which can be used to explain changing environmental conditions during the evolution of Australia and other continents
H9 evaluates the impact of resource utilisation on the Australian environment
H10 assesses the effects of current pressures on the Australian environment
H12 evaluates ways in which accuracy and reliability could be improved in investigations
H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14 assesses the validity of conclusions drawn from gathered data and information
H15 explains why an investigation is best undertaken individually or by a team
H16 — justifies positive values about and attitudes towards the living and non-living components of the environment; ethical behaviour; and desire for a critical evaluation of the consequences of the applications of science.
1. Evidence from early Earth indicates the first life forms survived in changing habitats during the Archean and Proterozoic eons

   Students learn to:
   - identify/geological time is divided into eons on the basis of fossil evidence of different life forms
   - define cyanobacteria as simple photosynthetic organisms and examine the fossil evidence of cyanobacteria in Australia
   - outline the major factors/processes and environmental conditions involved in the depositional environment of a Banded Iron Formation (BIF)
   - examine and explain processes involved in fossil formation and the range of fossil types
   - outline stable isotope evidence for the first presence of life in 3.8 x 10^9-year-old rocks
   - compare and contrast the nature of stromatolites with modern examples

   Students:
   - gather and process information from secondary sources to draw up a timeline to compare the relative lengths of the Hadean, Archaean, Proterozoic and Phanerozoic eons
   - gather and analyse information from secondary sources to explain the significance of the Banded Iron Formations as evidence of life in primitive oceans
   - gather information from secondary sources to describe the structure of ancient stromatolites and to determine the conditions under which the different groups of stromatolites form
   - gather, analyse and present information from secondary sources on the habitat of modern stromatolites and use available evidence to propose possible reasons for their reduced abundance and distribution in comparison with ancient stromatolites

2. The environment of the Phanerozoic eon

   Students:
   - outline the chemical relationship between ozone and oxygen
   - explain the relationship between changes in oxygen concentrations and the development of the ozone layer
   - describe the role of ozone in filtering ultraviolet radiation and the importance of this for life that developed during the Phanerozoic eon

   Students:
   - analyse information from secondary sources to identify the major era subdivisions used to describe the Phanerozoic and describe the general differences in life forms in each era
3. The Cambrian event

- interpret the relative age of a fossil from a stratigraphic sequence
- compare uses of relative and absolute dating methods in determining sequences in the evolution of life forms
- distinguish between relative and absolute dating
- discuss the possible importance of the development of hardened body parts in explaining the apparent explosion of life in the Cambrian period
- deduce possible advantages that hard shells and armouring would have given these life-forms in comparison with the soft-bodied Ediacara metazoans of the late Proterozoic, in terms of predation, protection and defence
- gather and process information from secondary sources to compare uses of relative and absolute dating methods in determining sequences in the evolution of life forms
- identify data and gather first-hand information or information from secondary sources to examine at least one example of a stratigraphic sequence and describe any fossils found in this sequence
- choose resources, gather information from secondary sources and use available evidence, including computer simulations, models and photographs to examine the changes in life forms that occurred during what is commonly referred to as the ‘Cambrian event’

4. Exploiting new environments

- outline recall the theory of evolution by natural selection
- outline recall evidence that present-day organisms have developed from different organisms in the distant past
- summarise environmental pressures faced when living things evolved for the main evolutionary changes resulting from the selection of required for living things exhibiting features that allowed them to survive in to adapt to terrestrial environments
- outline the major steps in the expansion to the terrestrial environments by land plants, amphibians and reptiles
- identify the advantages the terrestrial environment offered to enjoyed by the first land-dwellers plants and animals.
- gather and analyse information from secondary sources of a developed geological time scale and secondary sources to identify and date the major evolutionary advances made by plants and animals
- gather information from secondary sources to summarise the features and distribution of some of the first land plants, amphibians and reptiles
- identify data, choose resources and plan an investigation to gather and analyse information from a variety of secondary sources to summarise advances in our understanding of DNA in identifying evolutionary relationships
5. Past extinction and mass extinction events

- compare models of explosive and gradual adaptations and radiations of new genera and species following mass extinction events
- distinguish between mass extinctions and smaller extinctions
- explain using the recent extinction of the marsupial, bird and reptile megafauna in Australia, as an example of analyse smaller extinction events involving several large species
- compare these smaller extinction events such as the recent extinction of the marsupial, bird and reptile megafauna in Australia, and compare such events with widespread ‘catastrophic’ events in which entire ecosystems collapse with the extinction of many entire classes and orders
- assess a variety of hypotheses proposed for the mass extinctions at the end of the Permian and at the end of the Cretaceous

- gather information from secondary sources to compare the diversity and numbers of organisms from a fossil site
- process secondary information to outline the purposes and levels of classification in a hierarchical system using an appropriate diagram to distinguish between class, order, genus and species
- gather, analyse and present information from secondary sources to compare two different concepts used to explain mass extinction events
- gather information from secondary sources and use available evidence to identify the relationship between mass extinctions and the divisions of the geological time scale
- analyse information from secondary sources on at least two different hypotheses used to explain the extinction of the megafauna
9.4  Caring for the Country

Contextual Outline

The Australian continent has experienced tectonic stability for millions of years but this stability means that there has been only slow release of new mineral supplies into the rocks and little renewal of the soils across most of the continent for millennia. As a consequence, the Australian environment is fragile and, for the most part, arid, with old soils from which many chemical components have been leached.

The carrying capacity of each Australian ecosystem is determined by the interaction of local environment factors. The arrival and continent-wide dispersal of Aboriginal people coupled with the advent of another period of glaciation gradually changed the pre-human ecosystems and appearance of the landscape. The impact of the first human settlers in combination with global climate fluctuations led to the demise of Australia’s megafauna, changed the character of Australia’s flora and produced the environment encountered by the first non-Aboriginal settlers.

Aboriginal people have, through their long association with the fragile ecosystems, developed strategies to manage the land successfully but non-Aboriginal use of the land imposed agricultural practices suitable to a Northern Hemisphere context. The Australian environment, however, did not respond in the same way as did the environments in the Northern Hemisphere. European agricultural practices demanded more water, more fertilisers and more vegetation to support the introduced plants and animals than were needed by those parts of the biota that evolved here.

Australians are now realising that the pressures of our urban, agricultural and mining practices have produced unsustainable rates of resource use and abuse and that the unique biodiversity of this continent is at risk because of unnecessary habitat destruction. National strategies have been developed that acknowledge the key role of governments in setting the scene for the broad changes in direction and approach necessary to ensure that Australia’s future development is ecologically sustainable.

This module increases the students understanding of the historical background, the nature and practice of, the applications and uses, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1  evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H2  analyses the ways in which models, theories and laws in Earth and Environmental Science have been tested and validated
H3  assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
H4  assesses the impact of applications of Earth and Environmental Science on society and the environment
H5  identifies possible future directions of Earth and Environmental Science research
H6  evaluates the use of the Earth’s resources
H7 — discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments
H8 — describes models which can be used to explain changing environmental conditions during the evolution of Australia and other continents
H9 — evaluates the impact of resource utilisation on the Australian environment
H10 — assesses the effects of current pressures on the Australian environment
H11 — justifies the appropriateness of a particular investigation plan
H12 — evaluates ways in which accuracy and reliability could be improved in investigations
H13 — uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14 — assesses the validity of conclusions drawn from gathered data and information
H15 — explains why an investigation is best undertaken individually or by a team
H16 — justifies positive values about and attitudes towards the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. Australia’s land surfaces have undergone the effects of continuous long periods of weathering and erosion at rates that are very slow in comparison to worldwide averages

   Students learn to:

   - describe the low fertility of most Australian soils in terms of:
     - slow rate of soil formation
     - long period of depletion of nutrient ions
     - stability of the Australian continent in terms of the low relief of the Australian continent

   Students:

   - gather, process and present information comparing the fertility of a basalt-derived soil from recent volcanic activity in eastern Australia with a deeply weathered lateritic soil from Western Australia that indicates the long-term stability of the Australian continent and the great age of Australian soils and landscapes

2. Soil as a resource that requires careful management

   Students:

   - outline a cause of soil erosion in NSW due to:
     - an agricultural process
     - a natural process
     - urbanisation
     and identify a management strategy that prevents or reduces each of these

   Students:

   - plan and perform first-hand investigations a series of tests of investigations to determine the effect of compaction or tracking on a soil
   - gather information from first-hand or secondary sources to evaluate a program or strategy used in NSW to treat soil erosion

3. Salinity of soils and water

   Students:

   - identify regions of Australia with naturally saline soils
   - examine the possible consequences for soil salinity of land clearing and irrigation and outline precautions that could minimise the problem in each case
   - summarise a specific example of successful government or community strategy employed to rehabilitate salt-affected land in NSW

   Students:

   - identify data, choose resources and process information to draw sample cross-sections of salt-affected terrain in order to identify and define depth of bedrock and watertable
   - identify data sources and gather, process and present information on as a case study of a successful rehabilitation program of a salt-affected area, including:
     - the origins of the problem
     - the impact of the salinity problem on the biotic and abiotic environment
     - the rehabilitation strategy used and the scientific basis for this strategy
4. The effect of excessive use and long-term consequences of using some pesticides

- assess alternative management practices that do not require the use of pesticides
- discuss the effect of continually introducing new pesticides into the environment, including
  - effect on non-target species
  - accumulation in individuals (bio-accumulation) and magnification in animals higher up the food chain (biomagnification)
  - human health impacts

5. Maintenance of environmental flows and natural processes in water

- assess alternative management practices that do not require the use of pesticides
- assess management strategies and technologies that can be used to assist in the maintenance of natural processes in surface water, including by:
  - drip versus overhead irrigation
  - licensing irrigation/bore water users
  - treating stormwater treatment technologies
  - provision of environment flows from dams

- gather and present information from secondary sources as a flow chart to summarise the steps in forms of sewage treatment
- analyse information about methods of sewage treatment that do not require discharge into waterways or oceans, to explain how they achieve their purpose

6. The results of the Industrial Revolution on the atmosphere and hydrosphere

- summarise types of chemical reactions involved in the formation of greenhouse gases and acid rain from the burning of fossil fuels (word equations only)
- analyse different scientific views on the causes of global warming to discuss predictions on the effects of global warming
- assess predictions on the likelihood of global warming
- analyse implications of one international strategy related to maintaining and protecting the atmosphere and the hydrosphere

- gather information from secondary sources to identify a pesticide whose use is now banned and summarise its use, the reasons for stopping its use and available evidence to assess the impact of its residual chemicals in the environment
- gather and analyse information from secondary sources about alternatives to pesticides as a management practice

- gather and analyse information from secondary sources to list both the greenhouse gases and those that cause acid rain, their origins from both natural and made environments, and use available evidence to propose possible local and global strategies to achieve decreased emission of carbon dioxide, methane and sulphur dioxide
• outline the way in which chlorofluorocarbons and other halides can reduce the percentage of ozone in the stratosphere
• summarise the evidence for ozone depletion and the role of Australian scientists in this ongoing research

• gather and analyse information from secondary sources to evaluate and discuss the future impact of the Montreal Protocol and the Kyoto Agreement
  – one international strategy aimed at reducing ozone depletion
  – one international strategy aimed at reducing human causes of global warming

• gather information from secondary sources to summarise the uses of CFCs and other halides and describe the ways in which their use is being phased out and alternative products being used

7. Rehabilitation and safe use of previously contaminated sites

• define the qualities of geological features that need to be considered in selecting areas for waste dumps
• evaluate the methods currently used for the disposal, treatment and/or recycling of both solid and liquid waste

• assess attempts at rehabilitation of two contaminated sites

• plan, choose equipment and perform first-hand investigations to construct and test laboratory simulations of waste treatment processes, such as filtration, sedimentation and precipitation, and aeration

• gather information from first-hand investigations or secondary information to analyse the effectiveness of landfills in disposing of solid and/or liquid wastes

• process and analyse information from secondary sources to compare methods previously used to rehabilitate mine sites with current methods
9.5 Option — Introduced Species and the Australian Environment

Contextual Outline

Humans are not the only invaders of the Australian continent: approximately ten percent of Australia’s 15 000 – 20 000 species of vascular plants were introduced from somewhere else. (Invasion can be defined as the successful founding of a colony in a region where no colony of that species existed before, and the successful rapid expansion of that colony.)

Aquatic and terrestrial ecosystems of Australia have been invaded successfully by plants and animals. Many plant and animal species now regarded as pests in Australia were deliberately introduced. Introduced animals have included donkeys, camels, water buffalo, cats, rabbits and cane toads. With these came fleas, lice, and other insects, such as the American cockroach. Introduced plants include water hyacinth, lantana, bitou bush and skeleton weed.

The introduction of new species of plants or animals to the Australian environment causes great change to established and balanced ecosystems; as well, it causes degradation to the physical environments. This option allows students to concentrate on specific examples of introduced plants and animals. By studying the impact of introduced species, students can further develop their analytical skills to predict long-term consequences and design rehabilitation and control programs.

This module increases the students understanding of the historical background, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Sscience.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
H5 identifies possible future directions of Earth and Environmental Science research
H10 assesses the effects of current pressures on the Australian environment
H11 justifies the appropriateness of a particular investigation plan
H12 evaluates ways in which accuracy and reliability could be improved in investigations
H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14 assesses the validity of conclusions drawn from gathered data and information
H15 explains why an investigation is best undertaken individually or by a team
H16 justifies positive values about and attitudes towards the living and non-living components of the environment, ethical behaviour, and a desire for critical evaluation of the consequences of the applications of science.
1. **Survey of introduced species in Australia**

- define an introduced species as one that is not indigenous to a particular locality
- identify the criteria that can be used to classify introduced species
- discuss examples of introduced *aquatic or terrestrial plants or animals* to identify:
  - plants or animals
  - food, soil or nutrient requirements
  - areas of invasion
  - aquatic or terrestrial
  - levels of human mediated or non-human mediated
- discuss the reasons why different groups of people may have introduced plants and animals into the Australian environment
- discuss the reasons why different groups of people may have different opinions on the presence of an introduced organism as a pest, using an identified example such as the tourism value of water buffalo in the Northern Territory

2. **An analysis of introduced species indicates they may impact on either the biotic or the abiotic aspects of the environment**

- identify the biotic and abiotic components of a local environment
- explain how some introduced species alter the abiotic characteristics of why the physical aspects of the Australian environments they colonise and why such environments are so vulnerable to change some introduced species

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**Students learn to:**

- process and analyse secondary information to define and identify introduced species
- identify data sources, choose resources, plan and perform a first-hand investigation by visiting a local environment and identifying, classifying and accounting for the presence of non-indigenous flora and fauna
- gather, process and analyse secondary information to determine the reasons, location, time and mode of introduction of named introduced species

**Students:**

- perform a first-hand investigation by visiting a local environment, to identify and distinguish between biotic and abiotic, physical components aspects of the environment that may have been affected by introduced species
3. **Identification of the conditions leading to introduced species becoming pests**

- assess the relative contributions of the following conditions to **two named introduced plants** and **two named introduced animals** becoming pests:
  - suitable habitat
  - suitable climatic condition
  - range of food resources
  - relative lack of natural predators/grazers
  - high reproductive capacity
  - well-developed dispersal mechanisms

- summarise for each of the above named introduced plants and animals:
  - the history of introduction
  - the environmental conditions leading to the organism becoming a pest
  - the impact on the physical environment
  - dispersal techniques
  - reproductive capacity
  - control strategies

4. **Development of a case study on an introduced species that has had an impact on the physical and/or biological environment**

- summarise for **each of the above named introduced plants and animals**:
  - the history of introduction
  - the environmental conditions leading to the organism becoming a pest
  - the impact on the physical environment
  - dispersal techniques
  - reproductive capacity
  - control strategies

- analyse information from first-hand and/or secondary sources and use available evidence to assess the environmental impacts of **the named plants and animals**

- gather and analyse information from secondary sources to determine the relative merits of different possible control strategies for the named plants and animals

- evaluate for the above named introduced plant and animal:
  - the impact on the environment
  - control strategies

- examine and critically analyse the environmental impacts of the named plan

- gather, process and analyse information from secondary sources and use available evidence to identify the features of the named introduced plants and animals.
5. Rehabilitation programs for ecosystems damaged by introduced species

- explain what is meant by biological control
- describe the following types of biological control and give examples of the use of each:
  - predator–prey
  - bacterial/viral parasites
  - release of sterilised males
- outline the criteria used to determine the conditions under which an organism can be used for biological control
- describe the history of control of prickly pear as an example of successful biological control
- recount the role of the Bradley sisters in establishing the bushland regeneration program known as the ‘Bradley Method’
- identify broadscale environmental impacts of one or more introduced species on a local ecosystem
- examine and critically evaluate the strategies being used to rehabilitate this ecosystem or to minimise threatening processes
- recommend ways in which the strategies could be refined
- extrapolate current level of effectiveness of the identified strategies to the future in terms of:
  - costs
  - sustainability of the ecosystem
  - monitoring
  - management of the program

- process information from secondary sources on the uses and successes of the various forms of biological control
- gather information from secondary sources to contrast the main features and effectiveness of the Bradley Method of bush regeneration with an alternative method of bush regeneration
- process, analyse and present information about strategies being used to rehabilitate an ecosystem or minimise threatening processes
- analyse information and use available evidence to make predictions about future effectiveness of identified strategies.
6. Modern quarantine methods continue to restrict the introduction of new species to Australia

- outline the quarantine procedures in place in Australia to prevent introduction of new species
- identify use the example of the introduction of new species through off-loading of ballast water as an example of accidental introduction
- assess the effectiveness of procedures in place to prevent the spread of new species

- gather, process and present information to summarise the quarantine methods used by quarantine in Australia to control the introduction of new species and analyse the effectiveness of these procedures
9.6 Option — Organic Geology – A Non-renewable Resource

Contextual Outline

Organic resources are extremely important to modern human culture in all parts of the world but their availability continues to be a source of concern to scientists. This module allows students to increase their knowledge and understanding of the geological origins of fossil fuels. With this increased understanding should come better awareness of the conservation issues involved and the need to search for alternative fuels and materials.

This module increases the students understanding of the historical background, the applications and uses, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
H5 identifies possible future directions of Earth and Environmental Science research
H6 evaluates the use of the Earth’s resources
H9 evaluates the impact of resources utilisation on the Australian environment
H10 assesses the effects of current pressures on the Australian environment
H11 justifies the appropriateness of a particular investigation plan
H12 evaluates ways in which accuracy and reliability could be improved in investigations
H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14 assesses the validity of conclusions drawn from gathered data and information
H15 explains why an investigation is best undertaken individually or by a team
H16 justifies positive values about and attitudes towards the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. The properties of economically important Earth materials formed from organic material

- Students learn to:
  - distinguish between the natures of renewable and non-renewable resources
  - assess estimates of known reserves of non-renewable resources in light of technological innovation
  - define fossil fuels as ‘useful organic-matter-derived Earth materials’
  - describe the changes in coal with increasing rank in terms of:
    - physical properties
    - composition
    - grade
    - energy yield
  - describe properties of liquid petroleum in terms of composition and energy yield
  - describe properties of gaseous fossil fuels in terms of composition and compare the energy yields of coal-derived gas and petroleum-derived gas

- Students:
  - process information from secondary sources to classify renewable and non-renewable resources commonly in use
  - identify data sources, gather information and perform a first-hand investigation to identify and classify a variety of fossil fuels commonly used and compare their properties and uses
  - outline the characteristics of coal-forming environments
  - outline the process of coalification — transforming vegetable matter into peat and coal
  - describe the characteristics of petroleum-forming environments
  - outline the maturation of petroleum — diagenesis, catagenesis, metagenesis
  - outline the process of oil and gas migration
  - describe the features of source rocks, reservoir rocks and cap rocks
  - analyse the conditions under which petroleum accumulates in structural and stratigraphic traps

2. The environment, and process of coal and petroleum formation

- Students learn to:
  - outline the characteristics of coal-forming environments
  - discuss the process of coalification — transforming vegetable matter into peat and coal
  - describe the characteristics of petroleum-forming environments
  - outline the maturation of petroleum — diagenesis, catagenesis, metagenesis
  - outline the process of oil and gas migration
  - describe the features of source rocks, reservoir rocks and cap rocks
  - analyse the conditions under which petroleum accumulates in structural and stratigraphic traps

- Students:
  - analyse information from secondary sources, including resource maps, to:
    - identify coal producing localities
    - identify petroleum producing localities
  - gather and process information from secondary sources to analyse the similarities between environments in coal and petroleum producing localities
  - use available evidence to deduce relationships between them
| 3. Searching for coal and oil | • describe the exploration methods used to determine the existence and extent of coal deposits  
• describe the exploration methods used to determine the locations of oil, including geophysical methods and drilling  
• identify the location and main geological features of known coal and oil localities and their relevance to the search for new ones  
• gather information from secondary sources to outline the methods and technologies used to locate fossil fuel reserves |
| --- | --- |
| 4. The uses of coal and oil | • describe the refining of coal by washing  
• describe the refining of petroleum, including distillation and catalytic cracking  
• describe and evaluate the uses of coal and oil as fuels and raw materials for industry  
• gather and present information from secondary sources to construct flow charts and diagrams of the processes used in refining fossil fuels |
| 5. The environmental impacts of fossil fuel use — complete versus incomplete combustion | • analyse and evaluate the types and effects of products of burning fossil fuels — gases, water, particulates  
• analyse the dependence of modern society on fossil fuels and assess attempts to limit emissions  
• describe and evaluate arguments concerning the greenhouse debate  
• identify data sources, select equipment, plan and perform a first-hand investigation to distinguish between the products of complete and incomplete combustion  
• identify data sources, analyse information and use available evidence to determine the effects of fossil fuel combustion products, using a variety of media  
• analyse information and use available evidence to predict scenarios that investigate the economic and environmental effects of removing all sources of fossil fuels  
• analyse information from secondary sources concerning the enhanced greenhouse effect |
6. The search for alternative sources of fuels

- identify and discuss alternative sources of energy — solar, wind, hydro-electric, nuclear, synthetic oil, ethanol, wave power — and evaluate the relative importance and future potential of each as an alternative energy source for the local community now and in the future
- describe and evaluate methods of conserving energy, including architectural design
- gather information from a secondary source to investigate alternative sources of energy
- solve problems and perform first-hand investigations to test the energy efficiency of various non-fossil fuel alternative energy sources substances
9.7 Option — Mining and the Australian Environment

Contextual Outline

Australia’s mineral resources continue to be an important part of the economy of Australia but there are increasing concerns about the impact of mining on the environment in the long term. This module allows students to become familiar with issues associated with the geology of mining. It also allows them to investigate processes that may be used to minimise environmental damage during and after the mining process in the light of national strategies for a sustainable future.

This module increases the students understanding of the historical background, the applications and uses, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
H5 identifies possible future directions of Earth and Environmental Science research
H6 evaluates the use of the Earth’s resources
H9 assesses the effects of current pressures on the Australian environment
H10 justifies the appropriateness of a particular investigation plan
H12 evaluates ways in which accuracy and reliability could be improved in investigations
H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14 assesses the validity of conclusions drawn from gathered data and information
H15 explains why an investigation is best undertaken individually or by a team
H16 justifies positive values about and attitudes towards the living and non-living components of the environment, ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
12. The relationship between minerals and geological formations indicates where to search for the ore and the appropriate technology that could be used.

Students learn to:
- identify the main geological features of two Australian mineral provinces including:
  - a base/precious metal producing locality in an island arc terrane, and
  - one selected from an iron ore producing locality in an ancient continental area or an area of sedimentary ore formation
- discuss theories concerning models of for mineral genesis, related to sedimentary and tectonic processes, responsible for the mineralisation in the two mineral provinces selected above
- outline exploration methods for the case study undertaken in point (4), below, that may include geophysical and geochemical techniques, mapping, satellite imagery, aerial photograph interpretation

23. The laws related to mining leases, rights of the land-holder and the role of governments in granting leases

Students:
- solve problems, identify data sources, gather and analyse information from secondary sources to identify the locations and geological structures associated with settings and main features of the chosen mineral provinces
- gather information and use available evidence to assess the impact of improvements in technology on exploration techniques

24. There is a range of conditions under which mining an ore deposit becomes economically viable

Students:
- make predictions about the implications of one landmark decision that has impacted on mining operations in Australia such as Wave Hill, Mabo, or Wik
- outline the effect of at least one local, state or federal and federal government policy on mining operations in the context of sustainability

- identify renewable and non-renewable resources commonly used in society in terms of the processes and time required to generate them
- define ore deposits in terms of financial costs incurred in exploration, extraction and refining compared with market price, and in terms of grade as bodies of rock containing ore minerals which can be mined and treated at a profit
- distinguish between waste rock and ores in rock
- distinguish between ore minerals

- process information from secondary sources to classify renewable and non-renewable resources commonly in use
- process information from secondary sources and use available evidence to estimate the financial cost incurred in exploration, extraction and refining compared with market price and in terms of grade
- process and analyse information from secondary sources on the interrelationships between financial costs involved in exploration, mining, refining
and gangue minerals in an ore deposit
• describe gangue minerals as those that must be removed to enrich the concentration and value of an ore deposit
• explain how the economic value of a deposit is dependent on its grade and tonnage; and the relationship between the market price and the cost of exploration, mining and processing determine the economic value of a deposit
• identify the relationship between tonnage and grade of deposit and the economic value of an ore deposit

4. Ore deposits need to be evaluated before they can be mined. The exploration and evaluation of a named ore deposit
• outline the common exploration methods used to identify indicate the presence of one named ore deposit (including satellite imagery, aerial photograph interpretation, geophysics, and geochemistry and drilling)
• describe the exploration methods used to indicate the presence and infer the role of drilling in determining the size and grade of one named ore deposit
• analyse the process of determining the feasibility of mining a named deposit, referring to the stages involved in its development from a resource to a reserve
• explain how local, state and federal government policies may affect the decision to mine a deposit
• assess the impact of installing infrastructure or using that which already exists on determining the feasibility of mining a named deposit
• outline the methods and technologies used in the extraction, concentration and refining of ore from a named deposit

• gather information to describe the impact of improvements in technology on exploration techniques
• plan and perform first-hand investigations to test for the presence of ore minerals or metals using:
  - a geophysical method
  - a geochemical method
• plan and perform first-hand investigations and/or gather information from secondary sources to carry out a case study of a named mineral deposit and use available evidence to evaluate the methods employed in analysing the processes used to determine the feasibility of mining a deposit
• plan and perform first-hand investigations and/or gather information from secondary sources to carry out a case study of a named ore deposit in terms of the examine methods used to extract and refine the ore from a named deposit
5. Environmental issues need to be considered and addressed during the exploration, extraction and processing of the ore from the deposit.

- assess the likely environmental effects of exploration, mining and processing methods for the named deposit.
- evaluate the purpose of the Environmental Impact Statement for the named deposit in terms of protection of unique and endangered species, protection of sacred sites, community consultation and local habitat management.
- describe the methods used in the planned, and practised, rehabilitation of the named mine site.
- evaluate the relationship between mining methods and mine site rehabilitation for the named deposit.

- plan and perform first-hand investigations and/or gather information from secondary sources, or field studies, to carry out a case study of the named ore deposit and present information in terms of the environmental impact of the exploration, extraction and processing methods used for the named mine site.
- solve problems, analyse information to outline features of major domestic and international markets for Australian minerals.
- plan and perform first-hand investigations and/or process information from secondary sources to describe carry out a case study of the named ore deposit in terms of the rehabilitation practices employed at the named mine site.
- analyse information from secondary sources to identify sustainable development practices.
9.8 Option — Oceanography

Contextual Outline

The oceans represent an important part of the Earth’s environment and an understanding of the natural processes of oceans assists in identifying methods of monitoring and maintaining the environmental health of the oceans. The Earth is essentially a water planet: nearly 71% of its surface is covered by oceans. The raw materials that formed much of the oceans also produced the atmosphere and ultimately life.

The processes of sea floor spreading and subduction have been the mechanism for the movements of continental drift. Together, they control the production and distribution of oceans relative to land. As the resource needs of humans increase, we are increasingly exploiting the resources of the oceans but these resources are limited. This exploitation creates a critical problem, so understanding of the physical and chemical processes occurring within ocean basins and the dependence and interrelationships of life forms on these processes is paramount.

This module increases the students understanding of the historical background, the nature and practice of, the applications and uses, the implications for society and the environment and the current issues, research and developments in Earth and Environmental Science.

Outcomes

The main course outcomes to which this module contributes are:

A student:

H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
H2 analyses the ways in which models, theories and laws in Earth and Environmental Science have been tested and validated
H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
H5 identifies possible future directions of Earth and Environmental Science research
H6 evaluates the use of the Earth’s resources
H7 discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments
H8 evaluates the impact of resources utilisation on the Australian environment
H9 justifies the appropriateness of a particular investigation plan
H10 evaluates ways in which accuracy and reliability could be improved in investigations
H11 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H12 assesses the validity of conclusions drawn from gathered data and information
H13 explains why an investigation is best undertaken individually or by a team
H14 justifies positive values about and attitudes towards the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science.
1. The oceans have evolved over the history of Earth

Students learn to:

- describe the modern oceans in terms of:
  - average temperature
  - mean depth
  - average salinity
  - average density
- identify the area of the Earth covered by oceans and explain how this influences conditions on the Earth’s surface
- identify the probable origins of the oceanic waters
- compare the evolution of the oceanic waters with the evolution of the atmosphere and explain how and why the two are linked

Students:

- process secondary information to estimate the age of oceanic waters
- process and present secondary information to produce a flow chart illustrating the movement of water, carbon and oxygen between the oceans and the atmosphere

2. The shape, distribution and age of the current oceans has been determined by plate tectonics

Students:

- identify recall the regions of the crust where new ocean basins are forming and where ocean floors are subducting
- outline the types of evidence used to date ocean floors
- assess the reliability of information used to estimate the age of ocean beds
- outline the reasons why the oldest sea floor present on the Earth today is generally less than 250 million years old
- identify the role of plate tectonics in maintaining the equilibrium between the area of sea floor and area of continental land present on the Earth
- discuss the reasons for, and impacts of, possible shifts in the equilibrium between the area of sea floor and the area of continental land
- describe evidence for the closing of former ocean basins in terms of the presence of deep marine sedimentary rocks in present-day continental mountain belts

Students:

- identify data sources, plan, choose equipment and perform a first-hand investigation to compare the solubility of common salts in water of different temperatures
- analyse information from the above investigation and from secondary sources to predict the difference in composition of hot and cold water in oceans in terms of salt concentrations
- perform a first-hand investigation to demonstrate the precipitation of salts from a cooling solution and solve problems to use this information to predict precipitation in naturally occurring bodies of water
- gather, process and analyse information and use available evidence to assess the impact of improved technological developments on understanding about the age of the sea floor
• identify the regions of the crust where new ocean basins are forming and where ocean floors are subducting
• outline the types of evidence used to date ocean floors
• assess the reliability of information used to estimate the age of ocean beds
3. There are differences in physical, chemical and biological environments within and between past and present-day oceans
   - outline the origin of salinity in the Earth’s seas and oceans
   - explain examples of common processes that change the salinity and temperature of oceans and small enclosed seas
   - relate the range of temperatures and salinities measured in selected areas of the Pacific Ocean to the distribution of specific species
   - discuss evidence that indicates that there are differences in the current and past distribution of oceans
   - identify possible resources from sites where oceans previously existed
   - describe the attenuation of light with depth of light-in oceanic waters, and the order in which the different wavelengths of light disappear with depth in oceans
   - discuss the implications of limited light for the distribution of marine plants in near-shore environments and photosynthetic plankton in the open oceans
   - process and analyse information that explains the origin of the water and salt in the world’s seas and oceans
   - process data from secondary sources to map and describe the range of temperatures and salinity levels in vertical and horizontal zones of the Pacific Ocean
   - plan and perform an investigation to simulate the effect of ocean depth on light penetration
   - identify data sources, plan, choose equipment and perform a first-hand investigation to compare the solubility of common salts in water of different temperatures
   - analyse information from the above investigation and from secondary sources to predict the difference in composition of hot and cold water in oceans in terms of salt concentrations
   - perform a first-hand investigation to demonstrate the precipitation of salts from a cooling solution and solve problems to use this information to predict precipitation in naturally occurring bodies of water

4. The mass motion of oceans influences terrestrial climates
   - describe the four types of mass motions of water:
     - surface currents
     - deep circulation
     - tides
     - tsunamis
   - and identify the energy source for each
   - explain how the oxygen supply on the ocean floor is renewed, making life there possible
   - gather and analyse information to identify the technology used to gather information about mass movements of ocean currents and discuss changes in ideas about oceans that have resulted from the use of this technology
5. The physical conditions at different depths in the oceans constitute different environments and can support different communities of organisms

- explain how long-lived materials, such as synthetic chemicals and heavy metals, that enter the sea in one place can be found thousands of kilometres away
- discuss the implications of the movement of materials by ocean currents for the use of the oceans for waste disposal, including:
  - pollution
  - ocean sewage outlets
- present information that identifies structures found in deep-sea organisms that are inferred adaptations to environmental conditions
- perform an investigation to simulate the role of varying concentrations of salinity on the rate of decomposition on a range of consumer products
- process information solve problems to explain why laws about the ocean are becoming increasingly important in the world society

- describe what is meant by a ‘community of organisms’
- review the range of abiotic characteristics of an environment that determines the nature of a community within that environment
- describe and compare examples of food chains that occur in the top layers of the oceans and those found at great depth, explaining the differences
- explain, using examples, why organisms living on the ocean floor will be different from organisms living in the top thirty metres of the ocean
- explain how increased understanding of ocean currents and sea floor topography can change the utilisation of ocean resources by society
- gather, process and present information from secondary sources to summarise the differences in abiotic characteristics with increasing depth in a named area of the Pacific Ocean
- process and analyse information on life forms at different depths in the oceans to compare the deep ocean environment and its organisms to that in the top thirty metres of ocean
- gather and process information and use available evidence to assess the range of resources provided by the ocean, including:
  - fishing and food
  - marine aquaculture
  - minerals from seawater
  - specific chemicals: sulfur, manganese and heavy metals
  - power
6. **Hydrothermal vents support unusual communities**

- describe the way in which seawater is heated by circulation within newly formed ocean crust
- relate the heating of the water to the cooling of the newly formed crust
- explain the ability of hydrothermal waters (brines) to scavenge elements from rocks
- outline and describe the products and process of hydrothermal fluid discharge from deep-sea vents
- describe examples of the unique bacteria and invertebrate species that live around hydrothermal vents
- solve problems, plan and perform an investigation to demonstrate the effect of surface area to volume ratio of solids on their cooling rate in water
- perform an investigation to assess the relationship between the rate of hatching of brine shrimp to salt water concentration and temperature
- gather, process and present information from secondary sources that describes the processes and characteristics of hydrothermal vents and their unique biotic communities

7. **The type of sediment that accumulates on the floor of the deep oceans varies according to water depth, supply of nutrients to surface waters, and distance to land masses**

- outline the origin, characteristics and the distribution of different deep-sea sediments in the Pacific Ocean Basin, including calcareous oozes; siliceous oozes; deep-sea clays; manganese nodules; glacial marine sediments; and continental margin sediments
- discuss the different circumstances required for the deposition of different deep-sea sediments in the Pacific Ocean Basin
- perform an investigation using primary materials or gather data from secondary sources to distinguish the textual and compositional differences between calcareous oozes; siliceous oozes; deep-sea clays; manganese nodules; glacial marine sediments; and continental margin sediments
8. Oceanographers have a range of technology available to assist the collection of data about the oceans.

- identify two of the following technologies used by oceanographers, and for each one, describe how they work and the evidence they provide:
  - echo sounders
  - dredges, grabs and core samplers
  - fish and plankton nets
  - bathythermographs
  - magnetometers
  - research submarines and deep-ocean drill-ships

- outline the range of data that can be collected by echo sounders and describe the principles involved in the collection of data
- describe the processes involved in the collection of sea-floor samples by dredges and grab and core samplers
- assess the use of biological nets for gathering plankton and other organisms and relate this assessment to the need for continuous data on food chains in the oceans
- identify the information obtained by nansen bottles with electronic sensors
- identify the role of bathythermographs in terms of continuous surface temperature measurements
- identify the use of magnetometers for measuring magnetic intensity and the polarity of ocean floor sediments and rocks
- describe the use of research submarines and deep-ocean drill-ships in collecting information about the oceans

- gather and process information to identify the range of technologies used to collect information about the oceans and outline the type of data collected by each technology, evaluating its use in increasing knowledge and understanding about the ocean.
- evaluate the role of each of the oceanographic technologies studied in increasing knowledge and understanding about the oceans.
and identify one example of
the importance of using such
research
10 Course Requirements

For the Preliminary course:

• 120 indicative hours are required to complete the course
• the content in each module must be addressed over the course
• experiences over the course must cover the scope of each skill as described in Section 8.1
• practical experiences should occupy a minimum of 45 indicative hours of course –time
• at least one open-ended investigation, integrating the skills and knowledge and understanding outcomes, is required.

For the HSC course:

• the Preliminary course is a prerequisite
• the content in each module of the core and one option elective must be addressed over the course
• experiences over the course must cover the scope of each skill as described in Section 9.1
• 120 indicative hours are required to complete the course
• practical experiences should occupy a minimum of 35 indicative hours of course –time
• at least one open-ended investigation integrating the skills and knowledge and understanding outcomes, is required.
11 Post-school Opportunities

The study of Earth and Environmental Science Stage 6 provides students with knowledge, understanding and skills that form a valuable foundation for a range of courses at university and other tertiary institutions.

In addition, the study of Earth and Environmental Science Stage 6 assists students to prepare for employment and full and active participation as citizens. In particular, there are opportunities for students to gain recognition in vocational education and training. Teachers and students should be aware of these opportunities.

Recognition of Student Achievement in Vocational Education and Training (VET)

Wherever appropriate, the skills and knowledge acquired by students in their study of HSC courses should be recognised by industry and training organisations. Recognition of student achievement means that students who have satisfactorily completed HSC courses will not be required to repeat their learning in courses in TAFE NSW or other Registered Training Organisations (RTOs).

Registered Training Organisations, such as TAFE NSW, provide industry training and issue qualifications within the Australian Qualifications Framework (AQF).

The degree of recognition available to students in each subject is based on the similarity of outcomes between HSC courses and industry training packages endorsed within the AQF. Training packages are documents that link an industry’s competency standards to AQF qualifications. More information about industry training packages can be found on the National Training Information Service (NTIS) website (www.ntis.gov.au).

Recognition by TAFE NSW

TAFE NSW conducts courses in a wide range of industry areas, as outlined each year in the TAFE NSW Handbook. Under current arrangements, the recognition available to students of Earth and Environmental Science in relevant courses conducted by TAFE is described in the HSC/TAFE Credit Transfer Guide. This guide is produced by the Board of Studies and TAFE NSW and is distributed annually to all schools and colleges. Teachers should refer to this guide and be aware of the recognition available to their students through the study of Earth and Environmental Science Stage 6. This information can be found on the TAFE NSW website (www.tafensw.edu.au/mchoice). This information can be found on the HSC / TAFE Credit Transfer website (www.det.nsw.edu.au/hsctafe).

Recognition by other Registered Training Organisations

Students may also negotiate recognition into a training package qualification with another RTO. Each student will need to provide the RTO with evidence of satisfactory achievement in Earth and Environmental Science Stage 6 so that the degree of recognition available can be determined.
12 Assessment and Reporting

12.1 Requirements and Advice

The information in this section of the syllabus relates to the Board of Studies’ requirements for assessing and reporting achievement in the Preliminary and HSC courses for the Higher School Certificate.

Assessment is the process of gathering information and making judgements about student achievement for a variety of purposes.

In the Preliminary and HSC courses those purposes include:

• assisting student learning
• evaluating and improving teaching and learning programs
• providing evidence of satisfactory achievement and completion in the Preliminary course
• providing the Higher School Certificate results.

Reporting refers to the Higher School Certificate documents received by students that are used by the Board to report both the internal and external measures of achievement.

NSW Higher School Certificate results will be based on:

• an assessment mark submitted by the school and produced in accordance with the Board’s requirements for the internal assessment program
• an examination mark derived from the HSC external examinations.

Results will be reported using a course report containing a performance scale with bands describing standards of achievement in the course.

The use of both internal assessment and external examinations of student achievement allows measures and observations to be made at several points and in different ways throughout the HSC course. Taken together, the external examinations and internal assessment marks provide a valid and reliable assessment of the achievement of the knowledge, understanding and skills described for each course.
The Board of Studies will adopt a standards-referenced approach to assessing and reporting student achievement in the Higher School Certificate examination.

The standards in the HSC are:
• the knowledge, skills and understanding expected to be learned by students – the syllabus standards
• the levels of achievement of the knowledge, skills and understanding – the performance standards.

Both syllabus standards and performance standards are based on the aims, objectives, outcomes and content of a course. Together they specify what is to be learnt and how well it is to be achieved.

Teacher understanding of standards comes from the set of aims, objectives, outcomes and content in each syllabus together with:
– the performance descriptions that summarise the different levels of performance of the course outcomes
– HSC examination papers and marking guidelines
– samples of students’ achievement on assessment and examination tasks.

12.2 Internal Assessment

The internal assessment mark submitted by the school will provide a summation of each student’s achievements measured at points throughout the course. It should reflect the rank order of students and relative differences between students’ achievements.

Internal assessment provides a measure of a student’s achievement based on a wider range of syllabus content and outcomes than may be covered by the external examination alone.

The assessment components, weightings and task requirements to be applied to internal assessment are identified on page 87. They ensure a common focus for internal assessment in the course across schools, while allowing for flexibility in the design of tasks. A variety of tasks should be used to give students the opportunity to demonstrate outcomes in different ways and to improve the validity and reliability of the assessment.

12.3 External Examination

In Earth and Environmental Science Stage 6 the external examinations include written papers for external marking. The specifications for the examination in Earth and Environmental Science Stage 6 are on page 88.

The external examination provides a measure of student achievement in a range of syllabus outcomes that can be reliably measured in an examination setting.

The external examination and its marking and reporting will relate to syllabus standards by:
• providing clear links to syllabus outcomes
• enabling students to demonstrate the levels of achievement outlined in the course performance scale
• applying marking guidelines based on established criteria.
12.4 Board Requirements for the Internal Assessment Mark in
Board Developed Courses

For each course, the Board requires schools to submit an assessment mark for each candidate.

The collection of information for the HSC internal assessment mark must not begin prior to the
completion of the preliminary course.

The Board requires that the assessment tasks used to determine the internal assessment mark must
comply with the components, weightings and types of tasks specified in the table on page 87.

Schools are required to develop an internal assessment program that:

• specifies the various assessment tasks and the weightings allocated to each task
• provides a schedule of the tasks designed for the whole course.

The school must also develop and implement procedures to:

• inform students in writing of the assessment requirements for each course before the
  commencement of the HSC course
• ensure that students are given adequate written notice of the nature and timing of assessment
  tasks
• provide meaningful feedback on each student’s performance in all assessment tasks
• maintain records of marks awarded to each student for all assessment tasks
• address issues relating to illness, misadventure and malpractice in assessment tasks
• address issues relating to late submission and non-completion of assessment tasks
• advise students in writing if they are not meeting the assessment requirements in a course and
  indicate what is necessary to enable the students to satisfy the requirements
• inform students about their entitlements to school reviews and appeals to the Board
• conduct school reviews of assessments when requested by students
• ensure that students are aware that they can collect their Rank Order Advice at the end of the
  external examinations at their school.
12.5 Assessment Components, Weightings and Tasks

The school assessment advice and the external examination specifications for the Stage 6 science courses are currently under review. The content of this section of the syllabus applies for 2003 only. Any modifications to this section will be distributed in mid-2003.

Preliminary Course

The suggested components, weightings and tasks for the Preliminary course are set out below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Weighting</th>
<th>Tasks could include</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet Earth and Its Environment</td>
<td>25</td>
<td>Assignments, Fieldwork studies and reports</td>
</tr>
<tr>
<td>The Local Environment</td>
<td>25</td>
<td>Model making, Open-ended investigations, Oral reports</td>
</tr>
<tr>
<td>Water Issues</td>
<td>25</td>
<td>Practical tests, Research projects, Reports, Topic tests</td>
</tr>
<tr>
<td>Dynamic Earth</td>
<td>25</td>
<td>and examinations</td>
</tr>
</tbody>
</table>

Note:
Tasks to assess students’ abilities to conduct first-hand investigations and communicate information and understanding based on these investigations should be included.

Marks 100

There should be a balance between the assessment of:

• knowledge and understanding outcomes, and course content
  and
• skills outcomes and course content.
## HSC Course

The internal assessment mark for Earth and Environmental Science Stage 6 is to be based on the HSC Course only. Final assessment should be based on a range and balance of assessment instruments.

<table>
<thead>
<tr>
<th>Component</th>
<th>Weighting</th>
<th>Tasks could include</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tectonic Impacts</td>
<td>25</td>
<td>Assignments, Fieldwork studies and reports</td>
</tr>
<tr>
<td>Environments through Time</td>
<td>25</td>
<td>Model making, Open-ended investigations, Oral reports</td>
</tr>
<tr>
<td>Caring for the Country</td>
<td>25</td>
<td>Practical tests, Reports, Research projects, Topic tests and examinations</td>
</tr>
<tr>
<td>Option Module</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- no more than 50% weighting may be allocated to examinations and topic test tasks
- a minimum of 30% weighting must be allocated to tasks that assess students’ abilities to conduct first-hand investigations and communicate information and understanding based on these investigations

**Marks** 100

There should be a balance between the assessment of:
- knowledge and understanding outcomes, and course content
- skills outcomes and content.

One task may be used to assess several components. It is suggested that 3–5 tasks are sufficient to assess the HSC course outcomes.
12.6 HSC External Examination Specifications

The school assessment advice and the external examination specifications for the Stage 6 science courses are currently under review. The content of this section of the syllabus applies for 2003 only. Any modifications to this section will be distributed in mid-2003.

The written examination in Earth and Environmental Science will consist of one examination paper of 3 hours duration (plus 5 minutes reading time). The examination paper will consist of TWO sections:

Section I – Core  
(75 marks)

Part A  
(15 marks)

There will be FIFTEEN multiple-choice questions.  
All questions will be compulsory.  
All questions will be of equal value.  
Questions will be based on the HSC core modules.

Part B  
(60 marks)

Short-answer and extended response question/s.  
Marks for individual questions will be shown on the examination paper.  
All questions will be compulsory.  
Questions will be based on the HSC core modules.

Section II – Option  
(25 marks)

There will be FOUR questions: one on each of the FOUR HSC options. Each question may consist of several parts.  
Marks for individual parts will be shown on the examination paper.  
Candidates must attempt ONE question.  
All questions will be of equal value.

HSC Options List
Introduced Species and the Australian Environment  
Organic Geology – A Non-Renewable Resource  
Mining and the Australian Environment  
Oceanography
### 12.7 Summary of Internal and External Assessment

The school assessment advice and the external examination specifications for the Stage 6 science courses are currently under review. The content of this section of the syllabus applies for 2003 only. Any modifications to this section will be distributed in mid-2003.

<table>
<thead>
<tr>
<th>Internal Assessment</th>
<th>Weighting</th>
<th>External Assessment</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Modules</td>
<td>75</td>
<td>A written examination paper consisting of:</td>
<td>75</td>
</tr>
<tr>
<td>Option</td>
<td>25</td>
<td>Core Modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Multiple-choice questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Short-answer questions</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Extended response</td>
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<tr>
<td></td>
<td></td>
<td>longer answer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>longer answer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>question/s</td>
<td></td>
</tr>
<tr>
<td>Note: assessment of knowledge, understanding, and skills developed through conducting first-hand investigations should be incorporated into the core and option as appropriate.</td>
<td></td>
<td>Option</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Short-answer questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extended response</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>longer answer</td>
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<td>longer answer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>question/s</td>
<td></td>
</tr>
<tr>
<td>Marks</td>
<td>100</td>
<td>Marks</td>
<td>100</td>
</tr>
</tbody>
</table>
12.8 Reporting Student Performance against Standards

Student performance in an HSC course will be reported against standards on a course report. The course report contains a performance scale for the course describing levels (bands) of achievement, an HSC examination mark and the internal assessment mark. It will also show, graphically, the statewide distribution of examination marks of all students in the course.

Each band on the performance scale (except for band 1) includes descriptions that summarise the attainments typically demonstrated in that band.

The distribution of marks will be determined by students’ performances against the known standards and not scaled to a predetermined pattern of marks.
## Appendix 1

The following information clarifies terminology used in the syllabus

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Archaea</strong></td>
<td>Microscopic, single-celled organisms that have no membrane-bound organelles within their cells. They differ from both eukaryotes and bacteria in that their membrane lipids are ether-linked not ester-linked and in that they are capable of methanogenesis. Although many books and articles still refer to them as &quot;Archaeabacteria&quot;, that term has been abandoned because they aren't bacteria.</td>
</tr>
<tr>
<td><strong>chemosynthesis</strong></td>
<td>A process in which carbohydrates are manufactured from carbon dioxide and water using chemical compounds as the energy source, rather than the sunlight used in photosynthesis. Certain groups of bacteria, referred to as chemosynthetic autotrophs, are fuelled not by the sun but by the oxidation of simple inorganic chemicals, such as sulfates or ammonia.</td>
</tr>
<tr>
<td><strong>cryosphere</strong></td>
<td>One of the interrelated components of the Earth's system. It is composed of frozen water in the form of snow, permanently frozen ground (permafrost), floating ice, and glaciers. Fluctuations in the volume of the cryosphere cause changes in ocean sea-level, which directly impact the atmosphere and biosphere.</td>
</tr>
<tr>
<td><strong>Gondwana</strong></td>
<td>Between 200 and 300 million years ago the supercontinent, Pangaea split into two with the southern half being the land mass we now call Gondwana. It eventually split to form the continents we now call Australia, South America, India, Antarctica and Africa. The name Gondwana derives from a major tribal group living in a region of India. It means, &quot;land of the Gonds&quot;. It is synonymous with Gondwanaland.</td>
</tr>
<tr>
<td><strong>photolysis</strong></td>
<td>The initiation of a chemical reaction by the absorption of electromagnetic radiation which normally results in the breaking of a chemical bond. It will normally give different products from the corresponding heat-initiated reaction.</td>
</tr>
<tr>
<td><strong>Tectonic supercycle</strong></td>
<td>This is also called the supercontinent cycle; several times in the Earth’s history, the continents have joined to form one body that later broke apart. The process seems to be cyclic; it modifies shape geology and climate and thereby influences biological evolution.</td>
</tr>
</tbody>
</table>