Earth Science

Senior Syllabus

Q U E E N S L A N D
Board of Senior Secondary School Studies

This syllabus is approved for general implementation until 2006 unless otherwise stated.

ISBN 1 74038 0231

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TO BE USED FOR THE FIRST TIME WITH YEAR 11 STUDENTS IN 2001.

1 A VIEW OF SCIENCE AND SCIENCE EDUCATION

Science is a social and cultural activity through which explanations of natural phenomena are generated. It incorporates ways of thinking that are both creative and critical. Scientists have a deep conviction that the universe is understandable.

Explanations of natural phenomena may be viewed as mental constructions based on personal experiences. They result from a range of activities that may include observation, experimentation, imagination and discussion, and are achieved by considering the complexities of the universe at a level that can be understood. The evolution of scientific understandings has been episodic, with chance sometimes playing an important role.

Currently-accepted scientific concepts, theories and models may be viewed as shared understandings which the scientific community perceive as viable in light of the available evidence and arguments presented and that have a predictive value. New understandings are continually arising, and current understandings are subject to questioning by the scientific community and may be challenged and modified, or replaced. This is an essential characteristic of science.

Students construct personal explanations of phenomena they experience in everyday life. One role of science education is to help students move from their personal constructions, which are often discordant with scientific explanations, towards theories and models accepted by the scientific community. As students progress through their formal education, explanations of phenomena encountered by them increase in complexity as does the level of sophistication of their observations.

Science students are encouraged to appreciate the social and cultural perspectives of science. They also participate in activities that help them construct explanations and recognise the nature of scientific understandings.

Through science education students are encouraged to develop critical and creative thinking skills as well as scientific understandings. This will empower them to envisage alternative futures and make informed decisions about science and its applications. Such decisions will influence the well-being of themselves, other living things and their environment.

2 RATIONALE

An extraordinary revolution in our knowledge of planet Earth during the latter half of the twentieth century has transformed earth science. We have viewed our earth from space and landed on its moon, we have seen the ocean floor and mapped its shape and structure, and we have discovered how the crust under the oceans differs markedly from the crust under the continents. We have employed modern remote-sensing technologies to investigate the earth's interior, and we now know how earth's internal heat is related to volcanism, earthquakes, mountain building, and drifting and colliding continents.

The scientific revolution of plate tectonics in earth science, initiated by the visionary Wegener, parallels others in history: Copernicus and astronomy, Darwin and evolution, Einstein and relativity, Bohr and the atom. The recognition of the dynamic character of our earth has enhanced our inherent curiosity in earth science as a natural science. We have gained considerable insight into the origin of the sun and its family of planets. In parallel with these new understandings has been the recognition of the immense age of the earth and the great changes that have occurred both within it and on its surface.

A study of Earth Science at senior level enables students to participate in this revolutionary knowledge of our planet, its dynamic systems, and its evolution. The subject involves much more, however. Earth is a unique planet and its natural environments represent our greatest asset. They provide the locations for homes and the resources essential for life: the materials produced from rocks and minerals and fossil fuels, the soil in which food is grown, the water humans drink, and the air they breathe. The global community will be sustained only if benefits can continue to be derived from earth's environments without jeopardising the availability of the resources and the integrity of the natural systems. While a study of Earth Science fosters an understanding of planet Earth, its systems, and its geological processes, a syllabus with an *environmental* focus strongly enhances this curriculum by adding the scientific study of human interaction with earth's systems.

Since the environmental focus of senior Earth Science inherently incorporates human interaction with Earth's dynamic systems, it is particularly important to emphasise that this human element in no way diminishes the rigorous scientific approaches that the discipline demands. In undertaking investigations in the wide range of topics that are relevant to an environmental Earth Science subject, it is therefore essential that this work be carried out in a scientific manner. Furthermore, learning by students while they work scientifically in Earth Science will be most effective if it draws on, and further contributes to, the factual information they possess and their understanding of relevant concepts in the discipline.

A study of Earth Science with an environmental focus enriches students' lives by enabling them to understand, interpret, and appreciate the geological environment in which they live. The subject aims to equip students to be aware of how the impacts of natural hazards such as floods, cyclones, landslides, earthquakes, and beach erosion can be minimised. It allows them to appreciate, furthermore, that as humans interact with the environment, a knowledge of earth science is crucial in the planning of buildings, highways, dams, harbours, and canals.

All earth materials, including minerals, fossil fuels, soils, water, and building materials, are developed and managed by a knowledge of earth science. This science affects decisions from those as big as choosing a nuclear power site to those as small as selecting an aesthetic and functional rock material for a retaining wall. It is becoming increasingly urgent to solve environmental problems such as global warming, ozone holes, resource depletion and the disposal of hazardous wastes in a geologically responsible way. Humans must therefore look to the future to determine how science, in conjunction with ethics, economics, and politics, can contribute to solutions and promote ecologically sustainable development. The interdisciplinary scientific basis and environmental context of this subject are invaluable in assisting students to contribute to these debates and decisions as informed and responsible citizens.

3 GLOBAL AIMS

A study of a senior science should provide an opportunity for and assistance in the further development of students' abilities to access, process, evaluate and communicate information so that they might be culturally and scientifically informed and aware. It should recognise that students come from varied geographical, socioeconomic, and sociocultural backgrounds and language backgrounds other than English. Their backgrounds legitimately and significantly influence the nature of learning within the school context for themselves and others.

In accordance with this, a course in Earth Science provides opportunities that will further develop in students:

- an understanding of planet Earth, its systems and their geological processes, and human interaction with these systems
- a knowledge and understanding of the dynamic nature and natural hazards of earth's systems
- an appreciation of the methods that have enabled earth scientists to interpret the past, understand the present, and predict the future of the earth and its space environment
- an awareness of how the impacts of natural hazards such as floods, cyclones, landslides, earthquakes, and beach erosion can be minimised
- an understanding of environmental problems such as global warming, ozone holes, resource depletion, and of the need for hazardous waste disposal in a geologically responsible manner
- a capacity to identify, gather and process information in the context of earth science investigations, including those that are based in the field or laboratory
- language skills specific to English language and earth science, through explicit teaching of, and immersion in, the language of earth science
- an ability to contribute to debates and decisions on ecologically sustainable development as informed and responsible citizens.

The global aims are expressed via the general objectives and developed at the school level by the work program's objectives.

4 GENERAL OBJECTIVES

The general objectives have been specified in terms of the specific attitudes, knowledge, behaviours and skills that students should acquire during the course of study in the subject. They arise from the interaction of a view of science and science education, the global aims and the rationale. The exit criteria are derived from these general objectives (see section 8).

The four general objectives have been defined as:

- Attitudes and values
- Knowledge, conceptual understanding and application
- Working scientifically
- Using information scientifically.

4.1 Attitudes and values

The objective 'Attitudes and values' refers to the feelings and ways of thinking about questions and issues in the field of study. Through participation in the learning experiences of the subject students will develop their appreciation of the significant issues relating to earth science, and the interaction of human behaviour, the environment and the practices of science.

Although the affective objectives are not directly assessable for the awarding of exit levels of achievement, they are fundamental to all other objectives and are essential to the development of learning experiences and to student achievement in the subject.

Objective	Learning outcomes
To develop positive attitudes and values …	…concerning personal behaviour in terms of cooperation in group tasks and tolerance of individual differences and cultural diversity within the social and geological environments. …concerning the practices of science in terms of being open-minded and critically respectful of data, being sceptical and willing to shift in the face of evidence, and being systematic and persistent in pursuit of understanding. …concerning the strengths and limitations of science in terms of its wise application and ethical use in the environment. …

4.2 Knowledge, conceptual understanding and application

The objective 'Knowledge, conceptual understanding and application' should be achieved across a range of simple-to-complex subject matter. The objective refers to the recall and the ability to explain previously learned factual material, to the development of understanding of the concepts in the field of earth science and to the application of knowledge and concepts in new situations. It encompasses the key competencies of collecting, analysing and organising information, and communicating ideas and information.

Objective	Learning outcomes
To recall knowledge	List, define, state, describe, select, identify, recognise, categorise, illustrate, tabulate, spell correctly: • facts and terms • symbols • scales • formulae • procedures • theories and principles • events • sequences • shapes, patterns and diagrams • …
To understand concepts	Perceive, describe, classify, explain, discuss, summarise, interpret, interrelate, compare, contrast, evaluate, exemplify, substitute, reconstruct: • ideas, themes, and issues • laws and principles • symbols and pictures • patterns • formulae • numerical magnitudes • …
To apply knowledge and understanding	Use previously learned concepts to: • solve a problem that has a single or best answer • calculate a value • extrapolate a trend • infer a relationship • predict an outcome • eliminate an incorrect hypothesis • propose a sequence of events • estimate a magnitude or approximate solution • explain a pattern or feature • translate knowledge into a new context or different form • draw a conclusion • deduce a result • …

4.3 Working scientifically

The objective 'Working scientifically' in earth science should be achieved across a range of simple-to-complex situations which include those based in the laboratory and field. The objective refers to devising and implementing investigations. It encompasses the key competencies of collecting, analysing and organising information, solving problems, and using mathematical ideas and techniques. This objective also includes planning and organising activities, and using technology. Skills developed will encourage students to work independently and with others as part of a team.

Objectives	Learning outcomes
To design and implement investigations	Recognise the problem or situation • recognise relevant issues and aspects • propose evidence that would be required to confirm or refute a particular theory or idea • propose hypotheses • … Plan the investigation • identify and control variables • design experimental procedures • develop a conceptual framework • combine several scientific processes into a coherent strategy for a given task • propose a test of a hypothesis • … Identify and use scientific techniques for laboratory and field settings • select appropriate techniques • use field and laboratory procedures correctly • identify safety issues and procedures • … Collect and organise data • use primary and secondary data sources • follow procedures in assembling, constructing, manipulating, handling, calibrating, measuring • collect qualitative and quantitative data using standard units • record observations using a variety of methods including sketches, drawings, graphs, tables, photographs • select measuring devices • use correct scales and units, with an awareness of limitations and errors • identify errors in measurement • describe properties and changes • classify objects using appropriate properties • estimate numerical magnitudes • substitute in formulae • … Assess the validity of qualitative and/or quantitative data • distinguish fact from opinion • distinguish relevant from irrelevant information • distinguish observations from inferences • make inferences or predictions consistent with a set of assumptions • critically evaluate the validity and/or adequacy of data • …

4.4 Using information scientifically

The objective 'Using information scientifically' should be achieved across a range of simple-to-complex subject matter within a range of simple-to-complex situations. It encompasses the key competencies of collecting, analysing and organising information, communicating ideas and information, planning and organising activities, and using technology. Skills developed will encourage students to work independently and with others as part of a team.

Objectives	Learning outcomes
To use information scientifically	Interpret • identify trends or anomalies • interpolate and extrapolate • insert an intermediate between members of a series • rank • analyse • infer and predict • generate analogies • reconstruct • follow procedures • develop a logical sequence • … Generalise and synthesise • relate cause and effect • describe relationships (qualitatively and/or quantitatively) • compare and contrast • integrate all relevant aspects in generating an explanation • propose a conceptual model • … Draw and evaluate conclusions • deduce, offer a solution • recognise invalid solutions • select relevant data and a procedure to reach a conclusion or support an argument • identify assumptions on which claims are based • reach a conclusion that is consistent with a given set of assumptions • justify an outcome based on given or generated information • … Present information in a variety of modes and forms • use spoken, written, pictorial, audiovisual and physical forms • use appropriate conventions of language and referencing • use suitable genres • …

5 LEARNING EXPERIENCES

5.1 Planning learning experiences

The range of learning experiences provided for students should promote the attainment of the global aims and objectives of the course of study. The integrative nature of learning experiences, language education, resources and the use of technology should be considered when selecting experiences for students in Earth Science.

Students will be involved in practical, written and spoken activities. The following list of teaching/learning modes is neither prescriptive nor exhaustive. Schools should, however, clearly list a broad range of appropriate learning experiences within each unit of work. Choices *may* include:

- collaborative learning
- laboratory investigations and experiments
- excursion-based and field-based learning activities individually or as a member of a group or team
- library research, collecting, analysing and organising information
- case studies or surveys
- assignment work and communicating ideas and information in a variety of formats
- model construction
- classroom debates, role-play and simulation games, individually or as a member of a group or team
- teacher exposition and questioning
- film, video and slide audiovisual observation
- computer-based learning, including the use of the Internet
- media presentation
- independent research study and communicating ideas and information in a variety of forms
- reporting orally
- …

For additional specific ideas refer to the learning experiences that are suggested within individual syllabus topics.

5.2 Learning experiences and the key competencies

In selecting learning experiences, teachers have many opportunities to deal with the key competencies, many of which occur naturally in the learning context and are essential to the study of Earth Science, namely:

- collecting, analysing and organising information
- communicating ideas and information
- planning and organising activities
- working with others and in teams
- using mathematical ideas and techniques
- solving problems
- using technology.

Earth Science provides opportunities for the development of these key competencies in contexts that arise naturally from the content and learning experiences of the subject. In the course of their studies, students will collect, analyse and organise information about the environment and will evaluate the validity of information. Both individually and in groups, they will plan and organise activities and will attempt to solve problems associated with the environment. They will be involved in the communication of ideas, information, arguments and conclusions, for a variety of purposes and in a variety of contexts. The course of study will provide opportunities for them to develop some mathematical techniques, especially those associated with accessing and manipulating data. They will also have opportunities to use certain technologies, particularly those relating to the use of equipment and computers.

In their study of planet Earth and human interaction with earth's systems, students will develop a knowledge, understanding and application of subject matter and concepts related to the geological context. At the same time, they will develop the processes and skills required when working scientifically and when using information scientifically in the field of earth science. These three aspects are of equal importance to their involvement in the subject.

5.3 Effective use of language

The effective use of language (written, spoken, and symbolic) is integral to the development of the general objectives of the subject. Science uses a rich spectrum of metaphors and similes to describe and communicate models that seek to explain natural phenomena. There is a general language of science, and each of the historical disciplines has its own arcane language and mental/verbal metaphors. Teachers need to devise learning experiences that develop awareness and understanding of this language. The language characteristics of individuals and groups, varieties of English used, ways in which students communicate and their preferred learning styles all influence the nature of learning in Earth Science.

During the process of second language or dialect learning, some students may approximate standard forms of English. These approximations need to be considered as acceptable forms of language. Teachers need to make judgments about the appropriateness of, and necessity for, the use of particular varieties of English, according to the intended outcome of the learning experience. As a consequence of these considerations, students should gain increased proficiency in expressing earth science concepts and knowledge.

Learning experiences must be based upon a range of resources consistent with an emphasis upon the development of scientifically literate adults. These learning experiences should require students to use language effectively for several purposes in different contexts and for a variety of audiences. Students should prepare and present communications in a range of forms and mediums.

Students should be engaged in learning experiences that involve them in experiences such as those shown in the following table.

Drawing upon sources of information, such as:	Using language for the purposes of:	Presenting information in forms such as:
observations demonstrations experiments textbooks handbooks of data manuals of procedures product brochures specification sheets computer files journal articles magazines newspapers broadcast media advertisements videos or films lectures interviews discussions …	restating information reporting results giving instructions formulating a hypothesis designing an experiment explaining a relationship arguing a proposition proposing action defending a position justifying a stand evaluating an argument developing an idea interpreting a theory persuading making conclusions following instructions predicting the results of an experiment evaluating scientific arguments …	laboratory/field notes formal reports letters abstracts précis reviews oral presentations seminars discussions demonstrations charts graphs sketches models photographs electronic media …

5.4 Quantitative concepts and skills

Success in dealing with issues and situations in life and work depends on developing and integrating a range of abilities, such as being able to:

- comprehend basic concepts and terms underpinning the areas of number, space, probability and statistics, measurement and algebra
- extract, convert or translate information given in numerical or algebraic forms, diagrams, maps, graphs or tables
- calculate, apply algebraic procedures, use algorithms
- use calculators and computers
- use skills or apply concepts from one problem or one subject domain to another

Senior Earth Science provides opportunities for learning experiences that promote the development of a range of these capabilities. Students are to be encouraged to develop their understanding and to learn through incorporating mathematical strategies and approaches to tasks where this is appropriate. Some of these learning experiences should stimulate their mathematical interest and hone quantitative skills that can be transferred to other subjects.

The distinctive nature of Earth Science favours the development of some particular mathematical concepts. Examples include magnitude in the context of both time and distance, and the mathematical and graphical concepts in visualising and interpreting the three-dimensional nature of the Earth's crust and the structures on its surface and within it.

Because of its environmental focus, the different time scales in which human beings and geological processes operate are both relevant to earth science. Furthermore, the time duration of geological events varies enormously, from the minutes for a tsunami to strike, to the millions of years that can be involved in mountain building, to the billions of years since the formation of the earth. Distances also vary tremendously, from the dimensions of a mineral grain to the vast distances of the cosmos. The extent of this range of magnitudes in distance and time is specific to Earth Science, and favours the use of exponential and logarithmic approaches in considering and comparing these events.

Maps, cross-sections, and diagrams are drawn to particular scales and used to illustrate and interpret the Earth's crustal structures. Computations based on these scaled diagrams are used in determining values for quantities as wide ranging as plate motion rates, slope angles, distances to earthquakes, fault displacements, drill-hole depths, rates of erosion, and ore body thicknesses. Learning experiences that include interpretations and calculations involving the Earth's crust provide opportunities for students to use mathematical skills they have developed in other subjects. As well as building their quantitative abilities, these activities with maps and cross-sections provide opportunities that enable students to develop their skills in problem solving in three-dimensional space.

5.5 Resource material

Selecting resource material to support a course in Earth Science with an environmental focus will be governed to some extent by local factors. It is unlikely that there is a single student or teacher resource that can be universally applied to school programs. Schools should draw on their own resources as well as the suggestions made in section 11. General community resources, for example libraries, museums, science centres, popular science periodicals and electronic media, are all available. In this regard, the government organisations AGSO (Australian Government Survey Organisation) and CSIRO (Commonwealth Scientific and Industrial Research Organisation) warrant particular mention.

The interdisciplinary and dynamic nature of Earth Science enhances the role of the Internet as a valuable resource that spans relevant science disciplines. It represents a rich source of material on topical issues.

5.6 Field and practical work

Practical work and field studies form an integral part of this subject. Practical studies must include time spent on:

- working with earth materials
- accessing maps, images, and electronic resources
- using equipment and instruments
- communicating results and interpretations.

Field studies provide unique opportunities to implement a variety of learning experiences in Earth Science. These range from the practical illustration of features and concepts to involving students in investigative studies designed to allow them to demonstrate higher-level cognitive processes as they analyse and evaluate field evidence and then synthesise cogent interpretations.

Field and practical work will provide students with the opportunity to become familiar with scientific equipment and methods of using these. These activities also give students opportunities in the collection of primary data. The equipment that students could use would include:

- geological hammers
- compasses
- clinometers
- equipment for environmental testing
- hand lenses
- telescopes
- binoculars.

It is important that schools recognise the need to provide adequate time for activities of a practical nature**. In addition, a minimum of three days per year or equivalent must be allowed for student field work.** This field work may range from local, short-duration studies to an excursion or camp.

5.7 Workplace health and safety

Schools should be aware of legislation such as the *Workplace Health and Safety Act 1995*, and the *Workplace Health and Safety (Hazardous Substances) Compliance Standard 1997.* There are mandatory obligations on principals, teachers and all other persons in schools, particularly in relation to the use of hazardous substances and specified dangerous goods.

The science safety requirements relating to teachers of science are clearly explained in *Aspects of Science Management: A Reference Manual for Schools* and in the *Workplace Health and Safety Guidelines—Curriculum—Core Module* (both from Education Queensland) and relevant activity modules.

6 COURSE ORGANISATION

6.1 Time allocation

The minimum number of hours of timetabled school time including assessment for a course of study developed from this syllabus is 55 hours per semester.

A total of at least 145 hours during the two-year course of study must be devoted to core areas of study in the introductory component and the four major topics. The core areas of study must represent at least two-thirds of the course. The remaining time may be allocated either to further study of the core areas of study or to elective areas of study chosen by the school.

Minimum time allocations are indicated in table 6.1. Schools may devote no more than 10 hours to the introduction.

6.2 Course structure

Table 6.1shows that the Earth Science syllabus focuses on an introduction followed by four major topics. The minimum depth of treatment for these, indicated as core areas of study, together with ideas for elective studies in the major topics, are indicated in section 7. Core areas of study are defined within the introduction and the four major topics.

Table 6.1 Topics and time allocations

Introduction and major topics	Minimum time allocation
Introduction to Earth Science	5 hours
1. Our Earth and its Systems	35 hours
2. Hazardous Earth Processes and Materials	35 hours
3. Earth Resources and Human Impact on the Environment	35 hours
4. Our Earth in Space and Time	35 hours
Total	**145 hours**

6.3 Introduction and major topics

Introduction

New and emerging emphases for the Earth Science subject, particularly the environmental aspect and the focus on the dynamic systems of our planet, justify this introductory section. It has a relatively small time requirement compared with the four major topics, yet its goals of nurturing students' interest and establishing the subject's relevance to their lives are crucial. The introductory section aims to achieve these by:

- focusing on earth from space to present a global view of the planet, which allows its unique character to be highlighted
- demonstrating the excitement of the subject by introducing the range of spectacular earth processes to be developed in the four major topics.
- illustrating the extent of human interactions with earth's environments, particularly in respect of resource management.

Major topics

The major topics represent four key environmental themes within Earth Science. The first semester of the subject should commence with the Introduction to Earth Science. Following this, the listed order of the major topics in section 6.2 is not intended to indicate a prescribed or preferred teaching sequence. Schools have the freedom to develop work programs in which one of the major topics is offered each semester, or in which the major topics are combined or reorganised, provided that all requirements of the syllabus are met.

Whichever option is chosen by a school, the two-year course of study must be outlined in a course overview that details, for each unit of work, the core area of study, the objectives, the learning experiences and the possible assessment activities. Schools should contextualise the objectives of the units of work for each major topic to ensure sufficient coverage of the full range of general objectives.

6.4 Elective material

Schools select material in addition to the prescribed core areas of study for about one-third of their course. Suggestions for possible elective material are listed in section 7. These are suggestions only and are neither exhaustive nor prescriptive. The areas indicate the depth and breadth of material that could be chosen to develop students' awareness and understanding of earth science, their ability to think and to solve life-related problems, and to be socially and culturally aware and scientifically literate. As illustrated by the suggestions, each elective topic should be selected on the basis of its meeting one or more of the following criteria:

- reflects recent developments or discoveries
- develops in more detail the fundamental principles that establish the environmental emphasis of the Earth Science course
- is specifically:
  - Australian
  - clearly interdisciplinary
  - related to science, technology, and society
  - career-related, or relevant to students
- highlights the international character of the discipline and its relevance to diverse cultures
- is important either historically, industrially or economically.

The elective earth science material must contribute to the general objectives in section 4. Once identified by a school, this elective material becomes a significant and integral aspect of the course, and as such must be reflected in the assessment.

Although schools have the flexibility to select elective material that builds on or complements the core, electives would not usually be concentrated on only one or two of the major topics within the two-year course of study.

7 INTRODUCTION AND MAJOR TOPICS

7.1 Introduction to Earth Science

Overview

The study of the earth has captured the interest and imagination of people throughout the ages. The desire to experience and understand earth's environments has pushed the frontiers of humankind's exploration across the entire globe and beyond, to earth's moon and to other planets. Astounding discoveries from space exploration have been matched in our knowledge of deep ocean environments and the interior of the earth. The driving force has been a deep human curiosity about our physical environment, coupled with a need to test hypotheses, to unravel earth's history, and to gain insights into the formation of our solar system and the universe of which earth is just a small part.

Our earth represents a dynamic system in which the atmosphere, hydrosphere, lithosphere, and biosphere are constantly interacting and where natural cycles that involve water, rocks, and atmospheric gases play their part in supporting and sustaining life. Natural earth processes shape landscapes and maintain the planet's environments by constantly reworking, conserving, and renewing its materials. The interaction of the atmosphere and hydrosphere strongly influences earth's weather system and produces catastrophic events such as floods, cyclones, hurricanes and tornadoes. Hazardous earth processes such as earthquakes and volcanic eruptions, on the other hand, reflect internal earth processes.

Rock sequences confirm that hazardous events have characterised earth's environments in past times. They also record an earth history involving even greater phenomena such as the opening of ocean basins and the formation of massive fold mountain chains. Major catastrophic events affecting earth's global environment have influenced life forms significantly, for example, causing the extinction of the dinosaurs.

An understanding of our earth, its processes, and its geological history, is the key to an ecologically sustainable development of the planet's resources. Only with this knowledge will humankind continue to derive the necessary benefits from the earth without jeopardising its environments. Although this knowledge also facilitates the choice of its safest environments for human habitation, history demonstrates that politics and economics largely dictate where communities settle and remain. Even when cities or towns are built in sites of high environmental risk, earth science plays an important role in allowing inhabitants to live with natural hazards. Technological advances have been made to improve the monitoring of the environment with the goal of minimising the impact of hazardous events. To predict exactly when and where catastrophic events will take place is not yet possible, however.

It is important to note that geological processes affect every living thing on earth. Some of these processes are very obvious and might be regarded as hazards. Others are not so obvious, but enable us to understand the evolution of the atmosphere, the emplacement of economic deposits of mineral resources, and the formation of productive and fertile soils and the sculpture of the landscape.

Humankind is dependent upon the earth for survival. An awareness of earth's systems and how they affect, and are affected by, human activities, is fundamental to any study of earth science.

Subject matter and approach

One goal of this introductory unit is to establish the relevance of Earth Science to the lives of students. Its purpose is also to stimulate their interest in their natural surroundings and generate excitement for the subject by illustrating both the dramatic and the subtle natural phenomena that reflect Earth's dynamic nature.

It is important to introduce students to the broad aspects of Earth Science. This should include illustrating the awesome yet delicate appearance of the 'blue planet' viewed from space, the magnificence of the rivers and forests, the wonders of the oceans, the tragedy and benefits of floods, the enormous strength of cyclones, the amazing spectacle of volcanic eruptions, the strength and power of earthquakes, and the importance of recycling our resources and taking care of our natural environment. It is crucial that the student appreciates that the earth is a highly dynamic planet, not only in terms of its hydrosphere and atmosphere but also in its land surface and interior.

Core areas of study

- earth in space
- the dynamic nature of the earth
- slow and continuous earth processes
- rapid and catastrophic earth processes
- the term *environmental* in the context of environmental earth science
- development versus sustainability.

Suggested learning experiences

- media study of recent catastrophic events
- a case study of a spectacular natural phenomenon
- a study of life-threatening events and their links to a dynamic earth.

7.2 Our earth and its systems

Overview

Studies in earth science are best approached by considering the planet from the point of view of its various dynamic systems, the largest of which are the hydrosphere, lithosphere, atmosphere, and biosphere. Examples of smaller but equally dynamic systems include shoreline, glacial, volcanic, and fold mountain systems. Studies using this systems approach highlight the earth processes that operate across the wide range of earth's environments. The flow of matter and energy between earth's dynamic systems is conveniently illustrated in terms of a series of cycles. Of greatest importance are the energy cycle, the hydrologic cycle, the rock cycle and various biogeochemical cycles.

Earth's dynamic processes involve the formation and destruction of rocks, ores, and soils. These solid earth materials are all composed of minerals. Changes in physical and chemical conditions as earth processes operate can cause mineral constituents to grow, melt, dissolve, or become broken or modified. As the earth's surface is weathered and eroded, for example, some minerals are destroyed and others develop in their place. Where sediments accumulate at the bottom of oceans and lakes, minerals may grow from solution. Other minerals crystallise during the cooling of lava extruded from volcanoes. Deep below the earth's surface, substantial pressures and temperatures can cause the rearrangement of atoms to form new minerals. The importance of earth materials is therefore not restricted to their value as economic deposits; studies of the materials and their mineral constituents can provide an insight into the environments of their formation.

As far as is known, a unique combination of geological and astronomical processes has resulted in the development of a planet on which life can survive. The composition of the earth stands in great contrast with planets such as Jupiter and Saturn. The earth has a much lower percentage of light elements such as hydrogen and helium, and a much higher percentage of heavier elements such as iron, silicon, aluminium, and oxygen. The unique combination of composition, mass and position in space has determined many of the earth's characteristics.

The earth we live on today is a result of interactions among the following factors:

- the way in which the earth formed
- the energy received from the sun, the energy stored inside the earth at the time of its formation, and the energy produced inside the earth by natural radioactivity
- the composition, mass and structure of the earth
- the movement of materials in and around the earth driven by its energy sources
- the immense span of geological time.

As humanity continues to search to understand the earth, three of the most powerful or enduring ideas are *uniformitarianism, catastrophism,* and *plate tectonics.* These are important concepts in an environmental earth science course.

Hutton's doctrine of uniformitarianism holds that the present is the key to the past. Ancient sandstones, for example, are interpreted as having started in much the same way as sand deposits today. On the other hand, much of what we have learned about the long history of the earth can be used to help us better understand the present and predict the future. Climate change models can be improved, for example, by incorporating knowledge of past climate change; and assessments of earthquake risk can be refined by drawing on previous behaviour as revealed by the geological record.

Catastrophism has waxed and waned in popularity among earth scientists. A central feature of geological paradigms up to the late eighteenth century, it was eclipsed by uniformitarianism in the nineteenth century and for most of the twentieth. In the late twentieth century, catastrophism has been invoked in events such as the extinction of dinosaurs.

The theory of plate tectonics has emerged as the most powerful geological idea of recent times. The predictive ability of this theory, together with its ability to draw together an enormous number of otherwise independent observations, has made it central to studies of the earth.

Subject matter and approach

Students should be familiar with the main concepts involved in a systems approach to studying the earth. Studies of the hydrologic, rock and energy cycles serve to interrelate the earth's systems. Although earth processes of importance to each of the large systems should be studied, greatest attention should be placed on the lithosphere to support theoretical and practical studies of minerals and rocks.

Students should be familiar with the theory of plate tectonics. They should understand how the theory of plate tectonics describes the relationship between the features and the processes of the earth's crust. At the same time, the students should also understand the nature of the interior of the earth.

Core areas of study

- major earth systems—lithosphere, hydrosphere, atmosphere
- the theory of plate tectonics
- common earth cycles—rock, energy, hydrologic
- common minerals and rocks—at least five of the rock-forming minerals and four representative examples from each of the igneous, metamorphic and sedimentary rock groups
- processes and landforms on the earth's surface
- the interior structure of the earth.

Suggested elective areas of study

- biogeochemical cycles
- structural geology
- Bowen's Reaction Series
- meteorology
- historical development of the theories of plate tectonics
- geology of the ocean floor
- mountain building
- isostasy.

Suggested learning experiences

- research the impact of geological phenomena such as weathering, erosion, flooding
- research landscape evolution in the local area
- sketch landforms and interpret their evolution
- test the properties of minerals using instruments such as a hand lens, knife, streak plate
- build a systematically organised collection of minerals and rocks from the local area
- sketch mineral and rock specimens
- construct scaled geological diagrams using drawing instruments
- generate a geological map of an area from field data
- research the work of scientists such as Lyell, Hutton, Darwin and Wegener, and their influence on the development of earth science

- sketch large-scale structures associated with plate tectonic settings
- critically evaluate controversial or contentious phenomena, for example: min min light; Bermuda Triangle
- simulate stream processes using stream tables
- investigate different viewpoints of the greenhouse debate.

7.3 Hazardous earth processes and materials

Overview

Earth processes that we refer to as ‘hazardous’ have existed throughout earth history. Even the most destructive events are part of the normal functioning of this dynamic planet; to a great extent, they make the planet habitable. Earthquakes and volcanic eruptions, for example, are among the processes that have formed the continents, shaped the landscape, influenced climatic zones, and allowed for the creation and stabilisation of the atmosphere and oceans. The action of wind and water causes flooding, landslides, and windstorms but also replenishes soil and sustains life.

Earth processes affect our lives daily in ways that are both subtle and conspicuous, beneficial and harmful. A knowledge of these processes and the hazards associated with them should play an integral role in the planning of human activities.

Earth hazards include earthquakes, volcanic eruptions, floods, and landslides. They are included in the broader concept of natural hazards, which encompasses processes or events such as locust infestations, wildfires, and tornadoes in addition to strictly geological hazards.

Some natural hazards are catastrophic events—occurrences that strike quickly but with devastating consequences. Other hazardous processes operate more slowly. Droughts, for instance, can last ten years or more. The socioeconomic impacts of extended drought are caused by the cumulative effects of season after season of below-average rainfall.

In general, natural processes are labelled ‘hazardous’ only when they present a threat to human life, health, or interests, whether directly or indirectly. In other words, we tend to take a human-centred approach to the study and management of natural and geologic hazards. This is human nature, of course; we are justifiably concerned with the protection of human life and property. But this approach has important implications, because it can lead to a style of hazard management in which geologic processes are cast as the ‘enemy’ and efforts made to manipulate the environment into submission. A somewhat different approach, which is currently receiving a lot of attention, focuses on improving scientific understanding of natural processes and their triggering mechanisms in order to provide a foundation for better management.

A different category of hazard, sometimes referred to as technological hazards, is associated with everyday exposure to naturally occurring hazardous substances such as radon, mercury, asbestos fibres, or coal dust, usually through some aspect of these substances in our built environment. Still other types of hazards arise from pollution and degradation of the natural environment, which have led to problems such as acid rain, contamination of surface and underground water bodies, depletion of the ozone layer, and global warming; we might refer to these as primarily human-generated hazards.

In order to incorporate knowledge about natural processes into the planning of human activities, we need to assess the hazards and risks associated with them. Ideally, scientific understanding can contribute to the establishment of an integrated system in which environmental earth scientists cooperate with government and private-sector decision makers to apply scientific and technical knowledge to the reduction of natural hazards.

Earth scientists have a particular responsibility to contribute to such efforts. Because so many natural disasters are associated with geological processes, earth scientists play an important role in furthering our understanding of hazardous earth processes, assessing the hazards and risks involved, accurately predicting hazardous events, and assisting in the prevention or the mitigation of impacts. All of these tasks depend on effective communication of scientific understanding about geologic processes.

Subject matter and approach

Students should become familiar with a range of hazardous earth processes and the effects of these on human life and property. Emphasis should be placed on the geological processes that cause each geohazard. At the same time, students should recognise that people's actions may cause or increase the risk of earth hazards. The monitoring, prediction and potential control of geohazards should be considered. Studies of these processes should result in students coming to understand the relationship between plate tectonics and many earth hazards.

Students should be familiar with a range of hazardous materials and the effects of these on people's lives. They should develop an understanding of the techniques developed to manage such materials.

Core areas of study

The nature, monitoring, and management of:

- mass wasting
- earthquakes
- volcanic eruptions
- tsunamis
- floods
- adverse weather
- hazardous materials.

Suggested elective areas of study

- geohazard risk assessment
- El Niño and La Niña effect
- meteorite impacts
- wave action and coastal erosion
- engineering geology.

Suggested learning experiences:

- remote sensing studies, for example with respect to weather
- seismometer operation and use
- epicentre determination
- historical studies relating to severe storms, cyclones and floods
- sea level change—the data, the reasons, the predictions
- engineering application—dam-site analysis, building foundations, instability in the walls of road cuttings
- gathering and interpreting data from the Internet about recent geohazards
- modelling the factors that cause and/or promote mass wasting
- evaluating the validity of 'disaster movies' that feature geohazards
- predicting potential geohazards on the basis of geographical and geological location
- modelling viscosity using household liquids (e.g. water, oil, honey)
- investigation of the flood mitigation techniques of the local area
- modelling the effect of channel modification on the behaviour of flood waters.

7.4 Earth's resources and human impact on the environment

Overview

All organisms on this planet are entirely dependent on the earth for a supply of clean air, water, and food. Humans also actively use the earth's natural resources as a source of raw materials for their own endeavours—manufacturing, housing, and transport. Any earth material that is necessary or valuable to humans therefore represents a resource. In this context, the range of earth's resources is extensive. Air, water and soil are extremely important to our everyday existence; without any one of these resources, humankind would become extinct. Water also has important uses in industry. Various materials, rocks, and even fossil fuels such as oil are the raw materials used in the manufacture of almost every conceivable product—construction products, jewellery, electronics components, chemicals and even medicines.

Fossil fuels such as coal, oil and natural gas are vital sources of energy but, because fossil fuels are not renewable, alternative forms of energy are being sought. These include nuclear power, and solar and geothermal energy. We are also learning how to harness the energy of tidal action, windpower, and even biomass-derived energy extracted from alcohol and methane produced by the decay of organic material in landfill.

An understanding of the limited availability of earth resources has come with their escalating use. As a result, our use and management of such resources is now much more considered than it was previously.

Rehabilitation and sustainability are now integral components in the activity of extractive industries. In conjunction with this, the techniques used to find, extract and process resources have improved markedly, to such an extent that re-mining the tailings of 'old' mines has now become a significant part of the mining industry.

While we are reliant on earth resources, their extraction and use causes us to have a significant impact on the earth's environment. Scientific endeavour is demonstrating the extent of this impact, from a historical, current and future perspective.

With an increasing understanding of the earth's systems, scientists have identified evidence of human impact on the environment. Depletion of the ozone layer, the possible acceleration of the greenhouse effect, acid rain, thermal inversions, and decreasing air and water quality standards are commonly cited. It seems that these are the result of pollution and inadequate waste disposal. Unfortunately, any attempt to decrease pollution frequently increases the amount of waste requiring disposal.

In addition to the impact humans have on the atmosphere and hydrosphere, we also have an impact on the physical environment, often resulting in catastrophic events. Examples include flooding due to altered run-off patterns in cities, increased seismic activity under large dams, promotion of mass movement, and altered rates of erosion. The placement of all forms of constructions—dams, freeways, buildings, wells or even retaining walls—can have an effect on the physical environment.

In all cases, planning for the various forms of impact that humans have on the environment is essential. This may involve changing the way that we use the earth's resources, developing new methods of waste disposal, and more careful studies of the ways human endeavour affects the environment.

Subject matter and approach

Students should become familiar with the range of earth resources and their use. Emphasis should be placed on the non-renewable nature of a large number of these resources. An understanding of the processes of formation of earth resources should be accompanied by an appreciation that humanity is using these resources at many times the rate of their formation. Students should understand the techniques involved in the exploration, extraction and processing of earth resources. It is important that they recognise the need for careful planning of mining processes due to the impact they can have on the local environment.

Students should also understand the impact that humans have on the environment. Sources of pollution, waste and other forms of environmental impact should be recognised, along with the techniques employed to control them. It is important that students are aware of the fragile state of the earth and the role that earth science plays in understanding and helping to reduce and minimise the impact humans have on our planet.

Core areas of study

- earth resources—types, formation and uses
- exploration, extraction, processing, and management of earth resources
- forms of human impact on the environment
- environmental monitoring
- rehabilitation of environments affected by human impact.

Suggested elective areas of study

- waste management
- earth resources and the economy
- history of extractive industries in a specific location
- gemstones
- medical geology
- issues relating to extractive industries, including Native Title
- case studies in economic geology
- alternative sources of energy
- engineering geology.

Suggested learning experiences

- create working models of extractive technologies, for example froth flotation, magnetic and gravitational separation
- visit local mining and resource industries
- investigate the use of resource materials in construction industries, for example building stones
- develop experiments to test alternative forms of energy, for example, solar, wind
- undertake a quantitative field study of a local stream (temperature, velocity, bed shape, turbidity, pH, dissolved materials)
- investigate the effects of breakwater and groyne construction on coastal processes
- make and/or test apparatus to purify water, for example commercial filters, student-constructed filtration and distillation apparatus
- create models to demonstrate human impact on aquifers
- study the waste management techniques and technologies employed by the local council
- recycle materials
- evaluate and suggest potential improvements for the waste management plan for the school
- invite guest speakers from relevant resource industries and/or government bodies to discuss resource management
- test soils for composition, moisture levels, humus content, pH level
- investigate the properties of earth resources
- study the environmental impact statements for extractive and/or processing industries.

7.5 Our earth in space and time

Overview

Scientific discoveries have made humankind realise the vastness of space. Even though it travels at 300000 kilometres per second, light takes 100000 years to cross our own galaxy; yet ours is just one of a myriad of galaxies in the universe. The light from distant quasars started the journey to earth billions of years before our solar system was formed. The study of electromagnetic radiation from different sources in space has allowed astronomers to understand the processes and events within stars and galaxies.

Many hostile environments exist throughout the cosmos. The mysterious quasars, located at the edges of the observable universe, radiate vast amounts of energy. During the violence of supernovas, enormous forces crush stars to form neutron stars, perhaps even black holes. Gamma rays from nearby supernovas as well as the impacts of asteroids and comets may have profoundly influenced life on our planet. Data from space probes indicate that the other planets in our solar system, at the present time, are inhospitable to life as we know it. Some scientists argue that the molecular building blocks necessary for life are found in space and that organic compounds from comets may have contributed to the origin of life on earth. Even if habitable planets exist in other star systems, we cannot travel to them using current technology. We must therefore preserve earth's environments.

The fossil record shows a rich diversity of past life and environments on earth. Fossil remains have been found of strange creatures, quite unlike those living today. The fossil record has contributed many clues to the origin of today's species. It is likely that many more discoveries will be made, resulting in a more complete fossil record. Studies of fossils have revealed a unique insight into the life forms of our earth in past times; it is on the basis of this evidence, for example, that we know that dinosaurs walked on our planet and swam in its seas millions of years ago.

The theory of evolution is one of the major concepts in science. Earth science, through the evidence provided by the fossil record, adds a special dimension to the theory. Although it is now widely accepted that there have been changes to life forms through time, debate about the exact implications of the fossil record continues. Does it reflect a smooth, steady change through time, or is it one of slight change punctuated by relatively short periods of major change? The mechanisms of biological change or evolution are constantly debated, and this debate reflects the dynamic nature of science itself. It is a process of enquiry where ideas old and new are continually being tested.

The significance of catastrophes in the history of life is being re-evaluated. The Darwinian view shows a strong uniformitarian influence, and catastrophes have generally been avoided in geological theories. However, strong evidence has been found supporting a catastrophe for the extinction of groups such as the dinosaurs.

The immensity of space is matched by the enormous extent of time. Radiometric dating and other techniques reveal that the Australian continent and its earliest lifeforms are far older than previously imagined. The earth preserves a record of past environments and events within the materials of its crust. Many years of geological detective work have given us insights into the past environments, climates, catastrophes, tectonic upheavals, and fauna and flora of our continent. By employing stratigraphic principles and the principle of uniformitarianism, we are able to infer the geological history of an area from clues in the rock record.

Subject matter and approach

This topic considers the origins of the earth and its place in the universe, and examines the history of the planet, from the time of origin to the present day. It involves the student in the search for meaning in the events of the present and the past, from the

Big Bang to the most recent volcanic eruption. Whereas the present is the key to the past (Principle of Uniformitarianism), the past and the present provide the key to predicting the future.

Humans are recent passengers on planet Earth as it orbits its way around the sun, around the galactic centre, and through the universe. To know something of the events that shaped the earth and the life that has flourished upon it takes us from the realms of astronomy to the hunt for fossils and their meaning in palaeontology, and from the sequencing of geological events in geological mapping to the natural processes that reveal the ages of rocks.

Core areas of study

- exploration of space
- the universe and its formation
- the solar system and its formation
- life forms from the past
- geologic time
- stratigraphy.

Suggested elective areas of study

- Kepler's Laws
- space colonisation
- the search for extraterrestrial life forms
- history of astronomy
- study of local fossils
- major and minor extinctions
- Darwinian theory of natural selection
- evolution of coral reefs
- dinosaurs and their extinction
- famous fossil deposits, for example Riversleigh, Burgess Shale, Ediacara
- ancient Australian environments.

Suggested learning experiences

- construct models and dioramas
- collect, prepare and classify fossils
- make fossil casts, moulds and imprints
- make analogous models of geologic time
- make scale models of the solar system
- calculate the velocity of dinosaur movement on the basis of preserved footprints
- study Voyager and Hubble images of the planets
- visit the Planetarium
- visit NASA, Jet Propulsion Laboratory and similar sites on the World Wide Web
- use telescopes, binoculars and the naked eye to study the night sky.

8 ASSESSMENT

8.1 Underlying principles

A judgment of student achievement is made at exit from the course of study. This will be made after two years for most senior Earth Science students but may be made after one, two or three semesters for others. Assessment of student achievement should not be seen as a separate process, but as an integral part of the developmental learning process. Assessment should reflect the learning experiences of the students. An effective course of study includes a variety of learning experiences; therefore, a range of assessment techniques that reflect the learning experiences of the students should be used to gather assessment information.

The nature of the Earth Science syllabus promotes a wide range of contexts and learning experiences for developing the general objectives, and it urges schools to take into account the particular needs and interests of the individual student and the available resources.

Judgments about student achievement must be made in terms of the stated exit criteria and standards of the syllabus (see section 8.3).

The Board’s policy on exit assessment requires consideration to be given to the following principles when devising an assessment program (see ’Underlying principles’, next section). These principles are to be considered together and not individually in the development of an assessment program.

Underlying principles of exit assessment

- Exit achievement levels are devised from student achievement in all areas identified in the syllabus as being mandatory.
- Assessment of a student’s achievement is in the significant aspects of the course of study identified in the syllabus and the school’s work program.
- Information is gathered through a process of continuous assessment.
- Exit assessment is devised to provide the fullest and latest information on a student’s achievement in the course of study.
- Selective updating of a student’s profile of achievement is undertaken over the course of study.
- Balance of assessment is a balance over the course of study and not necessarily a balance over a semester or between semesters.

Mandatory aspects of the syllabus

Judgment of student achievement at exit from a school course of study must be derived from information gathered about student achievement in those aspects identified in a syllabus as being mandatory. The exit assessment program, therefore, must include achievement of the assessable general objectives of the syllabus. In Earth Science, these are:

- Knowledge, conceptual understanding and application
- Working scientifically
- Using information scientifically.

Mandatory aspects of the syllabus that must be incorporated in the exit assessment program include:

- a balance among the general objectives
- inclusion in the course of study of the four major topics
- the four assessment categories for the verification folio.

Significant aspects of the course of study

Significant aspects refer to those areas included in the course of study, determined by the choices permitted by the syllabus, and seen as being particular to the context of the school and to the needs of students at that school. These will be determined by the choice of learning experiences appropriate to the location of the school, the local environment and the resources selected.

The significant aspects of the course must reflect the objectives of the syllabus.

Achievement in both mandatory and significant aspects of the course must contribute to the determination of the student's exit level of achievement.

The assessment of student achievement in the significant aspects of the school course of study must not preclude the assessment of the mandatory aspects of the syllabus.

Continuous assessment

Levels of achievement must be arrived at by gathering information through a process of continuous assessment at points in the course of study appropriate to the organisation of the learning experiences. They must not be based on students' responses to a single assessment task at the end of a course or instruments set at arbitrary intervals that are unrelated to the developmental course of study.

Continuous assessment involves the teacher and the student in monitoring achievement over time. Students must be provided with frequent opportunities to evaluate and reflect upon their development in the subject. The syllabus objectives and the task-specific criteria and standards provide the focus for student and teacher reflection. It is essential in Earth Science, in which the three exit criteria are of equal importance, that students and teachers regularly review achievement in each criterion.

Assessment information is gathered for two main purposes, formative and summative. Formative assessment is primarily concerned with identifying a student's needs and learning difficulties, and with informing practices in teaching and learning. It is also used as the basis for feedback to students and parents.

Summative assessment is concerned with arriving at a judgment of a student's level of achievement at exit from a course of study. Summative achievement should satisfy the principles outlined here (section 8.1), requirements regarding mandated assessment categories (section 8.4) and verification folio requirements (section 8.7).

Fullest and latest information

Judgments about student achievement made at exit from a school course of study must be based on the fullest and latest information available.

‘Fullest’ refers to information about student achievement gathered across the range of assessable general objectives. ‘Latest’ refers to information about student achievement gathered from the latest period in which the general objectives are assessed.

Fullest and latest information consists of both the most recent data on developmental aspects together with any previous and not superseded data. Decisions about achievement require both to be considered in determining the student’s level of achievement.

Selective updating

Selective updating is related to the developmental nature of the two-year course of study. It is the process of using later information to supersede earlier information.

As the criteria are treated at increasing levels of complexity, assessment information gathered at earlier stages of the course may no longer be typical of student achievement The information should therefore be selectively updated to reflect student achievement more accurately. Selective updating operates within the context of continuous assessment.

Balance

Balance of assessment is a balance over the course of study and not necessarily a balance within a semester or between semesters. The exit assessment program must ensure an appropriate balance over the course of study as a whole. In Earth Science, to ensure balance of assessment, the program must reflect the following:

- the representation of the general objectives through the range of learning experiences
- the range of learning experiences
- the range of contexts
- the necessary breadth and depth of study in each of the major topics
- the range of assessment categories
- the equal importance given to each of the three exit criteria.

In addition to giving consideration to these principles of assessment, schools must pay attention to the quality of evidence gathered on student achievement. Issues which require particular attention in developing an assessment program are:

- **student ownership**—confidence that the work produced is genuinely that of the student
- the inclusion of assessment tasks which **discriminate across the range** of student achievement
- adequate **sampling** of the significant aspects of the course of study
- accumulation of **sufficient information** to allow reliable decisions to be made on an individual's achievement on each of the three criteria.

8.2 Special consideration

Guidance about the nature and appropriateness of special consideration and special arrangements for particular students may be found in the Board's policy statement on special consideration, entitled *Special Consideration Exemption and Special Arrangements in Senior Secondary School-Based Assessment* (30 May 1994). This statement also provides guidance on responsibilities, principles and strategies that schools may need to consider in their school settings.

To enable special consideration to be effective for students so identified, it is important that schools plan and implement strategies in the early stages of an assessment program and not at the point of deciding levels of achievement. The special consideration might involve alternative teaching approaches, assessment plans and learning experiences.

8.3 Exit criteria

The following exit criteria must be used in making judgments about each student's level of achievement at exit from the course of study. The exit criteria reflect the three assessable general objectives of the syllabus and carry the same name as the general objectives (section 4). The three criteria are of equal importance.

Each criterion is set out below. The standards in table 8.1 describe how these criteria are met by students. The exit criteria are:

- Knowledge, conceptual understanding and application
- Working scientifically
- Using information scientifically.

Table 8.1: Standards associated with exit criteria

Criterion	Standard A	Standard B	Standard C	Standard D	Standard E
Knowledge, conceptual understanding and application	The student consistently: • recalls extensive knowledge in most areas • demonstrates a clear understanding of concepts in depth in most areas • recognises and explains relationships amongst straightforward and complex concepts, comparing and contrasting them where appropriate • successfully applies knowledge and concepts in most situations, including many that are novel and/or complex • evaluates both the relevance and scientific merit of information provided in or derived from earth science contexts	The student consistently: • recalls basic knowledge in most areas together with considerable knowledge in many of these • demonstrates a clear understanding of concepts in most areas • recognises and explains most of the relationships amongst straightforward concepts • successfully applies knowledge and concepts in most straightforward situations and some that are novel and/or complex • evaluates the relevance of information provided in or derived from earth science contexts	The student consistently: • recalls basic knowledge in most areas • demonstrates a broad understanding of concepts in most areas with few misconceptions • recognises and explains most of the obvious relationships amongst straightforward concepts • successfully applies knowledge and concepts in most straightforward situations • selects some relevant information from that provided in or derived from earth science contexts	The student consistently: • recalls some knowledge in several areas • demonstrates some understanding of concepts in several areas but with many misconceptions • recognises some relationships amongst straightforward concepts • applies some knowledge and concepts in some straightforward situations • uses information but does not reflect on its relevance and/or scientific merit	The student consistently: • recalls some knowledge • demonstrates some understanding of a few concepts • demonstrates an understanding that some concepts are interrelated • applies some knowledge and concepts but with errors • uses some information

Criterion	Standard A	Standard B	Standard C	Standard D	Standard E
Working scientifically	Either individually or as a member of a group, the student consistently: • recognises and identifies investigation questions for a range of problems including those that are novel and/or complex • plans a range of scientific investigations of problems including many with elements of novelty and/or complexity • implements investigations using scientific techniques and following procedures safely and correctly • records and organises relevant information logically and systematically • assesses and critically evaluates the validity and adequacy of qualitative and quantitative data	Either individually or as a member of a group, the student consistently: • recognises and identifies investigation questions for a range of problems including some with elements of novelty and/or complexity • plans a range of scientific investigations of problems including some with elements of novelty and/or complexity • implements investigations using scientific techniques and following procedures safely and with few errors • records and organises relevant information • assesses the validity and adequacy of qualitative and quantitative data	Either individually or as a member of a group, the student consistently: • recognises and identifies investigation questions for a range of straightforward problems • plans a range of scientific investigations of straightforward problems • implements investigations using scientific techniques and following procedures safely but with some errors • records relevant information • assesses some aspects of the validity and adequacy of qualitative and quantitative data	Either individually or as a member of a group, the student consistently: • recognises a range of straightforward problems • participates in planning some scientific investigations of straightforward problems • implements investigations using scientific techniques and following procedures safely but with many errors • records some information • offers observations about the validity and adequacy of qualitative and quantitative data	Either individually or as a member of a group, the student consistently: • recognises some problems • participates in some aspects of planning scientific investigations of straightforward problems • follows instructions for some aspects of investigation but with little attention to safety issues and with little procedural accuracy • records minimal information • offers observations about qualitative and quantitative data

Criterion	Standard A	Standard B	Standard C	Standard D	Standard E
Using information scientifically	Either individually or as a member of a group, the student consistently: • provides logical and detailed interpretations of information, and of relationships within the information • makes generalisations about and synthesises information with considerable insight, in well integrated and convincing explanations • offers convincing and valid conclusions, and logical and well-supported evaluations of conclusions • presents information cogently and clearly in a variety of modes, using a range of genres, demonstrating control of the conventions of language and using accurate referencing	Either individually or as a member of a group, the student consistently: • provides logical and clear interpretations of information • makes generalisations about and synthesises information in convincing explanations • offers valid conclusions, and logical evaluations of conclusions • presents information clearly in a variety of modes, using a range of genres, using appropriate conventions of language and using reasonably accurate referencing	Either individually or as a member of a group, the student consistently: • provides simple explanations of information • makes generalisations about information in simple explanations • offers justifiable conclusions, and partial evaluations of conclusions • presents information clearly for the most part, in a variety of modes, using given genres, using some basic conventions of language and using some referencing	Either individually or as a member of a group, the student consistently: • provides opinions and some explanations about information • makes some generalisations about information • offers conclusions and opinions about conclusions • presents information, using basic conventions of language and using some referencing	Either individually or as a member of a group, the student consistently: • provides opinions about information • makes generalisations about aspects of information • offers conclusions • presents information, using some basic conventions of language

8.4 Assessment tasks

The general objectives in section 4 must be considered in constructing and evaluating all assessment tasks. An overarching requirement is that there is a balanced assessment of the general objectives over the two years.

A school should not use just one type of assessment task. Since an effective course of study includes a variety of learning experiences, a program of assessment must include a range of tasks in order to gather assessment information on which to base judgments of exit achievement.

Some tasks will be better suited to the demonstration of particular general objectives than others. For instance, the 'Working scientifically' general objective should be demonstrated by students through assessment tasks that involve investigations.

Students may be required to undertake assessment tasks individually or as a member of a group or team. However, schools must develop procedures and strategies that will allow assessment tasks generated from group activities to demonstrate individual accomplishment.

The overall assessment plan must consist of a balance of a number of assessment tasks suited to demonstrating the general objectives. Requirements for the number and type of assessment tasks for the verification folio are provided in section 8.7. This requires mandatory inclusion of the four assessment categories listed. Schools may choose to develop additional relevant tasks.

At least one task undertaken in Year 12 from each of the following four assessment categories must be included in the 6–10 tasks gathered in the verification folio.

Tasks related to short laboratory-based or field-based investigations

An investigation of short duration would normally engage students for:

a) one or a few laboratory sessions, or

b) a short field study close to the school or a discrete segment within an extended field investigation.

Examples of short investigations of this nature include:
- sketching an outcrop and interpreting relationships
- distinguishing features on a remotely sensed image
- modelling flood levels in a local stream
- systematically identifying an unknown mineral
- explaining the evolution of a prominent landform in the local area
- locating, identifying and establishing the age of an assemblage of fossils
- measuring the attitude of dipping rock layers
- comparing and contrasting the modern and ancient environments for the local area on the basis of field evidence.

Either written or non-written responses could be used to assess investigations of short duration with a field or laboratory focus. Written responses would generally be brief (less than 500 words) and might be expected to:
- outline the objective(s) of the activity
- present gathered and processed data
- summarise conclusion(s).

In accordance with the field or laboratory setting in which the short investigation takes place, non-written responses by students would typically include maps, cross-sections, sketches, models, collections, posters, charts, web pages, or images.

Tasks related to extended laboratory-based and/or field-based investigations

Extended investigations will normally span several weeks or even a term. Both field work and laboratory studies may be incorporated in a single extended investigation. Since earth science with an environmental emphasis offers numerous possibilities for investigations of real-world problems in interdisciplinary contexts, projects can be designed to have an authentic character.

Investigations of this type enable students to construct their knowledge and conceptual understanding, and develop their ability in application while working scientifically on a project of relevance and interest to them. Students can demonstrate, in an integrated manner, the full suite of objectives in section 4 under ‘Knowledge, conceptual understanding and application’, ‘Working scientifically’, and ‘Using information scientifically’.

Assessment tasks related to extended laboratory-based or field-based investigations could include written reports and/or non-written presentations.

Written report

Extended investigations that involve field and/or laboratory work will normally require students to present a written report or assignment. These will normally be of extended length (600–1000 words), be structured using headings and subheadings, and follow formal conventions, including those for referencing the sources of information.

Evidence comprises secondary data sources together with primary field and/or laboratory observations and results. Students would be expected to demonstrate logical and analytical thinking and synthesise cogent arguments in relation to a research question or hypothesis. Interpretations that students make in their written report, as well as discussion they provide and conclusions they draw, should be distinct from the data and observations on which these are based.

Non-written presentations

Non-written presentations enable the student to provide evidence of communication skills in addition to those related to the written reports and assignments. These include formal oral presentations, which permit the consideration of task-specific criteria such as audience involvement and awareness, audibility, and presentation style and structure.

Non-written presentations could include:

- a demonstration of a practical technique with accompanying oral presentation
- the development of a map, model, video, computer simulation, web page, PowerPoint presentation, or poster
- an oral presentation, typically 5–8 minutes in duration in Year 12
- a seminar presentation, typically 5–8 minutes in duration in Year 12, followed by a question-and-answer segment with the audience
- a forum in which an issue is formally evaluated using key data
- a role-play followed by an out-of-role discussion with the audience of the rationale and key items of evidence
- real-life situations such as student presentations to employers or community organisations.

Tasks related to extended investigations other than those based in the laboratory or field

Extended investigations other than those that are field-based or laboratory-based can demonstrate all of the objectives indicated in section 4 except those related to implementing investigations in field and laboratory settings and the collection of primary data.

Examples of extended investigations of this nature include case studies of major earth resources outside the local area, and research projects for which primary data may be inapplicable or difficult to collect, for example:

- major geological theories and their historical development
- topics relating to space or the Earth's interior
- studies of extinct life forms such as dinosaurs
- geohazard investigations.

The outcomes of extended investigations undertaken outside the laboratory or field may be presented as a written response and/or a non-written presentation. Although primary data will not have been collected, the means of assessment will be similar to those for extended laboratory-based or field-based investigations.

Written tests

Written tests commonly include quantitative and qualitative tasks that allow students to demonstrate their knowledge, conceptual understanding and application of earth science. It is expected that these tests would enable students to demonstrate their knowledge, understanding and application in a range of simple-to-complex situations, including those that are unrehearsed.

Written tests can include:

- questions requiring definitions or a one-word answer; multiple-choice questions
- objective and/or short-answer questions
- questions requiring reasoned answers
- questions requiring extended answers
- practical exercises using mineral, rock or fossil samples, maps, images, graphs, tables, diagrams, data
- questions requiring a response to a stimulus.

Test items that incorporate stimulus material and related specific questions represent a form of assessment that is highly suited for demonstrating students' understanding of scientific concepts. Students can demonstrate higher-order cognitive processes where questions require them to interpret, analyse and evaluate the material. The responses required may vary in form and length. Stimulus materials may take a wide variety of forms including:

- maps, cross-sections, diagrams, images, drawings, models
- tables, graphs, charts, statistics, brochures
- extracts from scientific articles
- media articles, reports, advertisements
- field or laboratory data
- field and laboratory equipment
- computer software and Internet sites
- case studies.

8.5 Authentication of tasks

To attest that the response to a task is genuinely that of the student, procedures such as the following are suggested:

- the teacher monitors the development of the task by seeing plans and a draft of the student's work
- the student produces and maintains documentation of the development of the response
- the student acknowledges all resources used (this will include text and source material and the type of assistance received)
- the school develops guidelines and proformas for students in relation to both print and electronic source materials/resources, and to other types of assistance, including human resources, that have been accessed.

8.6 Exit levels of achievement

On completion of the course of study, judgments made about student achievement in the three criteria of 'Knowledge, conceptual understanding and application', 'Working scientifically' and 'Using information scientifically' contribute to the exit level of achievement.

The school must award an exit standard for each of the three criteria, based on the principles of assessment described in this syllabus. The criteria and standards are derived from achievement in all of the general objectives and are described in section 8.3. In allocating a standard for each criterion, the majority of descriptors that best portray the student's achievement should be selected.

The exit standards will then be used to determine each student's exit level of achievement. The three criteria are of equal importance in making these judgments.

A student's exit level of achievement will be in one of five categories:

- Very High Achievement
- High Achievement
- Sound Achievement
- Limited Achievement
- Very Limited Achievement.

Table 8.2 indicates the minimum requirements for awarding the exit levels of achievement.

Table 8.2: Minimum requirements for exit levels of achievement

Very High Achievement	Standard A in two criteria and no less than Standard B in the third criterion.
High Achievement	At least Standard B in two criteria and no less than Standard C in the third criterion.
Sound Achievement	At least Standard C in two criteria and no less than Standard D in the third criterion.
Limited Achievement	At least Standard D in two criteria.
Very Limited Achievement	Two Standard E results.

8.7 Verification folio requirements

Evidence of each student's achievement of the general objectives will be contained in a student folio used to validate judgments on exit levels of achievement. Verification folios are natural extensions of folios compiled by students with their teachers. They are compiled in accordance with the Board's assessment policy. Accordingly, the verification folio must include work that represents a balanced range of assessment tasks and conditions as specified in the work program.

A verification folio is compiled over time and should comprise a genuinely representative sample of a student's work and standard of achievement across the general objectives. The folio should permit the student to demonstrate achievement across the exit criteria and standards.

Schools must ensure that the verification folios presented in the October of Year 12 contain all summative assessment instruments and corresponding student responses upon which judgments about interim levels of achievement have been made to that time. The material contained must be sufficient to provide evidence of each student's achievement of the general objectives in order to validate judgments made on exit levels of achievement. The minimum and maximum number of assessment instruments are stipulated below. Collectively, these must adhere to the underlying principles of assessment outlined in section 8.1.

Verification requirements

An individual student folio submitted for verification in October must contain:

- a minimum of **six** and a maximum of **ten** assessment tasks. These are to include at least one task undertaken in Year 12 from each of the four assessment categories outlined in 8.4:
  - tasks related to short laboratory-based or field-based investigations
  - tasks related to extended laboratory-based and/or field-based investigations
  - tasks related to extended investigations other than those based in the laboratory or field
  - written tests
- documentation of any spoken tasks included in the folio
- a student profile detailing the pattern of achievement in the summative tasks.

Students' achievements in the separate criteria are to be recorded in a student profile so that students are provided with useful feedback. The methods of recording and the frequency with which records will be updated should be shown on a student profile. The student profile must be congruent with the assessment overview. A student profile is best presented in graphical form.

9 WORK PROGRAM REQUIREMENTS

The work program is a formal expression of the school's interpretation of this syllabus. It has three primary functions. First, it provides guidance to the teachers of the subject on the nature and requirements of the Earth Science program at the school. Second, it provides similar guidance to the school's students and their parents, in relation to the subject matter to be studied and how achievement of the course objectives will be assessed. Third, it provides a basis for accreditation with the Board for the purposes of including students' results for the subject on the Senior Certificate.

This section provides a summary of elements that must be dealt with before accreditation can occur.

A work program in Earth Science must include the following elements:

Table of contents

A view of science and science education

Rationale

Educational equity

Global aims

General objectives

Learning experiences

Course organisation

Assessment

Resources

Table of contents

Pages and sections in the work program should be numbered, and these numbers reflected in the Contents.

A view of science and science education

A work program should include a statement regarding a view of science and science education. The statement from the syllabus can be used.

Rationale

The rationale must provide the justification for incorporating this course of study in the curriculum of the target student population. This must be derived principally from the syllabus statement. It should also detail particular features of the school and its student population that influence the course.

Educational equity

An educational equity statement must show how the school intends to satisfy the requirements of the ministerial statement on educational equity (see section 10).

Global aims

Global aims listed in the syllabus (section 3) must be included in a work program. Any special aims identified by a school may be included to take account of the particular circumstances of the school and its student population.

General objectives

The general objectives of the syllabus (section 4) are a mandatory aspect of a work program. They should take account of the particular circumstances of the school and its student population.

Learning experiences

A broad range of learning experiences should be offered to students to promote the general objectives (see sections 5 and 7). A list of learning experiences relevant to the study of earth science should be listed in the work program. Statements regarding learning experiences and the key competencies, effective use of language and quantitative concepts and skills should also be provided.

Information regarding field and practical work should be provided in this section (see section 5.6). The number of days devoted to field work over the two years of the course must be stated. A general statement regarding the types of learning experiences that will be used to develop practical work should also be provided.

The workplace health and safety statement (see section 5.7) should be included.

Course organisation

Each of the major topics of the syllabus identifies the core areas of study. Together, these core areas of study must occupy at least 145 hours of a two-year course of study. The remaining 75 hours should be devoted to either:

- some of the suggested elective areas of study, or
- more in-depth treatment of aspects of the core areas of study.

Elective areas of study or more in-depth treatment of core areas identified in a work program constitute significant aspects of the course of study and must be assessed accordingly.

A course of study must be based on a sequence of planned units of work designed by the school. A unit of work may consist of any one of the following:

- core area of study of major topic(s) only
- core area of study of major topic(s) plus elective chosen by the school
- elective area of study only.

A school may choose to structure the course so that the topics are incorporated into units of work in a developmental manner or so that they make up semester units. In either case, the work program must clearly indicate the structure of the course.

The following specific information about each unit must be included in the course organisation section of the work program.

Identification and summary of the units of work

Course outline

This subsection provides information about how the time requirements of the syllabus will be met. The style of course outline used will depend on the composition of the units of work. Tables 9.1 and 9.2 are two different examples of a course outline.

Table 9.1: Sample course outline showing time allocation for a course dealing with major topics and electives together

Units of work	Introduction and major topics										Total hours/ unit
	Intro-ductory topic		Major topic 1		Major topic 2		Major topic 3		Major topic 4		
	*C	El	C	El	C	El	C	El	C	El	
1											
2											
3											
Sem.1											55 min.
4											
etc.											

*C — core. El — elective.

Table 9.2: Sample course outline showing time allocation for course dealing with major topics as discrete units of work

Introduction and major topics		Semesters				Total hours
		1	2	3	4	
Introduction to Earth Science	Core					
Our earth and its systems	Core					
	Elective					
Hazardous earth processes and materials	Core					
	Elective					
Earth resources and human impact on the environment	Core					
	Elective					
Our earth in space and time	Core					
	Elective					
Total hours						

Table 9.1 would be useful for a course of study in which any particular unit of work deals with more than one of the major topics, or is comprised solely of elective material. Table 9.2 would be useful for schools that decide to teach the major topics as semester units of work.

Coverage of general objectives

Each general objective is of equal importance and should be developed in a balanced way over the two-year course of study. A single unit of work does not need to cover all the general objectives. A completed table similar to table 9.3 should be included in the work program to indicate which of the general objectives are developed in specific units of work. At the same time, the table should also demonstrate the balanced development of all the general objectives over the duration of the course.

Table 9.3: Sample general objectives coverage template

General objectives		Units of work						
		1	2	3	4	5	6	...
Knowledge, conceptual understanding and application	to recall knowledge							
	to understand concepts							
	to apply knowledge and concepts							
Working scientifically	to recognise problems or issues							
	to plan investigations							
	to identify and use scientific techniques for laboratory and field settings							
	to collect and organise data							
	to assess the validity of qualitative and/or quantitative data							
Using information scientifically	to interpret							
	to generalise and synthesise							
	to draw and evaluate conclusions							
	to present information in a variety of modes and forms							

Unit outline

The unit outline should include the objectives specific to each unit of work. These can simply be an expression of the general objectives contextualised for the particular unit of work. Learning experiences and resources relevant to specific units of work should also be listed in this subsection.

Assessment plan

The school assessment plan must adhere to the assessment principles outlined in section 8.1. It must include an assessment overview (see table 9.4) indicating the following:

- the approximate duration and timing of each assessment instrument and the unit(s) that it relates to
- the relationship between assessment tasks and the general objectives (see table 9.3)
- the types of instruments employed (refer section 8.4), the task-specific criteria and standards to be used for assessing student achievement on each, and how the tasks will be used in the summative assessment program—a variety of assessment instruments must be used and must include the task types specified in section 8.4
- an explanation of how the school has ensured student ‘ownership’ and authorship of the assessment tasks included (refer section 8.5).

To accommodate students who exit early from courses of study, assessment in each semester should cover all criteria:

- Knowledge, conceptual understanding and application
- Working scientifically
- Using information scientifically.

The emphasis placed on the criteria and their contribution to exit levels of achievement may vary throughout different semesters depending on the type of course offered.

The degree of contribution of assessment information at exit from each criterion should be approximately equal.

The work program should clearly identify the elements of the course that are revisited and how the fullest and latest information supersedes the earlier information.

The student folio for October verification must contain at least one of each of the types of assessment tasks specified in section 8.4 and undertaken in Year 12. Collectively, these assessment instruments must cover the full range of dimensions in the three criteria, be sufficient to enable valid judgments of student achievement, and reflect a suitable level of difficulty and degree of discrimination.

At least one significant summative assessment instrument must be included in the assessment program after the October verification.

Table 9.4: Sample assessment overview (incomplete example)

School topics	Assessment instruments and timing	Approx. duration and/or length	Knowledge, conceptual understanding and application	Working scientifically	Using information scientifically
Introductory units 1, 2	Report mid-semester 1	500 words	✓	✓	✓
Units 3-4	Oral May	15 min.			✓
Unit 10	Test July	30 min.	✓		
Unit 11-15	Test mid-semester 4	45 min.	✓	✓	
October verification					

Table 9.5: Sample general objectives and assessment match

This table illustrates the way the general objectives in section 4 are assessed by the various assessment tasks outlined in section 8.3 for a particular course of study.

General objectives		Assessment tasks						
		1. Investigation of the local weather conditions (SFL)	2. Research assignment—earth cycles. (EI)	3. Test 1 (WT)	4. Seminar presentation (EI)	5. Geohazards Problem-solving exam (WT)	6. Extended environmental monitoring project (EFL)	7. Stimulus-Response test (WT)
Knowledge, conceptual understanding and application	to recall knowledge			✓	✓	✓		
	to understand concepts			✓	✓	✓		✓
	to apply knowledge and concepts			✓	✓	✓		✓
Working scientifically	to recognise problems or issues	✓		✓		✓	✓	
	to plan investigations	✓		✓			✓	
	to identify and use scientific techniques for laboratory and field settings	✓	✓		✓	✓	✓	
	to collect and organise data	✓	✓	✓		✓	✓	✓
	to assess the validity of qualitative and/or quantitative data	✓		✓		✓	✓	✓
Using information scientifically	to interpret	✓	✓	✓		✓	✓	
	to generalise and synthesise	✓	✓	✓		✓	✓	✓
	to draw and evaluate conclusions	✓	✓	✓		✓	✓	✓
	to present information in a variety of modes and forms	✓	✓	✓			✓	✓

SFL — Short Field or Laboratory task. EFL — Extended Field or Laboratory task.
EI — Extended Investigation (non field/laboratory-based). WT — Written test

The work program must include two sample assessment tasks—one for a field-based investigation, the other for a non–field-based investigation. Criteria sheets and standards schema for these tasks must be provided. The sample tasks and their associated criteria and standards should be included in an appendix.

Authentication of tasks

The work program must include an explanation of how the school ensures student ‘ownership’ and authorship of assessment tasks (see section 8.5).

Exit levels of achievement

The work program should include a copy of the standards associated with the exit criteria (see table 8.1).

Determination of exit levels of achievement

The work program must include a clear explanation of how exit levels of achievement will be determined (see section 8.6). Table 8.2 indicates the minimum requirements for awarding the exit levels of achievement and should be included in the work program.

For clarity, a sample student profile should be included. This should provide a clear indication of the method of determining levels of achievement. The sample profile should be included in an appendix.

Resources

This section provides details of the resources that are needed for carrying out the work program.

Summary

A work program in Earth Science must include at least the following elements:

Section heading	Elements	Syllabus reference
A view of science and science education	Inclusion of the syllabus statement.	Section 1
Rationale	Syllabus emphasis and school reasons for offering Earth Science in the curriculum.	Section 2
Educational equity	Commitment to syllabus requirements.	Section 10
Global aims	Inclusion of syllabus global aims and any special aims identified by the school.	Section 3
General objectives	Inclusion of syllabus general objectives and any general objectives identified by the school.	Section 4
Learning experiences	Identification of the broad range of learning experiences selected for each unit of work.	Sections 5 and 7
	Inclusion of statements regarding learning experiences and the key competencies, effective use of language and quantitative concepts and skills.	Section 5
	Indication of the magnitude and scope of field and practical work in the course.	Section 5.6
	Inclusion of statements regarding Workplace Health and Safety.	Section 5.7
Course organisation	Identification and summary of the units of work.	Section 6
	Course outline indicating the sequence of units of work.	Tables 9.1 and 9.2
	Identification of general objectives that are relevant to each unit of work.	Table 9.3
	Expression of the contextualised general objectives that are relevant to each unit of work.	Sections 4 and 6
	Listing of unit specific learning experiences.	Sections 5 and 7
	Listing of resources specific to particular units of work.	Sections 5.5 and 11
Assessment plan	An indication of tasks, timing, duration/length and objectives assessed. The assessment plan should reflect the stated course outline.	Section 8 and table 9.4
	A table illustrating the way the general objectives are assessed by the various assessment tasks.	Table 9.5
	Two sample assessment tasks—one for a field-based investigation, the other for a non–field-based investigation. Criteria sheets and standards schema should be included. These should be included in the appendices.	
	Identification of verification folio requirements with sufficient summative data in each criterion ensured. See section 8.7	Section 8.7
Authentication of tasks	Explanation of how student ownership and authorship of assessment tasks is ensured.	Section 8.5
Exit levels of achievement	Inclusion of syllabus criteria and standards.	Table 8.1 and section 8.6
Determination of exit levels of achievement	Explanation of how exit levels of achievement are determined. See section 8.6	Section 8.6, table 8.2
	Inclusion of sample student profile. This should be included in an appendix.	
Resources	A general list of the resources to be used as part of the learning experiences. This will supplement the unit-specific resources in the course outline.	

10 EDUCATIONAL EQUITY

Equity means fair treatment of all. In developing work programs from this syllabus, schools are urged to consider the most suitable means of incorporating the following notions of equity.

Schools need to provide opportunities for all students to demonstrate what they know and what they can do. All students, therefore, should have equitable access to educational programs and human and material resources. Teachers should ensure that the particular needs of the following groups of students are met: female students; male students; Aboriginal students; Torres Strait Islander students; students from nonBEnglish-speaking backgrounds; students with disabilities; students with gifts and talents; geographically isolated students; and students from low socioeconomic backgrounds.

The subject matter chosen should include, where appropriate, the contributions and experiences of all groups of people. Learning contexts and community needs and aspirations should also be considered when selecting subject matter.

In choosing suitable learning experiences teachers should, where possible, introduce and reinforce non-racist, non-sexist, culturally sensitive and unprejudiced attitudes and behaviour. Learning experiences should encourage the participation of students with disabilities and accommodate different learning styles.

It is desirable that the resource materials chosen recognise and value the contributions of both females and males to society and include the social experiences of both sexes. Resource materials should also reflect the cultural diversity within the community and draw from the experiences of the range of cultural groups in the community.

Efforts should be made to identify, investigate and remove barriers to equal opportunity to demonstrate achievement. This may involve being proactive in finding out about the best ways to meet the special needs, in terms of learning and assessment, of particular students.

The variety of assessment techniques in the work program should allow students of *all* backgrounds to demonstrate their knowledge and skills in a subject in relation to the criteria and standards stated in this study area specification. The study area specification criteria and standards should be applied in the same way to all students.

Teachers may find the following resources useful for devising an inclusive work program:

Australian Curriculum, Assessment and Certification Authorities 1996, *Guidelines for Assessment Quality and Equity* 1996, Australian Curriculum, Assessment and Certification Authorities,, available through QBSSSS, Brisbane.

Department of Education, Queensland 1991, *A Fair Deal: Equity Guidelines for Developing and Reviewing Educational Resources*, Department of Education, Brisbane.

Department of Training and Industrial Relations 1998, *Access and Equity Policy for the Vocational Education and Training System*, DTIR, Brisbane.

[Queensland] Board of Senior Secondary School Studies 1994, *Policy Statement on Special Consideration*, QBSSSS, Brisbane.

[Queensland] Board of Senior Secondary School Studies 1995, *Language and Equity: A discussion paper for writers of school-based assessment instruments*, QBSSSS, Brisbane.

[Queensland] Board of Senior Secondary School Studies 1995, *Studying Assessment Practices: A resource for teachers in schools*, QBSSSS, Brisbane.

RESOURCES

The following list of possible resources for schools is divided into types of material. There are instances of incomplete references, but it was thought better to include them as they are than to delete them just because they are not complete.

Books and other printed texts

Workplace Health and Safety Act 1995 (Qld)

Workplace Health and Safety (Hazardous Substances) Compliance Standard 1997 (Qld)

Aplin, G. and Mitchell, P. 1998, *Global Environmental Crises: An Australian perspective*, Oxford University Press, Melbourne.

Beatty J. K. and Chaikin, A. 1999, *The New Solar System*, Cambridge University Press.

Bolt, B.A. 2000, *Earthquakes*, Freeman.

Butcher, S. S. and others 1992, *Global Biogeochemical Cycles*, Academic Press, London.

Conacher, A. and Conacher, J. 1995, *Rural Land Degradation in Australia*, Oxford University Press, Melbourne.

Crowder, R. B. 2000, *The Wonders of the Weather*, AusInfo Press, Canberra.

Dawes, G., Northfield, P. and Wallace, K. 1998, *Astronomy 1998: A practical guide to the night sky for 1998* (Eastern Australian Edition), Quasar Publishing, Strathfield. (A new copy is available each year.)

Dietrich, R. V. and Skinner, B. J. 1990, *Gems, Granites and Gravels: Knowing and using rocks and minerals*, Cambridge University Press, Cambridge.

Dolan, C. 1994, *Hazard Geography*, Longman, Melbourne.

Doyle, P. 1996, *Understanding Fossils: An introduction to invertebrate palaeontology*, John Wiley, New York.

Education Queensland, *Aspects of Science Management: A reference manual for schools.*

Education Queensland, *Workplace Health and Safety Guidelines—Curriculum—Core Module*.

Ellyard, D. 1994, *Droughts and Flooding Rains*, Angus and Robertson, Sydney.

Environmental Science Project Committee (Chair: Craig D. P.) 1994, *Environmental Science*, Australian Academy of Science, Canberra.

Emiliani, C. 1992, *Planet Earth and Cosmology, Geology, and the Evolution of Life and Environment*, Cambridge University Press, Cambridge.

Goudie, A. 1999, *The Human Impact on the Natural Environment*, Blackwell, Oxford.

Hamblin, W. K. 1995, *Earth's Dynamic Systems*, Prentice Hall Engineering, Science and Math., New Jersey.

Haynes, R. and others 1996, *Explorers of the Southern Sky: A history of Australian astronomy*, Cambridge University Press, Cambridge.

Keller, E. A. 1999, *Environmental Geology*, Prentice Hall Engineering, Science and Math., New Jersey.

Lang, K. and Whitney, C. 1991, *Wanderers in Space*, Cambridge University Press, Cambridge.

Lapidus, D. F. 1990, *Collins Dictionary of Geology*, Collins, London.

Lewis, G. B. 1994, *Earthquakes: Student activities*, Australian Geological Survey Organisation, Canberra.

Lewis, G. B. 1994, *Plate Tectonics: Teacher notes and student activities*, Australian Geological Survey Organisation, Canberra.

Lewis, G.B. 1994, *Silicate Chemistry: Teacher Notes and Student Activities*, Australian Geological Survey Organisation, Canberra.

Lewis, G.B. 1994, *: Time and Life: Teacher Notes and Student Activities*, Australian Geological Survey Organisation, Canberra. Lewis, G.B. 1994, *Volcanos: teacher Notes and Student Activities*, Australian Geological Survey Organisation, Canberra.

Lutgens, F.K. and Tarbuck, E.J. 2000, *The Atmosphere: An Introduction to Meteorology*, Prentice Hall, New Jersey.

MacKenzie, F.T. 1998, *Our Changing Planet: an Introduction to Earth System Science and Global Environmental Change*, Prentice Hall Engineering, Science and Math., New Jersey.

Milner, R. 1990, *The Encyclopedia of Evolution*, Facts on File, New York.

Murck, B.W. 1996, *Environmental Geology: Instructors Manual and Test Bank*, John Wiley, New York.

Murck, B.W., Skinner, B.J. and Porter, S.C. 1997, *Dangerous Earth*, John Wiley, New York.

Murck, B.W., Skinner, B.J. and Porter, S.C. 1996, *Environmental Geology*, John Wiley, New York.

Montgomery, C.W. 1997, *Environmental Geology*, Wm C Brown, Dubuque, Iowa.

Norman, D. 1991, *Dinosaur*, Prentice Hall.

Pinna, G. 1995, *The Illustrated Encyclopaedia of Fossils, Facts on File*, New York.

Skinner, B.J. and Porter, S.C. 1999, *The Blue Planet: An Introduction to Earth Systems Science*, John Wiley, New York.

Skinner, B.J. and Porter, S.C. 1995, *Dynamic Earth: Introduction to Physical Geology*, John Wiley, New York.

Tarbuck, E.J. and Lutgens, F.K. 1999, *Earth Science*, Prentice Hall Engineering, Science and Math, New Jersey.

Computer software

Drifting Continents. Geoimages, 700 Tanglewood, Arlington, Texas. [Animation of the last 600 million years of plate tectonics movement, in 10 million year increments.]

Geologic Hazards. CD-ROM. Volume 1: Earthquakes. Volume 2: Volcanoes and other phenomena. Available from the National Geophysical Data Centre, code E/GC, 325 Broadway, Boulder, Colorado.

Redshift 2. CR ROM (Macintosh; Windows)

Small Blue Planet—The Electronic Satellite Atlas. CD ROM. Now What Software, San Francesco, California. [Various images from space.]

The Geology of Australia. CD-ROM (Windows). CD Solutions, 5th Floor, 225 Miller St, North Sydney NSW 2060. [Comprehensive introduction to the Earth Sciences.]

Theory of Plate Tectonics. (Macintosh; Windows). Tesa Graphic Arts Inc, 15 Nexus Lane, Tijeras, New Mexico. [Animation of aspects of plate tectonics.]

Topographic Maps. Tesa Graphic Arts Inc, 15 Nexus Lane, Tijeras, New Mexico. [Various aspects of maps.]

Internet sites

These sites may prove helpful sources of information. The inclusion of a site does not imply endorsement of any kind of the contents of the site.

General

Australian Academy of Science: http://www.science.org.au/

Australian Broadcasting Corporation Science page: http://www.abc.net.au/science/

Australian Geological Survey Organisation: http://www.agso.gov.au/

British Broadcasting Corporation News Science & Technology: http://news.bbc.co.uk/hi/english/sci/tech/default.stm

CNN*: http://www.cnn.com/index.html

Discovery.com http://www.discovery.com/news/earthalert/earthalert/.html

Earth Introduction: http://www.solarviews.com/eng/earth.htm

Encyclopaedia Britannica: http://www.britannica.com/

Exploratorium: http://www.exploratorium.edu/

Geological Society of Australia: http://www.gsa.org.au/

Geology and the Geosciences, History of: http://geoclio.st.usm.edu/

Planet Diary—Prentice Hall: http://www.phschool.com/sf/planetdiary/

Science Daily Magazine: http://www.sciencedaily.com/

Earth Today, The: http://www.geologylink.com/

National Academies of Science, The (US): http://www.nas.edu/

U.S. Geological Survey: http://www.usgs.gov/

Virtual Science Centre: http://www.sci-ctr.edu.sg/

*With CNN and similar websites, follow space, science, nature, technology etc links as desired.

Our Earth and its Systems

Asteroid and Comet Impact Hazards: http://impact.arc.nasa.gov/index.html

Craters—Terrestrial Impact Craters Slide Set: http://cass.jsc.nasa.gov/publications/slidesets/impacts.html

Dynamic Earth, This: http://pubs.usgs.gov/publications/text/dynamic.html

El Niño Theme Page: http://www.pmel.noaa.gov/toga-tao/el-nino/nino-home.html

Glacier: http://www.glacier.rice.edu/

Glaciers, All about: http://www-nsidc.colorado.edu/glaciers/

Global Warming International Center: http://www.globalwarming.net/

Global Warming Site, EPA: http://www.epa.gov/globalwarming/

Greening Earth Society: http://www.greeningearthsociety.org/

NOAA Paleo Global Warming Home:
http://www.ngdc.noaa.gov/paleo/globalwarming/home.html

Ocean Planet Homepage—Smithsonian Institution:
http://seawifs.gsfc.nasa.gov/ocean_planet.html

Plate Tectonics, Introduction to:
http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/introduction.html

Smithsonian Gem & Mineral Collection: http://galaxy.einet.net/images/gems/gems-icons.html

Hazardous Earth Processes and Materials

Cascades Volcano Observatory: http://vulcan.wr.usgs.gov/

Flood, NOVA Online: http://www.pbs.org/wgbh/nova/flood/

Geology of Iceland: http://norvol.hi.is/jar.html

Hawaiian Volcanoes: http://www.solarviews.com/eng/hawaii.htm

Incorporated Research Institutions for Seismology (IRIS):
http//www.iris.washington.edu/EandO/

Queensland University Advanced Centre for Earthquake Studies:
http://shake2.earthsciences.uq.edu.au/~quakes/home_page.html

Recent Seismic Activity: http://hoshi.cic.sfu.ca/quake.html

VolcanoWorld: http://volcano.und.edu/

World-Wide Earthquake Locator, The: http://www.geo.ed.ac.uk/quakes/quakes.html

Earth Resources and Human Impacts on the Environment

Australian Conservation Foundation: http://www.acfonline.org.au/

Club of Rome : http://www.clubofrome.org/

Environmental Ed. Bureau of Land Management:
http://www.blm.gov/education/teacher.html

Fossil Fuels: http://www.fossilfuels.org/

Greenpeace International Homepage: http://www.greenpeace.org/

Ocean98 Homepage: http://www.ocean98.org/ocean98.html

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