A-level
ENVIRONMENTAL SCIENCE
7447/1

Paper 1

Mark scheme

June 2019

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, i.e. if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Qu	Part	Marking guidance	Comments	Total marks	AO
01				5	**AO1a = 5**

Description	Letter
	A
	G
Rock with a grainy texture, e.g. sandstone	F
	D
	C
	B

Qu	Part	Marking guidance	Comments	Total marks	AO
02	1	(Soil C is the) least permeable / has lowest sand content		1	**AO3a**
02	2	Compaction and high clay content		1	**AO3a**
02	3	Any **two** from: • hold soil together • vegetation cover reduces impact of raindrops on soil surface • act as natural windbreak / reduces wind velocity • adds OM / humus (colloidal) binds particles together • increases water infiltration / reduces runoff volume		2	**AO2**
02	4	**C** Sandy clay loam.		1	**AO2**
02	5	• weigh dry soil • heat to 500°C / Bunsen burner to a constant mass [**A** 200 – 700] • $\frac{\text{(dry soil mass – burnt soil mass)}}{\text{dry soil mass}} \times 100$		3	**AO1b**
02	6	Any **two** from: • reduced nutrient solubility / leaching • reduced toxic / heavy metal solubility • less soil deflocculation • increased population / action of decomposers / detritivores / decomposition • increased nutrient release / humus production / nitrogen fixation / stated action of soil biota • increased germination rate • greater ease of nutrient / anion uptake		2	**AO2**

Qu	Part	Marking guidance	Comments	Total marks	AO
03	1	**One** for each stage in the calculation: Selection of 4 correct values: • 3.4, 2860, 2.6, 2270 Calculation of N-contents • 97.2(4), 59.0(2) Calculation of difference • = 38.2 [**A** 38 or 38.22] ecf Award 3 marks for correct answer		3 Maths for first two marks	**AO3**
03	2	• 56.7 • 40 kg [**A** 39.7 kg or 39.69 kg] ecf Award 2 marks for correct answer	3.0% of 1890 = 56.7 70% of 56.7 = 39.69 kg	2 Maths 2	**AO3**
03	3	**One** of: nitrogen fixation by root nodule bacteria / *Rhizobium* (free-living) nitrogen fixing bacteria / *Azotobacter* OR **One** of: decomposition / ammonification action of decomposers / saprobionts / named decomposers breakdown of proteins / amino acids / urea		1	**AO2**

03	4	Methods / human activities that help re-establish levels in carbon reservoirs / dynamic equilibria. Descriptions of methods / specific named examples. Use of methods / human activities / descriptions to explain re-establishment of levels in carbon reservoirs / dynamic equilibria. e.g. Use of low-C / non fossil fuel resources Solar, wind, HEP, nuclear, other low C energy resource More efficient fossil fuel energy technology (to reduce carbon emissions) Combined cycle turbines, CHP, other named technology, description of method Carbon capture and storage (CCS), carbon sequestration (human technology) Oil secondary recovery, depleted oil, gas reservoirs, aquifers, low-carbonate rock reactions Carbon sequestration (natural processes) Afforestation, storage by photosynthesis in carbohydrates Conservation of natural carbon stores Forests, peat bogs, soil DOM	9	AO1b = 4 AO2 = 3 AO3b = 2

Examiners are reminded that AO1, AO2 and AO3 are regarded as interdependent. When deciding on a mark all should be considered together using the best fit approach. In doing so, examiners should bear in mind the relative weightings of the assessment objectives. More weight should therefore be given to AO1 than AO2 and AO3.

Level	Marks	Descriptor
3	7–9	A comprehensive response to the question, with the focus sustained. A conclusion is presented in a logical and coherent way, fully supported by relevant judgements. A wide range of knowledge and understanding of natural processes/systems is applied. The answer clearly identifies relationships between environmental issues. Relevant environmental terminology is used consistently and accurately throughout, with no more than minor omissions and errors.
2	4–6	A response to the question which is focussed in parts but lacking appropriate depth. A conclusion may be present, supported by some judgements, but it is likely not all will be relevant. A range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there may be a few inconsistencies, errors and/or omissions. The answer attempts to identify relationships between environmental issues, with some success. Environmental terminology is used, but not always consistently.
1	1–3	A response to the question which is unbalanced and lacking focus. It is likely to consist of fragmented points that are unrelated. A conclusion may be stated, but it is not supported by any judgments and is likely to be irrelevant. A limited range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there are fundamental errors and/or omissions. The answer may attempt to identify relationship between environmental issues, but is rarely successful. Limited environmental terminology is used, and a lack of understanding is evident.
	0	Nothing written worthy of credit.

Qu	Part	Marking guidance	Comments	Total marks	AO
04	1	Any **two** from: • water / CO_2 / sand grains / solvents at high pressure • creates fractures / fissures / cracks in rock • increased permeability / secondary permeability / greater ease of flow / gas released from rock [**R** references to enhanced gas recovery]		2	**AO1b**
04	2	Explanation including any **three** from: • avoid named sensitive area / surface activities • directional / horizontal drilling allows large area to be exploited from a single site • not near aquifers / water sources • use of non-toxic chemicals • regulation of chemicals used e.g. quantity • recirculation / recovery / named treatment method of water / fluids • borehole liners • collection / treatment of gaseous emissions • geologically stable areas / no faults • seismic monitoring • minimum depth • noise reduction methods		3	**AO2**

Qu	Part	Marking guidance	Comments	Total marks	AO
05	1	no contamination with other microorganisms / bacteria / fungi that may: any **one** from: • break down oil • compete for named resource, e.g. oxygen • pathogenic to test species • make original bacterial population inaccurate		1 1	**AO2**
05	2	**One** mark for calculation of difference in actual number of bacteria over the 49-day period 6.35 – 1.2 = 5.15 OR 63 500 – 12 000 = 51 500 ecf **One** mark for correct calculation of percentage increase 429%	Answers derived from day 0 and day 49 51 500 ÷ 12 000 x 100 / 5.15 ÷ 1.2 x 100 = 429% [**A** calculations using 6.3 to 6.4 for final population, giving answer in range 425% - 433.3% rec]	2	**AO3**
05	3	Less than 5%		1	**AO2**
05	4	Bioremediation inhibited / prevented by any **three** from: • anaerobic conditions • presence of toxins • low temperatures • competition with other microbes • lack of nutrients • extreme pH • extreme salinity • dispersed oil e.g. stormy conditions • large / concentrated spills (because too slow) • if rapid cleaning is required		3	**AO2**

05	5	**One** advantage from: • breaks up oil slick / produces an emulsion of oil droplets • reduces viscosity of emulsion [**R** reduces viscosity of oil] • oil becomes more mobile / disperses more readily • increases surface area for bioremediation/break down by bacteria • can be applied quickly so large area can be covered **One** disadvantage from: • may be toxic to organisms • may increase the toxicity of oil • may take longer to break down in the environment (than oil) • oil molecules not broken down • oil remains in the environment • greater mobility so other areas affected	1 1	**AO1b**

Qu	Part	Marking guidance	Comments	Total marks	AO
06	1	(Oxidation of) ores / mine spoil / rocks containing sulfides / sulfur / production of sulfuric acid		1	**AO1a**
06	2	Any **three** from: Standardisation of: • same net size / dimensions of opening / shape / mesh size • work from downstream to upstream • same length of time (for comparability) • same vigour of substrate disturbance / collection effort / collection area • multiple samples at each site • comparable sampling sites / comparable habitat		3	**AO1b**
06	3	Any **four** from: • normally present • normally common • easily seen / collected • easily identified • generally distributed • range of sensitivities / specific sensitivity [**R** all highly sensitive]		4	**AO2**
06	4	Higher number of species downstream due to any **two** from: • within range of tolerance / reduction in named impact • dilution / dispersal of pollutants • lower concentrations of pollutants, e.g. toxic metals / zinc / copper • higher pH		2	**AO2**

Qu	Part	Marking guidance	Comments	Total marks	AO
07	1	Any **two** advantages from: • data collected from all areas / globally [**R** deployed globally/dispersed] • greater numbers of Argo floats gives larger quantities of data (per unit time) • lack of seasonal bias / floats operate all year round / ships avoid winter months / severe weather / dangerous or inaccessible areas • less labour intensive / energy intensive / polluting when operational • repetitive over long term		2	**AO3**
07	2	18.9 – 14.7 = 4.2 4.2 ÷ 7 = 0.60 [**A** 0.6] [**A** range 0.57 to 0.64] **One** mark for correct answer		1	**AO3 1a**
07	3	Any **three** from: • increasing (atmospheric) temperature • (increased) melting of land ice / (increased) freshwater flow into sea • freshwater less dense / reduced salinity / density • reduced sinking / sinks more slowly • obstructing surface current		3	**AO1b =3**

07	4	Lack of data on past trends: • absence of ship-based data Lack of understanding of natural fluctuations: • natural / long term / decadal fluctuations in flow rate Future changes in human activities not known: • GHG emissions • Carbon sequestration / CCS • geoengineering Impact of other positive feedback mechanisms on increased temperatures: • melting permafrost • increased DOM decay • increased forest peat fires Impact of negative feedback mechanisms: • low-level cloud cover albedo • natural carbon sequestration Lack of understanding of natural processes affecting: • temperature • precipitation • wind direction • velocity • evaporation Lack of understanding of interconnections of natural processes Time delay between cause and effect Different timescale of effects	9	**AO1** **a=2** **b=2** **AO2= 3** **AO3** **c = 2**

Examiners are reminded that AO1, AO2 and AO3 are regarded as interdependent. When deciding on a mark all should be considered together using the best fit approach. In doing so, examiners should bear in mind the relative weightings of the assessment objectives. More weight should therefore be given to AO1 than AO2 and AO3.

Level	Marks	Descriptor
3	7–9	A comprehensive response to the question, with the focus sustained. A conclusion is presented in a logical and coherent way, fully supported by relevant judgements. A wide range of knowledge and understanding of natural processes/systems is applied. The answer clearly identifies relationships between environmental issues. Relevant environmental terminology is used consistently and accurately throughout, with no more than minor omissions and errors.
2	4–6	A response to the question which is focussed in parts but lacking appropriate depth. A conclusion may be present, supported by some judgements, but it is likely not all will be relevant. A range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there may be a few inconsistencies, errors and/or omissions. The answer attempts to identify relationships between environmental issues, with some success. Environmental terminology is used, but not always consistently.
1	1–3	A response to the question which is unbalanced and lacking focus. It is likely to consist of fragmented points that are unrelated. A conclusion may be stated, but it is not supported by any judgments and is likely to be irrelevant. A limited range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there are fundamental errors and/or omissions. The answer may attempt to identify relationship between environmental issues, but is rarely successful. Limited environmental terminology is used, and a lack of understanding is evident.
	0	Nothing written worthy of credit.

Qu	Part	Marking guidance	Comments	Total marks	AO
08	1	• 3.77×10^{12} J (in 3 hour period) • 349 MW [**A** 350] ecf [**A** Ma calculation with correct decimal figures]	Unit changes: hr to s W to MW $0.5 \times (7.5 \times 10^{6}) \times 1025 \times 9.81 \times 10^{2}$ $= 3.77 \times 10^{12}$ J [**A** 3.8×10^{12} J] $3.77 \times 10^{12} \div 10800 = 349.07 \times 10^{6}$ W = 349 MW [**A** $3.8 \times 10^{12} \div 10800 = 351.85 \times 10^{6}$ W = 352 MW]	2	**AO3a**
08	2	27 %	Power output = 25 kW Power available = 93 kW Efficiency = output/input x 100	1	**AO3a**
08	3	Any **two** from: • greater head of water / GPE • greater water velocity / flow rate [**A** kinetic energy] • greater water pressure / force • greater volume of water (passes turbines) • barrage full width of estuary		2	**AO1b**

08	4	**One** mark for method of measuring turbidity • use light source and light meter / photometer / colorimeter / turbidimeter / nephelometer OR • use Secchi disc / light and dark segments / turbidity bottle **One** mark for method of measuring flow rate • flow meter OR • floating object, distance and time measured Up to **three** marks for details of standardisation / reliability from: • range of flow rates tested (min 3) • repeats for reliable mean • sufficient (min 10) samples for statistics test • water samples / turbidity readings taken at same time as flow readings • calibration of light meter / flow meter For turbidity meter: • one light source / same light levels / wattage • same distance between light source and water container For turbidity bottle: • same size water container • same depth of water in bottle For Secchi disc • same light levels	2 3	**AO1b =2** **AO2=3**

Qu	Part	Marking guidance	Comments	Total marks	AO
09	1	**C**		1	**AO3 1a**
09	2	**B**		1	**AO3 1a**
09	3	Any **three** from: multiple panes of glass leads to: • reduced heat conduction • reduced convection / static air gap with inert gas: • low conductivity / reduced convection gap with vacuum: • reduced conduction / no convection gap size: • larger to reduce conduction • not large enough for convection low emissivity glass: • reflects IR frame design: • low conductivity materials smaller windows: • walls lose less heat than windows		3	**AO3b = 3**

Qu	Part	Marking guidance	Comments	Total marks	AO
10	1	Any **three** from: • air current / wind direction • highest Cs-137 levels in areas of highest precipitation / (Cs-137) washed out of atmosphere into soil • highest Cs-137 levels in upland areas • lower availability in high clay soils (Cs adsorbed onto clay particles) • pH affects mobility / availability of Cs • different uptake by different grass species		3	**AO3**
10	2	Max **three** from: (field study) • systematic sites selected across the country • selection of suitable grass areas within each grid square selected • same method of selecting sampling sites within grass area e.g. systematic / random • sampling at similar time • same sample area size • same collection area / quadrat size • same number of quadrats at each site • large number of quadrats (min 10) Max **three** from: (lab analysis) • same weight of grass used per test • same radiation detectors / Geiger counters / scintillometer used • same length of time for detection of radioactivity • same distance from test sample to detector • repeat tests on same sample		5	**AO2 = 5** **PS = 5**
10	3	1509 Bq kg $^{-1}$		1	**AO2**
10	4	Any **one** from: • where individuals live in relation to the source • time spent outside, for example, farmers, dog walkers, anglers, walkers • heavy rain, people outside during rain • proximity of individuals to geology / soil that adsorbs radioisotopes • sources of food, for example, local food: milk, seafood, vegetables • source of water, for example, a shallow well [**R** workers in nuclear industry]		1	**AO1 1a**

Level	Marks	Descriptors
5	21–25	A comprehensive response with a clear and sustained focus. Content is accurate and detailed. Relationships are identified, reflecting the holistic nature of environmental science and the answer as a whole is coherent. A wide range of relevant natural processes/systems and environmental issues are described and articulated clearly. These are applied systematically to the question, with clear relevance to the context. Where conclusions are made, these are fully supported by judgements and presented in a logical and coherent way. Relevant environmental terminology is used consistently and accurately throughout. If there are errors, these are very minor indeed and not sufficient to detract from the answer.
4	16–20	A response in which the focus is largely sustained, with content that is mainly accurate and detailed. Relationships are identified and the answer is largely coherent. A range of natural processes/systems and environmental issues are described and articulated clearly. In most cases, these are applied appropriately to the question but, in some, it is less clear why they are relevant. Where conclusions are made, these are supported by judgements which are mostly coherent and relevant. Relevant environmental terminology is used consistently and throughout, with no more than minor errors.
3	11–15	A partial response which is focussed in parts. The content is mostly accurate but not always detailed. There is an attempt at identifying relationships, but the answer as a whole is not fully coherent. A range of natural processes/systems and environmental issues are described, most are articulated clearly. In some cases, these are applied appropriately to the context but, in most, it is less clear why they are relevant. Where conclusions are made, it is not always clear how they relate to the judgments given and are likely to contain errors. Relevant environmental terminology is used, but not consistently and there may be errors.
2	6–10	An unbalanced response, lacking in focus. The content may be inaccurate and lacking detail. There is some attempt at identifying relationships, but the answer is not coherent. A limited range of natural processes/systems and environmental issues are described but not articulated clearly and likely to contain errors and/or omissions. There is a limited attempt to apply them to the context. Any conclusions are likely to be asserted, with no supporting judgements and fundamental errors. Environmental terminology is used, but not always appropriately and sometimes with clear errors.
1	1–5	Fragmented points, whose relevance to the question and relationships to each other are unclear. A few natural processes/systems and environmental issues are listed, but unlikely to be described and many may be irrelevant. There is no clear attempt to apply them to the context. It is unlikely that a conclusion will be present. There is an attempt to use environmental terminology, but seldom appropriately.
	0	Nothing written worthy of credit

Qu	Part	Marking guidance	Comments	Total marks	AO

Qu 11	Part 11.1	AOs: AO1 = 10 AO2 = 10 AO3 = 5			
Evaluation Students need to consider **both** the positive and negative aspects of treatment of a particular type of solid waste, i.e. those aspects of environmental damage that have been controlled by treating the waste in a particular way and the environmental damage that has not been controlled.					
Solid wastes	**Treatment methods**	**Topic areas**	**Extent of environmental impact**	**Spec ref**	
Domestic waste	Landfill	Conservation of Biodiversity	*negative* – land take, habitat loss, pests *positive* – leachate collection	3.4.3.2.12 3.1.2	
		Atmosphere	*negative* – CH_4 and CO_2 production (GCC) *positive*- waste gas collection *negative* – subsequent incineration GCC *negative* – odours/H_2S *positive* – soil covering, sprays, land reinstatement after quarrying *negative* – transport of waste to sites inc. GCC, atmospheric pollutants	3.4.3.2.12 3.2.1.2	
		Soils/ hydrology	*negative* – contaminants may affect subsequent land use/leach into surrounding area/ watercourses dust blow	3.4.3.2.12 3.2.5	
	Incineration	Conservation of Biodiversity	*positive* – volume reduction, less to landfill	3.4.3.2.12 3.1.2	
		Energy resources	*positive* – district heating, generation of electricity reduced fossil fuel use RDF pellets	3.4.3.2.12 3.3	
		Mineral resources	*negative* – loss of recyclable materials	3.4.3.2.12 3.2.3	
		Atmosphere	*negative* – toxic dioxin production, atmospheric pollutants *positive* – pollution control methods, scrubbers etc.	3.4.3.2.12 3.2.1.2 3.4.3	
	Recycling	Conservation of Biodiversity	*positive* – volume reduction, less to landfill	3.4.3.2.12 3.1.2	
		Mineral resources	*positive* - conservation of mineral resources *negative* – material identification, some alloys too complex to separate, reduced quality, thermoset	3.4.3.2.12 3.2.3	
		Atmosphere	*negative* – transport of recyclable material to centres, inc. GCC,	3.4.3.2.12 3.2.1.2	

			atmospheric pollutants	
		Energy	*negative* – increased energy usage recycling some materials *positive* – energy saved on recycling others, e.g. aluminium	3.4.3.2.12 3.3
	Composting	Conservation of Biodiversity	*positive* – soil improver, methane collection	3.4.3.2.12 3.1.2 / 3.2.5
Industrial spoil and waste	Spoil heaps	Conservation of biodiversity	*negative*- land take, habitat loss, leachate *positive*- pH modification, phytoremediation, landscaping	3.4.3.2.12 3.1.2 3.2.3.6
		Atmosphere	*negative* – *toxic/*flammable wastes *positive* – *spraying* fine grained waste reduces dust blow	3.4.3.2.12 3.2.1.2
Radioactive waste	Encapsulation & vitrification (High & intermediate level waste)	Atmosphere biosphere, lithosphere hydrosphere	*negative* – heat generated in storage, well ventilated cooling systems, long term storage a problem, potential leakage *positive* – radiation contained	3.4.3.2.12 3.2.1.2 3.1/3.2
	Low level waste (cooling ponds)	Hydrosphere biosphere	*negative* – discharge to sea, bioaccumulation	3.4.3.2.12 3.1/3.2

Qu 11	Part 11.2	AOs: AO1 = 10 AO2 = 10 AO3 = 5

Evaluation:

- **resource extraction –** environmental impacts for both fossil fuels and renewables:
  fossil fuels-for direct use
  raw materials for equipment manufacture in renewables
- **site development/operation/processing –** all energy resources have impacts-dependent on fossil fuels for transport, construction etc.
- **in use –** fossil fuels have a greater environmental impact than renewables on a global scale. In use, renewables have less environmental impact which tends to be localised
- **embodied energy in equipment –** all energy resources
- **end of life/use –** equipment recycling **–** reuse of materials. Habitat restoration/creation-all energy resources.

Students need to evaluate the impacts at all stages of use of fossil fuels and renewables. Details of impacts given to illustrate points made.

Energy resource	Environmental impacts	Spec ref
Fossil fuels - coal	**Extraction:** acid mine drainage, leachate spoil mining – noise, dust habitat damage **Processing & transport Use:** atmospheric pollution – smoke particulates, smoke smogs, acid precipitation, GHGs aquatic pollution – thermal pollution from power stations	3.3.4.1 3.4.3.2.1 3.4.3.2.6 3.4.3.2.10 3.2.3.6 3.3.3
Fossil fuels - oil	**Extraction & transport**: leakage from drilling wells, spills from ships, refineries, accidents **Processing Use:** aquatic pollution – habitat damage, food chain effects, thermal pollution from power stations atmospheric pollution – PM10, photochemical smogs, GHGs	3.3.4.1 3.4.3.2.1 3.4.3.2.4 3.4.3.2.6 3.4.3.2.7
Fossil fuels - gas	**Extraction & transport:** drilling, tankered liquid form, piped habitat damage **Use:** atmospheric pollution – GHGs aquatic pollution- food chain effects, thermal pollution from power stations	3.3.4.1 3.4.3.2.4 3.4.3.2.6
Solar power	**Manufacture of solar panels:** extraction and processing of materials to construct SP. toxic wastes produced ($SiCl_4$,Cd) **Use:** solar farms – land take cleaning – increased water use	3.3.4.1
HEP	**Reservoir construction**: dam – large amounts of rock, sand, gravel, and cement.	3.3.4.1 3.2.3.6

	extraction, processing, and transport of the materials requires energy – fossil fuels habitat loss - access roads, flooding **In use:** anaerobic conditions – CH_4 sedimentation–retention of nutrients altered flow regime impact on migratory organisms	
Wind power	**Manufacture and installation**: raw material extraction & processing requiring fossil fuels **Use:** noise habitat damage – access paths bird strikes bat deaths visual impact	3.3.4.1
Wave power	**Manufacture and installation**: raw material extraction & processing requiring fossil fuels anchorage to sea bed-habitat destruction/creation	3.3.4.1
Biofuels	**Production:** habitat loss, fertiliser & pesticide use, fossil fuels for machinery. **Use:** atmospheric pollution- smoke particulates	3.3.4.1
Geothermal	**Infrastructure**: steam and hot water pipes impede animal movements **Use:** gas emissions: CO_2, H_2S waste water: salts, heavy metals	3.3.4.1
Tidal power	**Tidal barrages construction**: extraction, processing, transport of sand, gravel, rock, cement, tarmac **Use:** reduced tidal range increased sedimentation, lower turbidity affects distribution of photosynthetic organisms pollutant concentration migratory species impeded tidal lagoons: less impact than barrages in-stream turbines: tidal flow not impeded tidal turbines produce noise	3.3.4.1