AQA

AS
ENVIRONMENTAL SCIENCE
7446

Specification
For teaching from September 2017 onwards
For AS exams in 2018 onwards

Version 1.0 9 January 2017

Contents

Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at aqa.org.uk/7446
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose AQA for AS Environmental Science

Students who enjoy a multi-disciplinary approach to learning and have a keen interest in the sustainability of our planet will find this new specification engaging and thought provoking.

We've kept much of the popular content that we know you like and key topics include the conservation of biodiversity, water resources, global climate change and the lithosphere. With opportunities to include real life case studies in your teaching, this contemporary qualification has never been more relevant.

The new assessment structure is clear and straightforward and we've used a mixture of question styles, so that students have the best opportunity to demonstrate their knowledge and understanding.

We've ensured that the AS and A-level are fully co-teachable. The AS exams include similar questions to those in the A-level, with less difficulty, allowing for future growth.

This is a great accompaniment to A-levels in geography, biology, physics and maths and develops key skills including communication, teamwork and critical thinking.

You can find out about all our Environmental Science qualifications at aqa.org.uk/environmentalscience

1.2 Support and resources to help you teach

We've worked with experienced teachers to provide you with a range of resources that will help you confidently plan, teach and prepare for exams.

1.2.1 Teaching resources

Visit aqa.org.uk/7446 to see all our teaching resources. They include:

- flexible schemes of work to help you plan for course delivery in your own way
- specimen assessment materials that will give your students a clear idea as to what is expected in the exams
- training courses to help you deliver AQA Environmental Science qualifications
- subject expertise courses for all teachers, from newly qualified teachers who are just getting started to experienced teachers looking for fresh inspiration.

1.2.2 Preparing for exams

Visit aqa.org.uk/7446 for everything you need to prepare for our exams, including:

- past papers, mark schemes and examiners' reports
- specimen papers and mark schemes for new courses
- Exampro: a searchable bank of past AQA exam questions
- example student answers with examiner commentaries.

1.2.3 Analyse your students' results with Enhanced Results Analysis (ERA)

Find out which questions were the most challenging, how the results compare to previous years and where your students need to improve. ERA, our free online results analysis tool, will help you see where to focus your teaching. Register at aqa.org.uk/era

For information about results, including maintaining standards over time, grade boundaries and our post-results services, visit aqa.org.uk/results

1.2.4 Keep your skills up-to-date with professional development

Wherever you are in your career, there's always something new to learn. As well as subject specific training, we offer a range of courses to help boost your skills.

- Improve your teaching skills in areas including differentiation, teaching literacy and meeting Ofsted requirements.
- Prepare for a new role with our leadership and management courses.

You can attend a course at venues around the country, in your school or online – whatever suits your needs and availability. Find out more at coursesandevents.aqa.org.uk

1.2.5 Help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/7446

If you'd like us to share news and information about this qualification, sign up for emails and updates at aqa.org.uk/from-2017

Alternatively, you can call or email our subject team direct.

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2 Specification at a glance

This qualification is linear. Linear means that students will sit all their exams and submit all their non-exam assessment at the end of the course.

2.1 Subject content

Working scientifically: opportunities for skills development and independent thinking

At the end of each subject content section, there are details of opportunities for students to develop scientific skills within the context of that topic.

These include:

- skills related to the methodologies and sampling techniques that students must gain through first-hand experience
- skills related to research methods that can be gained through class-based and/or practical activities.

2.2 Assessments

Paper 1
What's assessed • The living environment • The physical environment • Research methods Students will be expected to draw on knowledge and understanding of the entire course of study to show a deeper understanding of the interconnections between topics.
How it's assessed • Written exam: 3 hours • 120 marks • 100% of AS
Questions A combination of multiple choice, short answer and extended writing questions.

3 Subject content

The key scientific principles of the subject should be developed throughout the course, using examples to illustrate these whenever appropriate.

Environmental science is a holistic subject with many interconnected systems and processes. A change to one process can affect many other processes over different spatial and temporal scales.

Consideration of environmental issues and the conclusions reached should be based on reliable evidence-based information and quantitative data.

Students must develop an understanding of how human society relies upon natural systems for resources and life support systems.

An understanding of these systems should be used to propose changes in society that would produce sustainable lifestyles.

The requirements set out in scientific principles (page 58) must be integrated into theoretical and practical contexts where appropriate.

3.1 The living environment

The emphasis should be placed on the interaction of living organisms with each other and their abiotic environment, and how an understanding of this can inform decisions that lead to sustainable human activities. Students must apply their understanding of these interactions in a wide range of contexts throughout this area.

3.1.1 Conditions for life on Earth

3.1.1.1 How the main conditions, which allowed early life to develop and survive on plant Earth, came about

Students should understand how the conditions of planet Earth allowed early life to develop and survive.

Content	Additional information
Atmosphere	The mass of Earth and force of gravity retained an atmosphere. The atmosphere provided gaseous resources: carbon dioxide, methane, nitrogen. Atmospheric pressure and temperature maintained liquid water.
Insolation	A suitable temperature range was controlled by incoming insolation and its behaviour in the atmosphere. This was controlled by the surface albedo, absorption of infrared energy and the presence of the atmosphere.

Content	Additional information
Position in the solar system	Suitable temperatures were maintained by the distance from the Sun.
Orbital behaviour	The rotation and tilt of the Earth on its axis and its orbit around the Sun, controlled daily and seasonal variations in insolation and temperatures.
Magnetosphere	The magnetosphere provides protection from radiation: the Earth's molten core produced a magnetic field (magnetosphere) that deflects solar radiation.

3.1.1.2 How the presence of life on Earth has brought about environmental change

How biota have helped to maintain stability

Content	Additional information
Oxygen production	Oxygen was first produced by photosynthetic bacteria, then by algae and plants.
Ozone layer	Ozone was produced by chemical reactions involving oxygen and ultraviolet light in the stratosphere.
Carbon sequestration	Atmospheric carbon dioxide concentrations were reduced by photoautotrophs.
Biogeochemical cycles	The processes of biogeochemical cycles are linked by living organisms, preventing the build-up of waste products or shortages of resources.

How historical conditions for life were monitored in the past and how these methods have been developed over time

Students should understand how changes in monitoring methods have allowed more accurate estimation of past conditions on Earth.

Content	Additional information
Limitations of early methods: • lack of ancient historical data • limited reliability of proxy data for ancient conditions • limited coordination between researchers • lack of sophisticated equipment for accurate measurements • inability to measure many factors • lack of data collection in many areas • reliance on proxy data, eg dendrochronology, pollen analysis.	
Improved methods: • collection of long-term data sets • the use of electronic monitoring equipment • gas analysis of ice cores • isotope analysis of ice cores • improved carriers for monitoring equipment, eg helium balloons, aircraft, satellites.	(See Research methods (page 43))

3.1.2 Conservation of biodiversity

3.1.2.1 The importance of the conservation of biodiversity

Resources and how sustainable habitat management strategies can be used to secure future supplies

Content	Additional information
Wood	Timber for structural uses.
Fibres	Plant and animal fibres.
Oils	Uses of vegetable oils.
Fuels	Biofuels.
New foods	Many plant species have the potential for commercial cultivation.

Knowledge and how decisions over habitat conservation can be made to protect those species that have not yet been investigated

Content	Additional information
Biomimetics	Students should understand that features of living organisms can be copied in the development of new structures and materials, eg: • vehicle design • architecture • structures • adhesion • materials • ultrasound diagnosis.
New medicines	New medicines can be developed from the chemicals produced by plants and animals.
Physiological research	Animal species may be more useful or practical than humans for physiological research.
Wildlife species as pest control agents	Many wildlife species can be used to control agricultural pests. They may be predators, herbivores, parasites orpathogens.
Genetic resources	New genes to improve crop genetic characteristics may be found in the wild relatives of the cultivated crops. The importance of Centres of Diversity/Vavilov centres for crop wild relatives (CWRs).

Ecosystem services and their interaction with each other

Content	Additional information
Atmospheric composition	The role of living organisms in the regulation of the composition of the atmosphere: O_2, CO_2, water vapour.
Biogeochemical cycles	The importance of iving organisms in biogeochemical cycles.
Interspecies relationships	Living organisms often provide services that aid the survival of other species, eg pollination, seed dispersal and habitat provision.
Soil maintenance	Living organisims are important in soil formation and erosion control, eg plants, detritivores, decomposers.

3.1.2.2 How humans influence biodiversity, with examples in a range of different context

Content	Additional information
Direct exploitation	Populations of many species have been reduced by over-exploitation for resources or deliberate eradication, eg: • food • fashion • entertainment • furniture and ornaments • traditional medicines • other products.
Deliberate eradication	Eradication of predators and competitors.
Changes in abiotic factors	Human activities may change the abiotic features of a habitat, making it more or less suitable for the survival of wildlife. • The changes may be caused by an action, or by inactivity, eg stopping plagioclimax management. • Water availability, eg by drainage or flooding. • Light levels, eg by forest clearance. • Oxygen availability, eg by pollution of water with organic matter. • Nutrient levels, eg fertiliser runoff from farmland. • pH, eg acid mine drainage. • Temperature, eg thermal pollution from power stations.
Changes in biotic factors	Changing the population size of one species often has an impact on the population size of other species. • Introduced species. • Loss of inter-species relationships.
Habitat destruction	Many human activities remove the natural communities of species: • deforestation • expansion of farmland • urbanisation • mineral extraction • flooding by reservoirs.

3.1.2.3 Methods of conserving biodiversity

Setting conservation priorities

Content	Additional information
	Students should understand that the conservation of biodiversity requires setting priorities about which species and communities are to be conserved.
International Union for Conservation of Nature (IUCN) criteria	The roles of the IUCN: • coordinating global data on biodiversity conservation • increasing understanding of the importance of biodiversity • deploying nature-based solutions to global challenges in climate, food and sustainable development. Students should have knowledge of the criteria used by the IUCN to identify the species that should be prioritized for conservation. These are developed further elsewhere in the specification: • red list categories for threatened species • classification of habitats, threats and required actions • evolutionary uniqueness • endemic species • keystone species • flagship species • threats to survival • population dispersal.
Evolutionary uniqueness	EDGE species (Evolutionary Distinct and Globally Endangered) are threatened by extinction and diverged from other taxa long ago so they have greater genetic differences.
Endemic species	Species found within a single area, especially if the population is small.
Keystone species	Species whose survival is important for the survival of many other species.

Legislation/protocols

Content	Additional information
	How legislation and protocols protect species and habitats by establishing restrictions and management agreements.

Content	Additional information
Protection of habitats and species	The key features of the Wildlife and Countryside Act (1981). Students should understand the different ways in which designated areas protect species and habitats by restricting activities and establishing management plans. Designated protected areas in the UK, eg: • Sites of Special Scientific Interest (SSSI) • National Nature Reserve (NNR) • Special Area of Conservation (SAC) • Special Protection Area (SPA) • Natura 2000 sites • Ramsar sites • Marine Nature Reserve (MNR) • Local Nature Reserve (LNR) • Marine Protected Area (MPA) • Marine Conservation Zone (MCZ).
Trade Controls	How the Convention on International Trade in Endangered Species (CITES) protects selected species: • Appendix I. • Appendix II.
Regulation of sustainable exploitation	Organisations that aim to exploit living resources sustainably: • International Whaling Commission (IWC) • European Union Common Fisheries Policy (EU CFP) • International Tropical Timber Organisation (ITTO).

Captive breeding and release programmes (CBR)

Content	Additional information
Ex-situ conservation is needed when conservation of species in their natural habitat is impossible or insufficient to protect the species.	• Criteria for the selection of species for captive breeding programmes. • Difficulties in keeping a captive population. Reasons why keeping species in captivity may be difficult.

Content	Additional information
Methods of increasing breeding success	• Provision of essential conditions for breeding. • Group dynamics. • Difficulties in providing required abiotic conditions. • Artificial insemination. • Embryo transfer.
Soft and hard release programmes	The selection of suitable release sites: Soft release. Hard release. Post-release monitoring.

Habitat conservation

Content	Additional information
In-situ conservation protects communities of species not just individual selected species.	
Habitat creation	New habitats may be created as a consequence of other human activities. New habitats may be created when wildlife conservation is the main aim. • New conservation habitats: wetlands, woodlands. • Habitat restoration – rewilding. Structural features of habitats may affect the success of conservation programmes: • habitat area • habitat shape • age structure • ease of colonization/need for introduction • biological corridors.
Management and conservation of habitats	Students should use a range of ecosystems and habitat areas to analyse their similarities and differences, especially the controlling ecological features and how this can inform conservation strategies. The importance of conservation should be related to the threats from human activities.

Content	Additional information
Temperate broadleaf woodland Features: • regular water supply • summers not very hot • winters not very cold • seasonality.	
Importance: • high biodiversity • resources • climate control • soil erosion control • recreation.	
Threats: • deforestation for other land uses • fragmentation of remaining woodland • management change.	
Conservation efforts: • designated protected areas • legal protection of ancient woodland in the UK • conservation management.	
Tropical rainforest Features: • warm/hot • high rainfall • high light levels • inter-species relationships • low seasonality.	
Importance: • high biodiversity • resources • carbon sequestration • hydrological cycle • soil erosion control.	

Content	Additional information
Threats • fuelwood collection • timber for construction and furniture • agricultural expansion • mineral extraction • reservoirs • global climate change • exploitation of individual species.	
Conservation efforts: • establishment of protected areas • debt for Nature Swaps • sustainable exploitation.	
Tropical coral reefs Features: • cnidarians • nutrition systems • high light levels • warm, stable temperatures • low turbidity • constant salinity.	
Importance: • fisheries • erosion protection • medicinal discoveries • climate control • tourism.	
Threats: • physical damage caused by human activites • souvenir collection • sedimentation • climate change • pollution • fishing • introduced species.	
Conservation efforts: • control of damaging activities • establishment of protected areas.	

Content	Additional information
Deep-water coral reefs Features: • cold and dark • slow coral growth.	
Importance: • research • fisheries.	
Threats: • trawling • oil and gas exploration • ocean acidification.	
Conservation efforts: • establishment of protected areas • control of damaging activities.	
Oceanic islands Features: • isolation • few or no indigenous mammal predators • endemic species.	
Importance: endemic species.	
Threats: • species exploitation • introduced species • habitat change/destruction • sea level rise.	
Conservation efforts: • eradication of introduced species • control of developments and visitors.	
Mangroves Features: • tropical climates • halophytic trees • low oxygen availability.	

Content	Additional information
Importance: • coastal erosion protection • fisheries • timber supplies • trap suspended solids.	
Threats: • clearance for urban development/ aquaculture • coral reef destruction • pollution • global climate change.	
Conservation efforts: • reforestation • control of damaging activities • establishment of protected areas.	
Antarctica Features: • very low temperatures • low precipitation • high albedo • high levels of marine nutrients • large variations in ice cover • extreme seasonal changes.	
Importance: • water store • ice albedo • carbon sequestration • resources • research.	
Threats: • global climate change • ozone depletion • tourism • overfishing • future mineral exploitation • scientific research.	

Content	Additional information
Conservation efforts: • The Antarctic Treaty (1959) • fisheries control • waste management • tourism control.	

The importance of ecological monitoring in conservation planning

Content	Additional information
It is important to identify the species present and features of their populations in planning conservation strategies.	Population dynamics: • size • distribution • survival rate • age structure. (See Research methods (page 43))

The development of new technologies for ecological monitoring

Students should understand how new technologies improve the validity of ecological research by allowing the collection of more representative data and new information.

Content	Additional information
New technologies used in ecological research	• Satellite/radio tracking. • DNA databases, eDNA. • Image recognition, including software • Acoustic monitoring, sonograms. (See Research methods (page 43))

3.1.3 Life processes in the biosphere and conservation planning

3.1.3.1 How adaptation to the environment affects species' habitat requirements and influences conservation decision-making

Students should be able to use examples of habitat management which benefit species that are adapted to particular abiotic and biotic factors. The deliberate provision of these conditions may increase species' survival.

Content	Additional information
Abiotic factors: • light • water • nutrients • pH • abiotic habitat provision.	
Biotic factors: • food • control of predation • pollination • seed dispersal • biotic habitat provision • other inter-species relationships.	

3.1.3.2 Terminology to describe the roles of living organisms in their habitats and their interactions with the physical environment

Students should be able to use appropriate terminology to describe the roles of living organisms in their habitats and their interactions with the physical environment.

Content	Additional information
Ecological terminology	• Species. • Taxon. • Ecological niche. • Population. • Community of species. • Ecosystem. • Biome.

3.1.3.3 The control of ecological succession in conserving plagioclimax habitats

Students should understand that many wildlife communities have developed in plagioclimax habitats maintained by long-term human activities. They should understand the processes in ecological succession that can inform conservation strategies.

Content	Additional information
Ecological succession	• Colonisation and pioneer species. • Seres. • The modification of abiotic conditions by new colonisers. • Climax communities. • Deflected succession. • Secondary succession. • Plagioclimax communities.
Methods of maintaining plagioclimax communities: • grazing • mowing • burning • coppicing • pollarding.	

3.1.3.4 How population control and the management of desired and undesired species affects the conservation of biodiversity

Students should understand the concept of carrying capacity and the influence of density and density-independent factors on regulating populations.

Content	Additional information
Management of desirable species: • release programmes • habitat management.	
Control of undesirable species: culling/ eradication.	
r- and k- selection strategies and how they affect the ease with which species can be over-exploited.	

3.1.4 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.2	Students could use an appropriate number of decimal places in calculations, eg calculating mean population density from multiple sample sites in a habitat.
MS 0.3	Students could calculate and compare percentages loss, eg of rain forests over a given time period of declining populations of endangered species.

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.5	Students should demonstrate their ability to interpret population growth curves.
MS 1.1	Students could report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures, eg in calculating indices of biodiversity.
MS 1.2	Students could calculate mean population density from multiple quadrats.
MS 1.5	Students could compare and analyse data collected by random sampling and systematic, eg use Simpson's index of diversity to compare the biodiversity of habitats with different management regimes.
MS 1.10	Students should demonstrate their understanding of standard deviation as a useful measure of dispersion for a given set of data, eg for comparison with other data sets with different means such as populations of endangered species under different management regimes.
MS 1.11	Students could calculate percentage error where there are uncertainties in measurement, eg estimating total population using sub-samples in a preliminary study.
MS 2.1	Students could use = < << >> > when estimating maximum sustainable yield.
MS 2.3	Students could use Simpson's index of diversity to assess the impact of a new habitat management regime.
MS 3.1	Students could construct a kite diagram of the change in population density of species along a transect.
MS 3.3	Students could plot changes in species abundance with changes in abiotic factors, eg temperature water, pH.
MS 3.7	Students could measure the gradient of a point on a curve, eg rate of population growth.
MS 4.1	Students could calculate the circumference and area of nature reserves to assess the impact of the edge effect on wildlife conservation programmes.

Working scientifically

Students could plan activities to investigate environmental issues which they could carry out eg:

- population surveys in a habitat to be visited
- measurement of abiotic factors in a habitat to be visited.

Students could plan activities to investigate environmental issues in broader environmental contexts where first-hand experience would not be possible eg:

- monitoring the impact of invasive species on indigenous species
- monitoring the impact of the local extinction of forest elephants on plant species with animal-dispersed seeds

- monitoring changes in population size, age structure and diversity after an area gains protected status, eg new MCZs
- monitoring the survival and dispersal of animals in captive breeding programmes after release
- estimating increases in biomass of tropical forests in response to increases in CO_2 levels
- monitor changes in water turbidity on coral reefs caused by land use changes, eg deforestation
- monitor changes in penguin populations in Antarctica using satellite imagery
- monitor the impact of fishing controls by the EU CFP on fish populations
- monitor colonisation and changes in community composition in a recently created habitat.

Practical skill number	Opportunities for skills development and independent thinking
PS 1.1	Students could assess the knowledge required to solve the environmental problem eg: • population size • population density • biomass • distribution • movements.
PS 1.2	Students could analyse existing knowledge and data eg: • changes in species abundances • changes in age structure • current biomass.
PS 1.3	Students could evaluate and explain the contribution that the results of the planned study would make to solving the problem eg: • how changes in abiotic factors may cause changes in woodland floor plant survival • how a change in population of trees may be caused by the loss of forest elephants • how a change in age structure in an MCZ may indicate the effectiveness of protection.
PS 1.4	Students could plan studies to gain representative, reliable data, using the selected methodologies and sampling technique below.
PS 2.1	Students could evaluate the methods of previous studies and analyse the reliability of the data produced.
PS 2.2	Students could analyse their method and the results produced to identify limitations in the method and any inaccuracies in results eg: • limitations of population estimates from population sub-samples and the Lincoln Index • inaccuracies caused by the use of data that fluctuate unpredictably, eg abiotic factors related to weather.

Practical skill number	Opportunities for skills development and independent thinking
PS 2.3	Students could identify the other variables that could also affect their results eg: in a study of the affect of light levels on ground flora: soil pH, temperature, humidity, wind velocity. In a study of increased forest biomass caused by rising CO_2 levels: changes in water availability, temperature and forest management.
PS 2.4	Students could use a variety of methods to present data: • construct a table of raw data, eg abundances of species found in each quadrat • construct a table of changing abiotic factors along a transect across a habitat.
PS 3.1	Students could construct line graphs to show changes in data over time or correlations between variables.
PS 3.2	Students could use data on species richness and abundance to calculate Simpson's Index of diversity.
PS 3.3	Students could compare estimates of population size for the same habitat produced by different groups to consider possible causes of the variation.
PS 4.1	The practical skills of using equipment within scientific environmental studies are expanded in the selected methodologies and sampling technique below.

Opportunities to investigate the required methodologies of which students must have first hand experience. Further details can be found in Appendix A: Working scientifically (page 55)

Methodology skill number	Opportunities for skills development and independent thinking
Me 1	Students could plan the collection of samples using random sampling eg: ground flora in woodland or grasslands.
Me 2	Students could plan the collection of samples using systematic sampling eg: • abiotic factors along a transect • species abundance or distribution along a transect • data from moth or bat surveys at regular intervals, eg weekly.
Me 3	Students could identify appropriate timings for surveys to be carried out eg: • moth surveys carried out overnight with standardized conditions of temperature, precipitation, wind velocity • population surveys related to breeding cycles • plant surveys related to periods of emergence/flowering.

Opportunities to investigate the required sampling techniques of which students must have first hand experience. Further details can be found in Appendix A: Working scientifically (page 55)

Sampling techniques number	Opportunities for skills development and independent thinking
ST 1	Students could analyse the effect of wind velocity or temperature on the activity of bats or moths to consider the possible impacts of climate change.
ST 2	Students could compare plant biodiversity in grasslands with different mowing regimes.

3.2 The physical environment

The emphasis should be placed on understanding how anthropogenic activities are inter-connected with physical processes, to formulate management strategies and plan sustainable activities.

Supplies of renewable physical resources may be maintained by the control of activities that may cause over-exploitation and by protecting the processes that aid their production.

Supplies of non-renewable physical resources may be extended by controlling exploitation and developing improved technologies to harness them.

3.2.1 The atmosphere

3.2.1.1 How atmospheric energy processes involving ultra violet (UV), infrared (IR) and visible light in the stratosphere and troposphere affect life-support systems

Content	Additional information
Origins and roles of UV and IR in the atmosphere.	• Insolation. • Emissions from the earth. • Thermal stratification. • Chemical processes.
How different wavelengths of electromagnetic light behave in the atmosphere: • transmission • absorption • conversion to heat • conversion to chemical energy • reflection.	

3.2.1.2 Global climate change: how interconnected natural systems cause environmental change

Students should select, analyse and evaluate the data available on natural and anthropogenic climate change.

Content	Additional information
Greenhouse gases	The anthropogenic sources of greenhouse gases, residence times and relative effects: CO_2, CH_4, NO_x, tropospheric ozone, CFCs.
Changes in oceans	Changes in thermohaline circulation in the North Atlantic. Changes in ocean, wind and current patterns: El Niño. Sea level rise.
Changes in the cryosphere	Reduced snow cover – amount and duration. Glaciers: changes in extent and speed of movement. Land ice caps and ice sheets: changes in thickness and movements. Ice shelves: changes in the break-up of ice shelves and the impact on land ice movements. Sea ice: changes in thickness and area of sea ice cover.
Changes in climate processes	Precipitation changes: • amount, duration, timing and location • changes in proportions of rain and snow. Wind pattern changes: direction, velocity.

Content	Additional information
Difficulties monitoring and predicting climate change	Students should understand the limitations in the available data when attempting to predict future natural and anthropogenic climate change. They should be able to evaluate the reliability of existing information and discuss the methods that are used to fill gaps in current knowledge including remote sensing. Students should be able to discuss the importance of accurate, representative data in climate modelling. Uncertainty of ecological impacts of climate change: • changes in species survival caused by changes in abiotic factors • changes in species survival caused by changes in biotic factors • changes in species distribution • population fragmentation. Why there is uncertainty over the use of some data in drawing conclusions. • Lack of historical data: atmospheric composition, temperature, weather patterns. • Limited reliability of proxy data. • Lack of understanding of natural processes that control weather, ocean currents and their interconnections. • How understanding is improved by climate modelling. • Natural changes and fluctuations that mask changes caused by anthropogenic actions. • Time delay between cause and effect.

Content	Additional information
Feedback mechanisms and tipping points	Impact of negative feedback mechanisms caused by: • increased low-level cloud • increased photosynthesis. Impact of positive feedback mechanisms: • melting permafrost • ocean acidification • reduced albedo • melting methane hydrate • increased forest and peat fires • increased cirrus clouds • more rapid decomposition of dead organic matter in soil. The role of tipping points in climate change.
Carbon footprints and sustainable development	Students should compare the per capita carbon emissions and carbon footprints for different countries to evaluate different strategies to achieve sustainable development. How the control of greenhouse gases may help achieve sustainable lifestyles.

3.2.1.3 Ozone depletion

Students should consider the success of tackling ozone depletion and compare this with other environmental issues.

Content	Additional information
The study of ozone depletion should be used as an example of an environmental issue where all the stages of scientific investigation are present.	• Identification of an environmental issue. • Formulation of a hypothesis. • Collection, analysis and evaluation of data. • Proposal for solutions. • Enactment of solutions.

Content	Additional information
Rowland-Molina hypothesis	The properties of chlorofluorocarbons (CFCs) that lead to stratospheric ozone depletion. • Persistence of CFCs. • Dissociation by UV. • Reactions of chlorine with ozone. Effects of ozone depletion. Why increased UV(B) reaching the Earth's surface may cause problems: • human health • damage to plants • damage to marine organisms.
Collection, analysis and interpretation of data, an evaluation of data collection methods available and the reliability of data produced	The collection of data on ozone depletion: • ground-based data collection • aerial/satellite surveys • variability of results: spatial, temporal, altitude.
Why ozone depletion has been greatest over Antarctica	Unusual atmospheric conditions over Antarctica: • very low temperatures • ice crystals • stratospheric clouds • polar vortex winds.
The restoration of the ozone layer	Main features of the Montreal Protocol (on Substances that Deplete the Ozone Layer) (1987): • use of alternative processes • use of alternative materials • collection and disposal of CFCs and other ozone-depleting substances (ODSs).
Evaluation of the effectiveness of the methods used to restore the ozone layer compared with the effectiveness of tackling other atmospheric pollution problems	An analysis of the evidence for changes in area of ozone depletion, ozone concentrations and UV levels. A comparison with the effectiveness of tackling climate change.

3.2.1.4 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.2	Students could use standard form when dealing with carbon reservoir masses and transfer rates.
MS 1.3	Students could plot atmospheric carbon dioxide levels, atmospheric temperature and solar output over time represented on a graph.

Mathematical skill number	Opportunities for skills development and independent thinking
MS 1.4	Students could consider probability when assessing the various possible causes of climate change.
MS 1.10	Students could use standard deviation values to assess the significance of fluctuations in ozone levels over Antarctica.
MS 1.11	Students could calculate the percentage difference between estimated values and real outcomes from computer models of global climate change.
MS 2.2	Students could use and manipulate an equation to estimate carbon sequestrian rates.
MS 3.1	Students could construct a flow diagram of carbon reservoirs and transfer processes in the carbon cycle.
MS 3.4	Students could use data on different scenarios of carbon emissions to predict a graph of atmospheric CO_2 concentration.

Working scientifically

Students could plan activities in a range of environmental contexts related to the atmosphere, including ones where first hand experience of practical activities may not be possible.

Practical skill number	Opportunities for skills development and independent thinking
PS 1.2	Students could analyse the reliability of past data collected on ozone depletion.
PS 1.4	Students could plan how to collect representative data on changes in flow in the North Atlantic Conveyor. Students could plan how to collect data on UV levels in Antarctica to monitor the recovery of stratospheric ozone.
PS 2.1	Students could assess the reliability of using proxy data to monitor climate change.
PS 2.2	Students could assess uncertainties over predictions of sea ice loss, changes in atmospheric temperature and sea level rise.
PS 3.1	Students could construct graphs on changes in factors related to climate change: land ice volume, sea ice area, atmospheric CO2 concentration.
PS 3.3	Students could assess degrees of uncertainty of data collected on climate change and predictions of changes that will occur in the future.

Opportunitites to investigate the required methodologies of which students must have first hand experience. Further details can be found in Appendix A: Working scientifically (page 55)

Methodology skill	Opportunities for skills development and independent thinking
Me 2	Students could plan the location of temperature sampling sites and timing to produce reliable data on climate change.

3.2.2 The hydrosphere

3.2.2.1 The impact of unsustainable exploitation

Content	Additional information
Students should understand that the natural hydrological cycle is in a state of dynamic equilibrium. Human activities that alter the rates of processes in the hydrological cycle can lead to changes in residence times and quantities in the reservoirs of the cycle. Students should be able to use the technical terminology related to the hydrological cycle to discuss anthropogenic changes and strategies that may allow sustainable exploitation. Students should be able to explain how human activities change processes in the hydrological cycle. Students should be able to explain the consequences of changes in the hydrological cycle.	

3.2.2.2 Analysis and evaluation of strategies for sustainable management

Content	Additional information
Students should use examples of water resources that have been exploited unsustainably.	

3.2.2.3 Ocean currents: the importance of thermohaline circulation in distributing heat and regulating climate

Content	Additional information
Students should discuss the impacts of changes in thermohaline circulation on the climate of countries around the North Atlantic, including the UK.	

3.2.2.4 Increasing sustainability by treating contaminated water

Content	Additional information
The methods used to remove the following contaminants: • litter • suspended solids • some metals and odours • organic pollutants • salt • pathogens.	

3.2.2.5 Increasing sustainability by economical use and the exploitation of new sources

Content	Additional information
Management of water resources: • metering • low water-use appliances • greywater use • exploitation of new sources • rainwater catchment • new reservoirs/estuary barrages • unexploited aquifers • inter-basin transfers.	

3.2.2.6 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.1	Students could convert data and change the units used in transfer rates, volumes and residence times in the hydrological cycle.
MS 0.4	Students could estimate results to sense check that the calculated values are appropriate, such as when calculating residence times in different water reservoirs.
MS 1.2	Students could calculate the mean rate of water transfer between two water reservoirs.
MS 1.3	Students could interpret data relating to aquifer flow rates.
MS 1.6	Students could use data on changing transfer rates to calculate changes in the mean water content in an aquifer.
MS 1.7	Students could analyse a scatter graph of per capita water use against mean GDP to suggest reasons for different rates of water use.
MS 1.8	Students could make order of magnitude calculations using data on per capita and national water use.

Mathematical skill number	Opportunities for skills development and independent thinking
MS 3.1	Students could construct a flow diagram using data on processes and reservoir storage.
MS 3.6	Students could calculate the rate of infiltration into rocks of different permeabilities.

Working scientifically

Students could plan activities in a range of environmental contexts related to the hydrosphere, including ones where first-hand experience of practical activities may not be possible.

Practical skill number	Opportunities for skills development and independent thinking
PS 1.2	Students could analyse data on deforestation and precipitation levels.
PS 1.4	Students could plan monitoring programmes for the salinization of aquifers.
PS 2.1	Students could analyse results of previous studies on catchment area changes and difficulties in producing representative data.

3.2.3 Mineral resources

3.2.3.1 Minerals extracted from the lithosphere

Content	Additional information
The mineral resources extracted from the lithosphere are non-renewable as they are reformed too slowly to be replaced within timescales that would allow human use. Long-term use relies on an understanding of the scientific methods that will increase supplies, extend use and find alternatives for those in restricted supplies.	Students should understand the importance of resources extracted from the lithosphere on society. • Metals and metal ores. • Industrial minerals. • Construction materials.

3.2.3.2 Geological processes that produced localised concentrations of recoverable mineral deposits

Content	Additional information
Geological processes	• Hydrothermal deposition. • Metamorphic processes. • Proterozoic marine sediments. • Physical sediments. • Biological sediments.

3.2.3.3 Reserves and resource

Content	Additional information
The reserves include the amount of material that can be exploited using existing technology under current economic conditions. The resource includes all the material that could be exploited technically and economically now or in the future.	
Lasky's principle	As the linear purity of a deposit decreases, there is a logarithmic increase in the amount of the material that is included. The ability to exploit low-grade deposits results in a large increase in the reserves.

3.2.3.4 How a range of exploratory techniques work

Students should understand the methods that are used to discover the localised concentrations of deposits produced by geological processes.

Content	Additional information
Exploratory techniques	• Satellite imagery. • Seismic surveys. • Gravimetry. • Magnetometry. • Resistivity. • Trial drilling.

3.2.3.5 Factors affecting mine viability

Content	Additional information
For a mining operation to be viable, a wide range of geological and economic criteria must be met.	• Ore purity and cut-off ore grade. • Chemical form. • Associated geology: overburden, hydrology. • Economics: cut-off ore grade and mining costs.

3.2.3.6 Control of the environmental impacts of mineral exploitation

Content	Additional information
All mining activities impact on the environment, but good site management and post-mining restoration can minimise problems.	• Turbid drainage water. • Spoil. • Leachate neutralisation. • Site management. • Site restoration.

3.2.3.7 Strategies to secure future mineral supplies

Content	Additional information
As high-grade deposits become depleted, it is important to develop new technologies to find and extract new deposits, including low-grade and less accessible deposits. Manufactured products should be designed to minimise the amount of material needed and extend the lifetime of material use.	• Improvements in exploratory techniques including remote sensing. • Bioleaching with acidophilic bacteria. • Phytomining. • Cradle to Cradle design.
Recycling	The advantages of recycling: • conservation of mineral resources • reduced energy use (of mineral extraction) • reduced mineral extraction/processing impacts • reduced waste disposal impacts.
• Difficulties with recycling schemes	• identification of materials. • Separation of mixed materials. • Reduction in quality. • Increased transport costs/impacts. • Collection difficulties. • Lack of consumer cooperation.

3.2.3.8 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.5	Students could estimate the impact of a change in cut-off ore grade on the abundance of mineral reserves using the exponential trend of Lasky's principle.
MS 1.1	Students could demonstrate understanding that calculated results can only be reported to the limits of the least accurate measurement, eg in estimating lifetimes of mineral reserves.

Mathematical skill number	Opportunities for skills development and independent thinking
MS 1.7	Students could analyse a scatter graph of per capita water use against mean GDP to suggest reasons for different rates of water use.
MS 1.8	Students could make order of magnitude calculations using data on per capita and national water use.
MS 1.11	Students could identify the uncertainties of predictions in mineral reserves using trends in population, per capita use and improvements in extraction technology.

Working scientifically

Students could plan activities in a range of environmental contexts related to the hydrosphere, including ones where first hand experience of practical activities may not be possible.

Practical skill number	Opportunities for skills development and independent thinking
PS 1.2	Students could analyse trial core survey data to assess mine vaidity.
PS 3.2	Analyse metal ion concentration data in a mining area to identify the sources of contamination.

3.2.4 Biogeochemical cycles

3.2.4.1 The importance of biogeochemical cycles for living organisms

Content	Additional information
Many elements have low availability to living organisms. Biogeochemical cycles involve inter-linked processes that allow materials to be recycled and repeatedly re-used.	

3.2.4.2 The carbon cycle including human influences

Content	Additional information
The processes in the carbon cycle that are affected by human activities	• Photosynthesis. • Aerobic respiration. • Anaerobic respiration. • Combustion. • CO_2 dissolving in the sea/exsolving from the sea. • Biomass movements. • Changes in carbon reservoirs. • Increased atmospheric concentration of CO_2. • Less soil dead organic matter. • Increased concentrations of dissolved CO_2, carbonic acid, hydrogen carbonate ions. • Increased atmospheric concentration of methane. • Reduced amount of carbon in plant biomass. • Reduced amount of carbon in fossil fuels.
Sustainable management of the carbon cycle: methods of counteracting human activities that alter the natural equilibria of the carbon cycle	• Alternatives to fossil fuel use. • Carbon sequestration. • Carbon Capture and Storage (CCS). • Matching afforestation to deforestation. • Increasing soil organic matter. • Conservation of peat bogs.

3.2.4.3 The nitrogen cycle including human influences

Content	Additional information
The processes in the nitrogen cycle that are affected by human activities	• The Haber Process fixing nitrogen in ammonia, mainly to produce agricultural fertilisers. • Land drainage increases nitrogen fixation and reduces denitrification. • The growth of legume crops increases nitrogen fixation in plant proteins. • Sewage disposal increases nitrate movements to rivers and the sea, together with phosphates, causes eutrophication. • Combustion processes cause nitrogen and oxygen to react, producing oxides of nitrogen. • Decomposition and ammonification affected by organic waste disposal policies.
• Consequences of changes in nitrogen reservoirs.	• Eutrophication. • Global climate change. • NO_x toxicity. • Photochemical smogs.

Content	Additional information
Sustainable management of the nitrogen cycle and methods of counteracting human activities that alter the natural equilibria of the nitrogen cycle	Methods of counteracting anthropogenic nitrogen movements: • reduced combustion processes • use of natural nitrogen fixation processes instead of the Haber process • management of biological wastes • methods of reducing soil nitrate leaching.

3.2.4.4 The phosphorus cycle including human influences

Content	Additional information
The processes in the phosphorus cycle that are affected by human activities	Phosphorus compounds are mobilised in more soluble forms for use in agricultural fertilisers. Eutrophication is caused by nutrient enrichment of water bodies, combined with the effect of nitrates.
Sustainable management of the phosphorus cycle and methods of counteracting human activities that alter the natural equilibria of the phosphorus cycle	The lack of abundant reservoirs of phosphates in the atmosphere or hydrosphere is often the limiting factor on biological productivity: • the use of biological wastes as fertilisers • breeding of crops that absorb phosphates more efficiently • providing suitable conditions for soil mycorrhizal fungi increases phosphate uptake combustion processes.

3.2.4.5 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.1	Students could convert values and units used in transfer rates, reservoir mass and residence time in the nitrogen cycle.
MS 0.2	Students could convert numbers in standard and ordinary form when using masses in biogeochemical cycles.
MS 2.2	Students could use and manipulate equations of nutrient transfer rates.
MS 3.1	Students could use data on reservoirs and transfer processes to construct a flow diagram of the nitrogen or phosphorus cycle.

3.2.5 Soils

3.2.5.1 How human activities affect soil fertility

Content	Additional information
Activities that control soil conditions and affect fertility.	• Aeration of soil by ploughing and drainage. • Addition of soil nutrients. • Irrigation. • Soil compaction, increasing bulk density. • pH control.

3.2.5.2 Causes of soil degradation and erosion

Content	Additional information
Types of soil erosion	• Rain splash. • Wind blow. • Surface runoff.
Natural features that reduce erosion.	• Vegetation. • Soil organic matter. • High infiltration rate.
The Universal Soil Loss Equation (USLE) can be used to estimate erosion rates.	
Human activities that cause soil erosion and degradation.	• Ploughing vulnerable soils. • Vegetation removal. • Overgrazing. • Reducing soil organic matter. • Reducing soil biota. • Cultivating steep slopes. • Soil compaction by machinery or trampling.
The environmental impacts of soil erosion.	• Reduced productivity. • Sedimentation in rivers and reservoirs. • Downstream flooding. • Coastal sedimentation. • Increased atmospheric particulates. • Desertification. • Landslides.

3.2.5.3 Soil management strategies to increase sustainability

Content	Additional information
Methods that can be used to reduce soil erosion: • long-term crops • contour ploughing • tied ridging • terracing • windbreaks • multicropping • strip cropping • mulching • increasing soil organic matter.	

3.2.5.4 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.3	Students could use data on mass and mass change during heating to estimate the percentage water and organic matter composition of soil.
MS 1.1	Students could demonstrate appropriate numbers of significant figures in calculations of soil water and organic matter content.
MS 2.4	Students could use data and the Universal Soil Loss Equation to estimate rates of soil loss.
MS 3.2	Students could demonstrate their ability to use data presented in a number of formats and be able to use these data, eg soil erosion rates presented in graphs, tables and formulae.

Working scientifically

Students could plan activities to investigate environmental issues which they could carry out eg:

- the impact of soil texture on soil water content
- the impact of soil water content on organic matter levels
- the effect of slope on rain splash soil erosion
- the effect of vegetation cover on rain splash erosion
- the impact of soil compaction on soil water levels.

Students could plan activities in a range of broader environmental contexts related to soils, including ones where first hand experience of practical activities may not be possible eg: the effect of soil erosion on downstream ecosystems.

Practical skill number	Opportunities for skills development and independent thinking
PS 1.1	Students could plan a strategy to monitor and reduce soil erosion, within the context of global food supply problems.

Practical skill number	Opportunities for skills development and independent thinking
PS 4.1	The practical skills of using equipment within scientific studies are expanded, as appropriate, in detail in the selected methodologies and sampling techniques below.

Opportunities to investigate the required methodologies of which students must have first hand experience. Further details can be found in Appendix A: Working scientifically

Methodology skill number	Opportunities for skills development and independent thinking
Me 2	Students could mark out a transect across a field to investigate changes in edaphic factors down a slope or away from a hedge/field margin.
Me 3	Students could calcuate mean values of selected factor, eg water content, to find the number of samples required to calculate a reliable mean.

Opportunities to investigate the required sampling techniques of which students must have first hand experience. Further details can be found in Appendix A: Working scientifically

Sampling technique skill number	Opportunities for skills development and independent thinking
ST 1	Students could investigate the effect of a hedgerow on the downwind wind velocity, in the context of soil erosion.
ST 3	Students could compare the water and organic matter contents of soil from fields with different long-term management systems. Students could use sedimentation or soil sieves to compare the textures of soils from areas with different bedrocks.

3.3 Research methods

Research methods include details of the methods used to investigate a wide range of environmental issues. It is not expected that students will have first hand experience of all of these although, where this is possible, it will enhance their learning experience. The required practical skills are detailed in Appendix A: Working scientifically and opportunities for developing these skills are signposted throughout the subject content.

Students must understand the general principles of scientific methodology and be able to apply these to a wide range of environmental situations and techniques.

Preliminary studies may be used to ensure the study will produce representative data.

Practical activities should be carried out with consideration of their environmental impacts and how these can be minimised.

Students must undertake experimental and investigative activities, inlcuding appropriate risk management, in a range of environmental contexts. They must also know how to safely and correctly use a range of practical equipment and materials.

Students must carry out practical activities using the best contemporary practices for risk assessment and safe working in the laboratory and during fieldwork.

3.3.1 Scientific methodologies

Content	Additional information
Sample location: random sampling	Importance of the avoidance of bias.
Sample location: systematic sampling	Regular sample intervals. Transects – applied to 'environmental gradients': • line transects • belt transects • continuous/interrupted transects.
Sample timing	To ensure data variability is detected. Selection of time intervals between samples.
Sample size	Dependent on sample homogeneity.
Number of samples	Dependent on data variability. To enable analysis of statistical significance.
Standardisation of techniques	To allow comparisons between different studies/ ensure consistent reliability.
Collection of statistically significant data	Experimental design should allow the assessment of statistical significance of the data collected.

3.3.2 Sampling techniques

3.3.2.1 Standard environmental techniques

Content	Additional information

Methods:
• quadrats
  • quadrat size selection
• types of quadrat
  • open frame quadrat
  • grid quadrat
  • point quadrat
• kick sampling
• surber samplers
• colonisation media
• pitfall traps
• sweep nets
• beating trays
• light traps
• Tüllgren funnel
• extraction of earthworms from soil.
Quantitative/comparative/numerical measures:
• abundance scales, eg DAFOR scales
• species richness
• species diversity
• species frequency
• species density
• percentage cover
• Lincoln Index
• Simpson's Index of Biodiversity.
Measurement of abiotic factors:
• light intensity
• temperature
• wind velocity
• humidity
• water turbidity
• water pH
• water ion concentration, eg nitrates
• soil analysis:
  • texture: sedimentation, sieving
  • pH
  • water content
  • organic matter content
  • measurement of bulk density
  • the use of a soil triangle.
	Students must understand the following features of each technique:
	• purpose/application of the method
	• how the method is carried out
	• limitations.

3.3.2.2 Fieldwork and laboratory activities

Content	Additional information
Fieldwork and laboratory activities. These should include, but not be limited to, the following: ecological studies in suitable available habitats: • population size/density • species frequency • species distribution • biodiversity • soil analysis. The effects of climatic variability on the use of renewable energy resources: insolation intensity, wind velocity. Factors affecting the rate of heat loss: insulation, volume. The use of biotic indices in monitoring pollution: lichens, aquatic invertebrates. The effect of pH on seed germination. The effect of water turbidity on light penetration. The effect of inorganic nutrients on the growth of aquatic plants/algae. Factors affecting noise levels: distance from source, acoustic insulation. The effect of slope and vegetation on rain splash soil erosion. The effect of trees on microclimates.	

3.3.2.3 Specialist techniques

Content	Additional information
Knowledge/understanding/application of the following techniques is required, but first-hand experience is not. Photography: • motion sensitive cameras • databases of physical features may be used to identify individuals, eg tiger stripe patterns, whaleshark spots, whale and dolphin fin damage. Marking: tags, rings, collars etc. Auditory monitoring (sounds)/sonograms: birds, bats, cetaceans. Radio/GPS/satellite tracking. Data collected by satellite sensors, eg to monitor habitat change, water availability, rock density, ice cover, ice thickness. Databases of blood/tissue samples/DNA/eDNA. Indirect evidence – shows the presence of the species even if it is not actually seen: • nests/burrows • droppings – can give information on diet, gender, territories • feeding marks, eg nuts, fruit • owl pellets – also give information on diet • tracks/footprints • territorial marks, eg scratching posts.	

3.3.3 Opportunities for skills development and independent thinking

Mathematical skill number	Opportunities for skills development and independent thinking
MS 0.3	Students could estimate mean percentage vegetation cover using data from a range of quadrats.
MS 1.1	Students could use appropriate numbers of significant figures in calculations of population, soil composition and reservoir mass in biogeochemical cycles.
MS 1.2	Students could calculate mean population densities of ground flora from quadrat survey data.

Mathematical skill number	Opportunities for skills development and independent thinking
MS 1.3	Students could represent a range of variables collected along a transect in a table, eg population density, % cover, biodiversity, light levels, humidity.
MS 1.4	Students could assess the probability of a link between changes in an abiotic factor and species distribution.
MS 1.5	The principles of sampling and data collection are fundamental to all the practical skills.
MS 1.6 + MS 1.10	Students could calculate mean values wherever multiple samples are collected and use standard deviation to assess the degree of scatter of values and the significance of difference between means.
MS 1.7	Students could construct and interpret a scatter graph.
MS 1.11	Students could use a preliminary study to establish an appropriate sample size for a specific level of sample variability.
MS 2.3	Students could use ecological algebraic formulae eg Simpson's Index of biodiversity or the Lincoln Index.
MS 3.1	Students could construct kite diagrams of abundance along a transect.
MS 3.2	Students could use data tables from field studies to construct line graphs of changing variables along a transect.
MS 3.3	Students could construct a line graph of mean seed germination rates for a range of pHs.

Working scientifically

Where appropriate, the research methods included in Section 3.3 can be incorporated into the required methodologies and sampling techniques included in Appendix A: Working scientifically, of which students must have first-hand experience.

The methodologies and sampling techniques of which students must have first-hand experience should not be carried out in isolation. They should be set in a clear environmental context, as exemplified throughout the other sections of the specification.

4 Scheme of assessment

Find past papers and mark schemes, and specimen papers for new courses, on our website at aqa.org.uk/pastpapers

This specification is designed to be taken over one or two years.

This is a linear qualification. In order to achieve the award, students must complete all assessments at the end of the course and in the same series.

AS exams and certification for this specification are available for the first time in May/June 2018 and then every May/June for the life of the specification.

All materials are available in English only.

Our AS exams in Environmental Science include questions that allow students to demonstrate their ability to:

4.1 Aims

Courses based on this specification must encourage students to:

- develop essential knowledge and understanding of different areas of environmental science and how they relate to each other
- develop and demonstrate a deep appreciation of the skills, knowledge and understanding of the scientific methods used to investigate the environment
- develop competence and confidence in a variety of practical, mathematical and problem solving skills related to environmental issues and the sustainable use of resources
- understand the importance of basing decisions on reliable data which allows evidence-based analysis of environmental issues
- develop interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject
- understand how society makes decisions about environmental issues and how these contribute to the success of the economy and society.

4.2 Assessment objectives

Assessment objectives (AOs) are set by Ofqual and are the same across all AS Environmental Science specifications and all exam boards.

The exams will measure how students have achieved the following assessment objectives.

- AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures, including in relation to natural processes/systems and environmental issues.
- AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures, including in relation to natural processes/systems and environmental issues.
- AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to environmental issues, to make judgements and draw conclusions.

4.2.1 Assessment objective weightings for AS Environmental Science

Assessment objectives (AOs)	Component weightings (approx %)	Overall weighting (approx %)
	Paper 1	
AO1	35–40	35–40
AO2	40–45	40–45
AO3	20–25	20–25
Overall weighting of components	100	100

10% of the overall assessment of AS Environmental Science will contain mathematical skills equivalent to Level 2 or above.

At least 15% of the overall assessment of AS Environmental Science will assess knowledge, skills and understanding in relation to practical work.

4.3 Assessment weightings

The marks awarded on the papers will be scaled to meet the weighting of the components. Students' final marks will be calculated by adding together the scaled marks for each component. Grade boundaries will be set using this total scaled mark. The scaling and total scaled marks are shown in the table below.

Component	Maximum raw mark	Scaling factor	Maximum scaled mark
Paper 1	120	x 1	120
		Total scaled mark:	120

5 General administration

You can find information about all aspects of administration, as well as all the forms you need, at aqa.org.uk/examsadmin

5.1 Entries and codes

You only need to make one entry for each qualification – this will cover all the question papers, non-exam assessment and certification.

Every specification is given a national discount (classification) code by the Department for Education (DfE), which indicates its subject area.

If a student takes two specifications with the same discount code, further and higher education providers are likely to take the view that they have only achieved one of the two qualifications. Please check this before your students start their course.

Qualification title	AQA entry code	DfE discount code
AQA Advanced Subsidiary GCE in Environmental Science	7446	TBC

This specification complies with:

- Ofqual *General conditions of recognition* that apply to all regulated qualifications
- Ofqual GCE qualification level conditions that apply to all GCEs
- Ofqual GCE subject level conditions that apply to all GCEs in this subject
- all other relevant regulatory documents.

The Ofqual qualification accreditation number (QAN) is 603/0977/5.

5.2 Overlaps with other qualifications

There is overlapping content in the AS and A-level Environmental Science specifications. This helps you teach the AS and A-level together.

5.3 Awarding grades and reporting results

The AS qualification will be graded on a five-point scale: A, B, C, D and E.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

5.4 Re-sits and shelf life

Students can resit the qualification as many times as they wish, within the shelf life of the qualification. NEA results can be carried forward for any students re-sitting the qualification. NEA results can be carried forward for any students re-sitting the qualification.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools and colleges.

However, we recommend that students should have the skills and knowledge associated with at least GCSE Combined Science or equivalent (see Appendix A: Working scientifically (page 55)).

5.6 Access to assessment: diversity and inclusion

General qualifications are designed to prepare students for a wide range of occupations and further study. Therefore our qualifications must assess a wide range of competences.

The subject criteria have been assessed to see if any of the skills or knowledge required present any possible difficulty to any students, whatever their ethnic background, religion, sex, age, disability or sexuality. Tests of specific competences were only included if they were important to the subject.

As members of the Joint Council for Qualifications (JCQ) we participate in the production of the JCQ document *Access Arrangements and Reasonable Adjustments: General and Vocational qualifications*. We follow these guidelines when assessing the needs of individual students who may require an access arrangement or reasonable adjustment. This document is published at jcq.org.uk

5.6.1 Students with disabilities and special needs

We're required by the Equality Act 2010 to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student.

We can make arrangements for disabled students and students with special needs to help them access the assessments, as long as the competences being tested aren't changed. Access arrangements must be agreed **before** the assessment. For example, a Braille paper would be a reasonable adjustment for a Braille reader.

To arrange access arrangements or reasonable adjustments, you can apply using the online service at aqa.org.uk/eaqa

5.6.2 Special consideration

We can give special consideration to students who have been disadvantaged at the time of the assessment through no fault of their own – for example a temporary illness, injury or serious problem such as family bereavement. We can only do this **after** the assessment.

Your exams officer should apply online for special consideration at aqa.org.uk/eaqa

For more information and advice visit aqa.org.uk/access or email accessarrangementsqueries@aqa.org.uk

5.7 Working with AQA for the first time

If your school or college hasn't previously offered our specifications, you need to register as an AQA centre. Find out how at aqa.org.uk/becomeacentre

5.8 Private candidates

This specification is available to private candidates.

A private candidate is someone who enters for exams through an AQA approved school or college but is not enrolled as a student there.

A private candidate may be self-taught, home schooled or have private tuition, either with a tutor or through a distance learning organisation. They must be based in the UK.

If you have any queries as a private candidate, you can:

- speak to the exams officer at the school or college where you intend to take your exams
- visit our website at aqa.org.uk/privatecandidates
- email privatecandidates@aqa.org.uk

5.9 Use of calculators

Students may use a calculator in the exam. They must ensure that their calculator meets the requirements as set out in the *JCQ Instructions for conducting examinations*. These instructions make it clear what the requirements are for calculators (what they must be) and what they are not (what they must not be). The instructions are regularly updated and can be found at jcq.org.uk

6 Appendix A: Working scientifically

Scientific research is a fundamental part of Environmental Science and good research skills are needed to collect representative data so that reliable conclusions can be formulated.

Students must be given the opportunity to carry out investigative/practical activities which cover the following requirements. These activities should be carried out within clear environmental contexts. Opportunities for developing the required practical skills are signposted within the subject content. Opportunities should also be taken to incorporate the required mathematical skills.

Students must undertake fieldwork which meets the minimum requirement of two days of fieldwork for AS. If a mixture of fieldwork and laboratory-based activities is chosen then the equivalent minimum requirement would be one day of fieldwork plus six laboratory-based activities for AS.

Schools and colleges are required to provide a practical work statement that confirms each student has been given the opportunity to fulfil this requirement. Schools and colleges must provide the practical work statement by 15 May in the year of entry. Any failure to provide this statement in a timely manner will be treated as malpractice or maladministration (under Ofqual's General Condition A8 (Malpractice and maladministration)).

Assessment of the knowledge and understanding of the practical skills in the AS specification will be by written exams only. Overall, at least 15% of the marks for an AS Environmental Science qualification will require the assessment of practical skills.

Students must undertake experimental and investigative activities, including appropriate risk management, in a range of environmental contexts. They must also know how to safely and correctly use a range of practical equipment and materials.

Students must carry out practical activities using the best contemporary practices for risk assessment and safe working in the laboratory and during fieldwork.

Investigative/practical activities undertaken throughout the course should enable students to develop the following skills:

6.1 Practical skills for assessment in the written papers

6.1.1 Independent thinking

Practical skill number	Description
PS 1.1	solve problems set in practical contexts
PS 1.2	analyse and evaluate existing scientific knowledge
PS 1.3	apply scientific knowledge to practical contexts
PS 1.4	plan scientific investigations and apply investigative approaches and methods to practical work.

6.1.2 Use and application of scientific methods and practices

Practical skill number	Description
PS 2.1	comment on experimental design and evaluate scientific methods
PS 2.2	evaluate results and draw conclusions with reference to measurement uncertainties and errors
PS 2.3	identify variables including those that must be controlled
PS 2.4	collect and present information and data in a scientific way.

6.1.3 Numeracy and the application of mathematical concepts in a practical context

Practical skill number	Description
PS 3.1	plot and interpret graphs
PS 3.2	process and analyse data using appropriate mathematical skills as exemplified in the mathematical requirements
PS 3.3	consider margins of error, accuracy and precision of data.

6.1.4 Instruments and equipment

Practical skill number	Decription
PS 4.1	Know and understand how to use experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification, including: • using appropriate apparatus/instruments to record quantitative measurements (for example temperature, length and pH) • using appropriate apparatus/instruments and methodologies to measure abiotic and biotic factors (for example, light intensity, humidity, population size) • sampling techniques (for example pitfall traps, Tüllgren funnel, soil texture analysis, water turbidity, light traps).

These skills can be developed through the following methodologies and sampling techniques and opportunities are signposted throughout the subject content.

6.2 Required practical activities

Students must develop a knowledge and understanding of all the scientific methodologies and sampling techniques included in Research methods (page 43).

In addition to this, they must have first hand experience of the methodologies Me1, Me2, Me3 and all the practical sampling techniques included in ST1, ST2 and ST3. These can be carried out through a range of practical activities based in the laboratory or during fieldwork. This practical work will build upon the knowledge and understanding gained from Research methods (page 43).

6.3 Methodologies

These are the underlying principles which are essential in the planning of all good scientific research. It is important that students understand how to plan environmental studies as well as how to carry out the specific techniques.

Students should have an understanding of all the methodologies covered in Research methods (page 43), which would always be included in the planning of any environmental study. In addition, suitable opportunities must be provided to allow students to investigate three of these methodologies in detail: Me1, Me2 and Me3. Students should develop an understanding of how these methodologies enable the planning of better scientific research so they can evaluate their impact on the reliability of the data collected.

To gain the greatest education benefit from these activities, the investigations should be planned within an environmental context where the results would inform environmental decision-making, eg the effect of abiotic factors on plant distribution in a nature reserve, the control of invasive plant species, the effect of field cultivation on river water or nutrient concentration or the effect of different farming techniques on soil organic matter content.

Students must understand that the methodologies for which they develop skills can be applied to any environmental research project, including those in locations they cannot visit and those which require equipment which they do not have. It is still possible to apply their planning skills in these theoretical contexts. This will help them develop their knowledge throughout the specification within the context of independent thinking and scientific research.

6.3.1 Planning for representative data

Methodology skill number	Description of skill
Me 1	Sample location – random sampling, where there is no directional difference in sample results or there is no environmental gradient.
Me 2	Sample location – systematic sampling, where there is an environmental gradient or fixed sample intervals are appropriate.
Me 3	Number of samples – an assessment of the number of samples needed, as influenced by the variability between samples.

6.4 Sampling techniques

These are the techniques that should be carried out to develop a knowledge and understanding of the practical methods used to collect representative, reliable data about the environment.

The first hand experience of practical techniques should build on the theory of the use of all of the techniques, as covered in Research methods (page 43).

At AS, students should gain first-hand experience of the sampling techniques included in ST1, ST2, ST3. The techniques should be carried out within environmental contexts that highlight how the data gained can be used to reach conclusions that inform future decision making.

Sampling technique skill number	Description
ST 1	Measurement of abiotic factors: • light intensity • temperature • wind velocity • humidity • water turbidity • water ion concentration, eg nitrates, phosphates • pH.

ST 2	The use of quadrats to measure biotic factors.
	Population size, species richness, species distribution, biodiversity
	• Selection of suitable quadrat size
	• Types of quadrat:
	  • open frame quadrat
	  • grid quadrat
	  • point quadrat.

ST 3	Measurement of edaphic factors.
	• Soil texture:
	  • sedimentation
	  • soil sieves
	  • soil triangle.
	• Soil water content.
	• Soil organic matter content.
	• Soil pH.
	• Soil bulk density.

There is no prescribed list of compulsory investigations that must be carried out. Schools and teachers must choose appropriate practical activities that allow students to gain first hand experience of the required methodologies and sampling techniques.

The time devoted to practical activities should equate to two full days of fieldwork or one day of fieldwork plus six sessions of laboratory based activities.

Practical activities should be carried out with the consideration of their environmental impacts and how these can be minimised. All activities should be planned and carried out to ensure the safety of the students and other people.

6.5 Scientific principles

Throughout the course, students must be given opportunities to develop the following skills and knowledge.

6.5.1 Use theories, models and ideas to develop scientific explanations of environmental processes

Students must be given opportunities to use theories, models and ideas to develop scientific explanations of environmental processes.

Suitable opportunities for this include:

- the control of ecological succession in conserving plagioclimax habitats. Students should understand the processes in ecological succession that can inform conservation strategies
- global climate change: how interconnected natural systems cause environmental change
- the processes in the carbon cycle that are affected by human activities
- the processes in the nitrogen cycle that are affected by human activities.

6.5.2 Use knowledge and understanding to pose questions, define scientific problems, present scientific arguments and scientific ideas related to the environment

Students must be given opportunities to use knowledge and understanding to pose questions, define scientific problems, present scientific arguments and scientific ideas related to the environment.

Suitable opportunities for this include:

- setting conservation priorities. Students could evaluate the information available to decide which taxa and habitats should be conserved
- difficulties monitoring and predicting climate change
- ozone depletion. Collection, analysis and interpretation of data, an evaluation of data collection methods available and the reliability of data produced
- reserves and resource. Students could consider how data from exploration and the development of new exploratory and extraction techniques affect estimates of mineral reserves.

6.5.3 Use of appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems

Students must be given opportunities to use ICT to access environmental information and data, and to manipulate data.

Suitable opportunities for the use of ICT include:

- data on IUCN Red List species
- interactive maps on protected areas
- IWC catch quotas
- current atmospheric CO_2 levels
- tracking satellites that monitor the cryosphere
- climate modelling
- carbon footprint calculations
- tracking satellites that research mineral deposits
- research methods:
  - tracking wildlife.

6.5.4 Undertake experimental and investigative activities, including appropriate risk management, in a range of environmental contexts

Students must be given opportunities throughout the course to undertake experimental and investigative activities, including appropriate risk management, in a range of environmental contexts.

Suitable opportunities for this include:

- research methods
- sampling techniques.

6.5.5 Analyse and interpret quantitative and qualitative data to provide evidence, recognising correlations and causal relationships

Students must be given opportunities throughout the course to analyse and interpret quantitative and qualitative data to provide evidence, recognising correlations and causal relationships.

Suitable opportunities for this include:

- the importance of ecological monitoring in conservation planning
- ozone depletion: collection, analysis and interpretation of data, an evaluation of data collection methods available and the reliability of data produced
- evaluation of the effectiveness of the methods used to restore the ozone layer
- reserves and resource
- Lasky's principle
- the Universal Soil Loss Equation. Students could use data to estimate soil erosion rates in different agricultural scenarios
- research methods.

6.5.6 Evaluate methodology, evidence and data, and resolve conflicting evidence to make judgements and reach conclusions and develop and refine practical design and procedures

Students must be given opportunities throughout the course to:

- evaluate methodology, evidence and data, and resolve conflicting evidence to:
  - make judgements and reach conclusions
  - develop and refine practical design and procedures.

  Suitable opportunities for this include:

  - regulation of sustainable exploitation. Students could analyse data on populations and exploitation rates to assess the effectiveness of the strategies
  - management and conservation of habitats. Students could evaluate secondary data to assess the effectiveness of habitat conservation methods
  - how population control and the management of desired and undesired species affects the conservation of biodiversity
  - difficulties monitoring and predicting climate change
  - ozone depletion: collection, analysis and interpretation of data, an evaluation of data collection methods available and the reliability of data produced
  - the hydrosphere: analysis and evaluation of strategies for sustainable management

- research methods and working scientifically. Students could apply their knowledge of scientific methodologies and sampling techniques to plan studies to collect more data and to critically analyse methods of data collection in scenarios throughout the specification.

6.5.7 Know that scientific knowledge and understanding of the environment develops over time

Students must be given opportunities throughout the course to develop and understand that scientific knowledge and understanding of the environment develops over time.

Suitable opportunities for this include:

- management and conservation of habitats
- changes in concentrations of greenhouse gases and the impact of global climate change
- changes in ozone depletion
- changes in mineral reserves
- strategies to secure future mineral supplies.

6.5.8 Communicate information and ideas in appropriate ways using appropriate terminology

Students should understand and use the subject technical terminology used throughout the specification.

6.5.9 Consider applications and implications of environmental science and evaluate their associated benefits and risks

Students must be given opportunities throughout the course to consider applications and implications of environmental science and evaluate their associated benefits and risks.

Suitable opportunities for this include:

- the importance of the conservation of biodiversity
- the advantages and disadvantages of the methods used in sustainable management of the carbon cycle.

6.5.10 Consider ethical issues in the treatment of humans, other organisms and the environment

Students must be given opportunities throughout the course to consider ethical issues in the treatment of humans, other organisms and the environment.

Suitable opportunities for this include:

- human influence on biodiversity
- regulation of sustainable exploitation
- management and conservation of habitats
- global climate change
- the impact of unsustainable exploitation of the hydrosphere
- the environmental impacts of soil erosion.

6.5.11 Evaluate the role of the scientific community in validating new knowledge and ensuring integrity

Students must be given opportunities throughout the course to consider the way that peer review within the scientific community is used to validate new knowledge and ensure its integrity.

Suitable opportunities for this include:

- species population monitoring for:
  - IUCN Red List species categorisation
  - CITES trade control categorisation
  - setting quotas for IWC, EU CFP and ITTO
  - monitoring rates of tropical rainforest loss
  - monitoring rates of coral reef bleaching
- difficulties monitoring and predicting climate change. Students should understand the limitations in the available data when attempting to predict future natural and anthropogenic climate change. They should be able to evaluate the reliability of existing information and discuss the methods that are used to fill gaps in current knowledge, including remote sensing
- the Rowland-Molina hypothesis
- monitoring ozone depletion
- evaluation of the effectiveness of the methods used to restore the ozone layer
- analysis and evaluation of the strategies for sustainable management of the hydrosphere.

6.5.12 Evaluate the ways in which society uses science to inform decision making

Students must be given opportunities throughout the course to evaluate the ways in which society uses science to inform decision making.

Suitable opportunities for this include:

- categorisation of species for CITES appendices
- management and conservation of habitats
- the importance of ecological monitoring in conservation planning
- the control of ecological succession in conserving plagioclimax habitats. Students should understand the processes in ecological succession that can inform conservation strategies
- how population control and the management of desired and undesired species affects the conservation of biodiversity. Students should understand r- and k- selection strategies and how these affect the ease with which species can be over exploited
- evaluation of the effectiveness of the methods used to restore the ozone layer
- impact of unsustainable exploitation of the hydrosphere. Students should be able to use the technical terminology related to the hydrological cycle to discuss anthropogenic changes and strategies that may allow sustainable exploitation.

7 Appendix B: Maths requirements and examples

To develop their skills, knowledge and understanding in Environmental Science, students must have been taught, and to be competent in, the appropriate areas of maths indicated below.

Overall at least 10% of the marks in assessments for Environmental Science will require the use of maths skills. These skills will be applied in the context of environmental science and will be at least the standard of higher tier GCSE mathematics.

The following tables illustrate where these maths skills may be developed during teaching or could be assessed.

This list of examples is not exhaustive. These skills could be developed or assessed in other areas of specification content. Other areas where these skills could be developed have been given throughout this specification.

7.1 Arithmetic and numerical computation

Maths skill number	Skill	Example
MS 0.1	Recognise and make use of appropriate units in calculations	Students should demonstrate their ability to: • convert between units such as length and volume, eg calculating surface area: volume ratios in energy conservation • select appropriate units and values for a calculation, eg estimating water and organic matter content of soils.
MS 0.2	Recognise and use expressions in decimal and standard form	Students should demonstrate their ability to: • use an appropriate number of decimal places in calculations, eg calculating mean population density from multiple sample sites in a habitat • carry out calculations using numbers in standard and ordinary form, eg when comparing production of different energy resources • convert between numbers in standard and ordinary form, eg when using masses in biogeochemical cycles.

Maths skill number	Skill	Example
MS 0.3	Use ratios, fractions and percentages	Students should demonstrate their ability to: • calculate percentage yields, eg in pollution control • calculate surface area to volume ratios and relate this to heat loss • calculate and compare percentage loss, eg of rain forests over a given time period or of declining populations of endangered species.
MS 0.4	Estimate results	Students should demonstrate their ability to estimate results to sense check that the calculated values are appropriate, such as when calculating residence times in different water reservoirs.
MS 0.5	Use calculators to find and use power, exponential and logarithmic functions	Students should demonstrate their ability to: • interpret population growth curves • compare noise values quoted in decibel units.

7.2 Handling data

Maths skill number	Skill	Example
MS 1.1	Use an appropriate number of significant figures	Students should demonstrate their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures, eg in calculating indices of biodiversity • understand that calculated results can only be reported to the limits of the least accurate measurement, eg in estimating lifetimes of mineral reserves.
MS 1.2	Find arithmetic means	Students should demonstrate their ability to find the mean of a range of data, eg mean power output of a wind farm.

Maths skill number	Skill	Example
MS 1.3	Construct and interpret frequency tables and diagrams, bar charts and histograms	Students should demonstrate their ability to: • represent a range of data in a table with clear headings, units and consistent decimal places, eg to compare the energy density, production cost, carbon intensity and mean load factor for a range of energy resources • interpret data from a variety of tables, eg data relating to aquifer flow rates • plot a range of data in an appropriate format, eg atmospheric carbon dioxide levels, atmospheric temperature and solar output over time represented on a graph • interpret data from a variety of graphs, eg change in electricity cost from renewable energy sources, industrial output and level of financial incentives/tax over a number of years.
MS 1.4	Understand simple probability	Students should demonstrate their ability to use the term probability appropriately when investigating causal relationships such as the link between human health problems and urban pollutants.
MS 1.5	Understand the principles of sampling as applied to scientific data	Students should demonstrate their ability to: • analyse random data collected by an appropriate means, eg use Simpson's index of diversity to compare the biodiversity of habitats exposed to different pollution types or management regimes • analyse systematic data along a transect to monitor impacts of pollution with increasing distance from a copper smelter.
MS1.6	Understand the terms mean, median and mode	Students should demonstrate their ability to calculate or compare the mean, median and mode of a set of data, eg of yields of fish farmed under different conditions or fish from commercial catches.
MS 1.7	Use a scatter diagram to identify a correlation between two variables	Students should demonstrate their ability to interpret a scatter graph, eg to compare human development index with environmental footprint of different countries.

Maths skill number	Skill	Example
MS 1.8	Make order of magnitude calculations	Students should demonstrate their ability to: • compare storage volumes of natural water reservoirs and transfer rates • calculate national energy use from population and individual use data.
MS 1.10	Understand measures of dispersion, including standard deviation and range	Students should demonstrate their ability to: • calculate the standard deviation, eg of crop yield for a given nutrient input • understand why standard deviation is a useful measure of dispersion for a given set of data, eg for comparison with other data sets with different means such as populations of endangered species under different management regimes.
MS 1.11	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Students should demonstrate their ability to calculate percentage error where there are uncertainties in measurement, eg estimating total population using sub-samples in a preliminary study.

7.3 Algebra

Maths skill number	Skill	Example
MS 2.1	Understand and use the symbols : = < << >> > and ~.	No example required.
MS 2.2	Change the subject of an equation	Students should demonstrate their ability to use and manipulate equations, eg nutrient transfer rates, energy conversion efficiencies and fish maximum sustainable yields.
MS 2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Students should demonstrate their ability to use a given equation, eg Simpson's index of diversity: $D = \frac{N(N-1)}{\Sigma n(n-1)}$ to assess the impact of a new habitat management regime.

Maths skill number	Skill	Example
MS 2.4	Solve algebraic equations	Students should demonstrate their ability to solve equations in an environmental context, eg calculations using the universal soil loss equation to assess the effectiveness of soil conservation programmes.

7.4 Graphs

Maths skill number	Skill	Example
MS 3.1	Understand data presented in a variety of graphical forms	Students should demonstrate their ability to interpret data in a range of graphical forms, including line graphs, which may involve logarithmic scales, bar charts, stacked bar charts, histograms, kite diagrams, pie graphs, scatter graphs, 3-dimensional graphs, flow diagrams, Sankey diagrams and circular (radar) diagrams to enable a wide variety of data to be analysed.
MS 3.2	Translate information between graphical numerical and algebraic forms	Students should demonstrate their ability to understand that data may be presented in a number of formats and be able to use these data, eg dissolved oxygen levels, soil erosion rates.
MS 3.3	Plot two variables from experimental or other data	Students should demonstrate their ability to select an appropriate format for presenting data, bar charts, histograms, graphs and scattergraphs, eg organic matter and oxygen depletion, nutrient inputs and yield increase.
MS 3.4	Understand that $y = m x + c$ represents a linear relationship	Students should demonstrate their ability to predict/sketch the shape of a graph with a linear relationship, whether with a positive or negative correlation, eg the relationship between insolation and solar panel output
MS 3.6	Calculate rate of change from a graph showing a linear relationship	Students should demonstrate their ability to calculate a rate from a graph, eg rate of infiltration through rocks with different permeabilities.

Maths skill number	Skill	Example
MS 3.7	Draw and use the slope of a tangent to a curve as a measure of rate of change	Students should demonstrate their ability to use this method to measure the gradient of a point on a curve, eg rate of heat loss through double glazing with varying gaps.

7.5 Geometry and trigonometry

Maths skill number	Skill	Example
MS 4.1	Calculate the circumferences, surface areas and volumes of regular and irregular shapes	Students should demonstrate their ability to: • calculate the circumference and area of nature reserves to assess the impact of the edge effect on wildlife conservation programmes • calculate the surface area and volume of cylinders or spheres, eg to estimate rates of heat loss in energy conservation programmes.

8 Appendix C: Previous science learning

To develop skills and knowledge in AS Environmental Science, students should have the skills and knowledge associated with at least GCSE Combined Science or equivalent. While an understanding of all GCSE Combined Science or equivalent topics is advantageous, there are a number of topics that have particular applications in AS Environmental Science.

The following table illustrates the GCSE Combined Science topics that have particular applications in the development of skills and knowledge in AS Environmental Science.

GCSE Combined Science topic	Application in AS Environmental Science
Osmosis	Hydrosphere: unsustainable exploitation.
Levels of organisation within an ecosystem	Conservation of biodiversity. Life processes in the biosphere and conservation planning.
The principle of material cycling	Biogeochemical cycles.
Biodiversity	Conservation of biodiversity. Life processes in the biosphere and conservation planning.
The genome	The importance of the conservation of biodiversity: • genetic resources • captive breeding and release programmes.
Variation and evolution	The importance of the conservation of biodiversity: • genetic resources • captive breeding and release programmes.
Selective breeding and gene technology	The importance of the conservation of biodiversity: • genetic resources • captive breeding and release programmes.
Chemical symbols, formulae and equations, including reaction stoichiometry and masses of reactants and products	Global climate change Ozone depletion Biogeochemical cycles

GCSE Combined Science topic	Application in AS Environmental Science
Life cycle assessment and recycling	Mineral resources
Different methods of extracting and purifying metals	Mineral resources
The composition and evolution of the Earth's atmosphere since its formation	Atmosphere
Carbon dioxide and methane as greenhouse gases	Atmosphere
The Earth's water resources and obtaining potable water	The hydrosphere

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