T A S M A N I A N

S E C O N D A R Y

A S S E S S M E N T

B O A R D

Science of Natural Resources

Senior Secondary

2C, 2B, 2A 3C, 3B, 3A 4C, 4B, 4A

SYLLABUS SUPPLEMENT

The Syllabus Supplement must be read in conjunction with the syllabus document. It contains advice to assist teachers delivering the syllabus and can be modified from year to year in response to consensus decisions arrived at in TASSAB Moderation meetings.

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EXPANDED SYLLABUS OUTLINE

INTEGRATED (AIR, WATER, SOIL, BIODIVERSITY) THEME

The questions, content and practicals listed below are suggestions only and not prescriptive. The essential core of the course is indicated in the key questions, major ideas and assessment criteria. The actual content delivered in this course will depend on the teacher, students and resources available both within the school and the local community. The emphasis should be on an enquiring, applied approach to learning, using local resources where possible.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued?	**Questions** What do humans need to stay alive? What things are essential and what things nonessential? How do humans use air/water/soil/biodiversity? How do we use rivers/ ocean? Where does plastic, paper, metals, clothing etc come from? Where did the planet earth come from? In what way are the earth's resources fragile? **Content** Meaning of biodiversity, ecosystem, resource, top soil. How humans use air, soil, water, biodiversity. How a range of common articles depend on natural resources. Changes in community values over time and what catalyses these changes. **Practical work** Excursions to local resources. Identification of how articles in common usage relate to basic natural resources. Identification of what humans need to stay alive. Resources in space: moon, sun, planets, stars and how we relate to them.	**Questions** *Build on level 2 questions* What is a resource? What is a natural resource? What sorts of things are of value to humans? What would you pack away in preparation for a long stay on a deserted island? What are the values that we can attach to a range of ecosystems? What was in this spot 100, 1000, 1000000, 10000000 years ago? What determines the price of a resource eg gold, air, water, oil, diamond, salt. What is meant by 'exponential growth' and what are some examples in resources use? **Content** *Build on level 2 content.* What is meant by a natural resource. Discussion of range of types of values: economic, aesthetic, spiritual, scientific, ethical, educational etc. Idea of a hierarchy of personal values. Market prices as related to supply and demand and government regulation (taxes). **Practical work** Case studies of ways we use local natural resources. Excursions. Surveys as to how people think a range of everyday articles relate to our natural resources.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
2. What scientific understandings are involved in the formation of this resource?	**Questions** What is in air/water (fresh, salt)/soil? What is in an ecosystem? How are basic resources (air, soil, water) formed/maintained? What biodiversity is found in named (local) ecosystems? How is it that bird faeces finish up in your morning cereal? **Content** Describe a range of ecosystems. Local environment studies. Examples of Interdependence of all resources – natural and human generated. Time and change. What is a species. Plant photosynthesis. Human respiration. Physicochemical properties water, air, soil. Soil types, composition, formation. Science of evolution, natural selection. Factors effecting evaporation. Viscosity and streamlining. Water cycle. History Australian ecosystems. **Practicals** Excursions to local ecosystems, ponds, gardens etc. Simple plant id. Soil profiles examination. Photosynthesis/respiration experiments. Streamlined shape experiments. Evaporation, condensation experiments. Plant growth and seed germination experiments. Worm farms. Aquarium/pond study.	**Questions** *Build on level 2 questions* What living and nonliving factors make up a defined ecosystem? What types of relationships exist between the above factors? What are some ways of collecting information about a natural area? **Content** *Build on level 2 content.* Base line studies. Techniques data collection in a natural area. Ecosystem study; biogeochemical cycling in nature. Population studies. Science of evolution, natural selection. Ecosystems and change. Biological succession. Elements, compounds, mixtures. Chemical reactions. Photosynthesis, respiration, evapotranspiration Plant morphology and development. Water/atmosphere on planets other than earth. Density. Atomic structure. Element formation and nuclear events in stars. **Practicals** Excursions to local resources. Base line studies to identify living and nonliving factors in local natural areas eg using waterwatch activities. Species keys as part of plant/animal id. Examination soil types. Types chemical reactions. Separating mixtures, measuring densities. Plant growth experiments. Observations on animal behaviour.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** What is combustion? Why do planes fly? What is the best shape for a submarine or a fish? Why is water a good coolant? Why is dissolved oxygen important in water? What is DNA identification? Why do metal ships float? Why are fertilisers added to soils? What are the ideal characteristics for a range of farm animals and plants? What are the ways that industry generates and uses energy? What industries use combustion, photosynthesis, evaporation, electrolysis? **Content** Experimental design. Basic requirements for combustion. Streamlining and human design. Fertilisers, irrigation Energy transformation Relationship of material properties to material use eg conduction, strength, density, flexibility.	**Questions** *Build on level 2 questions* Where do a range of farm animals and domesticated animals come from? How is petrol formed from crude oil? How is copper made from its ore? How is electricity formed? How do evaporative coolers work? What is the green house effect? Why do trout only live in cold water? What factors determine how much oxygen is dissolved in water? What is in vitro fertilisation? What is genetic engineering? What are the ways we fight a bush fire? What are some deep sea fishing techniques? How are mud bricks made? **Content** *Build on level 2 content.* Oxidation, reduction Science/genetics of selective breeding, GMOs Distillation Fishing technology. DNA and heredity Principles Archimedes, Flotation Bernouli principle Organic gardening Energy laws Interdependence of urban, agricultural and natural ecosystems Relationship of structure and properties range materials eg polymers, semiconductors, superconductors Electrochemical cells. Specific heat capacity water and other liquids.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource? (cont.)	**Practical work** Experimental design. Basic requirements for combustion. Streamlining and human design. Fertilisers, irrigation Energy transformation Relationship of material properties to material use eg conduction, strength, density, flexibility.	**Practicals** Making polymers in class (eg casein plastic} Electrodeposition of metals. Distillation of essential oils from eg tea tree leaves Making paper Comparison of energy content of various fuels/foods Physical properties of a range of materials.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and / or management practices result in its ecological sustainability?	**Questions** What does sustainable mean? What dangers do (local) ecosystems face? How can ecosystems be destroyed? How do humans impact on named ecosystems/ air, rivers, oceans, top soil? What is erosion? What human processes need to be controlled to maintain these ecosystems, natural resources. What are some examples of how ecosystems can be rehabilitated? What is meant by a minimum environmental flow for a river? What is risk? Is there any such thing as a risk free process? If we were to live in a space ship how could we sustainable manage our resources for a long time? Where do weeds come from?	**Questions** *Build on level 2 questions* What are some environmental issues? What is meant by ecological sustainability? In what ways do we compete for use of a resource? What are some principles of 'Ecologically Sustainable Development'? How do ecosystems change naturally over time? How can we arrive at agreement in a community as to the most suitable use of a resource? What are renewable and non renewable energy forms? What is a management plan for an area?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and / or management practices result in its ecological sustainability? (cont.)	**Content** Meanings Sustainability, rehabilitation. Main human impacts on ecosystems, natural resources. Risk analysis. Traditional Aboriginal land management techniques. Threats to atmosphere, water quality, soils, biodiversity. Weeds, feral animals, erosion, threatened species, habitat destruction **Practicals** Ongoing ecological monitoring. Habitat rehabilitation. Local case studies. Hazard identification in school. Waterwatch experiments. Landcare, bushcare, fishcare activities. Weed identification and mapping. Litter cleanup, mapping, identification. Nature walks and accompanying photo essays, art work. Threatened species projects.	**Content** *Build on level 2 content.* Meanings Ecological Sustainability. Discussion of some environmental issues. Elements of sustainability – what needs to be sustained. Main threats to quality of Australian water, soils, air and biodiversity. What is meant by management and management plans. Content of a management plan for a natural resource. Risk management. Internationally accepted 'Principles Ecological Sustainability' Risk Assessment and Management. Ways of solving environmental problems: examples of the use of science/technology, laws, economics, education. Traditional Aboriginal land management techniques. Organic farming techniques. Environmental river flow. Ecotourism. Occupational Health and Safety in selected workplace. **Practicals** Hazard identification around school, community. Design a 'Biodome' that people could live in indefinitely Devise management plan for local resource (fish tank, garden, bush block, stream etc). Weed management activities. How do local people best see a resource being used (carry out surveys). Local habitat rehabilitation. School recycling projects. School energy efficiency audits. Landcare, bushcare, fishcare activities.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource?	**Questions** Who invented the wheel, gun powder, printing, batteries, microscope, telescope, light bulbs, transistors etc? How has the invention of the above changed our lives? What is artificial insemination, plant breeding, animal husbandry? What do the following people do: biologists, zoologists, botanists, veterinarians etc? What are air scrubbers and how are they used? What are some techniques for treatment of sewage waste and waste water in general? What are biodegradable plastics? What are the consequences of using them? What are the following people famous for: Jenner, Faraday, Galileo, Nightingale, Einstein, Newton, Marconi etc. **Content** History of 'old fashioned' machines for range uses. Experiments on requirements for plant growth in classroom. History of development of technology in various areas resource use eg shipping, furnaces, fishing, water based recreation, medicine, waste disposal Changing patterns of energy transformation /generation eg wind, solar, nuclear. History modes public transport and effect on the way people live. **Practicals** Design and make model technologies. Classroom growth experiments with range equipment eg Aquaculture, hydroponics, worm farms, fish tanks. Student power point presentations of projects on history of technologies. Competitions on designing tools to best carry out a task eg carry water over a distance using paper only. Low energy design housing models	**Questions** *Build on level 2 questions* Who did what? - Project work on range inventors and history of technologies. What are some of the modern techniques available for waste water treatment? What are some technologies which allow for very efficient use of irrigation water? How does hydroponics work? What artificial growth media can be used to grow plants? How is tissue culture used to reproduce many modern plant lines? What is stem cell research? Would we be better off if the wheel had never been invented? What would be the consequences for the earth if scientists invented a way of generating unlimited energy very cheaply (eg cold fusion). Has the invention of ways to harness nuclear energy been good for humanity? How are rockets designed? What is jet propulsion? How can waste be used to generate usable energy? **Content** *Build on level 2 content.* History of development of range technologies eg energy generation, optical instruments, medicines, running shoes, sports training techniques. How invention of new technologies have impacted on our lifestyles and usage resources. Possible future technologies – science fiction. Cold fusion energy generation. History of aeroplane propulsion, boat design, racing car engines. **Practicals** Make a methane generator from cow poo Design and make model technologies - competitions. Using range technologies properly eg microscope, telescope, wood saw, burette, safety equipment. Student power point presentations on range projects related to development technologies and impact on society eg car.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures?	**Questions** What do we want for ourselves in 5 years time – possessions, lifestyle? What are some of the different uses a river (or ocean, forest, atmosphere) has? How do/can these uses compete with each other? How do we find out what other people want? How can we design a good survey? What is the best human population for Tasmania? What would a much larger/smaller population mean for Tasmania? Do people want more hydro dams in Tasmania? What is an old growth forest? Should we harvest an old growth forest for its timber? What are the uses of an old growth forest? How long does it take for a named habitat (eg old growth forest) to form? How long have humans been on the earth? What is the history of fossil fuel use by humans? Has the invention of (the wheel, computers, explosives, cars, chain saws, etc) been a good thing? What are the alternatives to using fossil fuels? Why do city atmospheres become polluted eg Launceston in winter. What choices can people make to remedy this? Why plant native gardens?	**Questions** *Build on level 2 questions* What do we want for ourselves in 10 years time – possessions, lifestyle? What doe we mean by the idea of 'development'? What choices need to be made for 'ecologically sustainable development' What are some of the different uses a local river (or ocean, forest, atmosphere) has? How do/can these uses compete with each other? How does competition arise for the use of a resource? How do uses of this river (or other natural resource) help generate employment and community wealth? How do people use the river for recreation? Does this generate community wealth? Environmental flow is being restored to the Snowy River – what does this mean? What difficult choices/decisions need to be made to do this? What is meant by social responsibility? Give some examples of socially responsible and socially irresponsible action. What sort of a future do we want for ourselves – career, living in a small city, large city, rural environment? What is meant by our 'standard of living'? How is it measured? What is meant by the idea of 'quality of life'? How is it measured? How might 'quality of life' differ from 'standard of living'? What is global warming? What is the greenhouse effect? Greenhouse gases? What difficult choices need to be made to limit greenhouse gas emissions in Australia? How do scientific inventions/technology change society? Examples. Who makes the decisions about use of newly invented technology?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures? (cont.)	**Content** Vision statements of desirable futures. All decision making has consequences – history of decision making and its consequences as applied to resource use in Tasmania. Time and change generally: Comparison of rates of change in processes eg resource creation compared to resource use. Relate to decision making. Examples of good decision making - sustainable resource use in Tasmania, Australia. What are some replacement metals for car or aeroplane manufacture in the future? Why? **Practicals** Community surveys. Survey design. Measuring impacts of pollution eg effect acid on growth plant experiments Making paper from different materials. Measuring erosion in an area. Measuring a variety of human impacts in an area eg weeds, litter, erosion and relating to human choices. Personal futures – investigation of jobs related to resource management.	**Questions** *Build on level 2 questions (cont.)* What is a consultative process? How can a consultative decision making process occur? What is an ideal population size for Tasmania? What impacts have the discovery of fossil; fuels had on the development of human civilisations? **Content** *Build on level 2 content.* Vision statement of where we want to be in say 20 years. Decision making and its consequences as applied to resource use. Examples and consequences of overuse/lack of proper management of a sea fishery, river water, top soil, air, ocean. GDP/GNP and its relationship to resource use. 'Quality of life' indicators in society. Examples of incompatible uses of a resource. Global warming and relationship to fossil fuel use. What are the consequences of a warming atmosphere, depletion of clean water resources, loss top soil. Consultative decision making – meaning. **Practicals** Making wall posters to illustrate the range of uses that various natural resources have for humans (eg raw materials for processing, tourist, habitat, medical, recreational, scientific, educational, spiritual). Values clarification exercises – eg surveys on preferred places to live. Surveys on usage of resources and preferred futures for an area. Carry out a consultative process for the class to reach a decision on something eg where to go for excursion, best use of money collected for a charity or the school, who does what for jobs in the classroom. Personal futures investigation – prepare portfolio of jobs, future training requirements, subject electives, qualifications etc to reach students presently preferred future. Class debates on use natural resources, stem cell research, population size Tasmania etc

FORESTS AND FORESTRY THEME

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued?	**Questions** What is a forest? What types of forests do we have in Tasmania? How do people use / value forests? What renewable resources can forests provide? What types of forest products have widespread everyday use? Who uses wood and wood products? Why are some Tasmanian timbers highly regarded for wooden boat building? Why has the timber industry been an important part of Tasmania's European history? **Content** Tasmania's forests, their characteristics and distribution. Conservation, recreation and tourism in Tasmania's forests. Products from native forests; honey, firewood, tree ferns, native pepper, water, solid wood and wood fibre products, … Products from tree farms; softwoods, hardwoods. Changes in community values related to forests. **Practical** Excursions to local areas (forests and industries) Identification of forest products in common usage. Identification of properties and characteristics of forest products that result in their use.	**Questions** *Build on level 2 questions* What factors have influenced the evolution of Tasmania's forests? How does biodiversity change as a forest ages? How might present community values have both positive and negative influences on biodiversity? How do humans value wood? What properties of wood do humans value? What unique values have made some Tasmanian timbers desirable across the world" **Content** *Build on level 2 content* The effect of continental drift and ice ages on Tasmania's climate and vegetation. Biodiversity and how it relates to forest systems? Distribution of vertebrate species in Tasmanian forests. Discussion of social, economic and environmental values of forests. Changing values and attitudes of society over time. **Practical** Excursions to local resources. Case studies of: the way we use timber products, links between people's use of forest products and values they have about forests locally and globally, native animal use of different forest types.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What scientific understandings are involved n the formation of this resource?	**Questions** What environmental factors influence forest type and distribution? How do different forest types renew themselves? What is the function of each pert of a tree? What unique adaptations do eucalypts have for survival in Australian conditions? What processes are involved in forest growth and decay? How do invertebrates contribute to a healthy forest? What is the role of fire, and how does it behave, in different forest communities? Who are the producers, consumers and decomposers in the forest? Why are only some eucalypt species used for timber production? What relationships exist between soils and forests? **Content** Make links between altitude, rainfall, temperature and vegetation maps of Tasmania. Ice ages and their effect on Tasmania's climate and vegetation. Soil profiles, stability and fertility in different forest types and on different rock types. Natural regeneration cycles for forests and plant adaptations to these. Photosynthesis, respiration, transpiration and nutrient cycling in different forest communities. Decay organisms in forests. Aboriginal fire-stick farming **Practical** Excursions to different forest environments Photosynthesis experiments Decay of plant material in soil with/without worms Examining soil profiles in different environments Soil structural stability tests	**Questions** *Build on level 2 questions* Why are some plants such as acacias, casuarinas, dogwoods and some fungi important in eucalypt forests? Does forest succession follow the same pathway everywhere? Why do soil profiles and properties differ from site to site? How does fire influence plant and animal communities? Can eucalypt forests exist without fire? How are eucalypt species adapted to specific environments? **Content** *Build on level 2 content* Forest succession on high /low rainfall areas and high/low fertility areas. The five soil forming factors and soil capability. The effect of fire frequency, intensity and season on diversity in different communities. Natural pests and diseases in Tasmanian forests. Nutrient use, adaptations and plant associations of the eucalypt. **Practical**

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** How is the WARRA Long Term Ecological Research site contributing to understanding wet eucalypt forest ecology? What research into different timber harvesting systems is being conducted at WARRA? What silvicultural (harvesting and regeneration) systems are applied to native forest in Tasmania and why? W hat types of defects make native forest timber unsuitable for sawmilling? What causes these? Why does it take one year to produce a dried hardwood board but only one day to produce a similar softwood board? Why are products such as chipboard and Medium Density Fibreboard used in preference to solid timber? What advantages do pre-stressed laminated timber beams have over steel beams? Why does sawn timber used in outside environments have to be painted? How are fibres extracted from plants? Why are eucalypt fibres so sought after for fine writing and printing papers as well as tissue paper? How are paper products recycled?	**Questions** *Build on level 2 questions* What forest and timber research bodies exist in Tasmania? What do they do? Is selective logging viable in wet eucalypt forests? What is the role of aerial photography and photographic interpretation in forest management? How can geographic information systems assist with forest management planning? Why can thin hardwood veneer slices be dried immediately but thicker boards must be air-dried for a year or more? Why is timber better than metals or plastics in propeller blades? Why doesn't marine ply rot in salt water? Why is blue gum highly regarded for fibre production but not for sawn timber?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource? (cont.)	**Content** Research projects in the WARRA Long Term Ecological Research site. Timber harvesting methods and regeneration treatments. The use of fire as a regeneration tool in native forest. Monitoring and protection of regenerated forests. Defects in eucalypt logs. The internal structure of a tree. The physical properties of hardwood compared to softwood. Drying and processing softwood and hardwood timbers. The properties of solid timber and reconstituted timber products. How paper is made. The properties of different papers and cardboards. **Practical** Excursions to local sites. Investigating air movement in convection columns. Response of germinating eucalypt seedlings to varying light levels. The effects of rapid drying of softwood and hardwood boards (microwave drying). Producing and strength testing miniature laminated beams. Fibre extraction from soft plants, (eg. celery). Testing paper properties (opacity, strength, water absorption, burst strength etc).	**Content** The roles and projects of University based forest and timber research bodies in Tasmania. Natural regeneration cycles in different forest systems. The importance of glue technology in timber products. Cell structure and fibre content of plants. **Practical**

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and / or management practices result in its ecological sustainability?	**Questions** What government regulations control timber harvesting in Tasmania? How does the Forest Practices Code promote environmental protection in forests? What is the basis for the CAR reserve system? Why does the WARRA Long Term Ecological Research site exist in the Southern forest s of Tasmania? How are harvested forests monitored, assessed and managed for successful regeneration? What research projects are being conducted into alternatives to current pest and disease management practices? What are forest practices plans and why must they be approves before any timber harvesting can occur? How can fire help to maintain ecological diversity? How can knowledge about soil structure, fertility and erodability affect forestry operations? Why does the Forest Practices Unit produce manuals for such things as threatened fauna, water quality, soils, geomorphology, visual landscape and cultural heritage?	**Questions** *Build on level 3-5 questions* What is the nature and purpose of the Australian Forestry Standard? How is research in the WARRA contributing to ecologically sustainable forest management? What is the role of the Cooperative Research Centre for Sustainable Production Forestry at the University of Tasmania? What is the purpose of the Management Decision Classification (MDC) mapping system? Is it necessary to have a range of different aged forests to maintain ecological diversity? Can fire, or lack of it, influence biodiversity? How? Why are a range of harvesting and regeneration systems (Silvicultural Systems) applied to forests in Tasmania? How can the Plantations Australia: 2020 Vision contribute to ecological sustainability? Does burning a given quantity of wood have a greater effect on greenhouse gas emissions than natural decay of the same quantity of wood?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and / or management practices result in its ecological sustainability? (cont.)	**Content** Forest based research in Tasmania. The Forest Practices Code. The content of Forest Practices Plans. Reserve systems, types and locations in Tasmania. Threatened species in Tasmanian forests. The role and habitat of beetles in forest systems Traditional Aboriginal use of fire, its aims and objectives. Modern land manager's use of fire, its aims and objectives. **Practical** Recreating a forest based research project in a local area. Excursion to a local area to review a Forest Practices Plan in action. Ongoing monitoring of a harvested and regenerated area. Ongoing monitoring of a wildfire affected patch in the local area. Threatened species and their habitat in the local area. Ongoing water quality measurements for a stream flowing through forests and farmland.	**Content** *Build on level 3-5 content* Forest based research in Tasmania. The Australian Forestry Standard and the international criteria for sustainable forestry arising from the 1992 'Rio Earth Summit' on sustainable development. The nature and use of the MDC mapping system. Traditional Aboriginal use of fire, its aims and objectives and its influence on the Tasmanian environment. Forest harvesting and regeneration systems used in Tasmania. Management of threatened species in Tasmanian forests. The chemistry of burning and decay. Water quality in forest streams. **Practical** Comparative case study of Tasmanian forest management with that of another country. Research into the source and use of timber and timber products in Australia. Water quality measurements along streams and rivers.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource?	**Questions** Why did Tasmania provide most of the timber for the building of Melbourne and the western Victorian gold rush towns? How did the development of the steam engine affect forest harvesting in Tasmania? Why was Tasmanian timber used for the construction of railways in Russia and Africa during the late 1800's? What was the social impact of the internal combustion engine (bulldozer, chainsaw, trucks, etc) on timber workers? How has the development of hydraulic systems in machinery improved worker safety in the timber industry? How has the advent of computer controls changed the operation of timber mills? How has the development of steel technology contributed to the increasing range of timber products? In what ways has the development of glue technology been important in the changing production and use of timber? How have modern, high-speed printing presses, colour magazines and photocopiers influenced the nature and processing of paper?	**Questions** *Build on level 3-5 questions* Why does split timber, such as shingles, last for years without rotting but modern sawn weatherboards rot quickly unless painted? How has the use of the excavator in forests improved environmental performance and safety in the timber industry? What features of laminated timber beams enable them to out-perform steel beams for large span areas? Why is medium density fibre board in such widespread use for internal furniture and housing fit-out? Why have eucalypt fibres become so important in the production of fine writing and printing papers as well as soft tissue and toilet papers?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource? (cont.)	**Content** Changing technology in the forest industries from the 1820's to the 1990's. Present day machinery in harvesting, transport, processing and manufacturing. Types of timber products available in the market place. The properties of eucalypt and softwood fibres. The technology involved in the production of a wide range of paper products. **Practical** Investigate mechanical advantage and velocity ratio values for pulley systems, wedges, levers and screws and link to moving and loading logs and timber I the early 1800's. Investigate pressure in liquids with particular reference to Pascal's Principle and its relevance to hydraulic systems. Load bearing properties of small scale solid softwood and hardwood, laminated and reconstituted timber products. PowerPoint projects on particular aspects of historical and present day use of technology. Separation of fibres from common plant materials (eg celery). Microscopic comparison of softwood, hardwood and other plant fibres and predicting their paper forming properties.	**Content** *Build on level 3-5 content* Characteristics and properties of different plant fibres. The use of glues in laminated and reconstituted timber products. Timber preservation techniques. The role of computer controlled machinery in the processing of dried timber. The technology required to produce reconstituted timber products.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures?	**Questions** Who uses wood and wood products? What everyday things are made from wood? How much carbon is released / stored in the manufacture of alternative building materials? What role does government play in regulating the forestry industry? Why was a forestry service established in Tasmania? Who benefits from multiple use forest management? What contribution does the timber industry make to the Tasmanian economy? What are the key economic, environmental and social objectives of Forestry Tasmania? What advantages and disadvantages does native forest timber production have compared with plantations? What products can only come from old growth forests? How have changing community values affected the timber industry?	**Questions** *Build on level 3-5 questions* Why doesn't Tasmania downstream process all its raw materials? Can placing tall eucalypts in reserves ensure their long-term survival? Should Australia be self-sufficient in timber and timber products? What are the environmental benefits of using timber and timber products instead of alternative materials? Can the Leatherwood honey industry survive if all old growth forests are placed in formal reserves? What would be an ideal balance between native forest timber harvesting and plantation timber? How might this affect employment and the local manufacturing industry? What are the implications for tourism and recreation if timber harvesting in native forest ceases? What does an Environmental Management System certified to ISO 14001 mean? What would be the advantages and disadvantages of a world scale pulp and paper industry in Tasmania?

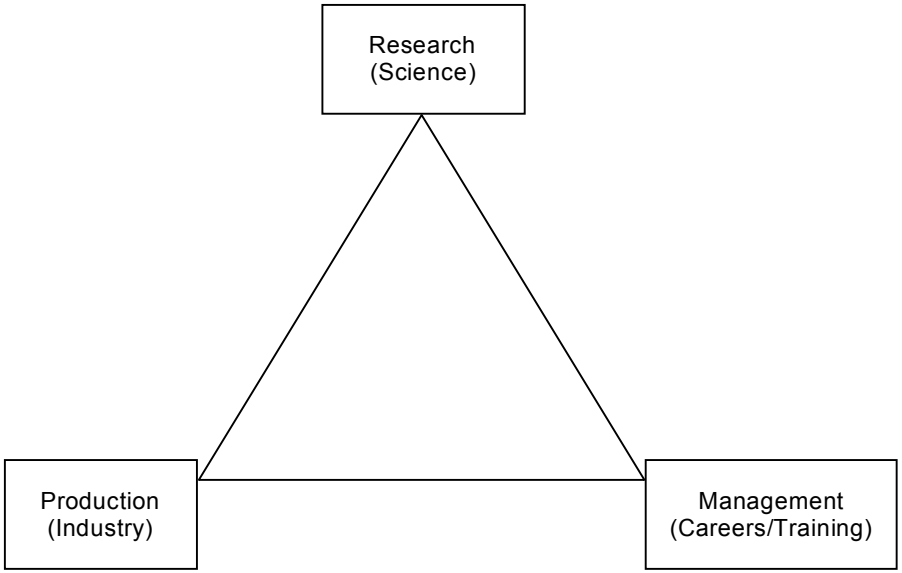
KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures? (cont.)	**Content** Timber and timber products in everyday use. Local community people making a living from an involvement with timber and timber products. The environmental properties of timber compared with alternative building materials. State and commonwealth laws and regulations related to the timber industry. The history of the forestry service in Tasmania. The nature of multiple use forest management. Sustainable forest management in Tasmania. Employment in managing, harvesting, transport, milling and downstream processing in Tasmania. Sustainable forest management in Tasmanian forests. A comparison of the properties of plantation and native forest timbers. Special species timber use in Tasmania and its source. How changing community values have affected the role of governments and forest use in Tasmania over time. **Practical** Survey of timber and timber products in everyday use. Matching timber product with alternatives and comparing their environmental properties. Survey of people's use of State Forests and its infrastructure. Comparison of physical properties of native forest and plantation timber (growth rates from growth rings, density, response to rapid drying in a microwave, …)	**Content** *Build on level3-5 content* Downstream processing of natural resources in Tasmania. Life cycles of eucalypts and succession in high rainfall areas. Australian trade in timber and timber products. The source of imported timber and timber products. Comparing the environmental properties and environmental costs of production of alternative building materials. Comparison of State laws and regulations governing use and management on State forests and conservation reserves. Comparison of the properties of native forest and plantation timbers. Road infrastructure and fire management responsibilities of the forest industries. The nature, content and processes of the Australian Forestry Standard. Pulp and paper production and environmental standards and monitoring. **Practical**

AGRICULTURAL SCIENCE THEME

The questions, content and practicals listed below are suggestions only and not prescriptive. The essential core of the course is indicated in the key questions, major ideas and assessment criteria. The actual content delivered in this course will depend on the teacher, students and resources available both within the school and the local community. The emphasis should be on an enquiring, applied approach to learning, using local resources where possible.

There is a wide variety of agricultural enterprises in Tasmania on which this theme could be based. The selection of the agricultural enterprise should be based on an enterprise which is relevant to the students. The use of the school farm is encouraged but should not be the only criteria in selecting the agricultural enterprise(s) to be investigated.

There are three main focuses to this theme which link together:



KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource?	**Questions** What are agricultural resources in the local area? What are some of the important local agricultural enterprises? What makes these enterprises successful in the local area? What are the products from these industries? How does the physical environment influence the production of the resource? **Content** Local / relevant industry (production) **Practical suggestions** *Study any local agricultural industry(ies) applicable to the local environment – horticulture or livestock,* Characteristics / value of products- eg (veg, dairy, sheep, beef) Study weather, soil, light energy, water or climate Case studies of local industries either through, excursions or on farm enterprises.	**Questions** What are agricultural resources in the Tasmania? What are some of the important Tasmanian agricultural enterprises? What makes these enterprises successful in Tasmania? What are the products from these industries? **Content** Tasmanian industry (production) **Practical suggestions** *Study any Tasmanian agricultural industry(ies) applicable to the local environment – horticulture or livestock,* Characteristics / Value of products- eg (veg, dairy, sheep, beef, plant extracts) Manipulation of the ecosystems. Topography Case studies of local / Tasmanian industries either through, excursions or on farm enterprises

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
2. What scientific understandings are involved in this resource?	**Questions** How can a farmer demonstrate that they are operating their agriculture enterprise scientifically? What are the inputs, processes and products from an agricultural enterprise? **Content** Scientific method – simple (aim) Systems approach to local agriculture Sustainability, ecosystems, cycling of energy and nutrients in the ecosystem **Practical suggestions** Conduct simple scientific method experiments with the students being directly involved in the planning and managing and monitoring the experiment(s). The students should collect data and process the data Investigate a variety of different ecosystems - both natural and modified.	**Questions** How can an agricultural researcher/farmer demonstrate that they are operating their enterprise scientifically? What does sustainability mean? What are the inputs, processes and products from an agricultural enterprise? **Content** Scientific method – extended (hypothesis) Systems approach to Tasmanian agriculture Sustainability, ecosystems, cycling of energy and nutrients in the ecosystem. **Practical suggestions** Conduct more complex scientific method experiments with the students being directly involved in the planning and managing and monitoring the experiment(s). The students should collect an increasing variety of data and extent the processing and interpretation of that data. Investigate a variety of different ecosystems - both natural and modified

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** The questions should reflect the agricultural enterprise under study. What are the underpinning general science concepts which made the particular agricultural enterprise successful? How do plants grow? What are the essential elements for successful animal growth – eg nutrition, reproduction, growth and development and animal health. **Content** The science content will vary greatly for this question, as it will be totally dependant on the agricultural enterprise under study. The study of this resource should include a variety of general science topics with examples being agriculture in nature. **Practical suggestions** All science concepts should be integrated with as much practical application / experimentation as possible Case studies / Second-hand data exercises / research	**Questions** The questions should reflect the agricultural enterprise under study. What are the underpinning biology, physics, geology, chemistry concepts which made the particular enterprise successful? **Content** The science content will vary greatly for this question, as it will be totally dependant on the agricultural enterprise under study. The study of this resource should illustrate the importance of all the scientific disciplines. **Practical suggestions** All science concepts should be integrated with as much practical application / experimentation as possible Case studies / Second-hand data exercises / research

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific management practices underpin this resource?	**Questions** How has management of agricultural enterprises changed over time? What could be the opportunities in the agricultural enterprises in the future? What are the training / study options for these future roles? **Content** Management **Practical suggestions** Investigate the different management approaches to the agricultural enterprise(s) under study. Importance of soil management both, physically and chemically. There could be a comparison between primitive and current, extensive and intensive, organic and traditional etc. Investigate training options and further study options in particular agricultural enterprises through research, case study, excursions and visiting speakers. Eg Weedbusters, Landcare, Water Watch.	**Questions** How has management of agricultural enterprises changed over time? What are some of the different management approaches? What are the benefits / problems associated with the different approaches? What could be the opportunities in the agricultural enterprises in the future? What are the training / study options for these future roles? **Content** Management **Practical suggestions** The use of scientific research in the management of the agricultural resource. Eg GMO, IPM, energy considerations, resistance or crop improvement. Investigate the different management approaches to the agricultural enterprise(s) under study. The importance of soil management both physically and chemically. There could be a comparison between primitive and current, extensive and intensive, organic and traditional etc. Investigate training options and further study options in particular agricultural enterprises through research, case study, excursions and visiting speakers. Eg Weedbuster, Landcare, Water Watch, soil conservation.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. What choices need to be made for responsible, social, economical and ecological futures?	**Questions** What are the choices that an agricultural research / farmer have to make of the future viability of agriculture? **Content** Sustainable resource management Practical / realistic choices in agriculture The importance of science in making responsible decisions about agricultural enterprises. Reasons for agricultural enterprises Native vegetation and wildlife in relation to agriculture **Practical suggestions** Investigate the topical issues of the day and develop the students' ability to make informed decisions and have them understand the bases of their decision.	**Questions** What are the choices that an agricultural research / farmer have to make of the future viability of agriculture **Content** Sustainable resource management Practical / realistic choices in agriculture Priority of management decisions for the future The importance of science in making responsible decisions about agricultural enterprises. Reasons for agricultural enterprises Native vegetation and wildlife in relation to agriculture. **Practical suggestions** Investigate the topical issues of the day and develop the students' ability to make informed decisions and have them understand the bases of their decision

INTEGRATED (EARTH RESOURCES) OR (MINERAL, ROCK AND FOSSIL FUEL RESOURCES) THEME

The questions, content and practicals listed below are suggestions only and not prescriptive. The essential core of the course is indicated in the key questions, major ideas and assessment criteria. The actual content delivered in this course will depend on the teacher, students and resources available both within the school and the local community. The emphasis should be on an enquiring, applied approach to learning, using local resources where possible.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued.	**Questions** What is a resource? Why are resources valuable? What are the things that we use in our everyday lives that come from the Earth? Where do plastic, metals, clothing, etc. come from? What things that we use come straight from the Earth and what things require downstream processing? Where are the resources found in the Earth? In what way are the Earth's resources fragile? What are renewable and non-renewable resources? **Content** Meaning of resource - top soil, mineral, rock, water. How humans use water, soil, minerals and rock. How the things humans need and use depend on earth resources. Importance of and changing use of resources in the Stone Age, Copper Age, Bronze Age, Iron Age, Fossil Fuels Age. Futures and Earth Resource use – Inter-planetary mining. **Practical work** Identification of basic human needs. Identification of Earth resources and of the materials and goods made from them. Location and distribution of Earth resources. Excursions to local resource producers and processors. Resources in space: moon, sun, planets, stars and how we relate to them.	**Questions** *Build on level 2 questions* What is a resource? What is a natural resource? What sorts of things are of value to humans? What was in this spot 100, 1000, 1000000, 10000000 years ago? What determines the price of a resource eg gold, water, oil, diamond, salt. Are rocks, minerals and fossil fuels renewable? **Content** *Build on level 2 content.* What is meant by a natural resource. Discussion of range of types of values: economic, aesthetic, spiritual, scientific, ethical, educational etc. Market prices as related to supply and demand and government regulation (taxes). **Practical work** Case studies of ways we use local Earth resources. Excursions. Surveys as to how people think a range of everyday articles relate to our natural resources.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
2. What scientific understandings are involved in the formation of this resource?	**Questions** What are Earth resources made of? How long does it take to make an Earth resource? When were our Earth resources formed and how can scientists tell how old they are? What processes in the Earth lead to the formation of Earth resources? Why are Earth resources non-renewable? Where are Earth resources formed? How do humans document the location and extent of Earth resources? **Content** Basic Earth Science principles. Formation and identification of mineral, rock, fossil fuel and water resources. Earth history and age determination (dating) Time and change. Earth resource forming processes through time – tectonics modelling (eg. plate tectonics, continental drift, earthquakes, volcanism). Soil types, composition, formation. Water cycle. Recent geological history of Tasmania Reading and interpreting a geological map **Practicals** Produce a geological time line. Grow crystals, make rocks. Examination and identification of basic rock and mineral resources. Make models and simulations of resource forming processes. Excursions to present locations where rocks are forming (Hawaii???) Soil profiles examination. Map reading exercises (in classroom and in the field)	**Questions** *Build on level 2 questions* What are some ways of collecting information about a natural area? **Content** *Build on level 2 content.* Techniques data collection in an area. Atomic structure. Element formation and nuclear events in stars. **Practicals** Excursions to local resources. Examination soil types. Types chemical reactions. Separating mixtures,

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** How and why do scientists develop theories and models to explain natural phenomena? What is a geoscientist? What methods do geoscientists use to gather evidence? Where do the resources that we use fit with the Earth and its position in space? What model best explains the structure of the Earth? What models have been proposed to explain the formation of minerals, rocks and fossil fuels? What scientific principles are used in Earth resource exploration? What economic, social and environmental factors determine that a resource is worth exploiting? What processes are used to mine, quarry or otherwise extract a resource? What downstream processing is employed to make a resource suitable for manufacturing useful things? How do resources get from an extraction site to the market?	**Questions** *Build on level 2 questions* How are some materials useful and what are the scientific principals of their use? What scientific processes are used to explore the crust of the Earth? What processes are used to mine, quarry, or otherwise extract the resource and what are the scientific principals of these methods? What are the methods of downstream processing and distribution and what are the scientific principals involved?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource? (cont.)	**Content** Uniformitarianism – "The present is the key to the past." Superposition – "This is older that that", "How old is it" Identifying resource-forming processes. Experimental design. Using Earth present and past processes as evidence for Earth structure. Map reading, aerial photographs, surveys Basic on ground exploration – collecting, examining, analysing, classifying; gravity separation (panning); magnetism; metal detection; drilling. Exercises in economics – world commodity prices and trends; assays (mineral content); volume calculations; The science and engineering of quarrying, mining and other processes used to extract the resource from the Earth. Extraction and transport- distribution infrastructure. Mining and quarrying – historical perspectives. Environmental considerations before, during and after extraction.	**Content** *Build on level 2 content.* What are minerals and why are some valued? What properties make them useful? What are rocks and how are they used – building stone, aggregates etc. What are weathered products and how used – clays, bauxite etc. The formation and uses of fossil fuels Basic geological principals including the history of our understanding – Uniformitarianism, Superposition etc. How are rocks formed Topographic and geological maps – reading and interpreting.. Methods of exploration. Historical development from surface observation to geochemical and geophysical methods and remote sensing to look inside the Earth. The science of quarrying, underground mining and other extractive processes. Underground mine development – coal compared to metals Open cut esp. limestone, aggregates, coal Methods of processing the resource – crushing, washing, concentrating (gravity, floatation etc.) Refining the resource – smelting, electrolysis Drilling for crude oil, gas – distillation Feasible, safe ways to transport materials- e.g. slurry in pipe, concentrate - important

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource? (cont.)	**Practicals** Relative age exercises. Geology excursions to local road cuttings and quarries. On-line geology simulations. Exercises in observation, collecting, recording and interpreting. Topographic and local geological map reading. Student project design work. Exploration challenges (eg Find the hidden mineral, Discover an orebody) Economic decision-making exercise – "To mine or not to mine?" Excursion to local Quarry and crushing plant.	**Practicals** Conductivity of different metals. Experiments to determine suitability of different materials for concrete, road surface, water storage etc. Investigate by talking to local potters details about local clays / glazes and their characteristics. Investigate local rock/ soil relationships and characteristics. Relate to land use. Experiments in sedimentation and crystal growth. Exercises in observation, collecting, recording, classifying and interpreting rocks and minerals. Use metal detector to find hidden objects. Mathematical modelling to determine viability of prospect. – assays, volume calculations etc. On line geo. Simulations. Exploration challenge – find the hidden mineral, discover an ore body Visit mine / quarry sites. What scientific training is needed by the employees. Uses of explosives – research methods / materials Distil hydrocarbons Collect copper sulphate from solution using electrolysis. Experiment on optimum transport conditions for different materials – eg. pumping iron ore as slurry, stability of moist concentrates in ships hold.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and/or management practices result in its ecological sustainability?	**Questions** What does sustainable mean and how does it relate to earth resources? Is a mineral, rock or fossil fuel deposit sustainable? What damage can a mining or quarry operation do to the immediate and surrounding ecosystem? What is the history of environmental impact by resource exploitation? What environmental management processes need to be in place before, during and after resource extraction? What are some examples of how ecosystems can be protected? What is environmental risk management? What controls the use of the environment? **Content** Meanings: sustainability, EIS, EMP, rehabilitation, risk, environmental audits Risk analysis. Threats to water quality, soils, air, biodiversity. Examples of environmental impacts. Modern environmental management. Customs, rules, laws and codes in environmental management.	**Questions** *Build on level 2 questions* What are some environmental issues? What is meant by sustainability? In what ways do we compete for use of a resource? What are some principles of 'Ecologically Sustainable Development'? How can we arrive at agreement in a community as to the most suitable use of a resource? What are renewable and non renewable resources? What is a management plan for an area? What is the role of science in this. Affect on ecosystems of appropriate / inappropriate practices. Legacy of past practices. How is science used to repair past damage and manage present processes in exploration, extraction and refining **Content** *Build on level 2 content.* Meanings Ecological Sustainability. Discussion of some environmental issues. Elements of sustainability – what needs to be sustained. Main threats to quality of Australian water, soils, air and biodiversity. What is meant by management and management plans. Content of a management plan for a natural resource. Risk management. Internationally accepted 'Principles Ecological Sustainability' Risk Assessment and Management. Ways of solving environmental problems: examples of the use of science/technology, laws, economics, education. Occupational Health and Safety in selected workplace.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and /or management practices result in its ecological sustainability? (cont.)	**Practicals** Develop a School Environmental impact study and management plan. Hazard identification in school. Environment rehabilitation Local case studies, with excursions. Introduced species (weeds and feral animals) and mapping. Litter cleanup, waste management. Nature walks and accompanying photo essays, art work.	**Practicals** Hazard identification around school, community. Devise management plan for local earth resource How do local people best see a resource being used (carry out surveys). Debate – Are past poor mining / land use practices ours to repair using case studies / excursion sites. Case studies to include comparison of good vs. poor practices," good" science vs none or " bad " science. Survey / Debate attitudes to land use issues – eg. Mining in world heritage reserves in Tasmania.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource?	**Questions** What is technology? Why does technology "develop"? Why were the ages of humans called Stone Age, Copper Age, Bronze Age, Iron Age, Age of Energy, "Silicon Age"? What might a future age be called? Futures and Earth Resource use – Inter-planetary mining. Why will existing Earth resources run out? What alternative resources might be used when existing resources run out? How has the discovery of new earth resources changed our lives? How has the use of new materials in technology changed our lives and made previously unused materials useful (and valuable)? How have new exploration technologies assured supply of Earth resources into the (short-term) future? How has new technology lead to increased recovery and more rapid depletion of Earth resources? How has new technology lead to safer working environments.	**Questions** *Build on level 2 questions* Would we be better off if the wheel had never been invented? Can we predict the material needs of the future. What are the current trends on the use of Earth resources and are these sustainable? What are the demands of new technologies on Earth resources? How has technology lead to increased discovery, recovery and depletion of Earth resources? Why is resource use not static – why do resources go out of fashion? How does space / undersea exploration affect resource use? How can new technologies help us manage Earth resources more responsibly? What would be the consequences for the earth if scientists invented a way of generating energy very cheaply (eg cold fusion). Has the invention of ways to harness nuclear energy been good for humanity? How can waste be used to generate usable energy?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource? (cont.)	**Content** The inter-relationship of science and technology. History of 'old fashioned' machines used in Earth resource industries. History of resource use related to the "Ages of Humans" Tasmanian aboriginal tool –making. Properties and use of Earth materials. Technology in various areas of resource use eg mining, extraction, transport, furnaces, metal production, refining, waste disposal Changing patterns of energy transformation /generation eg fossil fuels, nuclear. Resource depletion and obsolescence-case studies Technology and alternative resources – case studies Developments in health and safety in the workforce. **Practicals** Design and make model technologies related to the Earth resources industries. Produce stone tools; work with copper, watch a bronze "pour"; compare the properties of different metals. Design and build simple exploration tools. Projects on mining technologies. Student presentations of projects on history of technologies. Design and produce safety signs to suit the school environment.	**Content** *Build on level 2 content* History of development of range technologies Aboriginal use of Earth resources – consequences of this exploitation. Was this use sustainable. How inventions of new technologies have impacted on our lifestyles Patterns of resource use – projections for the future. Is this sustainable? What are the alternatives? Possible future technologies – science fiction. What materials might be needed and where can we find them? Cold fusion energy generation. **Practicals** Design and make model technologies - competitions. Using range technologies properly eg Student power point presentations on a range of projects related to developing technologies and what new materials might be needed eg car. Research where these materials might be found and what will be the consequences of their use?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures?	**Questions** What do we want for ourselves in 5 years time – possessions, lifestyle? What are some of the different uses ??? has? How do/can these uses compete with each other? How do we find out what other people want? How can we design a good survey? What would a much larger/smaller population mean for Tasmania? How long have humans been on the earth? What is the history of fossil fuel use by humans? Has the invention of (the wheel, computers, explosives, cars, chain saws, etc) been a good thing? What are the alternatives to using fossil fuels?	**Questions** *Build on level 2 questions* What materials do we need to sustain our lifestyle? How does this resource use generate wealth and employment? Are substitutes available for materials in short supply? What do we want for ourselves in 10 years time – possessions, lifestyle? What will be the effect of relying on old technologies? How do we determine what is considered responsible use of Earth resources? Does it matter if some materials are “used up“? Will technology enable us to replace “used up” resources? How do we resolve conflicting demands? Will technology enable us to replace depleted resources for others eg. Fossil fuels? What sort of future do we want ? How do multi-nationals control resource use and the global economy? What doe we mean by the idea of ‘development’? What choices need to be made for ‘ecologically sustainable development’ How does competition arise for the use of a resource? How do people use the area for recreation? Does this generate community wealth? What is meant by social responsibility? Give some examples of socially responsible and socially irresponsible action. What sort of a future do we want for ourselves – career, living in a small city, large city, rural environment? What is meant by our ‘standard of living’? How is it measured?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures? (cont.)		**Questions** *Build on level 2 questions (cont.)* What is meant by the idea of 'quality of life'? How is it measured? How might 'quality of life' differ from 'standard of living'? What is global warming? What is the greenhouse effect? Greenhouse gases? What difficult choices need to be made to limit greenhouse gas emissions in Australia? How do scientific inventions/technology change society? Examples. Who makes the decisions about use of newly invented technology? What is a consultative process? How can a consultative decision making process occur? What is an ideal population size for Tasmania? What impacts have the discovery of fossil fuels had on the development of human civilisations?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for responsible social, economic and ecological futures? (cont.)	**Content** Vision statements of desirable futures. All decision making has consequences – history of decision making and its consequences as applied to resource use in Tasmania. Time and change generally: Comparison of rates of change in processes eg resource creation compared to resource use. Relate to decision making. Examples of good decision making - sustainable resource use in Tasmania, Australia. What are some replacement metals for car or aeroplane manufacture in the future? Why? **Practicals** Community surveys. Survey design. Measuring impacts of pollution eg effect acid on growth plant experiments Measuring erosion in an area. Measuring a variety of human impacts in an area Personal futures – investigation of jobs related to resource management.	**Content** *Build on level 2 content.* Vision statement of where we want to be in say 20 years. Decision making and its consequences as applied to resource use. Examples and consequences of overuse/lack of proper management of a resource and its relationship to resource use. Which Earth resources are close to running out? How do we know and can we do anything about it? What can we use as substitutes. How will we find and extract them? Who will make the decisions – the market or planned economy? 'Quality of life' indicators in society. Examples of incompatible uses of a resource. Global warming and relationship to fossil fuel use. What are the consequences of a warming atmosphere, depletion of clean water resources, loss top soil. Consultative decision making – meaning. **Practicals** Making wall posters to illustrate the range of uses that various Earth resources have for humans. Investigate source of current materials used to maintain quality of life. Which ones have a high cost (material or environmental) ? Values clarification exercises – eg surveys on what is needed and what are luxuries. Surveys on usage of Earth resources and preferred futures for an area. Global commodity markets – research the decision making processes used to determine distribution and costs Carry out a consultative process for the class to reach a decision on something eg where to go for excursion, best use of money collected for a charity or the school, who does what for jobs in the classroom. Personal futures investigation – prepare portfolio of jobs, future training requirements, subject electives, qualifications etc to reach students presently preferred future. Class debates on use natural resources

AQUACULTURE THEME

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued?	**Questions:** What is an aquaculture resource? What types of aquaculture resources do we have in Tasmania? Why is the aquaculture resource valued? **Content:** Investigate an aquaculture enterprise, eg mussel, oyster, salmon farming Other products from an aquatic environment.	**Questions:** *Build on Senior Secondary 2 questions* How has an aquaculture product been developed? What factors need to be understood in order to farm or culture an aquatic organism? What are the impacts of an aquaculture enterprise on the local environment? **Content:** *Build on Senior Secondary 2 questions* The effect of an aquaculture industry on the local environment. Discussion of social, economic and environmental issues. Knowledge of the biology of an aquatic organism. Which organisms do we farm as distinct from those that we culture now and possibly in the future? The value of the industry to the local economy.
2. What scientific understandings are involved in the formation of this resource?	**Questions** What science underpins the aquatic enterprise? How does science assist the development of an aquaculture product? What are the inputs, processes and products from an aquaculture enterprise? **Content** Aquatic Ecology, Sampling methods, Designing investigations. Food chains and webs. Food sources. Reticulated systems **Practical** Setting up a simple reticulated system and maintaining a living organism	**Questions:** *Build on Senior Secondary 2 questions* What information do we need to gather about a local area before implementing an aquaculture enterprise? What are the non-living and living factors in an ecosystem that influence an aquaculture enterprise? What are the relationships between the physical and non physical factors? **Content** Techniques in measuring physical and non-physical parameters. Describe the science underpinning reticulated systems. Producers, consumers. Ammonia, dissolved oxygen, salinity, nitrates and phosphate. Closed systems versus open systems. Basic Water Chemistry. **Practical** Setting up a reticulated system, monitoring inputs/outputs.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** What science underpins a successful aquaculture enterprise? **Content** Growth rates, stocking densities, food conversion ratio's. Experimental design. Basic biological concepts. Anatomy and physiology of aquatic organisms. Osmosis, diffusion. Lifecycles Aquatic Ecology. Ammonia, Nitrogen Cycles. Water Chemistry	**Questions** *Build on Senior Secondary 2 questions* What are the impacts of the development of aquatic enterprises on the natural ecology of aquatic environments? What processes are required to ensure the ecological sustainability of a specific aquatic enterprise? Compare the impacts of different aquatic enterprises and emerging aquatic enterprises on the natural environment. **Content** Experimental design. Basic biological concepts. Anatomy and physiology of aquatic organisms. Osmosis, diffusion. Lifecycles Aquatic Ecology. Ammonia, Nitrogen Cycles. Water Chemistry. Animal husbandry, pathogenic organisms. Taxonomy.
4. What scientific processes and/or management practices result in its ecological sustainability?	**Questions** What does sustainable mean in terms of an aquaculture enterprise? What impacts do aquaculture enterprises have on the local ecology? How can the industry minimise impact on the natural environment? What are aquatic pests? **Content** Threats to the wild fish populations, and or natural ecology of the Tasmanian aquatic environment. Food sources and impacts on wild fisheries. Aquaculture impacts on local waterways. Monitoring of the impact of the aquaculture enterprise on the local environment.	**Questions** *Build on Senior Secondary 2 questions* What is meant by ecological sustainable development? What is meant by management and management plans? Elements of sustainability-What has to be maintained? How can we arrive at agreement of the expansion and/or location of new aquaculture enterprises? What are some principles of "Ecologically Sustainable Development"? **Content** *Include Senior Secondary 2 content but examine issues in more detail.* Tourism and the aquaculture industry The use of science/technology in achieving ecological sustainability and examples in the Tasmanian context eg Farming Seahorses, culturing *Macrocystis(Sea kelp)* Impact of escaped product into the natural environment.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource?	**Questions** What is technology and what technology has been developed to grow a specific aquatic organism? How has technology impacted on working environments in our local aquaculture industry? What technology had to be developed to culture or farm aquatic organisms? What technology has been developed to process the final product? **Content** Monitoring of nutrient loads, temperature and salinity in reticulated systems. Processing methods to ensure a quality product for particular markets. Minimising contamination during processing. Knowledge of both theoretical and practical equipment used in the Aquaculture Industry.	**Questions** *Build on Senior Secondary 2* What technological developments are required in order to develop new aquaculture enterprises? How can the development of technology improve the final product and reduce mortality? **Content** Monitoring of nutrient loads eg Ammonia, Nitrogen, Temperature, and Salinity in reticulated systems. Processing methods to ensure a quality product for particular markets. Occupational health and Safety in particular industries. Hazard identification on the farm and during processing. Knowledge of both theoretical and practical equipment used in the Aquaculture Industry.
6. What choices need to be made for responsible social, economic and ecological futures?	**Questions** Who decides on the location of salmon farms in our waterways? What must be considered before placing an aquatic farm in a natural waterway? Who should be consulted? **Content** Knowledge of the Marine Farm Planning Process as implemented by the *Department of Primary Industries Water and the Environment* DPIWE. Investigate the benefits of an aquaculture industry on wild fish populations.	**Questions** *Build on Senior Secondary 2* Who decides on the location of an aquaculture enterprise in a local waterway? What are the ethical issues involved in farming a living organism? Can we genetically manipulate growth rates in order to develop super fish? Who, how do we decide? How can science assist in this process? **Content** *Build on Senior Secondary 2* Use of natural foods for feed. Ecological Sustainability. Dilemmas in the Aquaculture Industry.

ENERGY THEME

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued?	**Questions** What do we use energy for? What is renewable energy vs non-renewable energy? What are the different types of renewable energy sources? What are non renewable energy sources? What energy sources do we use in Tasmania? How does this compare with overall energy sources in Australia? In other countries? Why do we use the sorts of energy we do in Tasmania? At home, do we use more electricity in winter or in summer? When was the first hydro electric power station built in Tasmania? What are the 'Roaring Forties?' What were the very first ways that wind energy was harnessed, thousands of years ago? What was it used for? How many hours of sunlight do the major cities in Tasmania get per year? How does this compare with elsewhere in Australia? Does Tasmania have a 'Hot Dry Rocks' resource? What sort of organic waste products can be burned to produce energy? Does Tasmanian industry use biomass as an energy source? What fuel is used to power the space shuttle?	**Questions** *Build on level 3-5 questions* How much energy per person do we use in a year in Tasmania? In Australia? How does this compare to other countries? What is the difference between energy and electricity? What is the difference between base load electricity demand and peak load? Who are the major industrial energy users in Tasmania? How many hydro electric power stations are there in Tasmania? What is the installed capacity in Megawatts? How much energy was generated last year from the hydro electric system in Tasmania (in Gigawatt hours)? How much did your house use? How much do we pay for our domestic electricity? How much gas is available in Tasmania through the undersea pipeline from Victoria?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
1. What is the resource and why is it valued? (cont.)	**Content** Industrial, domestic energy use; electricity, heat, fuel. Different forms of energy (eg mechanical, electrical, heat, chemical). Renewable energy sources (ie made from things that don't get used up): ▪ Hydro electricity, ▪ wind energy, ▪ solar (photovoltaic and solar thermal), ▪ geothermal, ▪ bioenergy (energy crops; agricultural and forestry by-products; industrial and municipal waste, liquid fuels eg ethanol, biodeisel), ▪ wave, tidal and ocean energy, ▪ hydrogen. Non renewables: natural gas, coal, oil, nuclear Relationship between availability of natural resources and energy use, eg hydro and wind in Tasmania, coal in Victoria and NSW, gas in WA, geothermal in Iceland, Nuclear in Europe etc **Practical suggestions** Survey class re home heating sources – who uses wood heaters, electric heaters, heat pumps, oil or gas heaters, etc. Investigate the weekend activities of the students and note those that use energy, either directly (eg fuel, cooling, heating, electricity) or indirectly (eg manufacturing materials, transport).	**Content** *Build on level 2 content* Features of first hydro scheme in Tasmania. Importance of hydro schemes in Tasmania and mainland Australia (eg Snowy scheme) in terms of employment, hydro industrialisation and post war migrant workers. Characteristics of hydro schemes in Tasmania – major catchments, lakes, powerstations, canals, tunnels. Wind developments in Tasmania and mainland Australia – locations, size, capacity. Distinguish between photovoltaic and solar thermal uses of solar. What is the opportunity for producing hydrogen (as a fuel source or energy storage) in Tasmania? **Practical suggestions** Have students look at home electricity bills, unit prices, discount prices (eg hydro heat), compare quarterly use. Calculate the energy used in the classroom for lights, heat, equipment etc in one week.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
2.What scientific understandings are involved in the formation of this resource?	**Questions** What are the factors that influence cloud formation? Why do most rivers in Tasmania continue to flow all year round? What time of year do the highest flows occur? How much of the rain that falls in a catchment ends up in lakes? How do we determine this? Are river systems in mainland Australia perennial or ephemeral? What makes the wind blow? How fast is the wind at the west coast of Tasmania? What factors besides wind speed are important when deciding how to use the wind resource to generate energy? How hot is the sun at the sun's surface? How far from the earth is the sun? What process generates energy in the sun? What sort of radiation does the earth receive from the sun? Why does it heat up in a car on a sunny day? What processes heat up the rock and magma in the earth's core? Why is the temperature of rock below the surface of the earth not the same at the same depth in all places? What processes occur to convert solar energy to chemical energy stored in plants? How can this chemical energy be used to generate electricity or heat energy? What causes the tides? How fast are tidal currents in coastal Australian waters? What tidal range in metres is typical in Tasmania? How is hydrogen produced? How does natural gas form? What is the composition of natural gas? How long does it take for natural gas, coal, oil to form? What raw materials are used for nuclear power generation? Do they occur in Australia?	**Questions** *Build on level 2 questions* What systems are used in Tasmania to collect and analyse meteorological information? What are the major catchments in Tasmania's hydro system? What is the highest, lowest, average annual rainfall in those catchments? What is the range of flow rate (highest and lowest) in the rivers of the major catchments in Tasmania? What factors influence evaporation from lakes? What 'types' of wind are there? What are the factors that cause these types of wind? What scale and units do we use to measure wind in Tasmania? Why do the 'Roaring Forties' occur where they do? How are wind data collected, collated and interpreted to create wind atlases? What spectrum do we use to measure solar radiation? How much of the energy from the sun that reaches the earth's outer atmosphere makes it to the surface? What are the factors that affect the intensity of the sun's energy at the surface? What is geothermal energy? Why do superheated rocks / water occur in some areas? What specific fuel crops are grown in Australia? Are any of these grown in Tasmania? What agricultural or forestry by-products can be used for bioenergy production? What is biodeisel? How is it produced? What natural features can accentuate tidal currents? What does the temperature gradient of the ocean's water look like from the surface down to increasing depth? What creates this gradient? What are the factors that affect it? How is uranium used to generate energy?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
2. What scientific understandings are involved in the formation of this resource? (cont.)	**Content** Conservation of energy and matter, tendency to disorder, kinetic, potential energy and energy contained in a field eg electromagnetic waves. Water cycle, cloud formation, surface water, groundwater, lakes, rivers etc. Relative proportions of water in various places in water cycle. Processes in water cycle, including conversion of solar energy to stored energy in lakes. Volume of freshwater available to humans compared to oceans and polar ice caps. Atmospheric systems, low pressure, high pressure, generation of wind. Solar energy driving convection currents in atmosphere and oceans. Wind features on national and state scale, eg occurrence of high winds on west coast of Tasmania and southern coastal Australia. Wind Atlas for Australia, and world. Sun facts, solar radiation components. Greenhouse effect, how it is used for solar energy. Biological processes: photosynthesis, transpiration, storage of energy in plant tissue. Efficiency of different plants at photosynthesis. Energy density of different biological storages eg fats, proteins, carbohydrates. Tidal processes, wave formation, ocean temperature. Natural gas formation and composition. **Practical suggestions:** Install 'weather station' instrumentation to measure rainfall, sunlight, wind speed and direction, temperature in school grounds. Calculate the amount of energy (joules) contained in the food you ate for breakfast and lunch today. Use tables of calorific values, weight of food etc. Photograph a stream bank or beach zone near the school from a fixed point. Revisit after severe storms or rainfall events and rephotograph to compare. If erosion or land form changes have occurred, where did the energy come from to do this? Create a large scale wall diagram showing the various energy sources and their link to solar energy (external) or internal energy from (a) gravitational energy from the earth's original formation or (b) decay of radioactive isotopes	**Content** *Build on level 2 content* Meteorological data for catchments in Tasmania. Hydrological model of water catchment, including inflows, evaporation, evapotranspiration, losses to groundwater, outflows etc. Influence of temperature, wind speed, vegetation cover, local geography on evaporation. Wind systems globally, eg trade winds, El Nino etc as affected by global scale features. Wind systems locally, as affected by local geography eg catabatic winds, wind turbine micro siting considerations. Process of energy creation in the sun – fusion. Production of hydrogen naturally by some organisms. Production using electricity – use of hydrogen as storage in systems where natural resource (eg wind) fluctuates. **Practical suggestions:** Use readings from weather station in school grounds plus info from met stations to calculate evaporation at school. Calculate the energy released from an open fire in a house that burns for an evening (estimate wood volume, efficiency of conversion etc). What age would the trees have been that were used? How much of one tree would have been burned? Draw a flow diagram showing the transfer of energy between states in a hydro electric system, from the lake to our houses.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
3. What science underpins the use of this resource?	**Questions** How does the height of a water intake in a dam above the power station affect generation capacity? What is the relationship between wind speed and power output from a wind turbine? How is kinetic or mechanical energy converted to electric energy in turbines? What can be used to power a turbine? What components of solar radiation are used to generate power? What is an OTEC system? How is hydrogen used to produce energy? What is the difference between Alternating Current (AC) and Direct Current (DC)? Why does our electricity transmission grid use AC? How is energy stored and transported to homes and industrial users? **Content** Conceptual relationship of head, flow rate, volume, wind speed etc to power output. Basic hydrological models for inflow prediction. Energy conversion in turbines, generating electric fields through moving magnets through a coil. Photovoltaic (Solar cell) systems, concentrating systems using high intensity heat to produce steam or mechanical power to be converted to electricity, solar water heating systems. Ocean thermal energy conversions systems – closed, open, hybrid. Production of hydrogen using heat from hydrocarbons or biomass; from water using electricity or sunlight, from bacteria or algae using photosynthesis. Electrical energy storage and transmission. **Practical suggestions:** Prepare a concept design of a simple solar hot water system for your house.	**Questions** *Build on level 2 questions* What is the relationship between 'head', water volume and velocity to power generation in a hydro turbine. What sorts of turbines are used for different applications, eg low or high head of water, wind, steam, gas. What is a typical profile of wind speeds from the ground level up to elevations of a few hundred metres? How do we measure solar radiation on earth? What infrastructure is required for a large hydro electric generation system? For a mini hydro system? For harnessing wave or tidal power? What are hybrid systems? **Content** *Build on level 2 content* Key elements of system model for Tasmanian hydro system. Equations relating head, flow, power output. Hybrid and remote area power systems, eg wind diesel, wind battery, solar battery etc. **Practical suggestions:** Choose river or creek near school, create basic hydrological model, measure climate parameters, calculate flow, compare to actual (published or measured) flow. Case study of emerging technology eg Ceramic Fuel Cells, geothermal, hydrogen for energy storage.

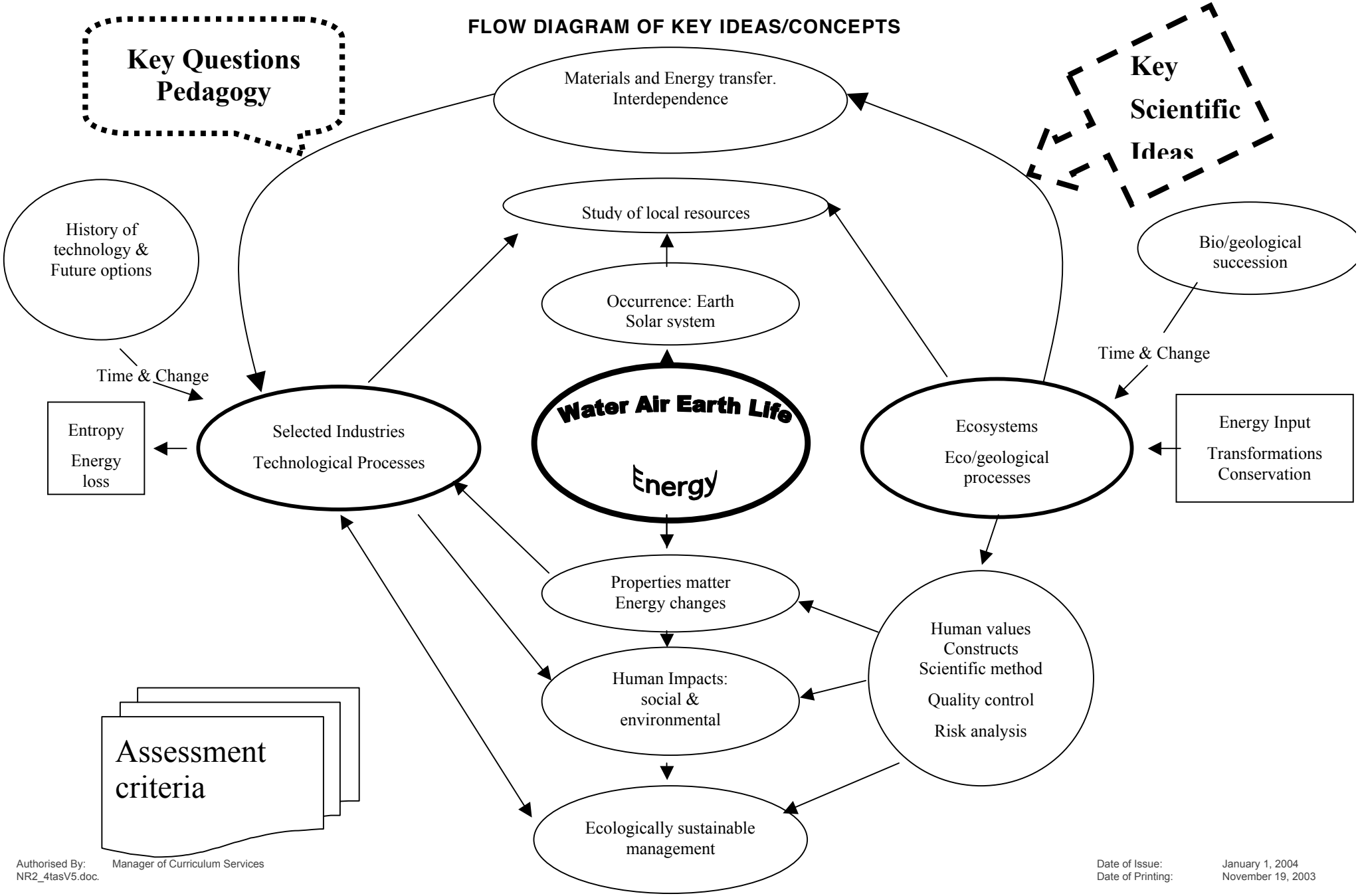
KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and/or management practices result in its ecological sustainability?	**Questions** How do the patterns of flow (over a day, season, year) in a river downstream of a hydro power station differ to those of a natural stream? What emissions to air, water or land, if any, result from generating energy from the different sources? How can upstream migrating fish or eels pass dams in a river? What are the possible impacts on the environment of new power developments? During construction? During operation? What different sorts of impacts are associated with hydro, wind, gas, solar developments? What are the impacts associated with energy transmission and distribution structures? What measures can be taken during construction of energy generating systems to minimise impacts on the environment? What is the difference between the greenhouse effect and the hole in the ozone layer? What are the issues associated with storage and transport of hydrogen? How long is a hydro electric generating system in Tasmania designed to operate for? How long is the gas supply to Tasmania via the undersea gas pipeline expected to last?	**Questions** *Build on level 2 questions* What sorts of disturbance are aquatic organisms most susceptible to? What is the potential long term impact of changing land use for power generation? What is a Remote Area Power Supply? Why don't all homes in Tasmania have their own self contained energy generating systems? What are the issues associated with connecting a local energy generation facility (eg solar panels) to a larger energy grid? What sorts of potential environmental impacts can be avoided by good design of a new scheme? What sorts of potential impacts cannot be avoided, but must be minimised?

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
4. What scientific processes and/or management practices result in its ecological sustainability? (cont.)	**Content** Aquatic environmental management for hydro systems; eg ecological monitoring, lake level agreements, fish/elver ladders, environmental flow releases, Ecological investigation and micro siting of wind turbines, eg location relative to bird use, vegetation communities. Potential impacts of developments. Location of developments EIA, environmental and planning approval processes. Emissions, temperature changes of cooling water, noise, visual impact of various energy sources. Linear infrastructure in the landscape. Other landscape impacts associated with eg wind farms, solar arrays, power stations, mines. Construction impact mitigation, eg minimising disturbance, rehabilitation plans, waste management procedures. Design life considerations, decommissioning processes. **Practical suggestions** Tour/visit of hydro power station in local area. Note oil management in station, any water level agreements or flow releases for downstream users etc.	**Content** *Build on level 2 content* Ecology of aquatic systems. Disturbances, threatening processes. RAPS and connection issues. Costs of RAPS, connections. Capital cost vs operating costs for large and small power generation schemes. **Practical suggestions** Find a recently cleared area of native vegetation in your region. Establish monitoring sites there, and create different treatments, eg fertiliser, fencing to exclude grazing, broadcasting locally collected seed, pegging down surface mulch. Which treatments are most effective for seed germination? Establish a river level and flow monitoring site at various points along a local stream. Monitor flow using data loggers. Try to determine cause of flow fluctuations eg rainfall, upstream use (pumping, releases from power stations). If possible, compare two streams in the same catchment with differing sub-catchment conditions.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
5. How can the development of technology influence the use, and processing of the resource?	**Questions** What are 'energy efficient' appliances? How much power can be saved in an average household by adopting energy saving design and appliances? What new hydro development are being planned and implemented in Tasmania? What different sorts of energy storage systems are currently used. What new ones are being developed? **Content** Cloud seeding. Advances in turbine technology. Mini hydro developments in Tasmania. Advances in solar technology, eg tracking and concentrating. Advances in hydrogen technology, eg hydrogen powered cars. Ceramic fuel cells Storage options: Vanadium redox batteries, Zinc Bromide batteries etc. **Practical suggestions:** Design and build parabolic solar collector Choose an area of land, and gather information from the Land Information System (LIST) website (www.thelist.tas.gov.au). Compile a map of the area describing the information you can gather, and decide if it is a good site for a potential power development.	**Questions** *Build on level 2 questions* What is the National Electricity Market? How many interstate 'interconnectors' are there in Australia's NEM? What is embedded generation? **Content** *Build on level 2 content* Hybrid systems, enabling technology eg inverters and controllers. Embedded generation for hospitals, schools etc. Co-firing biomass with coal. Landfill gas and biogas as supplementary fuel in coal fired power plants. **Practical suggestions** Hydro Tasmania's hydrogen powered go kart. Case study on electricity trading. Case study on system control in Tasmania.

KEY QUESTIONS	Senior Secondary 2	Senior Secondary 3/4
6. What choices need to be made for the responsible social, economic and ecological futures?	**Questions** Who builds new power generating schemes in Australia? How do governments and private companies decide what sort of new energy infrastructure to build, and where to build it? How does the Commonwealth government support new, emerging and 'green' technologies in energy? What are some state and commonwealth initiatives aimed at supporting renewable energy technology? **Content** Role of state, local, national government and Independent Power Producers in generation. Australian Greenhouse Office programs, greenhouse challenge, Mandatory Renewable Energy Target (MRET), implications for energy generation in Tasmania. State govt programs, CRC's, Green power schemes. **Practical suggestions** Case studies of public transport initiatives in other countries. (Resource: Rocky Mountain Institute). Class debate on the economic, environmental and social costs and benefits of proposed new wind farms in Tasmania. Investigate feasibility of solar energy system for part of school's energy needs.	**Questions** *Build on level 2 questions* What planning approval processes must a large scale energy generation scheme pass through before beginning construction in Tasmania? What role does the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 have in setting conditions for new energy developments? **Content** *Build on level 2 content* State and Commonwealth environmental approval processes, eg DPEMP and EPBC Act approvals. **Practical suggestions** Case study of project from the Australian Greenhouse Offices Renewable Energy Commercialisation Program. Class debate on the economic, environmental and social costs and benefits of proposed new wind farms in Tasmania. Organise an energy audit of the school, and design energy saving measures that would pay for themselves in one year.

FLOW DIAGRAM OF KEY IDEAS/CONCEPTS



REFERENCES AND RESOURCES

AGRICULTURE

Resources

CD / Web site- Chemistry and Physics in Tasmanian Agriculture

CD / Web site - Aspects of Experimental Design in Tasmanian Agriculture

Weedbusters- Activities, Information and curriculum Links complied by Gould League

EXAMPLE FORMAT FOR EXEMPLARS

SENIOR SECONDARY _ SUGGESTED TASKS

CRITERION _ CRITERION NAME

Text

SENIOR SECONDARY _ EXAMPLES OF TASKS AND RATINGS

CRITERION _ CRITERION NAME

ACTIVITY

Rating 'C'

Assess against

Rating 'B'

Assess against

Rating 'A'

Assess against