OUTCOMES SCIENCE 4

EARTH & BEYOND

INSTRUCTIONAL MODULE 4: LESSON 1

TARGET YEAR GROUPS: 8 / 9 / 10 / 11 / 12

Student Name:

Tutorial Group:

When did you last go body surfing at the beach? While body surfing have you ever accidentally swallowed some seawater? Can you remember the salty taste of the seawater? Just how much salt is dissolved in seawater? Do you know?

Seawater contains about 35 000 mg L^{-1} of dissolved solids. This means that each Litre of seawater contains about 35 g of dissolved solids, existing mainly as aqueous ionic salts.

In fact, seawater contains about 40 million tonnes of solids dissolved in every cubic kilometre of water.

1. Do you know which are the most abundant chemical elements dissolved in seawater? Can you list the dissolved elements from most to least abundant? Do you know which elements are commercially extracted from seawater? If you don't know, how could you find out?

TABLE 1: CONCENTRATIONS OF THE MOST ABUNDANT ELEMENTS IN SEAWATER

ELEMENT	APPROXIMATE CONCENTRATION (Tonnes per km^3)
Chlorine (Cl)	22 000 000
Sodium (Na)	12 000 000
Magnesium (Mg)	1 600 000
Sulfur (S)	1 000 000
Calcium (Ca)	450 000
Potassium (K)	440 000
Bromine (Br)	75 000
Carbon (C)	32 000
Strontium (Sr)	9 000
Boron (B)	5 600
Silicon (Si)	3 400
Fluorine (F)	1 500

How could you measure the **T**otal **D**issolved **S**olids (TDS) in a sample of seawater? What do we mean by Total Dissolved Solids?

Total Dissolved Solids (TDS) is a measure of the total concentration of all solids dissolved in water.

2. How would you measure the TDS of a sample of seawater provided to your Learning Group by your teacher?

   You are to **plan** and **conduct** a practical investigation of the Total Dissolved Solids (TDS) in a sample of seawater. In your plan you must **make a list** of all the required materials, assemble the materials, and then measure the TDS of your sample of seawater.

YOUR PLAN FOR MEASURING THE TDS OF SEAWATER

YOUR OBSERVATIONS AND MEASUREMENT OF TDS OF SEAWATER

TDS in water is measured by filtering off suspended particles, evaporating the water, and then weighing the solid residue.

3. In order to measure the TDS of your sample of seawater; you evaporated the water to recover the dissolved solids. Why did the water evaporate but not the dissolved solids?

Focus Question: When seawater evaporates, what is the order of crystallisation of the dissolved ionic salts? Which salts would crystallise out of solution first, and which last?

Answer: The Carbonates e.g., $CaCO_3$ crystallise out of solution first, then the Sulphates e.g. $CaSO_4$, next Sodium Chloride (NaCl), and lastly the Chlorides of Potassium (KCl) and Magnesium ($MgCl_2$).

4. What physical property of these ionic salts determines their order of crystallisation? Can you guess? How could you **verify your answer** to this Question?

The Table salt that you sprinkle on your food is mainly common salt, which you would know is sodium chloride. Raw salt is frequently obtained by the solar evaporation of seawater. You also now know that seawater contains many dissolved salts.

5. How does the Salt Industry refine the raw salt obtained by the solar evaporation of seawater to produce refined Table salt? What is the name of the process used?

Students in each Learning Group should now research the answer to Question 5 by visiting the web site whose Internet Address (URL) is given directly below.

http://www.saltinstitute.org/4.html

6. Where does the salt in seawater originate? What is the source of the salt in seawater? Can you **identify** and **describe** the biogeochemical processes that cause and maintain the salinity of seawater? Are these salt-producing processes occurring around the clock? If they are, why then is the mean salinity of the world's oceans not increasing? Do you know?

Students in each Learning Group should now research the answer to Question 6 by visiting the web sites whose Internet Addresses (URL) are listed below.

1. http://wwwga.usgs.gov/edu/whyoceansalty.html
2. http://www.utdallas.edu/~pujana/oceans/why.html
3. http://www.gi.alaska.edu/ScienceForum/ASF9/950.html
4. http://www.oceansonline.com/salty.htm

You should now realise that as the mean salinity of the world's oceans is not increasing, and given that dissolved salts are entering the sea around the clock, then there must be some biogeochemical processes operating that remove dissolved salts from seawater?

7. Can you **identify** and **describe** those biogeochemical processes that transport dissolved salts from the oceans and onto the landmasses. How do sea salts enter the atmosphere from the world's oceans and how are they then deposited onto landmasses?

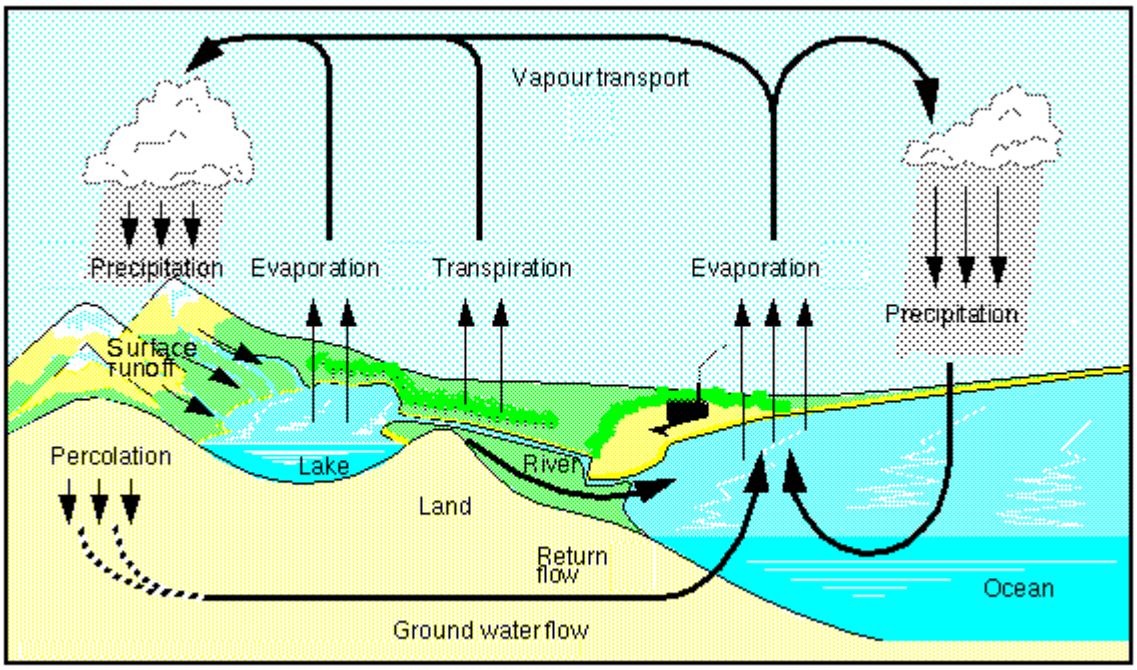
To successfully answer Question 7, from the previous page, you will need to **analyse** the interactions mainly between the hydrosphere, the atmosphere, the lithosphere and the biosphere, which sequester dissolved salts, mostly sodium chloride from the oceans, in the lithosphere.

The transport of salt from the oceans and onto the landmasses and back again to the oceans is part of the Global Salt Cycle. What would a diagram of the Global Salt Cycle look like? How would the Global Salt Cycle **connect with** the Global Hydrological (Water) Cycle?

Partial answers to the Questions, given above, may be found at the web site whose Internet Address (URL) is given directly below.

http://www.kheper.auz.com/gaia/biogeochemical/salinity.htm

The Global Salt Cycle is, in part, intimately linked to the Global Hydrological (Water) Cycle, which was first given as FIGURE 3 on page 4 of the previous E & B Lesson, and is now reproduced as FIGURE 1, given directly below.



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

FIGURE 1: THE GLOBAL HYDROLOGICAL (WATER) CYCLE

8. How does water vapour [H_2O (g)] enter the atmosphere?

FORWARD REFERENCE: How does the cycling of water vapour within the Global Hydrological Cycle affect the Global Climate System? You will study the Global Climate System in E & B Lesson 5 of Instructional Module 5. You could **conduct preliminary research** to answer this Question by visiting the web site whose Internet Address (URL) is given directly below.

http://www.agu.org/sci_soc/mockler.html

9. Can you **identify** and **describe** some of the connections between the Global Salt Cycle and the Global Hydrological Cycle?

10. Can you **identify** and **describe** some of the connections between the Global Salt Cycle and the Rock Cycle?

    BACKWARD REFERENCE: The Rock Cycle was first introduced as FIGURE 1 on page 16 of E & B Lesson 8 of Instructional Module 2, AND then revised as FIGURE 1 on page 7 of E & B Lesson 12 of the same Instructional Module.

11. How does salt leave the oceans and enter the atmosphere? What processes carry sea salt into the atmosphere? Does sunlight-heated water evaporated from the oceans contain sea salt? What simple experiment could you do to **investigate** the last Question?

12. What happens to sea salt that enters the atmosphere from the world's oceans? Where does it eventually end up, and how does it get there?

Please be **aware** that salt 'fall out' in rainfall from the oceans around Western Australia can range from about 20 kg / ha / per annum (usually inland with low rainfall) to more than 200 kg / ha / per annum (usually coastal with high rainfall).

This salt 'fall out' has been stored over tens to hundreds of thousands of years in our Western Australian soils, which now store between 300 to 10 000 tonnes of salt per hectare deep within the soil profile. For example, in Western Australia's wheatbelt, the soil now holds about 3000 tonnes of salt per hectare.

Soil salinity refers to the concentration of soluble salts stored within the soil.

Soil salinity poses no environmental problem while the salts remains deep within the soil profile. However, salt stored in the soil becomes an environmental problem when it becomes remobilised, causing it to migrate upwards into the root zone, and into freshwater streams.

Soil salinisation is the accumulation of salt in the root zone, which occurs in regions where the evapotranspiration is greater than the rainfall causing the salts not to be flushed from the root zone.

Shortly you will be asked to **define** selected scientific terms from hydrology and its related disciplines. You should try to define the terms by yourself without any help. However, should you be unable to define a specific term to your satisfaction? You may like to **search for its definition** by visiting the web sites whose Internet Addresses (URL's) are listed directly below.

1. http://www.wrc.wa.gov.au/waterdef/index.html
2. http://www.state.nv.us/cnr/ndwp/dict-1/waterwds.htm

Students in each Learning Group should now refer back to and analyse FIGURE 1: The Global Hydrological (Water) Cycle given on page 5 of this E & B Lesson. After studying FIGURE 1, they should then try to answer Focus Questions 13 to 19.

13. How does salt 'fallout' from rainfall, from oceans, falling onto the land surface accumulate deep within the soil profile? What is a soil profile? Can you sketch a typical soil profile from Western Australia's wheatbelt showing location of salt prior to land clearing? Print this page.

14. What is evapotranspiration? What role do plants play in the process of evapotranspiration? HINT: The leaves of plants play a role in both evaporation and in transpiration. **You may like to now conduct an investigation into the water loss from leaves by transpiration?**

15. What processes cause salt stored deep within the soil profile to remobilise and migrate upwards to the surface of the land? HINT: Make sure that you include capillary action in your answer to this Question. What is capillary action? **Ask your teacher to demonstrate capillary action using glass tubes of varying internal diameter.**

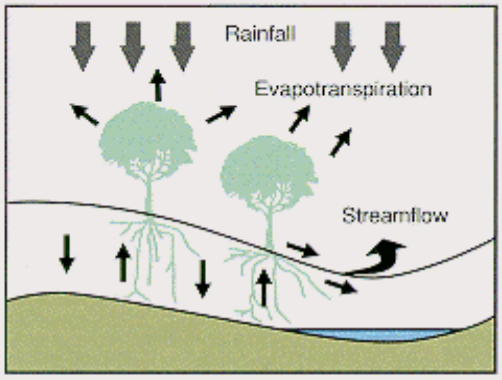
16. How does groundwater recharge and evapotranspiration affect the level of the water table? What is the water table? Explain by drawing a well-labelled sketch supported with brief notes. What is groundwater recharge? Print this page.

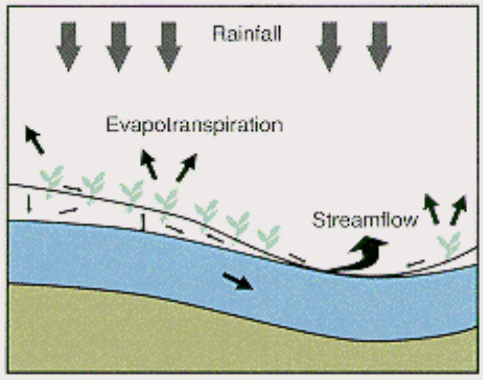
Students in each Learning Group should now check their answer to Question 16 from the previous page. In order to do so, they should study and analyse FIGURE 2, given below, which shows water table rise following land clearing.

PLEASE NOTE that FIGURE 2 has been copied, courtesy of the **WA Water and Rivers Commission**, from their electronic publication titled Salinity (p 3), which is available online at the following Internet Address (URL).

http://www.wrc.wa.gov.au/protect/Salinity/index.htm

Figure 1: Typical changes in water and salt balances following clearing
(for a catchment with rainfall of approx 700 mm per annum)





	Before clearing	After clearing
Rainfall	650-750 mm	650-750 mm
Evapotranspiration	640-720 mm	580-660 mm
Streamflow	10-30 mm	70-90 mm
Salt input	0.01 kg/m²	0.01 kg/m²
Salt output	0.001-0.005 kg/m²	0.3-0.5 kg/m²

FIGURE 2: WATER TABLE RISE FOLLOWING LAND CLEARING
(Copied courtesy of the WA Water and Rivers Commission)

17. How does the salt in saline groundwater, transported towards the land surface by a rising water table, become concentrated in the root zone? What processes bring about concentration of the salt?

Water salinity refers to the concentration of salts in solution.

18. How can shallow groundwater, base flow from aquifers contribute to the increasing salinity of a freshwater stream? What is an unconfined aquifer? How is it different from a confined aquifer?

Students in each Learning Group may like to further explore the link between groundwater, river and wetlands salinity by visiting the selection of web sites whose Internet Addresses (URL's) are listed directly below.

1. http://www.ec.gc.ca/water/en/info/pubs/FS/e_FSA5.htm
2. http://www.cwmb.sa.gov.au/kwc/section3/3-07.htm
3. http://www.wetlandcare.com.au/saline.htm
4. http://www.wrc.wa.gov.au/public/waterfacts/index.html #15 Stream salinity
5. http://www.environ.wa.gov.au/publications/soe/soe21a.htm
6. http://www.epa.nsw.gov.au/soe/97/ch3/7_3.htm
7. http://www.epa.nsw.gov.au/soe/97/index.htm
8. http://www.ifa.unimelb.edu.au/issues/wa/salinity.htm

Secondary dryland salinity in Australia results from the anthropogenic disturbance of the **hydrologic balance** of landscapes resulting from the clearing of native vegetation and the adoption of European agriculture, which remobilises the salt stored naturally within the soil profile.

19. What is meant by the words…"**hydrologic balance**"? How can farmers upset the hydrologic balance on their farms when they clear remnant vegetation and cultivate annual crops? What is remnant vegetation?

Soil salinisation is the accumulation of salt in the root zone, which occurs in regions where the evapotranspiration is greater than the rainfall causing the salts not to be flushed from the root zone.

The salinisation process is intimately linked to changes brought about in the hydrologic (water) cycle by alteration of the way water is routed through the landscape. For salinisation to occur there must be a change in the hydrologic cycle (with an increase in water flux to the groundwater system), and there must also be a source of salt to remobilize to the ground surface.

Soil salinity may be natural, referred to as primary salinity OR it may be anthropogenic (human-induced) salinity, referred to as secondary salinity.

There are two (2) kinds of secondary salinity: dryland salinity (occurring on land not subject to irrigation) and irrigated land salinity.

Secondary dryland salinity has resulted from water table rise following clearing. The water table rise has remobilized the salt stored in the soil profile above the original water table. This dissolved salt can then appear in new saline seeps in lower lying parts of the landscape.

20. In what four (4) ways can groundwater discharges produce saline seeps on hillsides in the western wheatbelt of Western Australia? HINT: The four possible ways are: Bedrock highs, Dolerite dykes, Changes in aquifer thickness, and Reduced slopes. Can you draw simple sketches to illustrate each of the four ways? Print this page.

To research the answer to Question 20, from the previous page, you may wish to contact the Soil Science and Plant Nutrition Group (SSPN) at the University of Western Australia at the following E-mail Address.

mailto:soilsci@cyllene.uwa.edu.au

Irrigation salinity is caused by water table rise due to excess irrigation, often with semi-saline water.

Students in each Learning Group should now evaluate the quality of their answers to Focus Questions 13 to 19 with the purpose of identifying gaps in their knowledge.

You should then conduct research at the salinity web sites whose Internet Addresses (URL's) are given below. On concluding your research, you should then try to incorporate your new knowledge into your answers to Questions 13 to 19.

Finally, you should compare and contrast your refined answers with those of the other members of your Learning Group.

1. http://www.environ.wa.gov.au/publications/soe/soe16a.htm
2. http://www.clw.csiro.au/research/catchment/publications/ndspcanberra/index.htm
3. http://www.agso.gov.au/information/structure/egg/mb/salinity2.html
4. http://www.agric.wa.gov.au/progserv/natural/trees/Salinity/salgen.htm
5. http://www.netc.net.au/enviro/fguide/saldl
6. http://www.cwr.uwa.edu.au/~ewing/envirowa/land/wheatbelt/drysal/drysal.htm
7. http://www.netc.net.au/enviro/fguide/salirr.html
8. http://www.sheppstc.org.au/srco/index.htm
9. http://www.saltcontrolsa.com/
10. http://www.nre.vic.gov.au/ **SELECT** Land & Water Management

PLEASE NOTE that at the excellent AGSO, "The Salinity Problem" web site, listed as #3 on the previous page, reference is made to "equilibrium" in unconfined aquifers when input fluxes of groundwater equal output fluxes.

In my opinion, this is an incorrect use of the word "equilibrium" because equilibrium can NOT be achieved in OPEN systems.

Equilibrium can only be achieved in a CLOSED system. An unconfined aquifer is an open system, therefore the correct words to use are "steady state", when input fluxes of groundwater equal output fluxes.

21. What do you think?

PLEASE NOTE: For further information and clarification on open and closed systems, please **refer back** to page 8 of the Introductory Lesson of E & B Instructional Module 1.

You should now be aware that increasing dryland salinisation and rising salinity levels in our freshwater resources are the greatest environmental problems that face all Western Australians.

Just how severe is land salinisation in Western Australia? To find out, study TABLE 2, given below.

TABLE 2: SALINITY AFFECTED AREA OF THE SOUTH WEST LAND DIVISION OF WA		
1994 Estimated Area (ha)	**2010 / 20 Estimated Area (ha)**	**Estimated Potential Area (ha)**
1 804 000	**3 296 300**	**6 109 000**
9.4 %	**17.1 %**	**31.8 %**
Total Area Surveyed (ha) = 19 231 400 (Includes some land partly covered with native vegetation.)		

PLEASE NOTE that I have copied the data in TABLE 2, given above, from Table 9 on pages 5 to 6 of the State of the Environment 1998 online publication available at the following Internet Address (URL).

http://www.environ.wa.gov.au/publications/soe/soe16a.htm

22. Can you sketch a pie graph from the data presented in TABLE 2, given on the previous page? Print this page.

Just how severe is the salinisation of inland waters in Western Australia? To find out, study TABLE 3, given below.

TABLE 3: SOME SALINITY AFFECTED RIVERS IN WESTERN AUSTRALIA

Rivers	Proportion of Catchment Cleared (% in 1986)	Current Salinity (mg / L TSS)	Trend = Rate of salinity increase since 1965 (mg / L / year)
Frankland River	**56**	**2 760**	**74**
Kent River	**40**	**2 087**	**58**
Swan-Avon River	**75**	**5 835**	**Insufficient data to form trend**
Greenough River	**50**	**4 908**	**Insufficient data to form trend**
Blackwood River	**85**	**1 760**	**58**
Collie River	**24**	**790**	**24**
Murray River	**75**	**2 260**	**93**

PLEASE NOTE that I have copied the data in TABLE 3, given above, from Table 12 on pages 5 to 6 of the State of the Environment 1998 online publication available at the following Internet Address (URL).

http://www.environ.wa.gov.au/publications/soe/soe21a.htm

PLEASE NOTE that TSS or **Total Soluble Salts** (mg / L) for most purposes can be read as TDS or **Total Dissolved** (Salts) **Solids** (mg / L) given that they are measured by different processes.

BACKWARD REFERENCE: You will recall that you previously measured the TDS of a sample of seawater in this E & B Lesson.

Students in each Learning Group should now assess the quality of the water contained in the rivers listed in TABLE 3, given on the previous page. To do this, you will need to refer to TABLE 4, given directly below.

TABLE 4: QUALITY CLASSIFICATION OF WATER RESOURCE SUPPLIES
[According to the Australian Drinking Water Guidelines (1966)]

Water Quality	Concentration of Dissolved Salts (TDS) [mg / L]	Usability of Water
Fresh	Less than 500	Drinking Quality and Irrigation
Marginal	500 to 1 500	Irrigation only
Brackish	1 500 to 5 000	
Saline	More than 5 000	
Seawater	35 000	
Hypersaline	More that 50 000	

23. Do any of the rivers listed in TABLE 3, on the previous page, contain good quality drinking water?

"Salinity has significantly affected over 80% of the rivers in the South West of Western Australia, including our divertible water resources (i.e., surface water that has potential for domestic or commercial supply)". (Water Facts from the Water and Rivers Commission, June 2000)

Thus far, we have mainly considered the effects of rising salinity on us humans, the Anthrosphere. What effects does increasing salinity have upon the remainder of the Biosphere?

24. For example, what is the effect of water salinity on the biodiversity of rivers and wetlands? To broadly answer this Question, please refer back to web site #4 listed on page 10 of this E & B Lesson.

If you are a West Australian, like me, you are probably now feeling quite depressed at the devastation caused by rising salinity.

On a global scale, land salinisation is now a major factor in the reduction of irrigated land in both developed and developing countries. You could **further research** the global use of water for agriculture by visiting the UNESCO web site whose Internet Address (URL) is given below.

http://www.unesco.org/science/waterday2000/water_use_in_the_world.htm

Given that land irrigation has been used to maximise food supply, less irrigation means less food to feed humanity. Also, the degrading of agricultural land by increasing dryland salinisation will inevitably further deplete world food supplies.

What are the economic costs, not including losses in biodiversity, to West Australians from increasing dryland salinity?

The capital value of land lost in Western Australia to salinity is estimated to be about $1 445 million, which will increase from a minimum of $64 million each year until a new hydrologic (water) balance is established.

What can we West Australians do about increasing dryland salinisation and associated increases in water salinity?

Hang on a minute! Don't include me, a city dweller, in the…'we'. I didn't cause dryland salinisation. Wasn't it caused by farmers who, with past WA Government approval and encouragement, were in past times obsessed with clearing more and more land for agriculture? In fact, didn't W.E. Wood back in 1924 warn us of the link between land clearing and dryland salinisation?

I didn't cause dryland salinisation, so why should I pay to fix it? What do you think?

I trust that you, like me, are convinced that we all own the environmental problem of dryland salinisation?

The following quotation, copied from a press release from the Avon Catchment Network, encourages me to realise that communities will work together to beat the curse of soil salinity, referred to by some farmers, as "white death". The press release is available online at the following Internet Address (URL).

http://www.avononline.com.au/~wcacpres/page10.html

"To find effective solutions (to dryland salinity) will take whole communities working together. In this (Avon) region steps are being taken to make sure this happens".

I would like to see school communities across the State of Western Australia working together to beat the problem of dryland salinisation. I therefore propose that each city school partner a mutually agreed school in the country whose surrounding landscape is plagued by soil salinity.

The network of schools, so formed, could incorporate into a **SCHOOL'S SALT BUSTERS PROJECT** (SSBP) to go online with its own Internet Address (URL) hosted by a consortium made up of say, the WA Education Department, Agriculture WA, CALM, EPA, the WA Water and Rivers Commission, and any other interested parties. The SSB Project to have its own distinctive logo designed by interested 'art specialist' students.

What could schools who take part in the proposed **SCHOOL'S SALT BUSTERS PROJECT** do?

They could communicate via emails. They could, if the web site was so designed, post their 'multi-media' electronic projects on salinity to be downloaded by other schools. Also, they could place their salinity projects onto their school's Intranet file sever. They could produce school newsletters on salinity for their respective communities and make them available as hard copy and online.

High school science departments in the SSB Project could conduct 'hands-on' workshops on salinity for their school communities. With the workshops supported by a University Group like the SSPN Group (previously mentioned on page 12 of this E & B Lesson). The workshops could be run in conjunction with the "Ribbons of Blue" Program co-ordinated by the WA Water and Rivers Commission.

http://www.wrc.wa.gov.au/ribbons/

Students from the city schools could visit and stay with their host country school parents provided funds were made available for such purpose. While on country visits, the city students could take part in salinity management projects on local farms such as 'alley' tree planting. With the participating farmers compensated for their time by being subsidised for the cost of the trees to be planted.

City students involved in the proposed **SCHOOL'S SALT BUSTERS PROJECT** (SSBP) could raise funds for the purchase of suitable trees from say the "Men of the Trees (WA) organisation, which may be contacted online at the web site whose Internet Address (URL) is given below.

http://members.iinet.net.au/~treeswa/

PLEASE NOTE that Agriculture WA provides online information on "Alley farming for salt land" at their Trees in Agriculture web site at the following Internet Address (URL).

http://www.agric.wa.gov.au/progserv/natural/trees/Uses/ALLEYSLT.HTM

Students in each Learning Group should now role play an involvement in the proposed SCHOOL'S SALT BUSTERS PROJECT (SSBP) by:

- **Designing a suitable Logo for the SSB Project.**
- **Designing and developing a suitable SSBP web site.**
- **Composing an E-mail to a selected country / city school inviting them to take part in the SSB Project.**
- **Composing an electronic newsletter, with a suitable banner, to advertise the environmental problem of dryland salinity. They should source information for the newsletter from this E & B Lesson and from the web sites whose Internet Addresses (URL's) are listed below.** PLEASE NOTE that any images you use are subject to copyright.

1. http://www.clw.csiro.au/photo/salinity/index.htm
2. http://www.agric.wa.gov.au/progserv/natural/trees/Salinity/salwa.htm
3. http://www.nlwra.gov.au/minimal/15_publications/22_fast_facts/fast_facts_21.html
4. http://www.enn.com/news/enn-stories/1999/06/062599/salt_3990.asp
5. http://www.econnect.com.au/salinity.html
6. http://abc.net.au/science/slab/salinity/default.htm

What 'hands-on' activities could the participants in salinity workshops conducted within the proposed **SCHOOL'S SALT BUSTERS PROJECT** (SSBP) program do?

The possible program for the proposed SSBP workshops could include the following:
PART A: A workshop designed to raise community understanding of the practical benefits to land managers of airborne geophysical methods, and remote sensing by satellite, currently being used to monitor the spread of dryland salinity.

Land managers and farmers need to know in practical terms:

- Where the salt is stored and where it is not stored,
- Where and how the salt is being remobilized from the salt store, and
- Where the salt is currently causing (or about to cause) a problem in the landscape.

I would expect that workshop participants would receive relevant materials from an actual salinity case study and hopefully delivered via the latest in Information Technology.

SSBP workshop participants could access the following web sites whose Internet Addresses (URL's) are listed below to **extend their understanding** of remote sensing techniques used to monitor the extent of dryland salinisation.

1. http://www.science.org.au/nova/032/032key.htm
2. http://wwwcomm.murdoch.edu.au/synergy/9702/computer.html
3. http://www.cmis.csiro.au/RSM/
4. http://www.cmis.csiro.au/RSM/casestudies/flyers/mapsal/index.htm
5. http://www.cmis.csiro.au/RSM/casestudies/flyers/predsal/index.htm
6. http://www.ndsp.gov.au/salinity/tools/package_fs.html

PART B: Laboratory based workshops where the participants actually measure the salinity of water and soil samples using Conductivity / Salinity meters like those displayed at the web sites whose Internet Addresses (URL's) are given below.

1. http://www.enviroequip.com/sales/wp84.htm
2. http://www.topac.com/conductivity.html

PLEASE NOTE that prior to the workshops, the SSBP science teacher / workshop leaders would need to take part in "Train-the-Leaders" professional development (PD) workshops conducted by say the SSPN Group (previously mentioned on page 12 of this E & B Lesson). At these proposed PD Workshops the SSBP workshop leaders would learn how to use and maintain the Conductivity / Salinity meters.

Electrical Conductivity and Salinity

Electrical conductivity (EC) is a measure of the extent to which water conducts an electrical current.

25. What factors would determine the electrical conductivity (EC) of a soil solution sample?

Electrical conductivity (EC) depends upon the total concentration and relative proportions of dissolved ions / salts, and the temperature of the sample.

Electrical conductivity (EC) meters, depending upon the setting used, usually display electrical conductivity in microSiemen per centimetre (μS / cm) or in milliSiemen per metre (mS / m).
[1 mS / m = 10 μS / cm]

The electrical conductivity of a sample of water can be directly measured with an EC meter by placing the probe directly into the water sample. However, to measure the electrical conductivity of a soil sample the usual techniques are:

- Saturated Extract (ECe)
- 1: 5 soil-water extract
- EM-38, using electromagnetic induction.

In the SSBP workshop PART B, I suggest that we measure the electrical conductivity of a 1: 5 soil-water mixture using the following experimental procedure.

1. Weigh 4g of the soil sample into a 30 mL plastic vial labelled with soil type and name of sampler.
2. Add 20 ml of de-ionised (DI) water to the soil and screw cap the vial.
3. Shake the soil-water mixture for 5 minutes and then centrifuge.
4. Calibrate the EC meter.
5. Record the conductivity of the 1:5 soil-water mixture using the EC meter, noting units displayed.
6. Refer to TABLE 6 on page 21 to estimate the approximate salt content of the soil sample.

Electrical conductivity and Soil types

When measuring soil salinity from 1:5 soil-water extracts, you must take into account the soil type. For example, sands will not hold as much salt in the soil water as clay. To allow for the soil texture effect on salinity, the EC 1:5 reading is often used to approximately estimate the ECe of the saturation extract.

Using a multiplier factor as displayed in TABLE 5 given below, you can convert the EC 1:5 (w / v) reading into a very approximate ECe estimation.

TABLE 5: CONVERSION OF EC 1:5 (w / v) INTO AN ESTIMATED ECe

Soil Type	Multiplier
Sand	15
Sandy loam	12
Loam	10
Clay loam	9
Light / medium clay	8
Heavy clay	6

PLEASE NOTE:

1. The conversion of EC 1:5 into ECe is necessary because in a subsequent section, you will study the salinity tolerance of plants, and the tables of data given at the web sites are ECe values in deciSiemen per metre (dS / m). [1 dS / m = 100 mS / m]
2. The proper measurement of the ECe of a soil sample is a laboratory technique, and is relatively expensive.
3. 1 mS / m equals approximately 5.5 mg / L [Total Soluble Salt (TSS)].

Conversion Tables for Different Measurements of Salinity

PLEASE NOTE that the tables on this page have been adapted from the "Farm Monitoring Handbook: A Practical Down-to-Earth Manual for Farmers and other Land users", by N. Hunt and B. Gilkes, The University of WA, Nedlands, WA, 1992, pp 168 to 171.

TABLE 6: APPROXIMATE CONVERSION TABLE OF SOIL SALINITY

Salt Content	TDS in 1:5 Soil-Water Extract (mg / L)	EC 1:5 (w / v) Soil-Water Extract (mS / m)	Approx. % Soluble Salt in soil	Indicator Plant species
Low	0 to 120	0 to 20	0 to 0.06	Agricultural species not affected
Mild	120 to 250	20 to 40	0.06 to 0.13	Wheat affected Barley preferred species
Moderate	250 to 500	40 to 80	0.13 to 0.25	Cereal crops affected Pasture becomes patchy Medic usually absent
High	500 to 1 000	80 to 160	0.25 to 0.5	Too high for crops
Severe	Greater than 1 000	Greater than 160	Greater than 0.5	Bare ground in pastures Patches of high tolerant species e.g., samphire

Participants in the proposed SSBP workshop PART B, after measuring the electrical conductivity (EC) of the samples of water, could estimate salt content and quality of their water samples by referring to TABLE 7, given below.

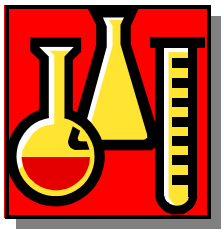
TABLE 7: APPROXIMATE CONVERSION TABLE OF WATER SALINITY

WHO guidelines	Total Dissolved Salts (mg / L)	Electrical Conductivity (mS / m)	Water Quality
	0 to 500	0 to 100	Suitable for all uses
	500 to 1 000	100 to 150	Suitable for most animals and irrigation
	1 000 to 2 000	150 to 300	Marginal for some animals and irrigation of sensitive plants
	2 000 to 5 000	300 to 800	Occasional use for stock and irrigation of moderately to highly salt-tolerant plant species
	5 000 to 10 000	800 to 1 600	Not suitable for any animals; irrigation of salt-tolerant plants only
Seawater	35 000	6 300	
Human taste threshold	1 000	180	
WHO maximum permissible level	1 500	270	
WHO desirable level	500	90	

Plants and Salinity

In PART C of the SSBP workshop program participants will study the effect of soil salinity on plants.

Plants are affected by both soil salinity and by water logging as indicated by water table depth. The extra effect of water logging on an already salinity stressed plant greatly reduces the plant's ability to survive.



[EB: IM4: L1: Activity 1] Students in each Learning Group should now plan and conduct an investigation into the combined effects of water logging and saline irrigation on the survival of plant seedlings such as tomato or flower seedlings.

You should separately investigate the effect of water logging and saline irrigation, and their combined effects on plant seedling survival. Remember to establish a 'control' for your seedling survival investigation.

Please note that, because of the heavy demand on materials, all Learning Groups will plan this investigation, but only five (5) Groups will carry it out. Each Learning Group will electronically 'write-up' the investigation.

Your teacher will provide to each Learning Group the following materials:

- ✓ Eight (8) Polystyrene cups to be used as seedling pots.
- ✓ Sixteen (16) Tomato or Flower seedlings. [Transplant Two (2) seedlings into each pot]
- ✓ Four (4) 500 mL labelled bottles containing tap water, NaCl solution (1.75 and 3.5 g / L) and seawater, respectively.
- ✓ Sufficient potting-mix to three quarters fill each cup.
- ✓ Eight (8) Plastic ice cream containers or similar.
- ✓ Eight (8) Wooden pop sticks.
- ✓ One (1) 100 mL plastic beaker.

Students in each Learning Group collaborate to produce an electronic report of their investigation.

Your report must be organised into four (4) sections: **Planning**, **Experimenting**, **Data analysis** and **Evaluation**. Your report must answer each dot-pointed question included within each of the sections listed below.

Planning

- What is the problem you are investigating?
- What do you already know about the topic you are investigating?
- What variables may affect the experimental results of your investigation?
- Which of the variables are you going to investigate as your **independent** variable? (This is the variable you will change to see what effect it has on the dependent variable)
- How will the independent variable be changed in the experiment?
- What is the **dependent** variable? (This is the variable that responds to changes made to the independent variable)
- How will you measure the dependent variable?
- What hypothesis are you testing? State your hypothesis as a relationship between the independent and dependent variables.
- Predict what you think will happen. Explain why.

- What variables are to be controlled (kept constant) to make it a fair test?
- Can you take a digital photograph of your experimental set-up?
- How are you going to collect your data?
- Are there any special safety precautions?

Experimenting

- Do you need to carry out some preliminary trials? If so, were there any problems?
- If required, how did you modify your experiment to fix the problems?
- Can you construct a suitable data table in which to record the data you need to test your hypothesis?
- How did you make sure your data were accurate?

Data analysis

- What is the best way to present your data? Is it appropriate to draw a graph? What type of graph is most suitable? Will you draw a line graph or a bar graph? Remember to plot the independent variable on the horizontal axis and to label axes.
- What is the relationship between the variables you have investigated? Is the hypothesis supported by the data?
- What is your conclusion? Explain why you can make this conclusion.

Evaluation

- What were the main sources of experimental error? (Sample size and selection, measurement error, poor control of variables)
- How confident are you with your conclusions?
- How could the design of your experiment have been improved to reduce error?
- What have you learned about the topic of your investigation? Was the outcome different from your prediction? Explain.
- What have you learned about the methods of investigating in science?

Remember to print your name and those of the other members in your Learning Group on your report.

Students with the best 'electronic' report of the seedling survival investigation may wish to E-mail their report to their partner school, in the proposed SSBP network, and / or upload it to the proposed SSBP web site.

Salinity units and conversion

Please note that TABLE 8, given below, provides equations for converting EC ranges into TSS (mg / L).

TABLE 8: CONVERSION OF EC INTO TSS (Courtesy R. George, 1992)

EC Range (mS / m) [At 25 ^{O}C]	Equation to calculate TSS (mg / L)
0 to 1 000	TSS = 5.45 EC + 11.4
1 000 to 2 000	TSS = 6.40 EC - 878
All data less than 2 200	TSS = 5.95 EC - 220
2 000 to 4 000	TSS = 7.21 EC - 2 500
4 000 to 11 000	TSS = 8.84 EC - 9 485
11 000 to 22 000	TSS = 23.22 EC - 193 050

Students in Learning Groups not doing the seedling survival investigation, given on pages 22 to 23, could further research salinity and plant tolerance by visiting the web sites whose Internet Addresses (URL's) are listed below. They then share their research with the Learning Groups that carried out the practical investigation.

1. http://www.general.uwa.edu.au/u/climaweb/beanfiles/salinity2.htm
2. http://www.agric.wa.gov.au/progserv/natural/trees/Salinity/saltol1.htm
3. http://www.agric.wa.gov.au/progserv/natural/trees/Salinity/salclass.htm
4. http://www.ext.usu.edu/publica/agpubs/salini.htm
5. http://www.sciam.com/1998/0898issue/0898glenn.html
6. http://botany.about.com/science/botany/library/weekly/aa103100a.htm

FOCUS QUESTIONS

- **Can you identify a common misconception concerning green-plant metabolism given at web site #6? What is the misconception?**
- **What are Halophytes and how do they adapt to life in highly saline habitats?**

Fixing salinity or preventing salinity?

In PART D of the SSBP workshop program participants will brainstorm a "toolbox of remedies" for dealing with increasing dryland salinisation in the catchments within local landscapes and on local farms.

Students in each Learning Group now role play an involvement in the proposed SCHOOL'S SALT BUSTERS PROJECT (SSBP) by forming into five (5) brainstorming groups to develop a "toolbox of remedies" for dealing with increasing dryland salinisation.

PLEASE NOTE that TABLE 9, given below, shows the connection between saline water table depth and the effect on crop yield.

TABLE 9: SALINE WATER TABLE DEPTH AND CROP YIELD

Groundcover	**Depth to Water table (m)**
Negligible effect	Greater than 2.0
Wheat yield decreased	Less than 1.8
Barley yield decreased	Less than 1.5
Pasture affected: Replaced by salt tolerant plant species	Less than 1.2

26. After studying the data in TABLE 9, given above, what can farmers do to minimise the effects of increasing dryland salinisation on their farms?

27. What is the **connection between** water table rise and 'hydrologic imbalance'? What can farmers do to help restore hydrologic (water) balance within a groundwater recharge zone? What is a groundwater recharge zone? You may like to refer back to pages 8 to 11 of this E & B Lesson.

Unfortunately, the time lag from land clearing to water table 'steady state' may take from between ten years in high rainfall areas (Greater than 800 mm per annum) to more than 200 years in low rainfall areas (Less than 300 mm per annum).

This means that dryland salinisation, in low rainfall areas, may continue increasing for up to 200 years following land clearing to allow time for the hydrologic (water) balance to re-establish within the water catchments of that landscape. This means that we may have to learn to live with our human-induced (anthropogenic) salinity for many years to come and possibly forever? We may need to establish priority areas to protect from salinity, like our catchments that supply divertible water resources.

SSBP workshop participants could now access the following web sites whose Internet Addresses (URL's) are listed below to develop a "toolbox of remedies" for dealing with increasing dryland salinisation.

1. http://www.cwr.uwa.edu.au/~avon/text/catch.html
2. http://www.avononline.com.au/ natural resource management
3. http://www.general.uwa.edu.au/u/dpannell/dpap9904f.htm
4. http://www.general.uwa.edu.au/u/aares/dpap0101.htm
5. http://www.ndsp.gov.au/15_publications/10_fact_sheets/fact_sheets.html
6. http://www.agric.wa.gov.au/programs/srd/south_coast/salinity/index.htm
7. http://www.dlwc.nsw.gov.au/
8. http://www.dnr.qld.gov.au/resourcenet/land/era/projects/sham.html
9. http://www.agric.gov.ab.ca/sustain/soil/salinity/
10. http://www.ussl.ars.usda.gov/

We have now, at long last, come to the end of this E & B Lesson on land and water salinity. However, it is not the end of the anthropogenic salinisation story. We must not give way to despair at this horrendous environmental problem devastating our agricultural landscape. Our communities must collectively work together to achieve a higher rate of adoption by farmers and land managers of salinity remediation strategies. You can make a difference!

How can you make a difference? You could E-mail me with your suggestions on how we could establish the SCHOOL'S SALT BUSTERS PROJECT (SSBP) that I have proposed. The SSB Project has the potential to capture the 'hearts and minds' of our intrinsically 'environmentally aware' students, who have the desire to better care for our ecologically fragile Biosphere.

mailto:m.mcgarry@bigpond.com

Could we apply for National Landcare Program (NLP) funding from the Natural Heritage Trust (NHT) to establish the proposed SCHOOL'S SALT BUSTERS PROJECT?

http://www.affa.gov.au/docs/nrm/landcare/nlp.html