Earth and Environmental Science Module 8 – resource management

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## Course overview

During the teaching of the Year 11 course, it is expected that students have been provided opportunities to develop all seven of the Working Scientifically skills. Ideally, these would be embedded into the teaching of the Knowledge and Understanding components of the course. In preparation for the Year 12 course, students in Year 11 could benefit from work that engages them in the following areas:

* Propose hypotheses and design and conduct valid and reliable practical investigations that enable the collection and analysis of data. Teachers should look for opportunities to engage students in these beyond where the syllabus explicitly states the need to conduct a practical investigation.
* Construct and analyse graphical data (particularly line graphs) for both primary and secondary sources. This will be essential for an understanding of a changing Earth over time, including geological events and climate changes.
* Assess the uses, benefits and limitations of various types of scientific models. Many of the processes that occur on the Earth are invisible (such as convection currents beneath the surface) or happen very slowly (for example movement of tectonic plates, the process of evolution over geological time). Models help people to better understand these types of processes.
* Determine the impacts of various technologies in improving the understanding of various concepts, including events that have occurred in the ancient past and potentially those that will occur in the future.
* Collect relevant information from secondary sources and determine the accuracy, reliability and validity. Many of the investigations will require students to obtain information from the Internet or other sources. Students will benefit from learning how to access the correct sort of information and appreciate how new evidence can change prevailing views about aspects of Earth and Environmental Science.
* Understand the major features of the Earth’s spheres and the relationships between each one. This is an underlying theme the spans both the Year 11 and Year 12 courses. It is essential that students understand the components of each one and can appreciate how changes in one can impact on the others.
* Develop skills in numerical scaling, with specific reference to periods of geological time. It is expected that students have developed a good understanding of the divisions of the geological timescale.
* Develop an understanding of relative and absolute dating of rocks and fossils. Using and constructing stratigraphic diagrams where appropriate and numeracy activities to build skills in applying radiometric dating principles.
* Construct simple diagrams of various processes, including tectonic boundary relationships and the geological and/or volcanic features associated with them, the formation of earthquakes at fault zones and the movement of warm and cool water in ocean currents across the Earth.
* Develop a deep understanding of the impacts of humans on the Earth and an appreciation of the importance of sustainability in its various forms. This includes understanding the roles of Aboriginal and Torres Strait Islander Peoples in caring for Country and Place.

## Module summary

This module investigates the extraction and use of renewable and non-renewable resources in Australia, with a strong focus on mining and rehabilitation. Strategies, including appropriate planning and engagement with Aboriginal and Torres Strait Islander Peoples, and management of wastes as a result of these activities is a focus. Sustainable options for the future are explored, which gives opportunities to discuss other impacts in the hydrosphere and biosphere. A strong focus is given to stakeholders in resource management particularly Aboriginal and Torres Strait Islander communities and other community and government organisations.

## Big ideas

* The Earth’s resources are not infinite and there are consequences for their extraction and use for the atmosphere, geosphere, hydrosphere and biosphere.
* Australia is rich in non-renewable resources and extracts these resources for use, but not necessarily in sustainable ways. It is extremely important that natural resources are managed sustainably.
* Human activities produce various types of waste that can impact on the environment. These wastes need to be managed effectively.
* Aboriginal and Torres Strait Islander Peoples play an important role in the management of resources, the environment and sustainability and their engagement is sought after by mining operations. An understanding of the cycles and variations in the natural world are integrated into the way that people control their exploitation of natural resources and these understandings are communicated and recorded through oral history traditions in Aboriginal and Torres Strait Islander communities (see resources).

## Relationship to other modules

Some areas to activate prior learning could include:

* Discussion of the location and extraction methods for non-renewable geological resources (Module 1).
* How human activities, including land and water use affect the surrounding environment and the need to manage these effectively (Module 4).

## Core concepts

Looking at the inquiry questions within this module, the key concepts that students need to develop a deep understanding of can be broken down. These include:

* Australia is rich in natural resources, some of which are renewable and some non-renewable. The extraction, use, impacts (on Aboriginal cultural sites, the environment and the land) and management of various types of renewable and non-renewable resources is important for a sustainable future.
* Various types of wastes are produced by human activities, including from resource extraction and usage. These need to be managed effectively for a sustainable future.
* The concept of sustainability is as an overarching idea for the future of our Earth, and different groups within society play an important role, including Aboriginal and Torres Strait Islander communities.
* If resources aren’t managed sustainably, there are significant consequences for the biosphere (habitat loss), hydrosphere (water pollution) and other environments.

## Opportunities for extending concepts

These are some suggested pathways students could investigate to allow for a deeper appreciation of the inquiry questions within this module:

* Examine Aboriginal and Torres Strait Islander perspectives on resource management, particularly evidence for agricultural activities, Native Title and historical movements to preserve lands.
* Research the mining of iron oxide (as found in banded iron formations) as a non-renewable resource to make steel. Additionally, research Aboriginal use of iron oxide as a source of pigments (for example to make ochre) for various purposes (see resources).
* Investigate the benefits and limitations of agreements between Australia and other countries (such as China) to buy and process waste.
* Assess the media coverage of recent changes to recycling in NSW such as the Return and Earn program.
* Analyse data that compares the volume of materials put out for recycling by households against how much is actually recycled into other useful products.
* Analyse and compare Australia’s sustainability initiatives (for example recycling habits) with that of other countries, such as Japan, Germany, Scandinavian countries.
* The syllabus asks students to outline management options of solid waste, however, there are management options for other forms of waste that could be investigated as part of the greater inquiry question which could provide excellent links to other modules.
* Investigate methods of solid or liquid waste treatment in NSW (or compare coastal and inland regions) and their effectiveness at reducing pollution in the environment.
* Examine case studies where overharvesting in fisheries in Australia have led to ecosystem and economic problems.
* Examine the concept of Ecologically Sustainable Development in detail with reference to issues in the local environment.
* Examine how modern landfill sites are being designed worldwide to have reduced environmental impact.
* Research current Aboriginal involvement in scientific research, in particular the impacts of fire and the management of bushfires and the management of wild harvest species in fisheries. Detail how these activities reflect a different perspective and methodology regarding scientific research.

## Alternative conceptions and misconceptions

* The experience of students in their own living context may differ greatly across other parts of Australia (and the world). Teachers should be encouraged to build student appreciation of their local context with regards to many aspects of this module, particularly sustainability. For example, not all places in Australia and the world have access to waste management services.
* Waste comes from many different sources, including homes, businesses and industries and in different forms, including solid, liquid and gases.
* Sustainability is not simply a “green” concept that only focuses on environmental protection–sustainability is a concept used in many facets of life, particularly economics. An opportunity to address definitions of sustainability is provided in the syllabus.
* The terms “sustainable” and “renewable” should not be used interchangeably. For example, there are renewable resources that can be extracted but not necessarily sustainably. This may need to be made clear by the teacher.
* Forms of waste may be biodegradable but are not necessarily eco-friendly. When wastes bio-degrade they release methane, a greenhouse gas. This concept could be investigated thoroughly in the third inquiry question.
* Students may need to be specifically taught that the terms “Country” and “Place” used in the syllabus have a different meaning than in the English language (see NESA definitions in syllabus glossary).
* There is a focus on traditions and processes used by, and impacts on, Aboriginal and Torres Strait Islander Peoples. For example, Aboriginal people managed land for their own subsistence and acted to produce biodiverse, productive and useful landscapes through fire, cultural practices and hunting prohibitions, and renewal practices including replanting species. Accessing appropriate and reliable information might prove somewhat challenging and teachers may need to use a variety of strategies to access it.
* Aboriginal and Torres Strait Islander Peoples’ knowledge systems do not make a distinction between the material and spiritual worlds and much practical, rational and material knowledge is expressed through the interconnected relationships of stories and songlines, culture and personal responsibility. This does not lessen the importance and value of that knowledge, or the process by which it was obtained. The responsibility of the teacher is to communicate this knowledge and to not to make judgements on its meaning, but instead to provide a sense of wonder and value to the information they provide. The important fact is, that these methods of scientific inquiry enabled Australia’s first peoples to thrive on this continent for many tens of thousands of years, in good health and in a sustainable way.
* The concept of sustainability is extremely broad and perhaps misunderstood when not used in context. It is important that this is investigated from a scientific perspective and compared with non-scientific and colloquial contexts to overcome this.

## Suggested teaching strategies

Ideally, this Module would be taught directly after Module 7 due to the easy transition following students’ learning about pollution due to human activities. Human impacts on the atmosphere is covered extensively in Module 7: Climate Science in relation to greenhouse gas emissions.

Some inquiry-based learning activities that could prompt investigations and address Working Scientifically skills could include:

* Analyse maps and/or plotting data of the location of different types of resources in Australia. Students could then predict the longevity of non-renewable resources.
* Students develop their own inquiry questions into the decomposition of compost, for example, do certain food scraps decompose faster than others? Do some release more methane than others? Does composting in your garden improve plant growth?
* Students develop their own inquiry questions predicting how mining could impact upon the environment, for example does leachate from mines impact on aquatic life or on plant growth?
* Students could use the [Foot Print Calculator](https://www.footprintcalculator.org/) to prompt discussion about students’ choices, population growth and sustainability in developed and developing countries. This may be difficult at first for them to understand as they may have limited understanding of how many people in the world live in poverty and with much less than Australians.
* Analyse fisheries data to determine impacts on the biosphere, e.g. particular species are under threat, impacts of bycatch, etc. Students could develop inquiry questions into potential impacts of overfishing on other species.
* Aboriginal people consider that the mining sites they have used in prehistory have significant cultural and spiritual value. Students could research the legislation regarding mineral exploration and extraction and reflect on the conflicting value systems regarding protection of a culturally significant heritage site versus environmental remediation of mining land.
* Research and report on agreements and conflicts between mining interests and Aboriginal custodians, where conflict has been resolved versus where Aboriginal values have been ignored or degraded.
* Research the subject, pose questions and design and carry out an investigation into the viability of native grain species, for example Panicum laevinode, Panicum decompositum, Themeda triandra, Marsilea drummondii, or yams, such as Dioscorea hastifolia, Microseris lanceolate.

These are some practical investigations that may help to encourage more use of the Working Scientifically skills:

* The prescribed practical investigation into the composition of household or organisational waste provides scope for many of the Working Scientifically skills to be explored. The investigation could focus on reusable and recyclable materials and could be used to prompt or support discussion on introducing small steps to sustainability. If done in conjunction with watching [ABC War on Waste](https://iview.abc.net.au/show/war-on-waste/) this could become a depth study with real benefits for the community and could even be presented to the local council (see appendix).
* Model the scientific separation techniques used in the management of different forms of waste, for example filtration or magnetic separation. Assess the effectiveness of these models in helping students to understand the actual processes involved.
* Compare the rate of decomposition of different types of compostable materials.
* Predict and measure whether soil that has compost added has any influence on the growth of plants over time.
* Investigate whether chemicals leached from mines has an impact on the biosphere. This could potentially be done using common laboratory equipment. Students could research some of the chemicals that could be used (see appendix).
* Investigate the demand in the local area for reused or recycled materials or reusable coffee cups/water bottles. Students could conduct a survey of local cafes to see how many people use reusable coffee cups as a percentage of total take away coffees. Patrons at cafes could be surveyed. If your school has gone straw-free or encouraged a reduction in straw use this may be another area that could be surveyed. If straw-free, the money saved by the canteen could be analysed before and after emphasising the economic benefits of sustainable practices.

## Appendix 1: Effects of soil pollution investigation

### Task outline:

This task was designed to allow teachers to engage students in aspects of experimental design using the concept of pollution that relates to content in both Year 11 and Year 12. This could lead to students modelling the actual experiment shown with materials available in the laboratory.

### Task:

The diagram below shows part of an investigation into mine waste (leachate) and its effects on one species of local vegetation. The results of a trial of the effectiveness of chemical X are shown. Each of the 3 sites are in approximately equal proximity from the mine site.



Experimental setup. Image credit: NESA

Some possible inquiry-based learning questions that could be posed to students:

* Develop an inquiry question that would be suitable for this investigation.
* Explain the results as shown by the diagram above. Consider what could be different at each site to allow for different levels of growth.
* Assess errors that may have contributed to the data shown.
* Evaluate the reliability of these results.
* How could you safely access mine waste or model mine waste using chemicals found in the lab? This may require secondary source research.
* Formulate a hypothesis and describe an investigation that could test the hypothesis fairly and reliably.
* Discuss problems that may arise in the collection of data for this investigation.

Following these discussions, an actual first-hand investigation could be conducted to observe and record the impacts of such pollutants on the growth or health of plants.

## Appendix 2: Composition of waste practical investigation and assessment task

### Content outcome:

Students describe and assesses renewable and non-renewable Earth resources and how their extraction, use, consumption and disposal affect the Earth’s systems EES12-15

Outcomes referred to are from [Earth and Environmental Science Stage 6 Syllabus](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/earth-and-environmental-science-2017) © 2017 NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales.

### Working scientifically skills:

* develops and evaluates questions and hypotheses for scientific investigation EES11/12-1
* designs and evaluates investigations in order to obtain primary and secondary data and information EES11/12-2
* conducts investigations to collect valid and reliable primary and secondary data and information EES11/12-3
* selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media EES11/12-4
* communicates scientific understanding using suitable language and terminology for a specific audience or purpose EES11/12-7

### Task Outline:

This is an open-ended inquiry-based task that relates to the concept of sustainability in Module 8. It would be possible to re-work this into a depth study. Students will be analysing the economic sustainability of environmentally sustainable choices. They will be required to come up with an inquiry question and then design and carry out an investigation to understand how environmentally sustainable choices can be economically sustainable. It is important that students define these two sustainability terms and use methods to assess them both (for example monetary savings and savings to landfill contributions).

Some suggestions from areas for investigation could include:

* Plastic bag changes in grocery stores.
* Reusable coffee cups at cafes.
* Straw use at the school canteen or a local business that has gone drinking straw free.
* Bulk buying rather than buying individually pre-packaged items.
* Use of reusable nappies instead of disposables

**Step 1: Choose an area to focus on and come up with an inquiry question.**

An inquiry question is a big picture question that encapsulates a concern, problem or issue that needs to be answered. If students look in the syllabus, they will see a variety of inquiry questions within each module. The inquiry question should be used to formulate a specific aim that can answer all or part of the inquiry question.

**Step 2: Plan an investigation.**

An investigation plan requires many things:

* Background research that is evidence based and referenced.
* A clear, specific aim that seeks to answer part or all of the inquiry question.
* A hypothesis that is related to the aim and makes a link between the independent and dependent variable.
* An outline of the independent, dependent variables and a discussion of controlled variables including a rationale for methods of collecting data (either qualitative or quantitative) and how variables will be controlled.
* A list of materials and a method that is clear, concise and easily followed. In the planning stage the method can be a working document, meaning changes and edits can be made when issues arise. Remember to ensure a large enough sample size and repeat the experiment. Safety and ethical considerations must be addressed.
* If surveys are being used to collect data, they should be checked before by the class teacher to ensure appropriate questions are being asked.
* A detailed logbook is kept with dates, description of activities undertaken throughout the investigation, ideas listed and rationalised (they don’t all have to be used), prototype resources and/or pilot studies. A logbook is a type of journal that outlines everything that is done during an investigation because not all activities that the experimenter undertakes will be able to be reported on.

**Step 3: Conduct the investigation.**

The investigation should be conducted with substantial time provided to modify the investigation, analyse results and write the report. It needs to be conducted in a professional manner. If people from the community or businesses are assisting in the collection of data, then their consent should be recorded. Surveys conducted with participants need to be anonymous. All data collected should be tabulated using MS Excel or similar. The logbook should continue to be used throughout this part of the investigation to record dealings with people and businesses, any data analysis and changes to methodology and materials.

**Step 4: Write the report.**

A scientific report describes why an experiment was done, how it was done, what was found and the significance of the findings. It is a formal report that brings all aspects together. It usually includes the following sections:

* **Introduction:** a summary of background research, posing of the inquiry question, statement of the aim and hypothesis.
* **Materials and Method**: a list of the materials (including surveys or raw data from a secondary source) and a method that outlines what was done to collect data and a rationale of variables. Methods of data analysis should not be overlooked. In junior high school students may have written it in steps, like a procedure. Now it becomes appropriate to recall what was done in full paragraphs using concise language with scientific terminology where appropriate.
* **Results:** a description of the results, including tables and graphs as well as accompanying text. Students should not delve into what the data means just yet, they should only describe it.
* **Discussion:** Analysis of results can be discussed here. Students must make a clear link between their results, their inquiry question, their aim and their hypothesis. Any area that could shed doubt on their results should be discussed transparently with regards to accuracy, reliability and/or validity. These three things must be commented on. Towards the end of the discussion students should be able to make some assessment of the impact of their findings on society, whether it be a recommendation to undertake more similar research or that the investigation has supported or refuted the hypothesis. Sometimes the conclusion to an investigation will be found in the discussion as a result of this.
* **Acknowledgements**: of any people or businesses that assisted the student to produce the experiment and a brief outline of how the person/business helped.
* **References:** a list of all sources used in the investigation formatted using an acceptable method.

## Resources

* Pascoe, B. (2014). Dark Emu. Broome, Western Australia. This book attempts to address many misconceptions and myths surrounding Aboriginal Australians, particularly pre-colonial. Focus is placed on Aboriginal Peoples as effective land managers. It provides evidence through early explorer journals and is useful for building background knowledge in teachers and students. This should be used in combination with other sources to be able to cover all areas of the syllabus.
* [Environmental Education Centres](https://www.sustainableschoolsnsw.org.au/connect/environmental-education-centres) by the NSW Department of Education. These facilities may be able to assist with Aboriginal and Torres Strait Islander perspectives. The EECs can often engage with Aboriginal elders in regions of NSW that may be able to share local knowledge.
* [NSW Aboriginal Education Consultative Group (AECG](https://www.aecg.nsw.edu.au/)). When working in the field and teaching Aboriginal and Torres Strait Islander perspectives, it is important to consult with the local community and the traditional owners of the land. This website provides information around these ideas.
* [Global footprint calculator](https://www.footprintcalculator.org/) by Global Footprint Network. This can be used to prompt discussion about students’ choices, population growth and sustainability in developed and developing country. This model provides students with an output that shows how many Earth’s would be required if 7 billion people lived their lifestyle. This may be difficult at first for them to understand as they probably have little understanding of how many people in the world live in poverty and with much less than Australians.
* Documentary series [War on Waste](https://iview.abc.net.au/show/war-on-waste/) by ABC. This series investigates Australia’s waste production and discusses things we can do to improve. It could be used in conjunction with student first-hand investigations.
* [About plastics recycling](https://chemistryaustralia.org.au/programs/plasticsrecyclingfacts) factsheet by Chemistry Australia. Investigates some truths and myths about plastics recycling. This could be used as a good motivator for learning about waste management and sustainability.
* [Data sets on waste generation and resource recovery](https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2013/data-workbooks) by the Department of the Environment and Energy. These could be used to enhance students’ numeracy skills and encourage the development of further inquiry questions.
* [BioCollect](https://www.ala.org.au/biocollect/) by Water Watch. This could be used to determine if some management strategy is having a positive effect or if a management strategy may be required (such as around a stormwater drain or in comparison with a control site).
* [What is the tragedy of the commons?](https://ed.ted.com/lessons/what-is-the-tragedy-of-the-commons-nicholas-amendolare) (duration 4:58) TedEd - investigates many human impacts with good focus on the concept of overharvesting.
* [Aboriginal water values and management in the Northern Territory](https://www.youtube.com/watch?v=XMKYybtUJ-o) (duration 14:16) by CSIRO. This provides an understanding of how the cycles and variations in the natural world are integrated into the way that people control their exploitation of natural resources and how these understandings are communicated and recorded through oral history traditions.
* [Iron ore country](http://www.abc.net.au/science/articles/2010/07/14/2953402.htm) article by ABC Science. This discusses mining or iron oxide for steel production and the fact that it may soon run out. Excellent links to Module 5 with regards to deposition of the banded iron formations.
* [Iron oxide pigments](http://www.energymining.sa.gov.au/minerals/invest/mineral_commodities/iron_oxide_pigments) by Department of Energy and Mining, SA. Provides some details on the past and current use by Aboriginal Peoples of various pigments selectively to create art works and body paint.