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NEW SOUTH WALES

Earth and Environmental Science

Stage 6

Syllabus

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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 the 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.

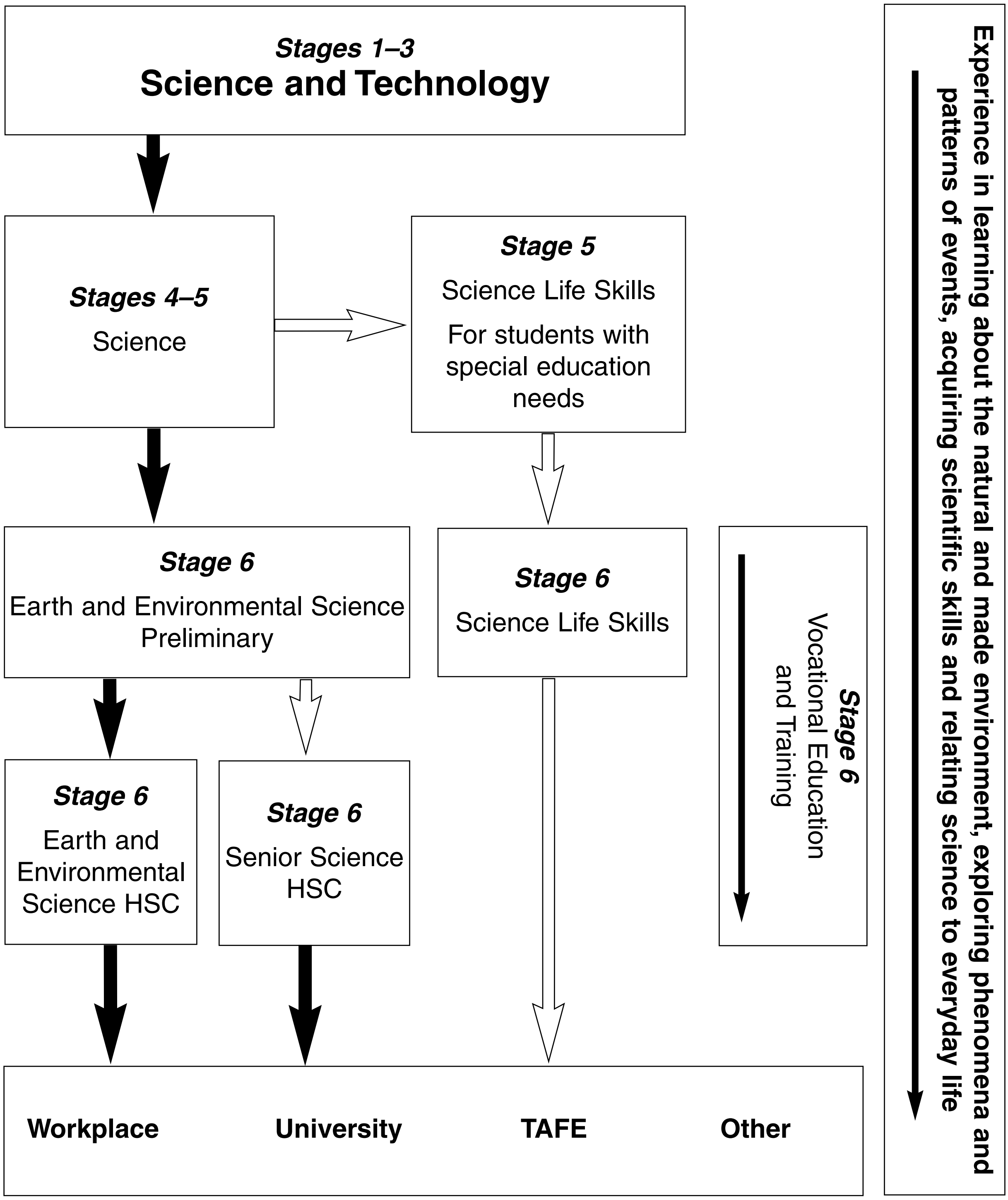
The common factor in all of the environmental hazards that humanity faces is that they are derived from peoples' lack of awareness that society is part of an environment that is composed of the interactions of the sub-systems: water, land, air, ice and living things. The history and philosophy of science 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.

3 Continuum of Learning for Earth and Environmental Science Stage 6 Students



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* (NSW), 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.

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* 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

	Objectives	Preliminary Course Outcomes	HSC Course Outcomes
PRESCRIBED FOCUS AREAS	Students will develop knowledge and understanding of:	A student:	A student:
	1 the history of Earth and Environmental Science	P1 outlines the historical development of major Earth and Environmental Science principles, concepts and ideas	H1 evaluates how major advances in scientific understanding or technology have changed the direction or nature of scientific thinking
	2 the nature and practice of Earth and Environmental Science	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	H2 analyses the ways in which models, theories and laws in Earth and Environmental Science have been tested and validated
	3 applications and uses of Earth and Environmental Science	P3 assesses the impact of particular technological advances on understanding in Earth and Environmental Science	H3 assesses the impact of particular advances in Earth and Environmental Science on the development of technologies
	4 implications for society and the environment	P4 describes applications of Earth and Environmental Science which affect society or the environment	H4 assesses the impact of applications of Earth and Environmental Science on society and the environment
	5 current issues, research and developments	P5 describes the scientific principles employed in particular areas of Earth and Environmental Science research	H5 identifies possible future directions of Earth and Environmental Science research
DOMAIN: KNOWLEDGE AND UNDERSTANDING	6 the resources of Earth	P6 identifies the origins of Earth's resources	H6 evaluates the use of the Earth's resources
	7 the abiotic features of the environment	P7 identifies and describes the physical and chemical features of the environment	H7 discusses geological, biological, physical and chemical evidence of the evolving Australian and world environments
	8 models to explain structures and processes of change	P8 discusses the interplay between the internal and external forces which constantly reshape the Earth's surface	H8 describes models which can be used to explain changing environmental conditions during the evolution of Australia and other continents
	9 Australian resources	P9 describes and locates available resources in Australian environments	H9 evaluates the impact of resources utilisation on the Australian environment
	10 biotic impacts on the environment	P10 describes human impact on the local environment	H10 assesses the effects of current pressures on the Australian environment

	Students will develop knowledge and understanding of:	A student:	A student:
DOMAIN: SKILLS	11 planning investigations	P11 identifies and implements improvements to investigation plans	H11 justifies the appropriateness of a particular investigation plan
	12 conducting investigations	P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources	H12 evaluates ways in which accuracy and reliability could be improved in investigations
	13 communicating information and understanding	P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science	H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding
	14 developing scientific thinking and problem-solving skills	P14 draws valid conclusions from gathered data and information	H14 assesses the validity of conclusions drawn from gathered data and information
	15 working individually and in teams	P15 implements strategies to work effectively as an individual or as a member of a team	H15 explains why an investigation is best undertaken individually or by a team
DOMAIN: VALUES AND ATTITUDES	Students will develop positive attitudes towards, and values about	A student:	A student:
	16. themselves, others, learning as a lifelong process, Earth and Environmental Science and the environment	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	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

7.2 Key Competencies

Earth and Environmental Science provides a powerful context within which to develop general competencies considered essential for the acquisition of effective, higher-order thinking skills necessary for further education, work and everyday life.

Key competencies are embedded in the Earth and Environmental Science syllabus to enhance student learning and are explicit in the objectives and outcomes of the syllabus. The key competencies of ***collecting, analysing and organising information*** and ***communicating ideas and information*** reflect core processes of scientific inquiry, and the skills identified in the syllabus assist students to continue to develop their expertise in these areas.

Students work as individuals and as members of groups to conduct investigations and, through this, the key competencies ***planning and organising activities*** and ***working with others and in teams*** are developed. During investigations, students use appropriate information technologies and so develop the key competency of ***using technology***. The exploration of issues and investigations of problems contribute towards students' development of the key competency ***solving problems***.

When students analyse statistical evidence, apply mathematical concepts to assist analysis of data and information and construct tables and graphs, they are developing the key competency ***using mathematical ideas and techniques***.

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.

Preliminary Course Outcomes	**Content**
A student:	Students:
P11 identifies and implements improvements to investigation plans	11.1 **identify data sources to**: a) analyse complex problems to determine appropriate ways in which each aspect may be researched 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 c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis 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

	c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations d) recognising the difference between destructive and non-destructive testing of material and analysing potentially different results of these two procedures
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

P13 identifies appropriate terminology and reporting styles to communicate information and understanding in Earth and Environmental Science	13.1 **present information by**: a) selecting and using appropriate text types or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate methods to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information
P14 draws valid conclusions from gathered data and information	14.1 **analyse information to**: a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles 14.2 **solve problems by**: a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those which could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem 14.3 **use available evidence to**: a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships

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 x 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 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.

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

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:	Students:
1. The solar system has evolved from a ball of gases released from a supernova explosion	• recall current scientific thinking about the origin of the universe • compare two hypotheses developed to explain the existence of matter in the universe, and describe the process of accretion of such matter to form stars and planets • recall 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	• 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 • 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 atmosphere and compare it with the composition of the present atmosphere	• gather, process and present 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 • 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 about the earth's earliest atmosphere and compare it with the present atmosphere
3. Living cells originated at a time when the atmosphere and environments were different to those presently found on Earth	• summarise the experiments of Urey and Miller and consider the importance of their findings to our understanding of how amino acids may have originated on Earth	• 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
	• outline the evidence that indicates how the first cellular organisms (archaeobacteria) may have developed and describe their mode of respiration (anaerobic fermentation)	• plan, choose equipment or resources and perform a first-hand investigation to demonstrate fermentation of sugar by yeast and use the appropriate chemical test to identify the produced gas as carbon dioxide
	• explain how the existence of archaeobacteria near fumaroles and submarine vents can be used to support ideas on early development of life	• gather and process second-hand information about both ancient archaeobacteria and present day archaeobacteria 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 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	• explain the links between the concentration of atmospheric carbon dioxide and average global temperature over geological time • outline the evidence from marine and lake sediments, ice cores and sea level changes that suggest global temperatures have gradually decreased over the last sixty million years and have fluctuated by 5°–10°C over the past two 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 geological 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.

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

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.

	Students learn to:	Students:
1. Rocks are formed from different materials	• 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 landscape	• perform a first-hand investigation 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
2. The properties of local soils affect the local biological environment	• 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	• 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	• 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
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 (eg environmental impact study, catchment management plan)	• 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	• 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	• 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 information from secondary sources, including the Register of the National Estate (ERIN) or other databases to identify significant 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. Liquid water can only be found on a planet of the right mass and chemical composition and the right distance from a neighbouring star.

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. 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.

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.

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.

	Students learn to:	Students:
1. Interacting sub-systems of the Earth that together produce a unique biome	• 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 • identify the interrelationship between sea levels, ocean currents, global temperatures and ice deposits	• 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 environments	• recall differences between biotic and abiotic features of the local environment • 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	• choose equipment and perform first-hand investigations to gather first-hand 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 first-hand 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	• identify data, plan and perform an investigation to demonstrate 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
4. The 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 • examine efficiency of water usage 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	• 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 • 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 — 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, showing that tectonic forces ripped through the young continent in the past.

Tectonic forces not only produce the mountain ranges and volcanic activity that contribute to global climate patterns, but also the earthquakes, which shape and shake the Earth. The consequent disruptions alter the environmental conditions that govern the distribution of plant and animal life forms. 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. Because landforms contribute to the production of varying sets of environmental conditions, natural disasters, mountain ranges, resources and climatic changes, the geological history of the Australian continent also allows for inferences to be made about the changing environmental conditions.

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.

	Students learn to:	Students:
1. Evidence that the Australian continental land mass began developing 4.1 thousand million years ago	• recall an appropriate model that has been developed to describe atomic structure • outline the 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)	• 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

- recall evidence that crustal plates move over time
- recall the relationship between movements of Earth's plates and convection currents in the asthenosphere, and to gravitational forces
- 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. The interaction of plates during subduction, collision and breakup	• recall how earthquakes, volcanic activity and new landforms result from the interactions at plate boundaries • 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 with data collected from earthquakes • 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	• 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 • 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

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.

HSC Course Outcomes	**Content**
A student:	Students:
H11 justifies the appropriateness of a particular investigation plan	11.1 **identify data sources to**: a) analyse complex problems to determine appropriate ways in which each aspect may be researched 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 c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis 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 or 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 c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations

	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	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 minimises 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

H13 uses terminology and reporting styles appropriately and successfully to communicate information and understanding	13.1 **present information by**: a) selecting and using appropriate text types or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate methods to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information
H14 assesses the validity of conclusions drawn from gathered data and information	14.1 **analyse information to**: a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles 14.2 **solve problems by**: a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those that could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem 14.3 **use available evidence to**: a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships

9.2 Tectonic Impacts

Contextual Outline

Throughout the history of the Earth, the movement of plates has resulted in continual global environmental change. The impact of plate tectonics can be considered on two levels.

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. 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.

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
- 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

	Students learn to:	Students:
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 current hypotheses used to explain plate motion	• gather and analyse information from secondary sources to compare and assess models of plate motion • identify data sources, gather, process and analyse data from secondary sources and use available evidence to predict the importance of plate tectonics in producing environments
2. The movement of plates results in mountain building	• describe mountains formed at: – ocean/ocean boundaries – ocean/continent boundaries – continent/continent boundaries in terms of general rock types and structures, including folding and/or faulting	• 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 collision
3. Continents evolve as plate boundaries move and change	• outline how the Australian continent has grown over geological time as a result of plate tectonic processes • summarise the plate tectonic super-cycle	• 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 describes 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 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

- 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 involved
  – its distance from the area of disaster
  – predictions on the likely recurrence of the tectonic movement
  – 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 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.

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 resources 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

	Students learn to:	Students:
1. Evidence from early Earth indicates the first life forms survived in changing habitats during the Archean and Proterozoic eons	• identify that 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 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 3.8×10^9 - year-old rocks • compare and contrast the nature of the first fossil stromatolites and their similarity and relationships to modern examples	• 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 first-hand information or information from secondary sources to describe the structure of fossil 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 fossil stromatolites
2. The environment of the Phanerozoic eon	• 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	• 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 • distinguish between relative and absolute dating • discuss the relevance of hard shells, preservable armour and skeletons in explaining the apparent possible 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	• recall the theory of evolution by natural selection • recall evidence that present-day organisms have developed from different organisms in the distant past • summarise environmental pressures faced when living things evolved for terrestrial environments • outline the major steps in the expansion to the terrestrial environments by land plants, the first land insects, lungfish and amphibians • identify advantages enjoyed by the first land-dwellers	• gather and analyse information from secondary sources of a developed geological time scale 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, insects, amphibians, reptiles and mammals and compare their anatomical characteristics with the nearest modern organisms from the same groups • 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

		• gather information from secondary sources to compare the diversity and numbers of organisms from a fossil site
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 • analyse smaller extinction events involving several large species, 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 the variety of hypotheses proposed for the end-Permian mass extinction with the popular bolide impact theory for the end-Cretaceous event • compare and contrast the scale and time frame of current rates of extinction of species within Australia with those that have occurred in geological time	• 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.

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.

	Students learn to:	Students:
1. Australia's land surfaces have undergone continuous weathering and erosion at rates that are very slow in comparison to worldwide averages	• describe the low fertility of Australian soils in terms of: – slow rate of soil formation – long period of depletion of nutrient ions – stability of Australian continent in terms of low relief	• gather, process and present information 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	• 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 three causes of soil erosion	• plan and perform first-hand 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	• identify regions of Australia with naturally saline land • 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	• 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 a case study of a successful rehabilitation program, 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	• 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
5. Maintenance of environmental flows and natural processes in water	• assess management strategies and technologies that can be used to assist in the maintenance of natural processes in surface water, including: – drip versus overhead irrigation – licensing irrigation/bore water users – stormwater treatment technologies – provision of environmental 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	• identify data sources, plan, choose equipment, and perform a first-hand investigation to measure and analyse emissions from vehicle exhausts OR • gather and analyse information from secondary sources on the composition of emissions from vehicle exhausts

	• analyse implications of national and international strategies related to maintaining and protecting the atmosphere and the hydrosphere	• analyse, process and present 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 each gas
7. The depletion of the ozone layer	• 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 information from secondary sources to identify and discuss the future impact of the Montreal Protocol and recent agreements in Kyoto • 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

8. 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 mine-site rehabilitation and current methods of rehabilitating mined areas	• plan, choose equipment and perform first-hand investigations to construct and test laboratory simulations of waste treatment processes, such as filtration, sedimentation, 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 by developing (an) appropriate simulation(s) • 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.

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.

	Students learn to:	Students:
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 species to identify: – plants or animals – food requirements – areas of invasion – aquatic or terrestrial – 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	• 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
2. An analysis of introduced species indicates they may impact on either the biological and/or the abiotic aspects of the environment	• identify the biological and physical aspects of an environment • explain why the physical aspects of Australian environments are so vulnerable to some introduced species	• perform a first-hand investigation by visiting a local environment, to identify and distinguish between biological and physical aspects of the environment that 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	• gather, process and analyse information from secondary sources and use available evidence to identify the features of the named introduced plants and animals.
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 • examine and critically analyse the environmental impacts of the named plants and animals	• analyse information from first-hand and/or secondary sources and use available evidence to assess the environmental impacts of 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

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 imports 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 about the main principles of the 'Bradley 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 • use the example of accidental introduction of new species through off-loading of ballast water • assess the effectiveness of procedures in place to prevent the spread of new species	• gather, process and present information to summarise the 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.

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.

	Students learn to:	Students:
1. The properties of economically important Earth materials formed from organic material	• 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	• 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 resources commonly used and compare their properties and uses • process information from secondary sources to identify the properties and classify fossil fuels according to their composition
2. The environment, and process of coal and petroleum formation	• outline the characteristics of coal-forming environments • discuss the process of coalification — transferring 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	• 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 and 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 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 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 — and evaluate the relative importance 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 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.

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.

	Students learn to:	Students:
1. There is a range of conditions under which mining an ore deposit becomes economically viable	• 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 • distinguish between waste rock and ores in rock • distinguish between ore minerals 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 • identify the relationship between tonnage and grade of deposit and the economic value of an ore deposit	• 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 • perform an investigation to distinguish between waste rock and ore, and ore minerals and gangue minerals • identify data sources, plan, select resources, gather, process and analyse secondary information on the conditions under which mining is economically viable, using a common named ore deposit as an example
2. The relationship between minerals and geological formations indicates where to search for the ore and the appropriate technology that could be used	• identify the main 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 • evaluate theories concerning mineral genesis related to sedimentary and tectonic processes, responsible for the two minerals 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	• solve problems, identify data sources, gather and analyse information from secondary sources to identify the locations and geological structures associated with the chosen mineral provinces • gather information and use available evidence to assess the impact of improvements in technology on exploration techniques

3. The laws related to mining leases, rights of the land-holder and the role of governments in granting leases	• discuss the implications of one landmark decision on mining operations in Australia such as Wave Hill, Mabo, or Wik • outline the effect of at least one local, state and federal government policy on mining operations in the context of sustainability	• gather information from secondary sources to predict the effect of one landmark decision on the exploitation of the named deposit
4. Ore deposits need to be evaluated before they can be mined	• describe the exploration methods used to indicate the presence and infer 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 • 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	• 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 determining the feasibility of mining the 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 methods used to extract and refine the ore

5. Environmental issues need to be considered and addressed during the exploration, extraction and processing of the ore	• assess the likely environmental effects of exploration, mining and processing methods for a named deposit • evaluate the purpose of the Environmental Impact Statement for a 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 or practised rehabilitation of a named mine site • evaluate the relationship between mining methods and mine site rehabilitation for a named 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 and present information in terms of the environmental impact of the exploration, extraction and processing methods used • 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 carry out a case study of a named ore deposit in terms of the rehabilitation practices employed • 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 process of sea floor spreading has been the mechanism for continental drift. Together, they control the production and distribution of oceans relative to land. As the 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.

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
- H9 evaluates the impact of resources utilisation 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.

	Students learn to:	Students:
1. The oceans have evolved over the history of Earth	• 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	• 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	• 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 • 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	• 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

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 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
4. The mass motion of oceans influences terrestrial climates	• describe: – 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 possible • 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	• 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 • 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

	• 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	• solve problems to explain why laws about the ocean are becoming increasingly important in the world society
5. The physical conditions at different depths in the oceans constitute different environments and can support different communities of organisms	• 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 ooze sediments; siliceous ooze sediments; 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 secondary sources to distinguish the textual and compositional differences between calcareous ooze sediments; siliceous ooze sediments; 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	• 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 and identify one example of the importance of using such research	• 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

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 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).

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.

Standards Referencing and the HSC Examination

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

Preliminary Course

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

<table>
<tr><th>Component</th><th>Weighting</th><th>Tasks could include</th></tr>
<tr><td>Planet Earth and Its Environment</td><td>25</td><td rowspan="5">Assignments
Fieldwork studies and reports
Model making
Open-ended investigations
Oral reports
Practical tests
Research projects
Reports
Topic tests and examinations

Note:
Tasks to assess students' abilities to conduct first-hand investigations and communicate information and understanding based on these investigations should be included.</td></tr>
<tr><td>The Local Environment</td><td>25</td></tr>
<tr><td>Water Issues</td><td>25</td></tr>
<tr><td>Dynamic Earth</td><td>25</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Marks</td><td>100</td><td></td></tr>
</table>

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>
<tr><th>Component</th><th>Weighting</th><th>Tasks could include:</th></tr>
<tr><td>Tectonic Impacts</td><td>25</td><td rowspan="5">Assignments
Fieldwork studies and reports
Model making
Open-ended investigations
Oral reports
Practical tests
Reports
Research projects
Topic tests and examinations

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</td></tr>
<tr><td>Environments through Time</td><td>25</td></tr>
<tr><td>Caring for the Country</td><td>25</td></tr>
<tr><td>Option Module</td><td>25</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Marks</td><td>100</td><td></td></tr>
</table>

There should be a balance between the assessment of:

- knowledge and understanding outcomes, and course content

and

- 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 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

<table>
<tr><th>Internal Assessment</th><th>Weighting</th><th>External Assessment</th><th>Weighting</th></tr>
<tr><td>Core Modules

Option

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>75

25</td><td>A written examination paper consisting of:

Core Modules

• Multiple-choice questions
• Short-answer questions
• Longer answer question/s

Option

• Short-answer questions
• Longer answer question/s</td><td>75

25</td></tr>
<tr><td>Marks</td><td>100</td><td>Marks</td><td>100</td></tr>
</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.