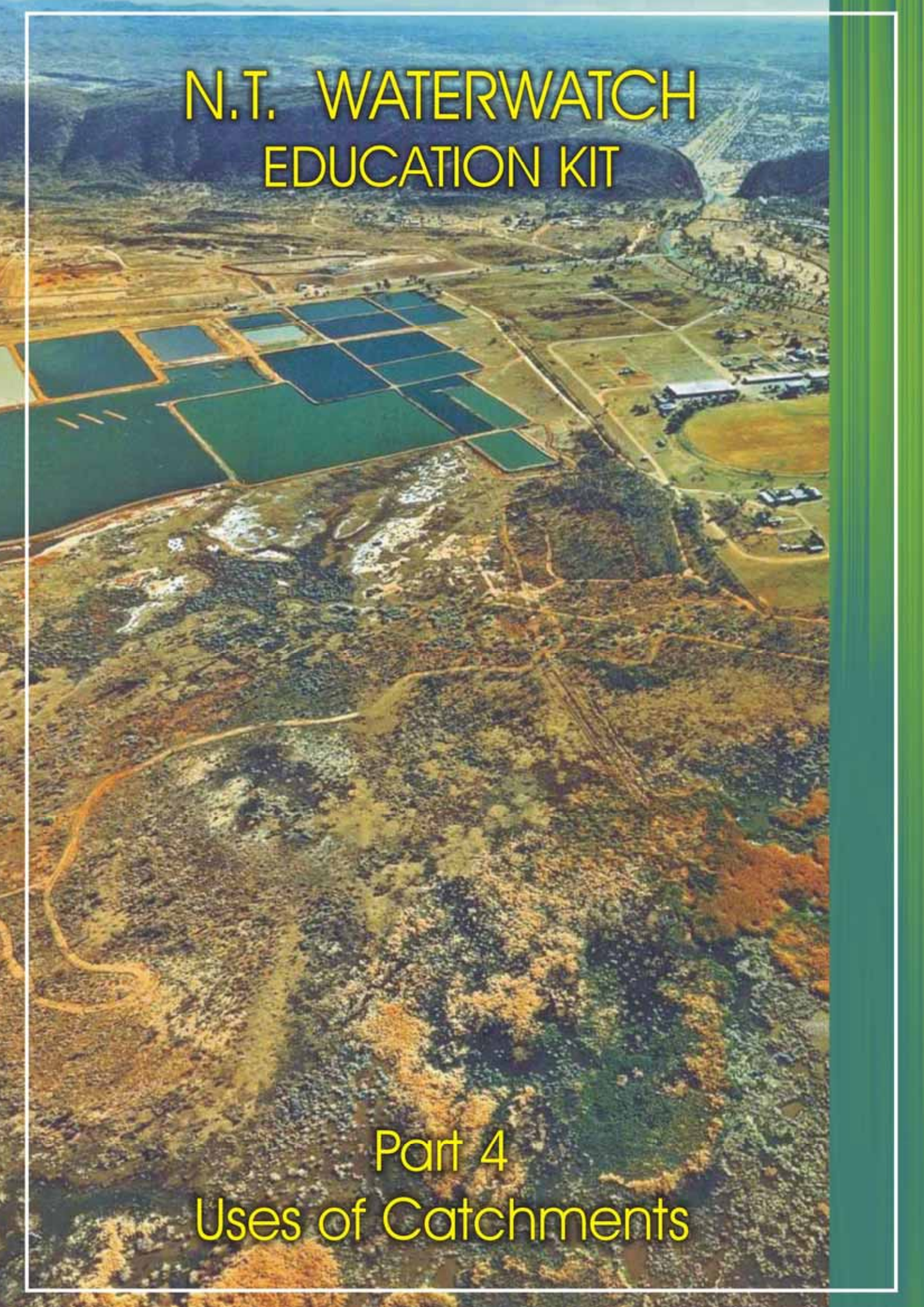

N.T. WATERWATCH
EDUCATION KIT

Part 4
Uses of Catchments

NT WATERWATCH EDUCATION KIT

PART 4:
USES OF CATCHMENTS

A program of the Natural Heritage Trust

Northern Territory Government
Department of Infrastructure, Planning and Environment

Natural Heritage Trust
Helping Communities Helping Australia
A Commonwealth Government Initiative

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PART 4: Uses of Catchments

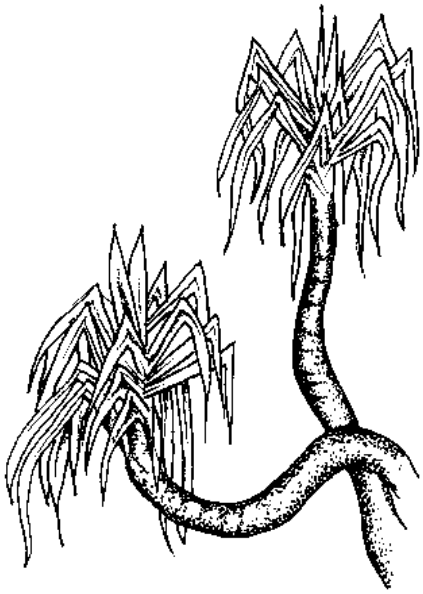
Introduction

Aquatic environments are important to people. There is a continual escalation in demand for our finite water resources that will have ramifications for water quality and catchment health in the future. The diversity of landscapes across a catchment provides for many varied uses. The Northern Territory's economic, ecological and cultural prosperity is dependent on efficient use and management of our water resources. The Northern Territory can learn from the solutions adopted by other Australian communities which have confronted problems resulting from the undervaluing of sustainable water management practices.

The 'Rio Declaration' (1992) defines ecologically sustainable development as 'Using, conserving and enhancing the communities resources so that the ecological processes upon which life depends are maintained and the total quality of life, now and in the future can be increased.' Sustainable development aims for economic gain, without ecological compromise on an extended time scale.

Rationale

How people use the land and water within the catchment affects the use of water by other people and importantly also impacts on the environment. Societies that respect and understand the need to protect and conserve water will better maintain this essential resource for future generations.



Values

Ecological Values

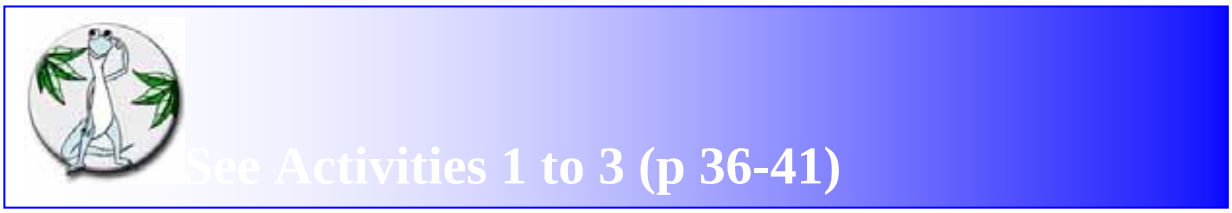
Ecology is the study of relationships which exist between living organisms and their environment. Ecological sustainability relates to maintaining the biodiversity of an ecosystem. Biodiversity should not be compromised to an extent where animals and plants can no longer provide sustenance to one another, in the forms of food, habitat and resistance to disease.

Economic Values

Economics is concerned with the production and consumption of goods and services. Environmental resources are an important economic resource. In Australia there are already examples of water use beyond sustainable extraction limits and reductions in water quality that now require expensive rehabilitative management strategies. The NT has the opportunity to learn from the examples of water use and management interstate.

Cultural and Spiritual Values

Aboriginal people have long communicated inextricable links to the land and the resources that the land provides. Country is importantly a place of origin, either through birth, through the birthplace of ancestors or through cultural and spiritual ties. Country provides the basis for sustenance and continued survival, in addition to cultural and spiritual links.



Indigenous Uses of Water

Prior to European colonisation Aboriginal people were predominantly self sufficient. Clan groups were either nomadic or semi nomadic dependent on resource availability and seasonality. Annual movements of traditional people in the Northern Territory were undertaken in the knowledge they would be near adequate food and water. As streams and wetlands dried up in the dry season, people moved to be near more permanent sources of water. In Central Australia water is more likely to be found in rock pools and soakages along dried riverbeds. Knowledge of the landscape, plants and animals associated with water is vital for survival.

How do Humans Source their Water?

How humans source their water will largely be determined by the climate and associated water sources available. Figures 1 and 2 illustrate the high level of variation which exists in the NT.

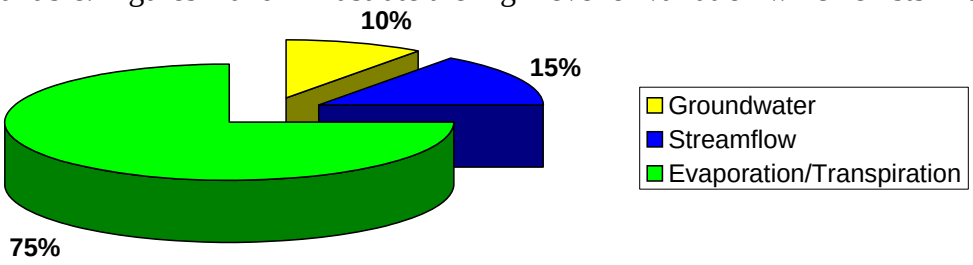


Figure 1 **Comparisons between groundwater, stream water and evapotranspiration in Darwin (Top End) (PAWA 1996)**

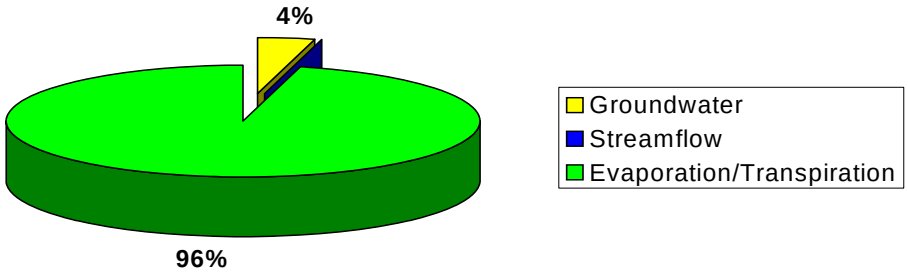


Figure 2 **Comparisons between groundwater, stream water and evapotranspiration in Alice Springs (Arid Zone) (PAWA 1996)**

Groundwater

Groundwater is a precious resource which supplies 90% of the Territory's water. Approximately 30,000 bores have been drilled for pastoral/stock bores (40%), rural/domestic (20%), water resource investigation (20%), town and community supplies (10%), mining (5%) and construction/roads and irrigation (5%) (DIPE 2002).

Surface Water

As explained in Part 1, surface water sources can be permanent, ephemeral or man made. The amount of surface water depends on climatic and geological variation. The majority of the Northern Territory's surface water is found in the Top End or humid zone. Darwin is dependent on both surface water and bore water for town water supplies, while Katherine utilises surface water and Alice Springs is dependent on bore water.

Land Uses and Impacts on Water Resources

Continued investment in our natural water resources has lead to a variety of land uses in the Northern Territory. Land uses include pastoralism, agriculture, mining, aquaculture, forestry, recreation and tourism. These industries are outlined below.

Livestock operations

Domestic livestock were introduced into north Australian savannas in late nineteenth century. The estimated 7.5 million cattle raised in Northern Australia equate to one third of Australia's herd (Taylor and Braithwaite 1996). The cattle industry relies heavily on available surface and ground waters to water stock (provide drinking water) and irrigate pastures. Water quality can be affected by the pastoralism industry through cattle induced erosion, introduced pasture grasses and pollution (DIPE 2002).

Plate 1 Stock watering

Stock Watering and Irrigation

Beef cattle require in the vicinity of 40 to50 litres of water each per day to survive. Water is also used in the production of pastures such as forage sorghum and for irrigation of pastures in times of drought (DIPE 2002).

Improved Pastures

The short growing season, poor quality native grasses and low soil fertility result in slow growth and weight loss in cattle and the death of pregnant and lactating cows. The cattle industry has attempted to overcome resource limitation by introducing species of improved pasture (grasses with a higher nutrient content than native grasses) which are often fertilised and treated with herbicides(Eyles and Cameron 1985).

Several species of introduced improved pasture are now recognised as having the potential to seriously degrade the environment, including wetland areas. Examples include Olive Hymenachne, Para grass and Gamba grass. Stock movements and disturbance can also facilitate the spread of weeds. Weeds can alter wetland ecosystems by out-competing native species and altering fire regimes (Smith 1995).

Pollution

Animal feedlots are pens and buildings used to confine animals for feeding, breeding, raising, or holding purposes. Poor feedlot management can allow stormwater run-off to carry pollutants from accumulating manure into surface and groundwaters. Pollutants from feedlots include nutrients, organic materials and bacteria that may affect humans and animals. High nitrate levels in the groundwater have been associated with improper storage of animal manure (Waterwatch Queensland 1994).

Erosion and Vegetation Degradation

Severe vegetation degradation caused by overgrazing and vegetation clearing can increase erosion and nutrient depletion. Grazing, in combination with the effects of trampling can enhance evapotranspiration and impede water infiltration rates, thereby increasing water run-off (Holmes & Mott 1993).

Plate 2 Brahman cattle on the Mary River Floodplains

Stock access to the banks of waterways can lead to soil compaction and erosion, fewer varieties of native plants and more weeds; and enrichment of the water with nutrients from manure (Holmes & Mott 1993).

See Activity 6 (p 48-49)

Agriculture

Major agricultural focus in the NT has been limited to areas associated with the Daly River Basin, T-Tree irrigation projects and the Darwin regional area. Tropical horticultural crops including mangoes, bananas, paw-paw, rambutan, heliconias, market gardens and other exotic fruits have proved successful, although the crops are dependent on irrigation, pesticides and fertilisers (http://www.nt.gov.au/dbird/dpif/general/industry/industry.shtml#horticulture).

Irrigation

North Australian soils are often of low water holding capacity. Shallow, stony and sandy soils drain rapidly and generally do not store moisture. Low natural water availability increases the irrigation requirements of crops (Lacy 1979). It is estimated that 80% of the total water usage in Australia is used for irrigated agriculture (Australian Water Association 2002).

Vegetation Clearing

Plate 3 Horticulture, Darwin rural area

Unfortunately riparian habitats are often preferentially chosen as sites for development on account of their close proximity to water and relatively high fertility levels. Clearing riparian vegetation leads to decline of rare and threatened riparian plants and animals, invasion by weeds, bank erosion and higher sediment and nutrient levels which decrease water quality (LWRRDC 1999).

Clearing can lead to increases in stormwater run-off. This run off from croplands and pastures may carry chemicals, sediments, nutrients, bacteria and organic material into nearby lakes and streams. Nitrates and pesticides can seep from agricultural lands and contaminate underlying groundwater supplies (Waterwatch Queensland 1994).

Plate 4 Land clearing

Riparian vegetation (vegetation which adjoins, directly influences or is influenced by a body of water) strongly influences the health of waterway ecosystems. Shade, provided by vegetation, decreases water temperature and available light and in doing so supports native flora and fauna, while preventing excessive growth of weeds and algae (LWRRC 1999).

Plate 5 Earthmovers

Riparian vegetation provides a rich food source for both aquatic and terrestrial flora and fauna and is the source of woody debris which creates habitats and assists in nutrient retention. Riparian vegetation reduces erosion and also acts as a buffer for nutrients and sediments entering the waterway from other regions in the catchment (LWRRC 1999).

Continued uncontrolled clearing will have disastrous affects on the integrity of these valuable ecosystems and quality of water (LWRRC 1999). While clearing is recognised as being essential for economic growth and development it is important to recognise that appropriate land management and broad scale, long-term planning concepts are essential for sustainable development.

Buffers

The retention or rehabilitation of vegetation areas (buffers) around riverine environments is essential in maintaining the health of waterways and long term productivity of the surrounding land. Buffers may vary in width according to the type of waterway, but should be sufficient to protect the riparian environment from surrounding land uses, weed infiltration and erosion.

Fertilisers

Most soils of North Australian savanna are deficient in nutrients, importantly nitrogen and phosphorous. Poor soil conditions are worsened by pastoral grazing and agricultural practices. The low available nutrient levels restrict the growth rate and productivity of plants, particularly introduced crop species. Continued production is generally dependent on large volumes of inorganic fertilisers (Tothill and Gillies 1992).

Nitrogen, phosphorus and potassium are the three primary nutrients applied to crops, gardens and lawns as fertilisers. Phosphorus entering water bodies in run-off from over-fertilised areas can cause heavy algal blooms and excessive weed growth, making waters unsuitable for drinking, swimming, water-skiing and other uses. The presence of nitrates in rural well water presents a risk to infants who may develop methaemoglobinaemia (blue-baby syndrome). Studies have indicated that nitrogen in fertilisers and manures is a probable source of elevated nitrate concentrations in rural groundwater supplies (Waterwatch Queensland 1994).

Pesticides

Pesticides are used to control undesirable plants or animals. They include herbicides, insecticides and fungicides. Pesticides are used on agricultural lands, on urban lawns and gardens, as well as in lakes to control some weeds, and in forest management (Waterwatch Queensland 1994).

See Activity 7 (p 50)

Mining operations

The mining industry in the Northern Territory is the most significant contributor to Gross State Product. The mining sector in the Territory includes metallic minerals, non-metallic minerals and energy minerals such as crude oil, natural gas and uranium oxide (http://www.dbird.nt.gov.au/mines_index.htm). Mining operations can cause dramatic changes in surrounding catchments. Surface and groundwater can be polluted by sediments, tailings, dust, chemicals and wastes from open pit, strip and underground mines (Waterwatch Queensland 1994).

Water Usage and Management in the Mining Industry

Water is required for many mining activities, including dust suppression, vehicle and equipment washing, irrigation of native bush and gardens around the mine, manufacture of sulfuric acid and most importantly, grinding and processing of ore (leGras 1999).

Release of contaminated water into the environment is licensed under Territory and Commonwealth law. To successfully confine and manage contaminated water, many mines construct and maintain retention ponds that enable the water to be stored and monitored (DIPE 2002).

Water, including rainwater, which has come into contact with potentially dangerous stockpiles and contaminated vehicles and machinery will be treated as potentially acidic and toxic. This water will be directed to an appropriate retention pond. Some water will evaporate back to the atmosphere as pure water vapour, and some is re-used in the mining process (leGras 1999).

Water used in the crushing, grinding and processing plant, particularly in uranium mines, is recognised as being highly contaminated. After use in the processing plant the water is pumped along with the tailings (water product)s to a separate tailings pond. This water either evaporates as pure water vapour back into the atmosphere, or is recycled back through the ore processing plant. Some water on mine sites will never be fit for release back into the environment (leGras 1999).

Plate 6 **Aerial photograph of Ranger Uranium Mine, NT.**

Some mines, including Ranger Uranium Mine, redirect water through large artificial wetlands, which contain the native reed *Eleocharis*. This plant assists in filtering out contaminants such as uranium and other heavy metals. For more information on Ranger Uranium Mine in the NT click on the following web link: http://www.energyres.com.au/environment/water.shtml

Erosion and Sedimentation

The extensive earthworks and vegetation removal associated with mining have the potential to cause widespread soil erosion, increased surface run-off and associated sedimentation of waterways. It is essential that mine sites are managed in such a way as to minimise vegetation removal, revegetate where possible and control water drainage, erosion and passage of sediment (leGras 1999).

Plate 7 Open cut mine

Aquaculture

The culture of aquatic animals such as barramundi, prawns and red claw in artificial environments involves intensive farming in ponds. Aquaculture is a relatively new industry within the Northern Territory and is currently limited in scope, but set for strong growth over the next few years. Black tiger prawns and barramundi are the principal sectors of interest by investors (http://www.nt.gov.au/dbird/dpif/general/industry/).

The major risks of environmental harm associated with aquaculture result from the discharge of pond waters containing high levels of nutrients, organic matter, suspended solids, low dissolved oxygen levels and abnormal pH into tidal waterways.

Forest Practices

Forestry in the Northern Territory has, to date, been limited. However new regions including the Tiwi Islands are currently viewed as a successful, long-term economic investments.

Poorly managed forestry can have negative implications on surrounding waterways. Forestry activities including the construction of roads, clearing of land for fire breaks, stacking and loading operations during harvest, mechanical site preparation, controlled burning for site preparation and application of pesticides and herbicides can transfer pollutants and sediment from land to water (Waterwatch Queensland 1994).

Tourism and Recreation

Tourism is the second largest industry in terms of gross regional profit in north western Australia, surpassed only by mining (Gray 1996). The appeal of northern Australia as a tourism destination draws strongly from the beauty of our natural landscapes including waterways, waterfalls and swimming holes. There are many opportunities for water based recreational activities within the Territory including fishing, boating, water sports and swimming.

The tourism industry has the potential to severely degrade water quality. Negative impacts can be blamed on the highly concentrated level of impact. Popular swimming holes can be frequented by hundreds of people, particularly in the Dry (Tourist season) when flow is naturally lower. Impacts on water quality result from rubbish, sewage, use of sunscreens, erosion and disturbance of aquatic ecosystems. Boating activities have the potential to pollute waterways with contaminants such as diesel and oil and can aid in the spread weeds such as *Salvinia* (Miles 1999).

See Activities 8 and 9 (p 51-52)

Domestic Uses of Water

Reticulated Water

During the 2000/2001 financial year, 93 of Australia's largest water utilities supplied an average of 259 litres of water per person, per day directly to households. Considering that humans generally only drink in the vicinity of 2 litres per day, this leaves an extensive volume which is obviously used for other applications. It should be noted that water usage per person varies extensively depending on seasonal variation and geographic location. An estimation of water allocation in households is illustrated in figure 1(Australian Water Association 2002).

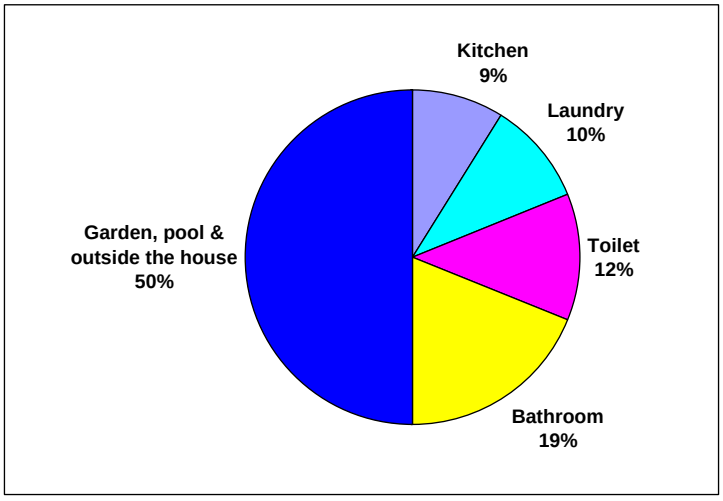


Figure 3 Water usage in different parts of the home

Sourcing Water in the NT

In the Northern Territory water is sourced from surface storages, rivers or groundwater. Table 1 shows the major water sources for various population centres in the NT.

Table 1 Water sources in the NT (PAWA 1996)

Location	Water Source	Location	Water Source
Adelaide River	Bore	Maningrida	Bore
Alice Springs	Bore	Milikapati	Bore
Alyangula	River/Bore	Milingimbi	Bore
Angurugu	River/Bore	Miniyeri	Bore
Baniyala	Bore	Minjilang	Bore
Barunga	Spring/Bore	Nauiyu Nambiyu	Bore
Belyuen	Bore	Nguiu	Bore
Beswick	Bore	Ngukurr	River/Bore
Borroloola	Bore	Nhulunbuy	Bore
Bulla Camp	Water Hole	Numbulwar	Bore
Bulman	Bore	Peppimenarti	Bore
Darwin	Dam/Bore	Pine Creek	Bore/Dam
Darwin Rural	Dam/Bore/Private Bores	Pularumpi	Spring
Kalkaringi	Bore	Ramingining	Bore
Galiwinku	Bore	Tennant Creek	Bore
Gapuwiyak	Bore	Umbakumba	Bore
Kunbarllanjnja	Bore	Wadeye	Bore
Katherine	River/Bore	Warruwi	Bore
Kildurk	Bore	Yirrkala	Spring
Lajamanu	Bore	Yulara	Bore

Power Water also provides water, sewage and other essential services to over 80 remote and isolated communities in the Territory (http://www.nt.gov.au/powerwater/index.shtml).

Water Treatment

As a result of catchment protection measures, water treatment is generally limited to chlorination. Chlorination disinfects the water and provides a barrier against future contamination. Water supplied in the Northern Territory consistently meets the National Health & Medical Research Council, Australia Drinking Water Guidelines and is regularly monitored in accordance with those guidelines (http://www.nt.gov.au/powerwater/index.shtml).

Bores and Wells

Not everyone in the Territory can rely on reticulated water supplies. Rainfall is either seasonal (Top End) or erratic (Arid Zone) and many of the populated areas are remote and isolated. It is often necessary to drill bores so people can access water directly from groundwater supplies (Power and Water Authority 1996).

Plate 8 Bore drilling rig

Dams

Dams provide a means of accessing water particularly in drier regions of the Territory. Dams along a watercourse may change the water conditions. Upstream, the raised water level behind the dam wall increases stream width as well as depth, potentially increasing erosion and sediment load. Downstream the dam will suppress the natural fluctuations in the flow. These changes affect the stream characteristics, especially water temperature, when discharges are drawn from the relatively deep and cold water in the storage (Boulton & Brock 1999).

To minimise environmental impacts, all surface water extraction is to be licensed by the Department of Infrastructure, Planning and Environment (DIPE 2002).

Plate 9 Manton Dam wall

The minimum flow of water required to sustain the normal aquatic ecosystem for the river is called an environmental flow.

Plate 10 Aerial photograph of Manton Dam

Sewage

Human wastes disposed of as sewage have to be treated before they can be released into the environment. Other materials such as fats, detergents and industrial wastes also need to be treated and removed. The main component of sewage is water. Water is used to transport sewage and to aid its decomposition. In towns, sewage from homes and other buildings is collected through a system of pipes before it is deposited into sewage mains. The sewage mains take the sewage to the treatment plant (Power and Water Authority 1996).

All major towns and cities in the NT are provided with a standard sanitary sewage reticulation system. Treatment is achieved by a number of different processes. These include lagoons, chemically assisted sedimentation, and the activated sludge process. These processes produce effluent which is either disposed of into the environment or re-used (Power and Water Authority 1996).

The quality of effluent is subject to licensing requirements of the Department of Infrastructure, Planning and Environment. Sewage effluent is re-used on a limited basis in Darwin, Pine Creek, Katherine, and Alice Springs in accordance with the National Health and Medical Research Council Guidelines and is also subject to approval by Department of Health and Community Services (http://www.nt.gov.au/powerwater/index.shtml)

See Activities 10 to 13 (p 53-58)

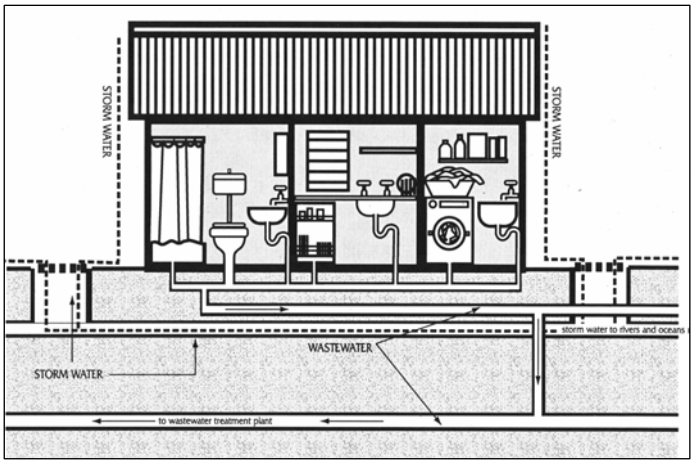


Figure 4 Differentiation between sources of sewage and stormwater (Power and Water Authority 1996).

Septic Systems

Many homes are not connected to municipal wastewater treatment systems and rely on septic tanks and trenches for sewage treatment. Septic systems have two main parts -a septic tank and a soil absorption system (Waterwatch Queensland 1994).

The septic tank is a cylindrical concrete container. It receives wastewater from the bathroom, kitchen, toilet and laundry, allowing the heavy, solid particles to settle and light materials to float to the surface of the tank (Power and Water Authority 1996)

The soil absorption system consists of at least one but preferably two leach drains. The absorption system receives wastewater from the septic tank and removes harmful, disease-causing micro- organisms, organics and nutrients. For this part of the system to work properly, it must be built carefully on suitable soil (Power and Water Authority 1996)

If septic systems are well designed, installed and maintained, septic systems will safely treat wastewater for 20 to 50 years. Improper design, installation or operation of septic systems or holding tanks can lead to pollution of ground or surface waters by bacteria, nutrients and household toxic chemicals (Waterwatch Queensland 1994).

Septic systems use natural decomposition to treat wastes. Holding tanks do not treat wastes, but simply contain them on site. Both septic systems and holding tanks must be periodically pumped out or cleaned. Care must be taken in the disposal of the materials removed in this cleaning. Solids cleaned out of septic systems can be land-spread since they are partially treated, but continuous spreading on a single site should be avoided. Wastes removed from holding tanks need additional treatment as they have usually undergone little decomposition (Waterwatch Queensland 1994).

Additional Impacts on Water Quality

Urbanisation and Run-off

Urban land is largely covered with non-absorbing surfaces including buildings, driveways, roads, footpaths and parking lots, which result in the production of urban run-off.

Plate11 Aerial photograph of urban land use

The amount of pollutants carried in urban run-off is influenced by traffic density, littering, fertiliser and pesticide use, construction site practices, animal wastes, soil characteristics, the topography of the area, percentage of impervious surfaces, air pollution levels and the amount of rain. Pollutants transported in urban stormwater systems to nearby waters include nutrients, bacteria, litter, soil, toxic chemicals and organic (oxygen-consuming) materials (Waterwatch Queensland 1994).

Stream flow in urban areas tends to vary more than in equivalent natural areas. The increased area of impervious surface in urban areas leads to greater flooding during storms. Water draining off hard surfaces reaches waterways more quickly and causing flooding and erosion. Hard surfaces can inhibit the recharge of groundwater which in turn lowers base flow level in dry times (Boulton & Brock 1999).

Plate 12 Urban run-off demonstrating high levels of turbidity

See Activities 14 and 15 (p 59-60)

Stormwater

Stormwater is run-off that collects in the roadside gutters and flows through a series of pipes until it reaches a stream, lake or the sea. Often stormwater can be polluted, because it can pick up wastes as it flows across the ground into the gutters. Usually water in the stormwater system is not treated although some places include rubbish traps to collect litter (Power and Water Authority 1996). Mapping stormwater may assist in determining pollution sources and therefore can assist pollution prevention strategies.

Draining wetlands

Wetlands are complex natural systems that provide an important habitat for many species and act to filter water and remove many pollutants.

Draining of wetlands for development removes habitat and can result in release of acid drainage from acid sulphate soils. Acid sulphate soils are generally found in low lying areas with saline or brackish waters, but can also be found in inland swamps and in some mine spoils or quarries. When these soils are exposed to air they form free sulphuric acid, which can potentially be very destructive to both ecological systems and human developments (Hunt 1992).

Additionally drains cut into wetlands may trigger large scale erosion problems which are extremely difficult to reverse (Waterwatch Aust. 2002).

Construction Sites

Construction activities can harm nearby waters in three ways. The first occurs when natural land cover is disturbed during excavation and grading operations. Soil stripped of its protective vegetation can be easily washed into nearby surface waters. Second, stormwater run-off often carries material used on the site - such as oil, grease, paints, glues, preservatives, acids, cleaning solutions and solvents - into nearby lakes or streams. Thirdly, badly designed projects can accelerate run-off and cause erosion (Waterwatch Queensland 1994).

River Management Works

Erosion does occur naturally but is more common and severe where catchments have been changed by human activity. It is worth considering how much your waterway has been altered from its natural condition. River management works include removal of logs and branches from the water, building levees or straightening the channel. Poorly considered works, such as the inappropriate use of weirs, groins and riffles, can remove or degrade habitat, and may ultimately lead to greater problems (LWRRDC 1999).

Removal of river gravel disturbs the normal pattern of flow so that the stream bed is deepened by erosion in one part of the stream and raised by deposition in other parts. Attempts at straightening the channel to move water on downstream more quickly and prevent flooding have often caused greater erosion, head cutting and bank collapse (LWRRDC 1999).

Channelisation shortens the channel length and increases the slope and velocity of the water leading to greater erosion. Building levees to confine floods waters also has the effect of increasing channel velocity and channel and bank erosion. De-snagging reduces resistance to flow and increases scouring (LWRRDC 1999).

Sinkholes

Many collapses are induced by human activities, which have resulted in alterations in drainage patterns (eg: increased surface run-off) or water storage (eg: for dams). Leaky water and sewer lines and excessive groundwater pumping can also induce collapses. Figure 5 illustrates how human activities can induce collapse and sinkhole formation. The formation of sinkholes can have negative environmental and economic outcomes (Karp 2002).

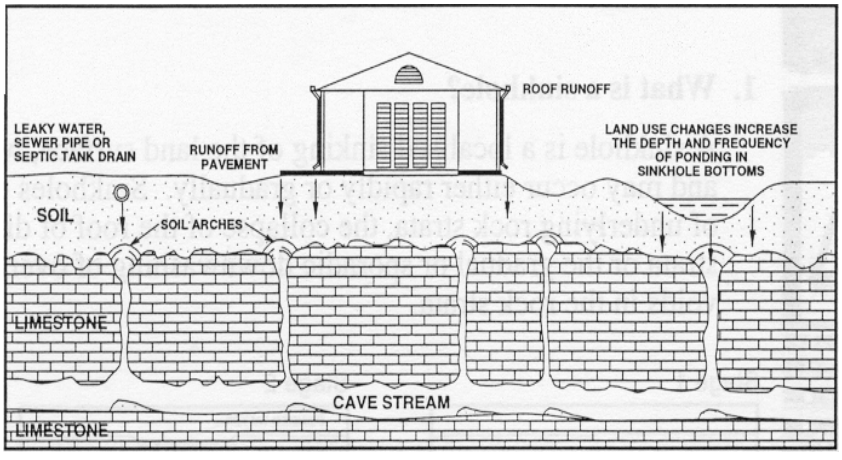


Figure 5 **Growth of soil arches towards the surface induced by modification of surface run-off and infiltration conditions**

Sinkhole formation can be minimised by (Karp 2002):

- selecting an appropriate site for the desired land use;
- minimising hydrologic changes;
- combining land use and groundwater management strategies together; and
- pre-construction testing.

Remedial treatment of sinkholes can best be achieved by (Karp 2002):

- maintaining drainage;
- minimising soil erosion;
- reducing rates of water entry into the sinkhole; and by
- completing engineering work.

Introduced Animal Species

*Feral Pig (*Sus scrofa*)*

The feral pig is thought to have arrived into Australia either as domestic stock, in southern farming areas, or from Timor or Papua New Guinea in northern areas of Australia. Feral pigs are omnivorous, they compete with native and pastoral animals for feed and have been observed to hunt small animals and birds. Feral pigs can also significantly alter their habitat by destroying vegetation and by compacting and eroding soils. Additionally feral pigs have the capacity to spread disease to livestock (Strahan 1995).

*Cane Toad (*Bufo marinus*)*

Cane toads were introduced into Australia in 1935 in the hopes that they would be a successful control agent for sugar cane grubs. Originally introduced into Queensland there are now millions of cane toads in the Northern Territory. The cane toad excretes toxins to poison would be attackers. This means many native animals higher up the food chain are at risk from the toad's invasion. Additionally these toads have been found to pollute water, erode soil and disperse the eggs of human parasites (Parks and Wildlife Commission of the NT).

Mosquito Fish (Gambusia holbrooki)

Gambusia holbrooki, the mosquito fish, are native to south-eastern USA and north-eastern Mexico. The species was introduced into eastern Australian waters in the 1920s as a biological control agent for mosquitos. In Australian waterways *Gambusia* compete with native fish for habitat and resources, feeding on small fish, frog eggs and tadpoles additionally these intruders could potentially facilitate the spread of disease. *Gambusia* have been associated with decreasing aquatic biodiversity in some regions of Australia (Mitchie 2000, http://www.nt.gov.au/dbird/dpif/fisheries/environment/pestman/index.shtml).

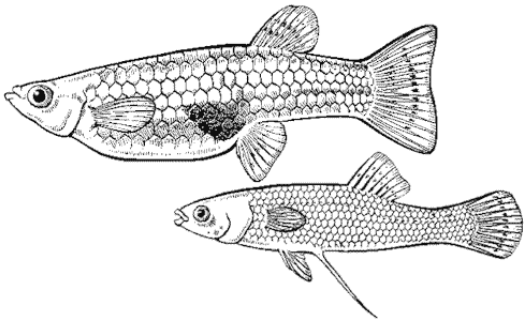


Figure 6 Mosquito fish (*Gambusia holbrooki)* (top: female, bottom: male; actual size)

In May 2000, students from Our Lady of Sacred Heart College, were undertaking Waterwatch monitoring activities at Illparpa Swamp, Alice Springs. The students found a single individual of an unidentified fish, which was later formally identified as *Gambusia holbrooki* or the introduced mosquito fish. Significant efforts have since been made by Waterwatch volunteers to control *Gambusia* populations in the Illparpa Swamp, which provides an important habitat for four native frog species and numerous freshwater invertebrates. If the Swamp was to link up with the Todd, and subsequently the Finke Rivers. The *Gambusia* could potentially negatively impact native fish species, of which three are endemic (Mitchie 2000).

See Activities 16 to 18 (p 61-67)

Introduced Plant Species

A weed is a plant which is growing, often prolifically, where it does not naturally occur (Knox *et al* 1994). Weeds which affect the health of aquatic ecosystems can be either terrestrial (land based) or aquatic (water) weeds. Valuable habitat for both aquatic and terrestrial fauna may be lost (Smith 1995).

Terrestrial Weeds

Terrestrial plant species can significantly alter waterways by concentrating in riverine areas. Terrestrial weeds can reduce the number and variety of native plants through competition, alteration of channel shape and width, by the affecting flow and drainage of waterways and by reducing habitat availability for fish, macro-invertebrates, birds and others. Aquatic plants and animals can become deprived of oxygen and light, particularly if water becomes stagnant (Australian Water Research Council).

Clearing and overgrazing of the natural vegetation along waterways can worsen the environmental weed problem. Remnant native vegetation may grow more slowly than weed species and be overtaken by weeds (Australian Water Research Council).

*Giant Sensitive Plant (*Mimosa pigra*)*

Plate 13 Giant sensitive Plant (*Mimosa pigra*)

Mimosa pigra is a declared noxious weed which unfortunately is already responsible for transforming vast areas of land in the NT. This plant forms dense, impenetrable thickets which exclude native plants and animals. Grasslands and in particular floodplains, such as those found in the Mary River region are worst affected (Smith 1995). *Mimosa*, present in the Darwin Botanical Gardens, late last century was probably imported on the basis of its unusual sensitivity to touch. The above plate illustrates how the feather-like leaves fold when touched.

Aquatic Weeds

The prolific growth of aquatic weeds costs Australians millions of dollars every year. Weeds affect our native wetlands physically, chemically and biologically (Australian Water Research Council).

Floating and emergent water plants can physically reduce light penetration into the water, which can reduce the growth of native submerged plants and algae. Extensive areas of plants can restrict natural flow and influence water clarity (Australian Water Research Council).

Chemically aquatic weeds rely on phosphates, nitrates and other nutrients for growth. Excessive release of nutrients into water systems following weed death or uptake from substrates can increase algal and further weed growth. Additionally weeds can affect pH and oxygen levels through photosynthesis (Australian Water Research Council).

Biologically aquatic weeds can out-compete native plants and animal species for resources including nutrients, light and space. Weeds can also provide habitat for pest insect species (Australian Water Research Council).

Salvinia molesta

Salvinia is a free-floating aquatic fern which rapidly forms thick mats of vegetation on the surface of affected waterways. *Salvinia* is most likely to be found in slow flowing waterways such as lagoons, where it rapidly out-competes native vegetation, effectively choking waterways (Smith 1995).

Plate 14 *Salvinia molesta*

How do Weeds find their way to Waterways?

Weed seeds are blown or washed into bushland and drains leading to streams, they can be transported inadvertently by people or on animals. Unfortunately seeds and cuttings are often directly dumped with garden waste into bushland and riparian zones. Similarly many outbreaks of aquatic weeds are thought to have developed from discarded aquarium material.

Getting Rid of Weeds

Prevention is better and cheaper than cure. Educating people not to dump garden waste near drains or the river, and never to empty aquarium plants from fish tanks or backyard ponds into rivers or drains is an important strategy. Pond owners can use local aquatic plants such as the fern-like *Azolla* rather than potential and declared weed species.

Information on weeds, including ways to identify and help reduce them can be found at www.dpif.nt.gov.au

See Activities 19 (p 68)

Effects of Fire – Positive and Negative

Fire is an annual event in North Australia savannas with over 50% burning each year. Fires of greatest intensity and extent occur during drier months, due to increased amounts of fuel (dry grasses and fallen leaves) and reductions in moisture availability (Andersen 1999).

Plate 15 Savanna fire, near Katherine, NT

Aquatic Flora

Plants growing near waterways are extremely sensitive to fire, so fires that take place in the late Dry Season can have a severely detrimental effect on riverine vegetation. Late Dry Season fires can reduce both vegetation cover and number of terrestrial plant species. Such burns also increase erosion associated with Wet Season storms, as the vegetation does not have enough time to regenerate and stabilise the soil prior to the heavy rains. Waterways in these catchments carry three times more sediment then those draining catchments that are either not burnt at all, or burnt early in the Dry Season (CSIRO 2001).

From a different perspective, fires that occur late in the Dry Season can result in an increase in the cover and richness of aquatic plants, such as lilies, which flourish in pools at the end of the Wet Season. This is probably due to increased nutrient loads entering the stream and the increase in available sunlight due to a reduction/removal of the dense streamside vegetation (CSIRO 2001).

Aquatic Fauna

Waterways provide habitats to an array of aquatic invertebrates, including tiny animals such as worms, water fleas, midges and other insects. These animals provide an essential source of food for fish and other larger predators. As is the case with aquatic plants the aquatic macroinvertebrates also benefit from catchment burning. It has been found that pools in burnt streams possess a much greater variety of aquatic invertebrates then pools in unburnt catchments (CSIRO 2001).

For more information see www.terc.csiro.au/firete.asp

Fire and Weeds

One of the major concerns with weeds is their ability to affect the frequency, timing and intensity of bushfires.

See Activity 20 (p 69)

*Gamba Grass (*Andropogon gayanus*)*

Gamba grass, native to tropical Africa, is now well established in Darwin and sub-coastal areas of the NT. Originally introduced into the NT as a pasture grass Gamba proved to be very beneficial to the pastoral industry, however it also proved hard to manage. Grass which was not adequately managed and grazed, spread rapidly, often out-competing native species and significantly increased fire danger. Late Dry season fires resulting from Gamba's high fuel loads and tall rank growth are extremely destructive and can kill even the most fire-resistant native vegetation. Unfortunately the death of native vegetation killed in these unnaturally hot fires opens up more country for the Gamba grass to invade, and so the cycle worsens (Smith 1995).

*Mission Grass (*Pennisetum polystachion)

Mission Grass is also native to Africa. This grass can out-compete native grasses, particularly in disturbed areas and as a result is easy to find in built up areas, particularly along roadsides (Smith 1995).

Mission grass is responsible for significantly altering fire regimes in the Top End. Where native grasses cure (dry out) early in the Dry Season, Mission Grass stays green until late in the Dry season, and in doing so provides a fuel source for late fires, which are much hotter and consequently far more destructive (Smith 1995).

Salt Water Intrusion

Saltwater intrusion occurs where freshwater environments become saline through the incursion of tidal waters. Since the 1940's, the breakdown of coastal cheniers (remnant coastal dunes) and development of tidal channels has linked saltwater to freshwater over much of the Mary River floodplains. Over 240 km^2 of freshwater wetlands in the Mary River catchment have been destroyed by the intrusion of saltwater within the last 50 years (DLPE 1998).

This process was initiated primarily through the impact of large populations of feral buffalo, although other natural processes increased the susceptibility of the wetlands to saltwater intrusion (DLPE 1998).

One third of the area already affected by saltwater intrusion lies within the Mary River Conservation Reserve. The remaining land lies within crown leases used for pastoral purposes. These wetlands previously supported large Melaleuca forests, magpie geese and crocodile habitats and other flora and fauna dependent on a freshwater environment (DLPE 1998).

A total of 1 000 km^2 of wetlands both within the Mary River Conservation Reserve and upstream of the Shady Camp barrage is under immediate threat of intrusion if this process continues. This would mean additional losses to important wildlife habitats and to the pastoral and tourism industries, which rely on those wetlands (DLPE 1998).

The fisheries value of these wetlands is also dependent on the maintenance of both the highly productive freshwater floodplains as well as tidal flats which act as nurseries for fingerlings. For many species, most notably the barramundi, fish breeding and growth cycles depend on an ability to move between saltwaters and freshwaters at various times of the year. Efforts to control saltwater intrusion must not hinder normal fish migration (DLPE 1998).

From 1988 to 1997, about $1,000,000 has been expended in the battle to control saltwater intrusion. Much of this work has been undertaken by Government to rehabilitate or prevent further loss of valuable conservation land and reserves. Over 25 km^2 of degraded floodplain within the Conservation Reserve has been rehabilitated. The largest barrage is constructed across Shady Camp billabong to prevent saltwater intrusion further south (DLPE 1998).

Plate 16 Salt water intrusion in the Mary River Floodplains.

See Activity 13 (p 105-107 in Part 5)

Physical Processes in Waterways

Flow

In addition to direct input from rain there are three other ways that wetlands and other water bodies receive water, these being from surface flow (run-off), through flow (water that has been absorbed into the top soil) and base flow (water that has sunk deep into the soil and met the groundwater) (Waterwatch Australia 2000).

Why does the flow of your waterways change?

Whether or not rain water flows across the surface or soaks into the soil depends on many factors including slope, rainfall and ground cover (Waterwatch Australia 2000).

Flow increases quickly in areas surrounded by hard surfaces such as roads, footpaths and parking areas. During heavy rain run-off water rapidly increases the volume and flow of waterways in the catchment (Waterwatch Australia 2000).

In some catchments flow may take a long time to respond to rainfall. In densely vegetated areas, the transport of rainwater is slowed by vegetation and more of the rainwater tends to soak into the ground. Some through flow is taken up by plant roots and discharged through leaves back to the air. However some water will continue to seep lower into the soil to meet with existing groundwater sources. This baseflow then maintains the reduced flow of waterways in the dry season, long after there has been rain in the catchment (Waterwatch Australia 2000).

Knowing the pattern of flow in a catchment is important in interpreting water quality data, because run-off and baseflow come from different sources with different levels of water quality (Waterwatch Australia 2000).

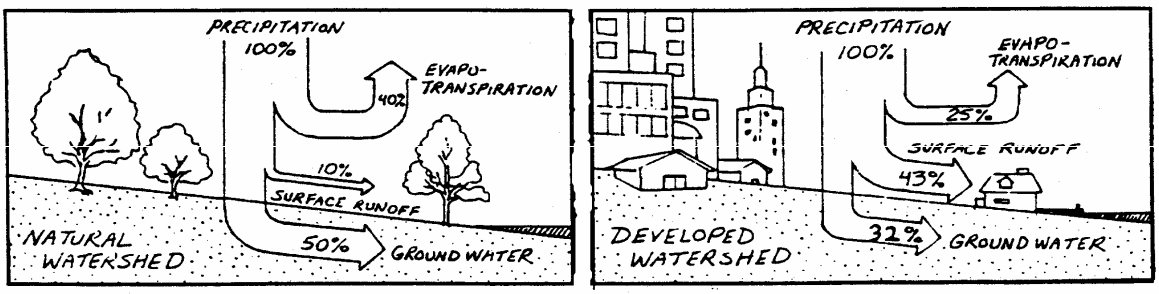


Figure 7 Effect of cities on the pathway of water from rain to rivers (TVA 1995).

How does Flow Affect the Health of Streams?

Flow rate (volume of flow in cubic metres per second) affects water temperature, dissolved oxygen, turbidity and pollution levels. Australian rivers have highly variable discharges and a big flood can transport very large amounts of sediment particularly from areas that have been disturbed (Waterwatch Australia 2000).

Stream flow is altered through the construction of weirs and dams. These obstructions reduce the flow of water downstream and even out periodic flooding which many aquatic ecosystems especially wetlands, depend upon (Waterwatch Australia 2000).

Low Stream Flows

Under low flow conditions, water entering the watercourse is largely groundwater (baseflow) from sub-surface seepage. During low flows the waterway can become semi-stagnant resulting in (Waterwatch Australia 2000):

- reduced flushing of pollutants;
- increased algal growth;
- low dissolved oxygen levels particularly at night;
- increased salinity where this is a problem; and
- larger temperature variations which increase stress on living things.

Moderate Stream Flows

The best water quality usually occurs under moderate flow conditions where there is sufficient flow to ensure (Waterwatch Australia 2000):

- dilution and flushing of pollutants;
- limits to the build up of algae; and
- good oxygenation of the water.

High Stream Flows

During and immediately after heavy rainfall, water flows over the surface of the ground, picking up pollutants, which results in (Waterwatch Australia 2000):

- increased sediment load (ie: increased turbidity); and
- increased nitrate and phosphate levels.

See Activities 21 to 24 (p 70-74)

Erosion

Erosion begins with run-off water dislodging soil particles on hill slopes and transporting them towards the watercourse. A thin film of soil removed in this way is called sheet erosion. If run-off is heavy or the slope steep, numerous small channels (rills) may form (rill erosion). Deep gullies can rapidly develop if several larger rills join together (gully erosion). In this way, clay, silt, sand, gravel, cobbles and boulders are transported over land into stream channels (Hunt 1992).

Erosion in the stream channel takes place in several ways. The impact and drag (hydraulic action) of water on loosely consolidated gravel, sand or clays in the stream bed can erode large quantities during floods. Material on the bed and banks is detached by the abrasive action of sand and gravel carried by flowing water and undermining of banks causes collapse and contributes much alluvial material to the stream (Hunt 1992).

Higher velocities produce more turbulence and greater drag on the stream bed which dramatically increases the power of the water to erode the channel and carry higher loads (cobbles, boulders). The greatest changes in a watercourse occur during floods rather than low flows (Hunt 1992).

Down cutting of the stream bed (incision) can quickly occur if the stream has been disturbed through either natural or human causes. Once channel incision is triggered, there is a local increase in slope, a substantial increase in the volume of water and stream energy and the channel responds by widening and/or deepening further. This deepening (erosion head or head cut) moves upstream as the stream tries to reach equilibrium. Banks may erode by scouring (direct removal of soil by the flow of water) or by slumping (collapse of the bank) (Hunt 1992).

Table 2 Causes of bed erosion

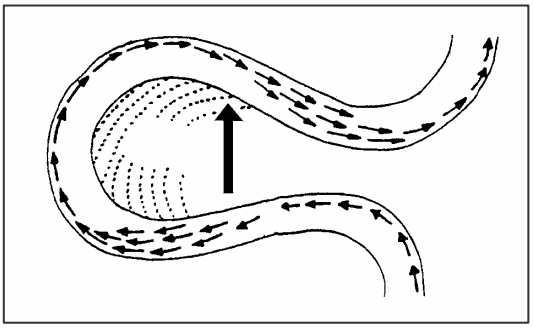
Natural triggers	Human caused triggers
Variations in water and sediment input (flood, wildfire landslips)	Removal of riparian vegetation which binds banks and beds and retards stream flows.
The natural cyclic process moving through the river as part of its dynamic balance.	Clearing and cleaning out channels including the removal of snags and obstructions from the bed and banks.
Change in bed or bank material encountered during natural channel movement	Channelisation of flows and draining of on-creek swamps by digging channels.
	Extraction of bed material.
	Concentration of flows through bridges.
	Extensive catchment clearing.
	Cutting off meanders and other flow modification.

Table 3 Causes of bank erosion

Natural triggers	Human induced triggers which amplify natural process
Channel bed erosion	Removal of binding and protective vegetation from banks.
Natural changes to water or sediment yield in the catchment	Human caused changes to sediment and water flow (eg: gravel removal, river straightening, stock access to river banks, weed infestation, increased run-off due to clearing).
Variations in channel water level.	Variations in channel water level due to irrigation and hydro-electric operations.
The presence of erodible material in bank.	
Acceleration of flow around stream blockages.	
Trees falling from the bank.	

Transfer of Sediment

When erosion and deposition are in approximate equilibrium, transfer of sediment is the dominant process. Here the stream tends to follow a winding course (meandering) on a broad plain. Streams naturally erode on the outside of bends (meanders) where water velocity is higher and deposit sediment on the inside of the bend where velocity is lower. However, changes in nearby land uses can cause a stream to become unstable, resulting in rapid erosion on bends. Sediment (generally sand or gravel) deposited on the inside of bends is called point bar deposits. Meanders migrate downstream the valley working and reworking alluvial deposits.



The broken arrows indicate the main flow of water under normal conditions. As the water rises, flow widens and may extend to the inside of the bank and remove some of the sediment previously deposited there. The main arrow shows the general direction of downstream movement of the meander over time.

Figure 8 River meander.

Deposition of Sediment

When excess sediment carried by the stream is deposited, the channel bed shallows and widens. Sediment is stored within the channel as sand bars or vegetated bars.

A flood plain may form adjacent to the channel which is covered by water during high flows. Each time the river floods, water overflowing its banks slows and drops the larger grains of sediment carried from upstream. A low embankment or levee is built up on each side. Beyond the levee, the ground slopes down and is liable to form back-swamps, wetlands, ponds or shallow lakes. You may find evidence of a complicated pattern of lateral streams. River works that aim to confine the stream to the channel by raising the levee banks raise the water level (for a given discharge) and cause deposition of sediment on the bed which in turn increases the danger of major floods. For example, in some areas, the bed of the Mississippi River is higher than its flood plain.

Physical Alteration to Waterways

Attempts to ‘improve’ waterways over the past two centuries, including the removal of native riparian vegetation, replacement with introduced species, channel straightening and stream regulation have altered the natural balance of rivers. Physical changes in one part of a stream can have flow on effects upstream and downstream which may be immediate or only occur when conditions are suitable. For example, a drainage channel dug through an instream wetland may appear stable in low flow conditions but a flood may trigger an erosion head that cuts into the stream bed and takes decades to run its course. Erosion upstream causes greater sedimentation downstream (Waterwatch Aust 2000).

Effects of Straightening a River

Swamp drainage and channelisation reduce the length of the channel which therefore increases the gradient over that part of the river. The steeper gradient increases water velocity which causes more erosion upstream and deposition downstream.

Velocity and Discharge

Velocity is measured directly and reported in metres per second. Discharge is the volume of water passing the site in cubic metres per second or litres/second. It is the product of velocity and cross sectional area of the stream at your site.

Velocity is the distance that water travels over a given period of time, ie: the speed of the water. Velocity is measured in metres per second (m/s).

Discharge refers to the volume of water in a river moving past a specific site every second. Discharge is measured in litres per second, cubic metres per second (m^3/s) or megalitres per day (ML/d). Note: one cubic metre of water equals 1000 litres: one megalitre is one million litres. An Olympic sized swimming pool is about 2.5 ML.

The discharge of a stream is directly related to the amount of water moving off the catchment into the stream channel. It is affected by weather, increasing during rain storms and decreasing during dry periods. It also changes during different seasons of the year, decreasing during the summer months (dry season in tropical areas) when evaporation rates are high and rainfall is low.

Animals and plants in and near water depend on the natural seasonal discharge patterns for growth, reproduction and the return of nutrients to the land. For example, the River Red Gum needs regular yearly flooding to survive, fish migrations need increased flow for spawning, and flood plains get their nutrient-rich soils from floods. Any changes in discharge may harm animals and plants in the ecosystems.

Stream velocity determines the kinds of animals and plants that live in the stream. Some need fast flowing well oxygenated riffles, others are adapted to quiet pools.

Often the natural flow is changed by building dams to provide water for irrigation, livestock, industrial and urban use. Water is stored behind the dam during times of high discharge and later released during drier months; this discharge pattern is the reverse of normal annual discharges experienced in natural rivers. Water pumped from the river for irrigation purposes and some industries can seriously deplete water discharge. This problem is now being tackled by many water managers by providing a minimum discharge - “environmental flow”. These environmental flows have been set aside to try to minimise the impact of the changed discharge patterns on native animals, and also to maintain water quality.

The size of a river and its discharge influence water quality. Pollution discharges will have less effect on large swiftly flowing rivers but small streams have less capacity to dilute and degrade wastes.

Pollution

Water pollution occurs when waste products or other substances such as litter, sewage and contaminated run-off change the water quality.

Pollutants are carried over the land and into waterways with surface flow or stormwater. Unfortunately some cases of pollution result from direct discharge into waterways. Pollutants can also leach through soil into the groundwater which may then gradually flow into waterways.

Pollutants that enter waterways may travel some distance downstream before they become less concentrated. At the discharge site and immediately downstream, water quality is poorest but may recover as pollutants are progressively diluted down river. Unfortunately, many waterways are affected by multiple sources of pollution as they flow down hill.

Plate 17 Pollution in a Darwin drain

Point Source and Diffuse Pollution

Pollutants come from a number of different places in urban, rural and industrial areas. Pollution is broadly divided into two kinds depending on the source, these being point source pollution and diffuse pollution (Waterwatch Aust. 2000).

Point source pollution comes from a clearly identifiable source such as a pipe that discharges material directly into the waterway. Examples include outfalls from factories, wastewater treatment plants and boats, and illegal pipes direct from homes (Waterwatch Aust. 2000).

The source of diffuse pollution (non point source) is more difficult to identify because it originates over a broad area from a variety of causes. Examples include (Waterwatch Aust. 2000):

- sediment from housing developments, timber harvesting, and mining;
- fertilisers and pesticides from crop lands, forests, homes, local parks and golf courses;
- bacteria from leaking sewer lines, animal wastes from livestock, wildlife and domestic animals;
- bacteria and leachate from land fills, open dumps and litter;
- oil, grease, heavy metals and toxic compounds from urban streets and parking areas;
- accidental chemical spills and atmospheric fallout from cars, buses, planes, factories, power plants and wood burning stoves.

The cumulative impact from many sources can be significant.

Sources of Pollutants

Pollution from homes

Pollution from the home can include fertilisers, pesticides and herbicides; lawn clippings and animal droppings washed from gardens; detergent from the water used to wash cars; oil and chemical spills; and nutrients and bacteria from septic tanks which let waste materials soak into groundwater (DIPE 2002).

Plate 18 Garden clippings deliberately dumped into a stormwater drain outlet

Suburban Pollution

Pollution in suburbs can come from run-off which accumulates on roads, parking lots and other hard surfaces. Water washing over these surfaces collects oil and fuel which has leaked from cars, rubber from tyre wear and heavy metals. This water eventually reaches our waterways via stormwater and other drains. Other urban pollutants include , bacteria and nutrients from waste disposal sites and fertilisers and animal droppings from parks and street verges (Boulton & Brock 1999).

Air Pollution

Air pollutants carried by rain or wind can readily be deposited into waterways. For example sulphur dioxide, produced by some human activities, is very soluble in water and readily becomes oxidised to form sulphuric acid. If this reaction occurs the sulphur dioxide can form ‘acid rain’ (Boulton & Brock 1999).

Industrial Pollution

Pollutants from industries include accidental chemical spills and waste water containing chemicals or nutrients which enter ground or stormwater instead of being treated and disposed of properly to a sewer or waste disposal facility. Wastewater treatment systems which are overflow or are not properly maintained can also contribute to water pollution (Boulton & Brock 1999).

Thermal Pollution

Thermal Pollution occurs when heated water is discharged into a waterway. The discharge of heated water usually occurs when the water has been used in industry for cooling purposes (Boulton & Brock 1999).

Agricultural Pollution

Pollutants from agricultural areas come from rainwater and irrigation which washes fertilisers, soil, salt, animal waste, pesticides and herbicides into waterways. These pollutants also leach into groundwater aquifers (Boulton & Brock 1999).

Plate 19 **Oil on water surface**

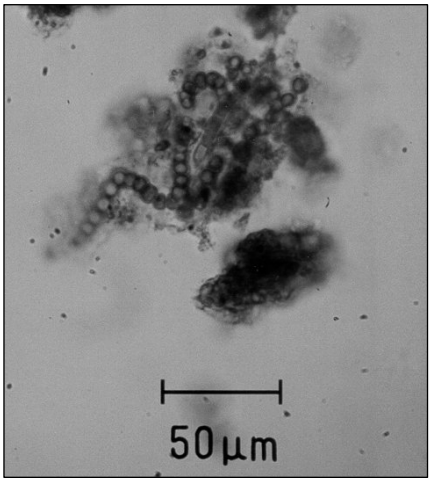
Solving Pollution Problems

If the problem is caused by a point source such as a pipe discharge into a lake, it can easily be identified and tested. Permits for discharging directly into waterways are required by under the *Water Act*. If monitoring indicates a problem the Department of Infrastructure, Planning and Environment can be informed and necessary action will be taken. These kinds of problems may be solved with engineering works (Waterwatch Aust. 2000).

Diffuse pollution is much more difficult to solve. Identifying the sources is challenging as diffuse pollution originates over a large area. It is often necessary to monitor many sites to actually find the main source or sources of pollution. Surveying land use, stream hydrology and riparian vegetation can help determine the causes. Fixing diffuse pollution requires working with many different land managers for this reason *Waterwatch* groups need to maintain good communication lines with all stakeholders in a catchment (Waterwatch Aust. 200)

See Activities 25 to 28 (p 75-81)

Algal Blooms



Naturally occurring algae is important in aquatic ecosystems, as it provides food and shelter for animals, stabilises sediments and helps to balance oxygen and nutrient levels. The presence of a great diversity of algae in a river indicates that it is healthy. The growth of algae is, however, strongly influenced by water salinity levels, temperature, light, water movement, sedimentation and most importantly nutrient availability (Boulton & Brock 1999).

Plate 20 **Magnified blue-green algae**

In contrast algal blooms (large populations of few algal species such as blue-green algae,) can cause a number of problems that can threaten the commercial, recreational and environmental values of a waterway. The strong-smelling slimy scum of algal blooms can rapidly become a nuisance to people. Blooms can become toxic, causing health problems (Boulton & Brock 1999).

What are nutrients and why can they become a problem?

Nutrients are chemicals that are essential for plant and animal growth and wellbeing. Nutrients are important in aquatic ecosystems, as they are crucial for primary production (production of plant material). Higher plants and animals obtain their nutrient intake from the environments through complex food webs (Boulton & Brock 1999).

However excessive amounts of certain nutrients in a wetland or waterway can be harmful. Human land-use activities can significantly increase nutrient loading in waterways. This process of nutrient enrichment is called eutrophication. The most important nutrients contributing to the eutrophication of the waterbodies are nitrogen and phosphorus, which enter the river in soluble form as organic matter, attached to sediment particles, directly in run-off or via groundwater (Boulton & Brock 1999).

Eutrophication can cause excessive growth of algae. Prolific algal growth can reduce light penetration and become toxic. Oxygen depletion, resulting from the decay of dead algae, can kill invertebrates and in severe cases can kill fish. Additionally algal blooms can produce offensive odours and potentially cause human health problems (Boulton & Brock 1999).

Where do Nutrients come from?

Nutrients come from a variety of urban and agricultural land uses (Boulton & Brock 1999):

- commercial fertilisers that are applied to crops and pastures;
- waste from animal feedlots, intensive animal industries and grazing areas;
- industrial wastes;
- leachates from rubbish tips;
- watercraft discharges;
- phosphates in detergents, waste from sewage and septic tank systems; and
- fertiliser run-off from parks and gardens in urban areas.

Management of Algal Blooms

Reducing algal blooms and improving water quality can be achieved by:

- conducting research into algal blooms and their causes;
- reducing the nutrient input to waterways from the catchment;
- changing the conditions in the waterway so that algae are less likely to bloom;
- conducting clean-up programs to remove accumulation of algae;
- increasing flushing to remove nutrients;
- educating urban and rural land holders to work together to tackle the problem at the source;
- implementation of best management practices.

The most practical way to control blooms is to prevent them.

See Activity 29 (p 82)

Groundwater Pollution

Many of the pollutants, which have been discussed in relation to the various land uses in the NT, are only considered in relation to surface waters. The truth is that many fertilisers, fungicides, pesticides, herbicides and other pollutants can dissolve, percolate through the ground and subsequently pollute groundwater (DIPE 2002).

On a smaller scale, septic tanks, stables and general household chemicals can also negatively affect groundwater quality. This is why there are rules and regulations which exist to protect groundwater resources and the people and animals which rely on the water (DIPE 2002).

Groundwater Protection in the NT

Because of our high level of dependence on groundwater it is essential that we protect and sustain it, both on a large scale through legislative mechanisms and on smaller scales by making sure all land-holders adhere to responsible practices (DIPE 2002).

The Northern Territory *Water Act* covers all aspects of sustainable water resource management, including investigation, use, control, protection, and allocation (DIPE 2002).

For example the Act stipulates that water bore drilling must be undertaken by a licensed driller. A licensed driller must meet qualification requirements set by the Australian Drilling Industry Association. A permit is required for any bore constructed in a Water Control District (DIPE 2002).

Bore placement in relation to potential pollution sources are stipulated in the NT by the Controller of Water Resources and the Department of Health and Community Services Code of Practice. Stipulations include separation distances of 50 metres between bores and drains carrying disinfected wastewater from a sewage treatment system, and from any area irrigated by disinfected wastewater. When the wastewater is not disinfected the separation distance should be increased to 100 metres. This also applies to any other obvious pollution sources such as fertiliser and agricultural chemical stores, packing sheds and plant workshops (DIPE 2002).

How can I help to Protect Groundwater?

- Everybody can help to keep our groundwater healthy, by adhering to the following instructions (DIPE 2002);
- Always apply chemicals according to the manufacturers instructions;
- reduce chemical, fertiliser and pesticide use where possible;
- regularly check your chemical storage area and sewage system for any leaks;
- do not store chemicals on the ground, ensure they are kept on a concrete base;
- dispose of unwanted chemical (such as engine oil) and their containers responsibly, by taking them to your local dump or recycling centre;

- dispose of household rubbish responsibly. Compost all food scraps, recycle glass, milk containers, aluminium cans, paper and plastic bottles and mulch your garden clippings;
- never dispose of chemicals such as paints, thinners, solvents and cleaning fluids through your septic system; and
- regularly check the condition of your bore to prevent problems associated with corrosion.

Integrated Catchment Management

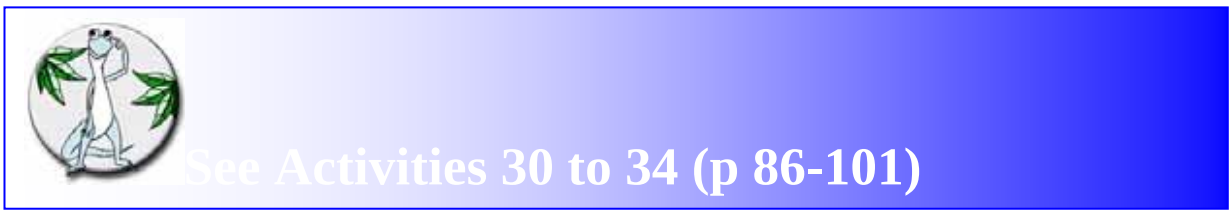
Clean water is a resource that many people take for granted; however its availability is being threatened by the high demand for catchment resources. Environmental degradation has resulted from rising salty groundwater, introduced plants and animals, weed infestations, erosion and sedimentation, pollution by nutrients and chemicals, and algal blooms (Water and Rivers Commission WA 1999).

Across a catchment various land uses can impact on one another as water flows through and across the catchment area. Without some system of rules being put in place, these factors may lend themselves to conflict and associated competition for land and water (Water and Rivers Commission WA 1999).

Integrated Catchment Management is a strategy that involves the whole community in managing the natural resources in a catchment. There are many different types of groups concerned with the care of land, bush and water in urban and rural catchments, including local community groups, local and state government, professional groups, schools and other educational institutions, scientific organisations and landowners. These groups want to see healthy waterways surrounded by healthy ecosystems, prosperous land uses that do not degrade soil or waterways, and clean industrial processes. They also want to see local communities conserving resources and acting to improve the health of both urban and rural catchments (Water and Rivers Commission WA 1999).

While the work of the various individual groups is very valuable, it is necessary to look at the 'big picture' in terms of catchment management. There is a need for a total management system to enable people to continue to use the catchment's resources in an ecologically sustainable way (Water and Rivers Commission WA 1999).

Integrated Catchment Management is a way to link and coordinate the activities of various groups to manage all the catchment's resources and to address the major environmental problems across the catchment. It enables the whole community to work together to manage the catchment into the future (Water and Rivers Commission WA 1999).



Global Warming

The average temperature of the Earth's surface is determined by solar energy of the sun. Some of the solar radiation which penetrates the Earth's atmosphere is absorbed by gases, liquids and solids, the remaining energy is lost to space (Segar 1998).

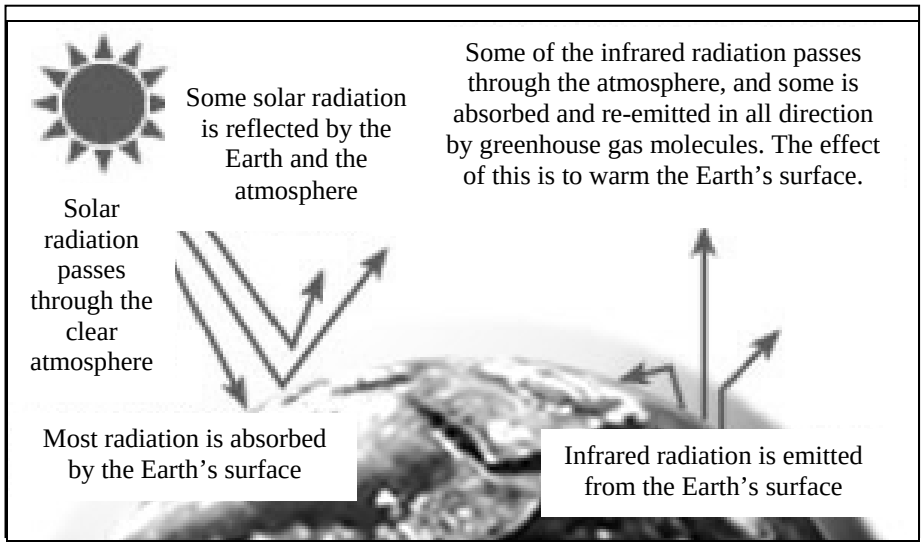


Figure 9 The Greenhouse Effect (http://www.epa.gov/globalwarming/climate/)

Recent human activity has increased the level of solar energy absorption and therefore heat retention in the Earth's atmosphere. This phenomenon has occurred as a result of higher concentrations of certain gases, termed 'greenhouse gases', including, carbon dioxide, methane, chlorofluorocarbons (CFCs), nitrogen oxides and ozone (Segar 1998).

It has been predicted that the Earth's mean temperature will rise by between 2 and 6° C within the next century. This increase will dramatically affect the water cycle. Possible implications may include sea level rise, associated flooding of coastal regions and huge variations in rainfall patterns. These changes will significantly affect freshwater resources and associated aquatic habitats (Segar 1998).

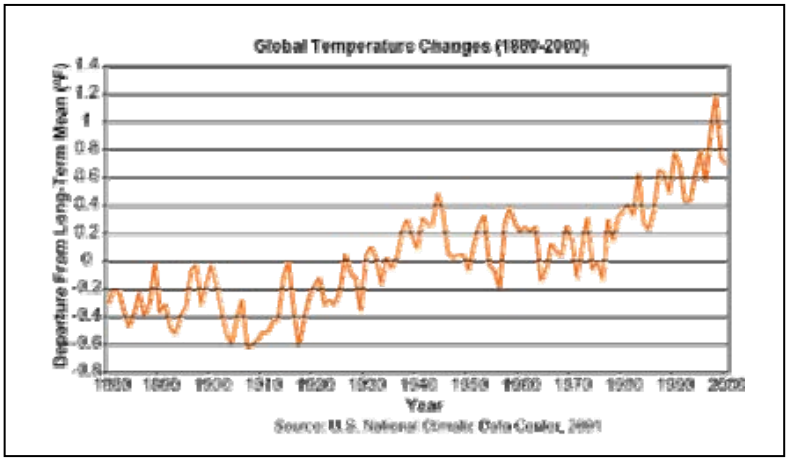


Figure 10 Global temperature change (http://www.epa.gov/globalwarming/climate/)

See Activity 35 (p 102)

How Do People Use the Catchment?

B3-B5

Activity 1

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Environmental Awareness and Care Env, 3.2, Env 4.2, Env 5.2

Indigenous Languages and Culture Natural Environment

Focus Question:

- **How do we use water in the catchment?**

Aim:

To identify the users of water resources in the local catchment.

Main Idea:

- There are often many different uses of water within any one catchment. Uses may include traditional uses by indigenous people, agriculture, pastoralism, recreation, mining, fishing and tourism.

Need:

Guest speakers who uses land and water in the catchment; transport or land use maps; clip boards and pens; appropriate clothing and a digital camera.

Consider/Analysis:

1. Undertake a catchment tour noting various land and water uses along the way. Photographs or sketches may enhance this record.
2. Map the land uses in the catchment at present.
3. Research the history of the catchment. Identify what land uses were 10, 50 and 100 years ago. Complete a summary of the main points of the discussion. Draw catchment maps or overlays showing these changes in land use over time.
4. By consulting with local community representatives establish the tribal and language group boundaries of the Aboriginal inhabitants of the area. Also establish any special areas of interest, particularly special food gathering areas. Draw a map of these areas.
5. Discuss how land use could change 20 years into the future.
6. Compile information as a poster, PowerPoint presentation, video or mural.

EXCURSION

Values Placed on Water

B3-B5

Activity 2

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Environmental Awareness and Care Env, 3.2, Env 4.2, Env 5.2

Indigenous Languages and Culture Natural Environment

Focus Questions:

- **How does the way society values water resources affect the way water is conserved or used?**

Aim:

To learn that there can be a variety of perspectives that need to be considered when managing water resources for multiple use.

Main Ideas:

- Managing water resources can not be done without consideration for the role that people's values and beliefs play in determining their behaviour and use of a resource.
- People coming together across a whole catchment area to discuss cooperative approaches to water resource management will need to recognise each others values and beliefs in order to make the necessary compromises that go with water allocation.

Need:

Access to the Internet site:

www.abc.net.au/4corners/archives/2001a_Monday12March2001.htm

Consider 1:

This activity is based on a Four Corners program called: "Water Pressure" presented by Chris Masters.

On this site are transcripts of different perspectives on Australia's water resource management:

Tim Fisher from the Australian Conservation Foundation;

Barry Steggall a politician with Agriculture interests;

Leith Boully, Community Advisory Committee chairman to the Murray Darling Basin Ministerial Council; and

Peter Cullen from the Centre for Cooperative Research in to Freshwater Ecology.

Analysis 1:

Divide the class into four debating teams.

Students use the above listed papers to debate any or all of the following statements:

1. Irrigation takes too much water away from the environmental flows and is unsustainable.
2. We are not paying enough for our food production as we are not accounting for the true cost of water supply.
3. Over many years the Australian society has taken our water resources for granted resulting in abuse of this resource.
4. Australia should be spending more funding on the repair of 'sick' river

systems rather than protecting those yet to become dramatically altered.

5. Funding should be spent on on-ground remediation of river systems rather then community education and awareness about catchment health.
6. We do not need to understand aquatic ecosystems, we just need to know what human populations minimum water requirements are and determine where to get it.
7. People can only learn from making their own mistakes, they can not learn from watching what their neighbours are doing.

Consider 2:

Research how local Indigenous communities value water resources and review the mechanisms they use to ensure communities conserve and protect water resources.

Reflection:

How is it that the water crisis has only become apparent relatively recently, ie: the last 30 years when the Indigenous people have lived in Australia for so long prior to this?

Exploring Feelings About Aquatic Habitats

B3-B5

(Adapted from the Swan River Education Kit, Water and Rivers Commission WA 1999)

Activity 3

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Environmental Awareness and Care Env 3.2, Env 4.2, Env 5.2

Indigenous Languages and Culture Natural Systems

Focus Question:

- **How does society value water?**

Aims:

1. To discuss feelings about a particular aquatic habitat, based on prior knowledge, experiences and interests.
2. To consider how others might view the same site.
3. To explore how the way people feel about a site will influence the values they place on it and how they behave towards it.

Main Idea:

- Societies that respect and understand the need to protect and conserve water will better maintain this essential resource for future generations.

Need:

Transport, Student Sheet 4.1 (below).

Consider:

As a class, create a retrieval chart about the values of aquatic habitats based on the student's own experiences and the experiences of others.

The chart could be a word association chart or card cluster about feelings associated with the place.

Consider changing a broad group of people's behaviours in order to protect the aquatic habitat. What difficulties might there be in convincing people to make those changes if only a single approach was taken?

Analysis:

Students choose from a variety of mechanisms to research their own values and perceptions about an aquatic site in the local area.

- State their interest in the river environment.
- In 'quiet time' sit, look around and reflect on the river environment. Look closely at the water and observe such things as movements, colours and reflections in the water. Record their impressions.
- Use senses other than sight to make observations about the river environment. Describe sounds, smells and textures.
- Create a 'Thought for the Day' that relates to the river.
- Record feelings associated with the site visit, perhaps by way of a journal entry, an illustrated story, poem, song or drawing.

EXCURSION

- Make a chart or mobile of key words that signify feelings elicited by the visit to the river.
- Make an illustrated postcard of the site and send it to a friend.

Students choose from a variety of mechanisms to research others' values and perceptions about an aquatic site in the local area.

- Interview an older person to find out what the aquatic habitat used to be like and how they think about it.
- Research how traditional Aboriginal people might perceive the river environment.
- Research historical aspects of the site. Darwin has many rivers which were utilised by troops during the Second World War.
- Collect and read poems, stories or legends about a river, or listen to some music that evokes images of aquatic habitats. Discuss feelings and perceptions.
- Draw a map of the site from the perspective of an animal such as a frog, heron, dolphin, snake or fish; or write a story or poem about how the animal perceives the environment.
- Students imagine they are the river bank, and respond to these questions: How would you feel about.… people walking over you; weeds invading you; students planting trees to protect you; frogs burrowing into you; people digging into you to put in drains or pipes; people lighting fires on you and people leaving rubbish on you?'
- Make a class scrapbook of the visit entitled 'Perceptions of our River Site', complete with pictures, poems, stories and sketches.
- Create a brochure that advertises the features of the site to visitors.
- Using a large sheet of paper, show by means of cut outs or drawings of peoples' faces and conversation balloons what people with different lifestyles/occupations might have to say about the river site.

Perspectives about environmental health:

- Describe the site first from an everyday perspective, noting aspects such as its natural and cultural features, interest value, recreational value, aesthetic value and health status.
- Describe the site from a scientific perspective, noting characteristics of the water and riverine landforms and of the living environment, including vegetation and animals.
- Consider how the environmental health of the site might be judged by observations alone.

Globally:

Think of a river in another part of the world and suggest its significance for the people who inhabit the area.

Recall a legend, ritual or ceremony related to water and rivers, eg: the Rainbow Serpent, an American Indian rain dance, Christian baptism and Muslim ablutions before prayer.

Research the spiritual significance of a river for one society in another part of the world, eg: the Ganges (said to flow from the mouth of a silver elephant).

Students present their findings to the rest of the class.

Student Sheet 4.1

How do I feel about the river environment?

(Adapted from Water and Rivers Commission WA (1999) and Great Barrier Reef Marine Park Authority (1988).

Sit in a quiet place (away from other people) and look around you. Listen. Concentrate on how your surroundings make you feel. Try to put all other thoughts out of your mind. Try to work out your own feelings about this place. Do this by looking at the pairs of words listed below and decide, for each pair, which one of the words best describes your own feelings about the surrounding environment. Put a tick on the line in the position between the two words that indicate your feelings. For example, if you think the environment is fairly tranquil, but a little busy, you would put a tick towards the tranquil end. Tick in the middle if you cannot decide one way or the other.

tranquil _____ busy

interesting _____ boring

safe _____ dangerous

impressive _____ unimpressive

exciting _____ dull

valuable _____ worthless

mysterious _____ ordinary

cheerful _____ depressing

friendly _____ hostile

pleasant _____ unpleasant

natural _____ artificial

unspoiled _____ degraded

wild _____ tame

alive _____ dead

cared for _____ neglected

thriving _____ struggling

Jilji Life in the Great Sandy Desert B3

Activity 4

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1 / Environmental Awareness and Care Env 3.2

Indigenous Languages and Culture Natural Environment

Focus Question:

- **How do traditional owners use water in the catchment?**

Aim:

To gain insight into how Traditional owners use water in the catchment.

Main Ideas:

- Indigenous people could not afford to take water resources for granted – their livelihood and culture centres around water and the life it supports.

Need:

Student Sheets.

Consider:

- Video: 'Living Deserts' PWCNT 1990.
- Jilji – 'Life in the Great Sandy Desert'.
- Yinti – 'Desert Child'.

As a class:

- Recall what knowledge the students have about water in desert country and indigenous use of water in central Australia and record as a retrieval chart;
- View the video focussing on the indigenous use of water in the deserts;
- Read the above pages in Jilji and Yinti OR teacher reads it aloud to the students; and
- After completing this activity regroup as a class and add the new knowledge learnt to the original knowledge/ retrieval chart.

Analysis:

See Student Sheet 4.2 (below).

Reflection:

How might local indigenous knowledge be used to monitor change in water supply over time?

What could be the implications of *not* maintaining sufficient, good quality water supplies in the environment?

Extension:

Students write a "past and present" report or poster about people living in the desert, focusing on how they obtain and use water.

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Student Sheet 4.2
Jilji – Life in the Great Sandy Desert'

1. Match the list: (draw lines to link the correct translation to the words on the left)

Jarlanyjarlany	river
Jila	water seepage point in Jila or Jumu
Jiwari	makeshift waterhole dug in a flat antbed
Juljul	storm cloud
Jumu `	claypan: holds water after rain
Kalpurtu	type of rockhole where rainwater collects
Pinawuuru	spirit snake said to inhabit a jila
Warla	permanent waterhole, underground spring/well
Kurtukurtu	type of waterhole/soak
Martuwarru	swampy ground
Ngapa mil	type of waterhole; gnamma hole
Wirrkuja	Wet season
Yitilal	wet ground after rain

2. What are some of the different types of water sources present in the arid zone, specifically the Great Sandy Desert?

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.....

3. What are some of the landscape features that indigenous people use to determine the location of water?

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4. What are the spiritual values placed on locations where water can be found?

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.....
.....

5. How does the supply of water influence the routes that indigenous people travelled?

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.....
.....

6. What is the relationship between the landscape features that give rise to water and indigenous dreamings? How does this affect the use of the water source?

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.....
.....

7. How might local indigenous knowledge about water sources be combined with western science in order to study water sources? Are there any examples of this in your region?

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.....
.....

8. How is local indigenous knowledge about water retained or passed on to future generations?

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.....
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9. How might local indigenous knowledge be used to monitor change in water supply over time?

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.....
.....

Top End Water Usage by Traditional Owners

B3-B5

Activity 5

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Environmental Awareness and Care Env 3.2, Env 4.2, Env 5.2

Indigenous Languages and Culture Natural Environment

Focus Question:

- **How do traditional owners use water in the catchment?**

Aim:

To gain insight into how traditional owners use water in the catchment.

Main Ideas:

- Indigenous people could not afford to take water resources for granted – their livelihood and culture centres around water and the life it supports.

Need:

Bush series (PWCNT posters) available to loan from the Waterwatch Regional Coordinator.

Book - Aboriginal Flora and Fauna Knowledge from Bathurst and Melville Island, Northern Australia PWCNT and Tiwi Land Council Darwin 2001.

Gove Waterwatch – Case Study, from 'Communities in action: Waterwatch Case studies' (below).

Internet site: 'Croc Dreaming' http://www.mesa.edu.au/friends/croc_kit/index.html

Analysis:

A. Using the Gove Waterwatch article:

What do you think Gulumbu meant by the following statements:

- "The water must stay healthy because we read the plants like signs and they need clean water to keep growing".
- "The most important knowledge is in the earth and the water".
- "Balanda (white Australians) have buried and polluted the real source of knowledge".

Given Gulumbu's statements above, what could be the implications of *not* maintaining sufficient good quality water supplies to the environments that support the plants that they use?

B. Using the Bush poster set:

1. Place these up on the walls of your class room and or borrow a copy of the Tiwi book from a library.
2. How many different Aboriginal uses of plants can you identify?

C. Using the poster set, Croc Dreaming Activity and the Tiwi book:

1. How many different Aboriginal uses of animals can you identify?
2. Research a plant for each of the categories of uses listed below:

- Food: fruit, vegetable, nut, flavouring
- glues
- source of water
- dyes
- indicator of underground water nearby
- shade/shelter
- indicator of seasonal change
- toys
- used in the creation of artwork

- poisons for fishing
- used for carrying things including water
- tools for hunting/defence
- creation of or transport of fire
- creating music
- medicine: intestinal, respiratory, skin

Plants also provide habitat for the animals that indigenous people use. Animals in indigenous culture are used for food; spiritual beliefs, ceremonial use and as indicators of the seasons among others.

3. Research plants and animals that are used to indicate the seasons. Create costumes for these plants and animals. Create a non-verbal play about the seasons. Present the play to other classes at an assembly – provide a simple 'program' that outlines the characters and their symbolic meaning. Include in the 'program' an explanation of why it is important to maintain good quality water resources to support these plants, animals and indigenous culture.
4. Looking at the Croc Dreaming' web site, read to each other some of the stories – research some local stories of aquatic animals.

Reflection:

What could be the implications of *not* maintaining sufficient good quality water supplies to the environments that support the plants and animals?

How might local indigenous knowledge be used to monitor change in water supply over time?

Gove Waterwatch

The Gove Waterwatch program is an initiative of Denise and Ron Spencer and has been ably supported by Dhimurru Land Management Aboriginal Corporation, an organisation which represents the Aboriginal landowners. The program will provide independent information on water quality in Gove.

Maintaining respect for water

As Denise and Gulumbu, a female landowner in the area, walk through the bush towards a lagoon, Gulumbu explains the importance of water. "Many medicines are here on our land. If our waterways are ruined we lose our medicines. You crush the leaves in your hands then breathe the smell or breathe from a billy of hot water. The water from the boiled leaves you swallow to stop coughs, colds and bad congestion. These trees need healthy water: to survive."

Sitting under a tree, Jerrignurr (second wife to one of the Yolngu men involved in the historic Gove land rights case) says "The water must stay healthy because we read the plants like signs and they need clean water to keep growing. They tell us when other food is ready. This Gadayka (stringy bark) has cream-white flowers, when we see them we know that the sugar bag must be collected because the bee hives are full of sweet honey at this time."

Outside Woolworths, Gulumbu rubs her hands over the concrete and says, "Under the ground there is water. The water sustains all life. See a big tree. It puts its roots down and takes the water from the stream up into all its branches. The most important knowledge is in the earth and the water. The tree draws it up and lets it

Yolngu showing Balanda bush tucker (gnatha) down at the lagoon

grow and spread out to produce shade, tools, medicines, clothing. Knowledge must come from the bottom up not be pushed down from the top. Balanda (white Australians) have buried and polluted the real source of knowledge. The only knowledge worth having is knowledge which makes us respect the earth and its water. Knowledge and understanding must always lead to respect"

Dhimurru was established in 1992 to assist communication between the Yolngu people and their white Australian neighbours. Waterwatch in Gove hopes to involve both communities in activities which incorporate Yolngu respect for the land and its water.

Contact:
Gove Waterwatch Coordinator,
Denise Spencer
(08) 8987 3269.

Pastoralism and Water

B3-B5

Activity 6

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Natural Systems Env 3.3, Env 4.3, Env 5.3

Focus Question:

- **How has human use of the catchment affected catchment health?**

Aims:

1. To determine how the pastoral industry may affect water quality.
2. To gain an understanding of management strategies used by the pastoral industry in the NT.

Main Ideas:

- Beef cattle require in the vicinity of 40 to 50 litres of water each per day to survive. Water is also used in the production of pastures and for irrigation of pastures in times of drought.
- Water quality can be affected by the pastoralism industry through cattle induced erosion and pollution.
- The cattle industry has attempted to overcome resource limitation, poor quality native grasses and low soil fertility, by introducing species of improved pasture (grasses with a higher nutrient content than native grasses) which are often fertilised and treated with herbicides.
- Several species of introduced improved pasture are now recognised as noxious and invasive.

Need:

Student sheet 4.3 (below).

You may like to invite a local representative of the pastoral industry to speak about the industry and in particular management strategies which are employed to protect the environment and water resources in pastoral regions.

The brochure series: Riparian Management (LWRRDC 1996) may be helpful. These are available for loan through the NT Waterwatch Facilitator (Ph: 8999 4456)

Consider:

Research the location and history of pastoral properties in your local region.

Analysis:

Complete Student Sheet 4.3: Station Country (below)

Student Sheet 4.3
Station Country

1. What impact have exotic pastures had on aquatic ecosystems in northern Australia?

2. How are pasture grasses affected by seasonal variations?

3. When is it most appropriate to burn pasture grasses to promote pasture growth without overly impacting on water quality?

4. Why are late dry season burns a problem for water quality?

5. Why is it important to ensure pastures are not overgrazed?

6. Explain the processes of gully and sheet erosion.

7. What role do stock and feral animals play in the process of erosion along river banks?

8. What other impacts do stock have on the riparian environment?

9. How can extraction of water for irrigation of pastures or watering of stock affect indigenous flora and fauna?

10. Why are watering points called ‘sacrifice zones’?

11. What are appropriate management strategies that the pastoral industry can implement to protect water quality and sustainability of arid zone aquatic ecosystems?

12. How easy is it for the pastoral industry to undertake these strategies? What government or economic support is occurring to support the implementation of these strategies?

Agriculture and Water Use

B3-B5

Activity 7

Curriculum Links

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Natural Systems Env 3.3, Env 4.3, Env 5.3

Focus Question:

- **How dependent are agriculturists/horticulturalists on fresh water supplies?**

Aim:

To determine associations between water usage, cost long term sustainability.

Main Idea:

- Tropical horticultural crops including market gardens, heliconia flowers, mangoes, bananas, paw-paw, pineapple, rambutan and other exotic fruits have proved successful in the Top End, although in many cases the crops are dependent on irrigation, pesticides and fertiliser use
- North Australian soils are often of low water holding capacity. This fact in combination with low natural water availability increases the irrigation requirements of crops.

Need:

Various fruit types.

Consider:

Ask the students to bring in a piece of fresh fruit for class.

Discuss the different types of plants that these fruit grow on and where the plants are grown in Australia.

Ask the students where they think the water comes from to grow these fruits ie: is it pumped from the ground water or irrigation from surface water supplies.

Ask the students to take a bite of their fruit and notice the amount of fluid/juice that wets their mouth.

Now consider what it costs to produce the fruit in terms of water used. If water was to cost one cent per litre, estimate the value of the fruit by the amount of water spent on producing it, including the water it took to establish the tree to fruit producing age.

You might estimate that 100L of water was used by the plant while the banana was being produced, so it may cost 100 x 1 cent = $1.

Teacher Note: The estimate does not need to be accurate in terms of actual water consumed, it is the concept of determining water use and consumption that is important.

Analysis:

Do this exercise, as a class, for each fruit type brought in by the students. As you do so, draw up three columns on the black board: the fruit, its estimated litres of water used to produce each fruit, an estimation of water used to produce fruit and the cost. .

How many litres of water they are trading when the fruit passes hands. Encourage students when next shopping to consider how much water they are buying.

Reflection:

What might be some costs to the catchment of diverting the water to produce the fruit?

Water for Recreation

B3-B5

Activity 8

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1, Env 4.1, Env 5.1 / Natural Systems Env 3.3, Env 4.3, Env 5.3

Focus Question:

- **How do we use water in the catchment?**

Aim:

To recognise the value of aquatic environments and the need to maintain good quality water.

Main Ideas:

- Many Australians spend recreation or leisure time in or around aquatic environments.
- In order to maintain these environments for primary contact, including swimming, certain water quality standards are required to be met.

Consider:

Survey and graph where students holiday or take recreation. Highlight the appeal of aquatic environments.

Discuss with the class the different types of water environments.

List the ways people use these aquatic environments for recreation, eg: fishing, swimming, boating, etc.

Each student compiles a list of the different aquatic places they have visited, how they use the environment and how often? Once students have completed the table of information, develop a class table of results.

Draw a map of the NT (or whatever is appropriate) and map the different destination points. Use different symbols to show which recreational activities are undertaken at the different destinations.

Analysis:

The results could also be graphed in a number of ways:

Who visits water for the holidays? (eg: Y axis: number of students. X axis: Water yes; Water-no).

When (times of the year) do we use the different types of water environment?

Example of appropriate table: Use of Aquatic Habitats

Place	Water Type	Use	When
Billabong	Permanent	Swimming, food gathering	All year, more so during the dry months
River/creek	Runs dry for three months of the year	Fishing, tour boats, transport, stock	Continuously while water depth allows
Spring	Permanent	Swimming	Mostly during the hotter months
Dam	Permanent, man made	Stock, drinking	All year, more so during the dry months

Research what water quality standards are required to be met in order to continue to use the aquatic environment for primary contact or recreation.

Catchments as Recreational Areas B3

Activity 9

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1 / Natural Systems Env 3.3

Focus Question:

- **How do we use water in the catchment?**

Aims:

1. To explore how people use a local catchment area for recreation.
2. To develop research skills while investigating possible impacts of recreational use on the natural environment.

Main Ideas:

- Water resources in a catchment can provide a basis for a variety of recreational uses.
- When planning recreational uses, we need to consider the impacts that these uses may have on water quality.

Need

Transport, maps, Internet (optional), library, authorities responsible for its management (contact), relevant government publications and assignment sheet.

Consider/Analysis:

Select a local catchment or water body where recreational activities occur.

Draw an A4 map of chosen site with scale and legend showing major features.

Find out how/where water in the area is used for recreation using the following reference material:

- Internet, library resources, local clubs (in phone book), local people, Government agencies (ie:.DIPE), Tourist Bureau and tourist operators.

Produce an overlay of these uses and where they occur for your site

Visit the site and observe for signs of environmental degradation including weed intrusion, litter, loss of habitat, water surface scums or odours.

Discuss findings in relation to potential effects on water quality.

Ask students to consider what actions could take place to minimise the impacts of recreational use at the site. For example, would interpretive signage advise visitors of the values of the area? Would a map showing tracks discourage use of native vegetation areas and reduce erosion?

Reflection:

Dscuss the statement: ‘The less we value our water resources, the more we will need to spend on their protection in the future’.

Wastewater or Sewage?

B3

Activity 10

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env 3.2

Science Concepts and Context / Natural and Processed Materials CC 3.1 / Life and Living CC 3.2

Focus Questions:

- **How do we use water in the catchment?**
- **What happens to our wastewater?**

Aims:

1. To investigate how and where local people dispose of their wastewater
2. To consider the potential for reuse of treated grey water.

Main Ideas:

- Human populations produce waste products, including raw faecal matter, urine, paper, food scraps, packaging and industrial and residential wastewaters.
- Due to inappropriate waste management, a large percentage of this waste ends up in the sewerage system, which is not designed to deal with much of this waste.
- If everyone in the community better understood the processing of their own wastes, they may be better able to protect and conserve water resources.

Need:

Transport, toilet paper, oil, dirt, detergent, bread, plastic, and paper materials.

Article: Alternative uses of sewage and sludge (provided below).

Consider 1:

Excursion to local sewage treatment plant (PAWA).

Analysis 1:

On site

- What does sewage contain?
- Where does it come from?
- What happens at the sewage treatment plant?
- How is sewage treated?
- Where does the sewage go?
- What affect does Wet season rainfall have on the treatment facilities' capacity?

Back in the classroom:

- Make your own sewage (add toilet paper, oil, dirt, detergent, bread, plastic).
- How can you clean it?
- How do you get back to clean water? (drinking water – distillation).
- What happens if this treatment and disposal does not occur?

Analysis 2:

Research what water borne diseases may take hold in the human populations if sewerage treatment did not occur. Many of these diseases affected previous generations and continue to affect developing nations (examples include typhoid, cholera, hepatitis, diarrhoea and meningitis).

Research the short term and long term ecological impact on the receiving waters - downstream from the sewage treatment works – if sewerage was released untreated.

EXCURSION

How can students reduce the amount of waste entering the sewage treatment?
How can students reduce the amount of water going to the sewage treatment works during the wet season to prevent overflow direct to our creeks?

Consider 2:

Use the article on the following page titled: Alternative Use of Sewage and Sludge.

Students take it in turns reading aloud parts of the article until the whole lot has been read. Teacher discusses anything that the students did not understand in the article.

Analysis 2:

How can we use grey water to minimise the waste of drinking water?

How can grey water be treated to make it a community asset? For example grey water lakes have been developed within new subdivisions as a type of stormwater storage basin. These can provide habitat for aquatic animals and plants, revegetation or commercial reforestation.

Is it possible to have separate grey water/systems in houses? Should this be a compulsory feature of new housing subdivisions?

Design a poster with a water efficient suburb for your area with the features discussed above.

Reflection:

Discuss the following statement: "If we value our water, we will find ways to protect it through water conservation and reuse".

Alternative Use of Sewerage Water and Sludge

Bill Pemberton, Surfrider Foundation Victoria (Source: NGANA 1996 December page 14)

Much of Australia's ocean outfall comes from small coastal towns which have large population increases over the summer holiday period.

The commonly held belief is that expensive hi-tech solutions to treat the sewage to almost potable (drinking) water, then discharge it into the ocean, is the answer. What a waste! This can also leave viruses which enter the marine ecosystem.

What is required is an inexpensive low-tech, easily managed system that recycles sewage all year round but can cope with the increased load over summer. Such a system is a high rate tower trickling filter with a holding/setting pond with enough wastewater to irrigate a 30-50 ha wood lot.

Fast-growing *Eucalypts* are favoured in a wood lot although small areas may be set aside for slower growing, more desirable timber trees which require more water than usually available in a non-irrigated wood lot.

A tower trickling filter is a secondary treatment system consisting of a tower 6-9m high filled with synthetic multi-faceted packing upon which grows biological slime. This biological slime absorbs the organics from the sewage which it uses for growth and energy.

This results in a 75-95% removal of the biological oxygen demand (BOD) and a 90-95% removal of suspended solids from the effluent flow.

Rainfall is sufficient in most coastal areas for-wood lots. In summer, however, rainfall decreases but this is when populations and the flow of sewage can increase. The sewage wastewater when secondary-treated contains vital nutrients in a liquid form ideal for plants.

The sludge that remains after treatment can be composted using the well documented BARC system which kills all bacteria and viruses within a month. The compost can be used to further increase growth rate in the wood lot.

Using such a system will enable the sewage to be recycled back onto the land where it originated. At the same time, slowing the depletion of nutrient extraction from the earth, while establishing new commercial wood lots will reduce demand on our state forests.

Industrial waste such as organic chemicals, poisons, heavy metals are a problem for all systems. Generally this is not a problem in coastal towns as such industries have not been established in these areas. However, if heavy industries are located together in an industrial estate tor instance, it is cheaper and more efficient to treat their wastes separately to residential sewage. This enables some chemicals to be recycled and reused.

The costs of such a system are very favourable when compared to new ocean outfall treatment systems needed to meet minimum EPA and community requirements. So if your local water board has a wastewater ocean outfall find out whether they have considered land- based treatment and reuse. Write to them and request an explanation As to why it is not occurring. Water boards are obliged to answer written queries from the community.

Recommended reading:

1. *Effluent irrigated plantations: Design and management,* CSIRO Publishing.
2. *'Don't overfeed the trees!', Ecos* 87 Autumn 1996.
3. *'Composting with sewage sludge'*; *Compost* 94, 3-4 May 1994 Brisbane, Australia.
4. *'Technological aspects of the BARC system as related to composting nightsoil', by Eliot Epstein, PhD Night Soil Composting* .

Waste Water

B3

Activity 11

Curriculum Links

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **How can human use of catchments affect catchment health?**

Aims

To develop an understanding of:

1. the sewerage systems and the impact of weather on these systems;
2. cause and effect of human activities.

Main Ideas:

- Students develop knowledge on waste water, Storm water, water quality monitoring; and perspectives and positions on future options.

Need:

'What is Effluent?' And 'What is Greywater?' (Power Water brochures)

Alice Springs Water Supply and Sewerage System

Alice Springs Urban Water Management Strategy Community Discussion Papers 1, 2 and 3.

The above materials are available from Waterwatch or Waterwise at the DIPE office in Alice Springs.

Analysis:

What uses create wastewater and where does it go?

Investigate sources on wastewater within the school. Examine the amount of water wasted.

What's in wastewater? Investigate substances that are in wastewater at school and investigate what's in water that reaches sewerage ponds.

Investigate wastewater in Alice Springs and its impact on the natural environment.

How is sewerage treated in Alice Springs/Darwin/your community?

What's in the raw sewerage as opposed to the treated effluent?

Where does the treated effluent go?

Does the treated effluent impact on the claypan that it is released into?

Investigate the Ilparpa swamp and compare it to a control site (the nearby claypans that don't have input of effluent).

What action could be taken (at school at in the community) to make sure the swamp is not impacted by effluent overflow?

Write and perform a play about the daily lives of wildlife supported by the wetlands. How are characters effected by pollution from sewerage effluent overflow or stormwater?

Reflection:

How might sewerage treatment works be better designed and what costs would this require to be implemented and how should this revenue be obtained?

Using Water at Home

B3

Activity 12

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env 3.2

Focus Question:

How do we use water in the catchment?

Aims:

To introduce students to:

1. Human water use and the need to conserve water.
2. That fact that water may be healthy or unhealthy.
3. That the actions we take can contribute to the health of the water.

Main Ideas:

Water in the community comes from a variety of sources. Humans use this water for a variety of activities. Humans also waste and pollute water supplies. We can all take actions to protect and conserve water resources.

Consider:

As a class, identify various places where we get water, eg: from a dam, from a bore (underground), from fast-moving rivers, by condensing water vapour and by buying it in bottles.

Discuss what water is used for in our homes, eg: for drinking, for washing ourselves and our clothes, to do the washing up, in our gardens and for animals and in toilets.

Discuss how students can conserve water:

- Do you have long or short showers? Do you have shallow or deep baths? More than one shower or bath a day?
- When you clean your teeth, do you leave the water running?
- When you wash your hands, do you use lots of water or put the plug in to save water?

Other activities they may be able to comment on include:

- Washing the car
- Using a garden hose or a drip system for watering plants.
- Leaving the sprinklers on for a long time.
- Hosing down concrete.

We can also make sure that water stays healthy by:

- Not throwing our rubbish into it, or going to toilet in it.
- Not swimming or having a bath when we know other people will use the water for drinking or cooking.
- Not taking dogs into these places.
- Making sure that no dead animals are left in or near water that is used for drinking or cooking.

Analysis:

Ask the students to create a code of conduct for water use and protection of water quality for the school community. Create a poster that can be displayed on toilet block doors throughout the school.

Reflection:

Ask the children to consider what might happen if we did not manage our water and separate polluted from healthy waters in the community.

Explore Community Attitudes to Water

B5

(Adapted from the PAWA Education Kit NT 1995)

Activity 13

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env 5.2

Focus Questions:

- **How does the way society values water affect the way it is used and conserved?**

Aim:

To explore the economics of water use and their local community attitudes to water as a finite resource.

Main Ideas/Consider:

- How people use the land and water within the catchment affects the use of water by other people and importantly also impacts on the environment.
- Societies that respect and understand the need to protect and conserve water will better maintain this essential resource for future generations.

Analysis:

Research current costs of water in the NT, they were 46 cents per kilolitre in 1994, has the increase since then simply reflected inflation rates over this time or have other factors been taken into account when determining the current price structure?

Conduct a survey in your local community to determine attitudes to water usage and conservation.

Use the results to write a report on how attitudes to water usage in your community can be changed. Your report should also include recommendations on how to reduce water consumption in your area. A community education campaign designed to enhance the way in which people in your area value water should also be included.

Reflection

In small groups, discuss whether price increases are sufficient to change attitudes to water usage and conservation in the NT.

Vegetation Cover and Erosion B3

Activity 14

Curriculum Links

Science Concepts and Context / Life and Living CC 3.2 / Earth and Beyond CC 3.4

SOSE Environments / Natural Systems Env 3.3

Science Working Scientifically / Investigating WS 3.2 / Evaluating WS 3.3

Focus Question:

What role does vegetation cover play in reducing flow rates?

Aim:

To demonstrate to students the role that vegetation plays in water flow in a catchment.

Main Idea:

Vegetation cover offers friction and absorption of water flow – slowing and often spreading water flow across the landscape.

Note: Under extreme conditions of saturated soil and high velocity the impact of vegetation in reducing water flow is significantly reduced.

Consider:

Ask students to review their catchment area for the types of surfaces that exist (natural or artificial).

Ask students to hypothesise which of these surfaces will allow fast flow of water and which of these may slow down water flow.

Analysis:

Ask the students to design an experiment to test their theory:

Eg simulate the surfaces in “disposable” aluminium baking dishes with:

- soil plus living grass
- no soil
- hay and soil
- soil and stones
- stones alone

Tilt the trays and run equal quantities of water over the surface. Measure the run off.

How much was absorbed?

How fast did the run off go (measure friction)?

Ask students to write up their experiment with analysis and conclusions.

Reflection:

How might this theory and results be applied ?

- Stormwater drainage
- Soil erosion control
- Vegetation clearance
- Water quality

Vegetation Cover, Sedimentation and Turbidity

B3-B5

Activity 15

Curriculum Links:

SOSE Environment / Place, Landforms and Features Env 3.1, 4.1 / Natural Systems Env 3.3

Focus Question:

- **How has human use of catchments affected catchment health?**

Aims:

1. To make links between the clearance of vegetation and changes to water quality.
2. To consider legislation relating to this issue.

Main Ideas:

- Loss of vegetation cover facilitates soil erosion. Construction works that break up the soil further compound the risk of soil loss and increased waterway turbidity.
- Sedimentation and turbidity can alter flow regimes of waterways, increase bank erosion and facilitate loss of biodiversity.

Need:

Land unit and land use map (or local knowledge) of your area.

Consider:

What have been the major reasons to clear vegetation in your area? Can you determine any correlation between land units and land use? For example which land units types are preferred for horticulture?

Analysis:

Divide the class into groups to study different portions of the maps. Each group identifies creeks and rivers that may be threatened by high turbidity and sedimentation based on surrounding land units.

See if the class's predictions were correct – ask the Litchfield Regional Waterwatch Coordinator to provide turbidity readings from the rivers where Waterwatch data has been collected.

Discuss the impacts of turbidity and sedimentation on the health of the waterway.

Research what legislation or government policies protect soil, water and biodiversity resources.

Reflection:

Could you now identify sedimentation and turbidity issues in your local environment? If so what would you then do about it?

Extension:

Explore some examples of best practice with respect to land developments that require soil conservation measures to be taken.
Research the major habitat types that have been cleared to date. Are these vegetation types included in any conservation reserves in the region to date? If not, should there be?

Exotic Invasions

B3-B5

Activity 16

Curriculum Links:

Science Concepts and Contexts / Life and Living CC 3.2, CC 4.2

SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **How can introduced animals and plants affect the health of aquatic ecosystems?**

Aim:

Students will be able to relate human activity to the well being of aquatic habitats.

Main Idea:

- Once exotic invaders become established in the wild, they compete with native and pastoral animals for feed or may hunt and kill native animals and birds.
- Larger ferals, such as Feral pigs, can also significantly alter their habitat by destroying vegetation and by compacting and eroding soils.
- Feral pigs and others also have the capacity to spread disease to livestock.

Need:

Access to reference materials

Consider:

Research many of the feral invaders (plant and animal), which have been brought to the NT by humans. Information can be obtained from the Department of Infrastructure Planning and Environment.

Analysis:

Each students should produce a poster which identifies the perpetrator and lists the crimes of which it is guilty. Facts including reason for introduction, estimated time of introduction and extent of its range might be included. You might like to adopt a 'Wanted Dead or Alive' theme.

Reflection:

Discuss as a class what can you do to prevent pollution. Act locally - think globally. What does this statement mean?

Feral Fish

B3-B5

Activity 17

Curriculum Links:

SOSE Environment / Natural Systems Env 3.3

Science Concepts and Contexts / Life and Living CC 3.2, CC 4.2

Focus Questions:

- **How can introduced animals affect the health of aquatic ecosystems?**

Aim:

To become more aware of being able to differentiate between native and native and exotic species, particularly fish.

Main Ideas:

- To mange populations of introduced species we first need to distinguish the population from native species
- Once an introduced species is identified the distribution and behaviour of the species should be studied in order to control it. Constant monitoring will then be necessary.
- Prevention is always better than cure!
- *Gambusia holbrooki*, the mosquito fish, are native to south-eastern USA and north-eastern Mexico. The species was introduced into eastern Australian waters in the 1920s as a biological control agent for mosquitos. In Australian waterways *Gambusia* compete with native fish for habitat and resources, feeding on small fish, frog eggs and tadpoles additionally these intruders could potentially facilitate the spread of disease. *Gambusia* have been associated with decreasing aquatic biodiversity in some regions of Australia

Need/Consider:

Gambusia Case Study. Student Sheet : Feral Fish (overleaf).

Analysis:

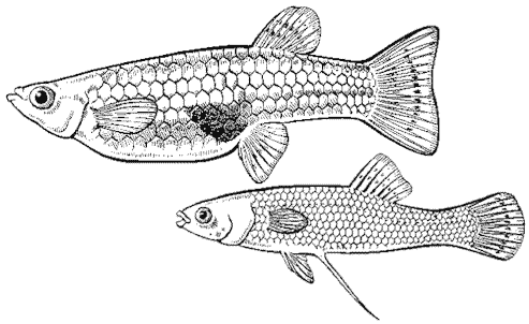
See Student Sheet.

Reflection:

What strategies could be employed to prevent new feral fish escapes?

Extension:

Students research what impact feral fish have had on indigenous culture in their region and report their findings to the class.



Mosquito fish (*Gambusia holbrooki)* (top: female, bottom: male; actual size)

Student Sheet 4.4:
Mosquito Fish, (*Gambusia holbrooki)* in Central Australia

Report 7 June 2000

Discovery of Gambusia

Year 11 students from Our Lady of Sacred Heart College discovered the *Gambusia* in Ilparpa Swamp. The students captured a single individual, it was formally identified by Scientist Helen Larson at the Northern Territory Museum. The students were undertaking Waterwatch monitoring activities with Waterwatch Regional Coordinator Robbie Henderson.

Survey of Swamp

Waterwatch has been surveying the Ilparpa Swamp for several years and fish were never previously recorded. Following the discovery of the single *Gambusia* on 11 May, a more thorough survey was organised. Prior to this survey the Regional Waterwatch Coordinator visited the Swamp on several occasions and captured a further 15 *Gambusia*. The survey, conducted on 1 June 2000, involved 18 community volunteers. A total of 8 *Gambusia* were captured and between 15 and 20 observed. A total of 10 hours were spent searching, the result indicating that a population of *Gambusia* is established but at this stage they are not exceedingly abundant. All fish captured or observed to date were in very shallow water on the perimeter of the Swamp, the deeper areas were well searched, however no *Gambusia* were found.

Monitoring

On 24 July 2 volunteers spent 45min searching the Swamp and adjacent creek. 6 *Gambusia* were captured in the swamp and greater than 50 observed in small schools around the swamp margin. No *Gambusia* were observed in the creek.

The Sewage Ponds

The sewage ponds have been overflowing into the Swamp since the recent large rain events. No *Gambusia* have been reported from the sewage ponds, however they could potentially enter via the overflow channels. Power and Water Authority staff have been informed of the *Gambusia* and are keeping an eye out for them. Waterwatch groups will monitor the Sewage ponds for *Gambusia*.

Media

Initial media contact served to alert the community of the *Gambusia* problem, to promote messages about protecting waterways from pests, to discourage the release of aquarium fish into natural waterways and to recruit Waterwatch volunteers for further survey and monitoring. The media were contacted on the 22 May by a Waterwatch press release. Impaja, ABC TV, Channel 8, Sun FM, Centralian Advocate, and NT News reported the story, which also went National through various TV networks.

Impaja and ABC TV also reported the survey held on 1 June 2000. Further awareness has been gained via the Impaja TV Children's program 'Yamba' that features Waterwatch on a monthly basis.

Impacts of Gambusia in Central Australia

There are no Native fish species found naturally in the Ilparpa Swamp, however it is the habitat of four Native frog species and numerous freshwater invertebrates that could be effected by G*ambusia*.

The Ilparpa Swamp is currently full of water, it is partially fed by a natural catchment from the MacDonnell Range and partly from overflow of effluent from the adjacent sewage ponds. The Swamp is overflowing into St Mary' Creek that drains toward the Todd River, but largely floods out near the Alice Springs Airport. Anecdotal accounts from DIPE scientists indicate that water flowing from St. Marys Creek did not enter the Todd River in the recent rain events. It is therefor likely that the *Gambusia* in the Swamp have been isolated thus far.

The Todd River has 2 recorded Native fish species that may be threatened by *Gambusia*. Channels exist that connect the Todd to St.Mary's Creek (and the Swamp), however the frequency of the two water courses connecting needs to be examined. The Todd River floods out in the Simpson Desert and does not usually connect with the Finke River. The Finke has a diverse fish fauna of 9 species, with 3 endemic species, *Gambusia* are a known threat to various species of the same fish genera found in the Finke. It is possible that on rare occasions the Todd and Finke may connect. The probability of this occurring also needs to be examined.

Management

The management options may include:

(i) Poisoning the Swamp with Rotanone

(ii) Emptying the Swamp

(iii) Waiting for the Swamp to dry out

(iv) Continual monitoring

The following questions may need to be answered before a decision can be made:

Poisoning the Swamp with Rotenone.

Can Rotenone treat an area as large as the Swamp? *The swamp has been estimated from satellite photos to be 183 hectares at present (full).*

What are the non-target species impacts of Rotenone? The Ilparpa Swamp is a protected area under the Parks and Wildlife Commission Act, it contains numerous significant bird species. *Non – target impacts appear to be manageable.*

Can Rotenone be used in sewage ponds? Will it interfere with normal sewage breakdown processes?

Is treatment necessary given the probability of the Swamp drying out naturally?

What is the cost of Rotenone? Volume required? Concentration required for *Gambusia*?

What are the barriers / limitations to successful treatment using Rotenone?

Emptying the Swamp.

Is this possible? An unrelated study commissioned by PAWA regarding reuse and storage of effluent from the sewage ponds may provide this answer (DIPE & Power & Water). *No this isn't possible in this time frame.*

Is finding a place to put the water necessary or feasible given the probability of the Swamp drying out naturally and the time needed to explore such options? *No not feasible.*

Waiting for the Swamp to dry out.

How long will this take? (DIPE may have records, anecdotal information indicates that it will persist through next Summer and potential rainy season.) *No records currently exist – seeking anecdotal accounts.*

What is the Risk of the Swamp connecting to the Todd River before this occurs? (DIPE may have some records) *Very difficult to determine*.

Continual monitoring.

Are there any other local populations?

Are the fish in the Sewage Ponds?

Is there population increasing in the Swamp?

Are they effecting any protected Swamp fauna?

Waterwatch will involve the community in ongoing monitoring activities

Progress

The Department of Infrastructure, Planning and Environment has been informed about the *Gambusia*

The Department of Business, Industry and Resource Development is being informed of the progress of *Gambusia* Surveys and the geography of the Swamp and drainage.

Museum and Art Gallery of the Northern Territory is providing information about the *Gambusia* and is receiving the new specimens for further examination.

Power Water sewage pond staff have been briefed on *Gambusia* and are keeping an eye out.

Waterwatch has initiated a media education campaign and has begun monitoring the sites for *Gambusia*.

Monitoring will continue.

Questions

1. What are some of the resources you might use to determine whether a fish is native or feral?

_____

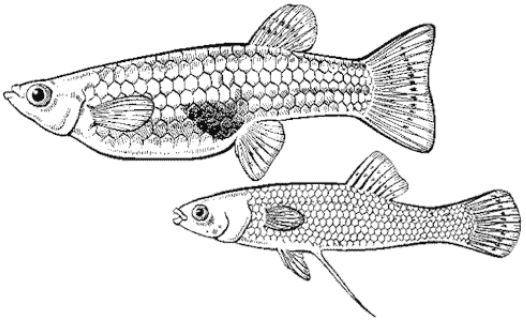
_____

_____

2. What impacts can feral freshwater fish species have on indigenous (native) species?

_____

_____



3. Name the feral fish (pictured left) that was recently eradicated from ponds and waterways of Alice Springs. Provide common and scientific names.

_____

4. How did this fish become introduced to the ponds and waterways if it is not native to the area? Suggest other ways that feral fish may enter waterways.

_____

_____

_____

Cane Toads

B3-B5

Activity 18

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Concepts and Contexts / Life and Living CC 3.2, CC 4.2

Indigenous Languages and Culture Natural Environment

Focus Questions:

- **How can introduced animals affect the health of aquatic ecosystems?**

Aim:

To become aware of the importance of frog/toad identification before taking action.

Main Ideas:

- In order to manage Cane Toad populations we first need to distinguish them from other native species. We can then study the Cane Toads behaviour and distribution in order to control it.
- Careful monitoring will assist in determining the impact Cane Toads have on aquatic ecosystems and native species.

Need/Consider:

The PWCNT information provided in this Kit.

The frogwatch web site: www.frogwatch.org.au and Student Sheet: Cane Toads

Analysis:

Student Sheet 4.5 (below).

Reflection:

Should industries that profit from sales of Cane Toad products be provided economic incentives from the Government?

OR

How will you educate your family about native Cane Toad identification?

Extension:

Student research:

How has/could the Cane Toad impact on Aboriginal culture in their region. Report on findings.

Student Sheet 4.5
Cane Toads

1. Where did the cane toad come from?

_____

2. Where was it first introduced and why was it introduced?

_____

_____

3. How long has it taken to get from where it was first introduced to its current distribution in the NT?

_____

_____

4. What are some features of the Cane Toad that separate it from some similar native frog and toad species?

_____

_____

5. What environmental conditions do the cane toads prefer and what do they eat?

_____

_____

6. As a class, debate the potential threats to native wildlife that the cane toad can impose in the short term and the long term.

_____

_____

Weeds in Aquatic Habitats

B3-B5

Activity 19

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Concepts and Contexts / Life and Living CC 3.2, CC 4.2

Indigenous Languages and Culture Natural Environment

Focus Questions:

- **How can introduced plants affect the health of aquatic ecosystems?**

Aim:

To gain insight into the impact that weeds can have on aquatic habitats.

Main Idea:

- The prolific growth of aquatic weeds costs Australians millions of dollars every year. Weeds affect our native wetlands physically, chemically and biologically.
- Weeds which affect the health of aquatic ecosystems can be either terrestrial (land based) or aquatic (water) weeds. Valuable habitat for both aquatic and terrestrial fauna may be lost.

Need/Consider:

Look at 'Weeds are a Menace' Education Kit that has been distributed to every school.

Hill L and Jan J (1998) 'Weeds are a Menace' Education Kit in Weeds Branch, Resource Management Division, DPIF, NT Government.

http://www.weeds.org.au

http://www.weedbusterweek.info.au

Analysis:

Research examples of terrestrial and aquatic weeds which are affecting waterways in you local area.

You may like to visit a local waterway to assess the impact the weeds are having.

One of the most important management strategies in controlling weeds is education. Determine how your class can help fight the battle against weeds by passing on information they have learnt about weeds.

You may like to produce fact sheets, posters or host a weeds demonstration day using weed examples in vases or photographs.

Reflection:

Why is weed control in aquatic environments so difficult?

Extension:

Students research the impact of weeds on Aboriginal culture in their region and report their findings to the class.

Altered Fire Regimes

B3-B5

Activity 20

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 4.1 / Natural Systems Env 3.3

Science Concepts and Context / Life and Living CC 3.2, CC 4.2

Indigenous Languages and Culture Natural Environment

Focus Questions:

- **What factors can affect the health of aquatic ecosystems?**

Aim:

To better understand the role that fire plays in ecosystem health.

Main Ideas:

- Over 50% of north Australia savannas burn each year.
- Fires of greatest intensity and extent occur during drier months, due to increased amounts of fuel (dry grasses and fallen leaves) and reductions in moisture availability
- Plants growing near waterways are extremely sensitive to fire, so fires that take place in the late Dry Season can have a severely detrimental effect on riverine vegetation. Late Dry Season fires can reduce both vegetation cover and number of terrestrial plant species. Such burns also increase erosion associated with Wet Season storms.
- Fires that occur late in the Dry Season can result in an increase in the cover and richness of aquatic plants, such as lilies, which flourish in pools at the end of the Wet Season. This is probably due to increased nutrient loads entering the stream and increases in available sunlight

Need:

Resource: 'Fire and the Top End' brochure (2002) EA, CSIRO.

Consider:

Read the brochure and discuss how fire can result in both positive and negative impacts to an aquatic environment.

Analysis:

Research where and when fires near/in waterways/waterbodies have occurred in your local area. You may like to ask the bushfires council or the Parks and Wildlife Commission of the NT.
Research the following questions:

- What percentage of fires are due to arson?
- How are weeds, such as gamba grass, affecting the frequency and intensity of fires?
- What evidence of habitat loss has occurred as a result?

Reflection:

Research some of the fire resistant adaptations which have enabled many Territorian plants and animals to withstand frequent natural burning.

Extension:

Research the role of fire in indigenous cultures. How might these practices influence water quality or habitat health? How have these regimes changed over the last 200 years?

Flow and Water Quality B3-B5

Activity 21

Curriculum Links:

Science Concepts and Context / Life and Living CC 3.2, CC 4.2

Science Working Scientifically / Investigating WS 3.2, WS 4.2

Focus Question:

- **How can changes in discharge rates affect water quality?**

Aim:

To be able to relate human activity to altered flow of waterways.

Main Ideas:

- Water quality may change significantly from low to moderate and flood level discharges.
- *Low discharges*: Under low discharges, the water entering the stream is mostly base flow from underground seepage. Sediment carried by slowing water will settle quickly on the bottom. Sections of a stream may become semi-stagnant resulting in low oxygen levels and increased growth of algae, if there is adequate light. Salinity and water temperature may both increase to a point which stresses life in the stream.
- *Moderate discharges:* The highest water quality in a stream normally occurs with moderate discharges. At this level, there is good mixing of oxygen with water, dilution and flushing of pollutants, and unfavourable conditions for algal blooms.
- *Flood discharges*: During heavy rainfall, excessive runoff can pick up many pollutants. Runoff causes marked changes to the quality of water by lowering conductivity and increasing turbidity. Fast moving water will keep sediment in suspension.

Need:

Waterwatch water monitoring equipment.

Analysis:

Design an experiment to compare flow and water quality within your catchment area.

Try and use sites where there are few variables other than flow. This is likely to be a 10 month study. Parameters to measure at each site include: depth, temp, turbidity, presence of algae and nutrients. Report on findings to peers.

Reflection:

How has flow been altered by humans in your catchment? Consider this question, carefully bearing in mind how seasonal variation has a dramatic influence on waterways in the NT.

If you suspect the flow has been altered describe how and why.

Discuss how important is site selection when it comes to drawing conclusions from the data collected? Were your sites chosen appropriately?

Water Flow: Natural Versus Human Influences

B1-B3

Activity 22

Curriculum Links

SOSE Environments / Natural Systems Env 2.3

Science Concepts and Context / Life and Living CC 2.2

Focus Questions:

- **How can changes in discharge rates affect water quality?**
- **What factors determine the flow, volume and velocity of water?**

Aim:

To investigate all factors that may influence water flow.

Main Idea:

- Flow can vary as a result of natural processes, which are unrelated to human activity.
- Flow can be influenced by human activity on a global, regional and local scales.

Consider:

Ask the students as a class to consider:

1. Where water in the catchment comes from (rainfall, groundwater, ocean).
2. How we use water (at home, in the community, rural and remote areas, industry, etc).
3. How we store water (dams, reservoirs, collection tanks).
4. Where waste water goes (from homes, industry, community, rural and remote areas).

In each instance list the answers. Then collaboratively regroup the answers into:

1. Factors that are unlikely to be influenced by humans, eg: tidal back flow, catchment geological features such as escarpments and contours, current season, rainfall intensity and duration, extent of soil saturation, evaporation rates, the amount going to or from ground water naturally, tidal effects.
2. Factors that are possibly influenced by humans on a global scale, eg: rainfall/ climate change theories.
3. Factors that are very likely to be influenced by human use of land and water within the catchment, eg: amount of vegetation cover or man made impervious surfaces in the catchment, amount of water put into storage, amount of water diverted for irrigation or industrial use, amount of water discharged back into the system, the amount of ground water usage, stormwater flows.

Ask students to consider the impact of each activity on the catchment's overall water flow.

Ask students to devise a diagram or model that might demonstrate these cause/effects within a catchment.

Reflection:

Can the students now consider their own surrounding and locate where these factors are actually occurring in their catchment?

Human Alterations to Flow

B3

Activity 23

Curriculum Links:

Science Concepts and Concepts / Natural and Processed Materials CC 3.1
SOSE Environments / Natural Systems Env 3.3

Focus Questions:

- **How are people dependent on water?**

Aim:

To gain an understanding of how and where water goes once people have used it.

Main Idea:

- Human wastes disposed of as sewage have to be treated before they can be released into the environment.
- All major towns and cities in the NT are provided with a standard sanitary sewerage reticulation system.
- Stormwater is untreated run-off which collects in the roadside gutters and flows through a series of pipes until it reaches a waterway or the sea.

Need:

Stormwater brochure: '*Keep it Clean'*, and transport.

Consider:

Read the brochure, then investigate local sewerage treatment and stormwater pathways.
You may choose to visit local sewage plants or identify stormwater drains and pathways.

Analysis:

What can happen to the water downstream if we allow a sewerage system to overflow into the environment below it?

How is stormwater different to sewerage waste water?

How might stormwater drains affect the natural flow of water within a catchment?

What impacts might this have on the ecology of waterways and estuaries?

Write a report of your investigation, discuss as group the classes findings, create educational materials for the school about the difference between stormwater and sewerage waters and where they end up.

EXCURSION

Water Allocation Demonstration Model

B3

Activity 24

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Focus Question:

- **How do we use water in the catchment?**

Aim:

Students learn that the more water that is diverted from the natural waterways, the greater the accumulative effect on reducing downstream flows.

Main Idea:

- Flow rate (volume of flow in cubic metres per second) affects water temperature, dissolved oxygen, turbidity and pollution levels.
- Flow is altered through the construction of weirs and dams. These obstructions reduce the flow of water downstream and even out periodic flooding which many aquatic ecosystems depend upon.
- Flow can also be significantly reduced by excessive water usage and diversion.

Need:

You will need the following irrigation supplies:

- 1 x 2 meter strip of black poly pipe hose approx 20mm diameter.
- 1 x hose hole punch.
- at least x 5 strips of black 4mm dripper tube approx 20cm long.
- at least x 5 dripper connections (that join the dripper tube to the main hose).
- several bungs to close off the puncture where the dripper tube connected to the main hose (these are used to reduce water use from the main waterway).
- 1 x connections for the main hose to the water tap.
- 1 x bucket with internal measures marked on it.
- at least 5 large container to collect the 'used' water.

Consider:

Students consider at least five uses of water in any particular local catchment eg::

Urban

- Environment
- Residential
- Sewerage treatment
- Retail Businesses
- Industrial Transport

Rural

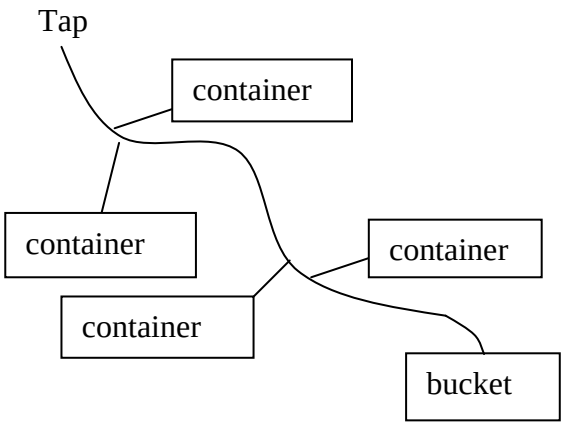
- Residential
- Transport
- Horticulture
- Aquaculture
- Industry

Remote

- Community townships
- Mining
- Pastoral
- Tourism accommodation
- Sewerage treatment

Students design small symbolic drawings for each use that will then be stuck onto the containers as symbols of water use.

Connect the parts listed above as shown in the diagram below:



How might this complicate the process of water allocation? What might need to happen to previously approved water extraction licences to allow for new land uses and water extractions without impinging further on the environmental flows?

Analysis:

Once the model is hooked up to the tap, watch what happens to the flow at the lower end of the catchment (the bucket) as each use is added along the waterway (hose).

Discuss what impacts this water extraction might be having on the biota and on human downstream users.

Discuss what would happen if the various users upstream where to also discharge wastewater back into the waterway?

What would happen if the environment was not allocated water flow?

As a class try to create guiding principles for water allocation. What information is required in order to make these type of decisions?

Reflection:

In reality all land uses in a catchment use/discharge some water, but they are not all planned at the same time. New land uses are often overlain on pre-existing land uses.

One Plus One Plus Cumulative Pollution

B3

(Adapted from Waterwatch Education Kit, Waterwatch Vic and Barwon Water)

Activity 25

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Concepts and Context / Life and Living CC 3.2

Focus Questions:

- **How can human use of catchments affect catchment health?**

Aims:

1. To demonstrate that many small impacts can create a major problem if many people do it.
2. To highlight that many small remedial actions by many people can overcome a major problem.

Need:

1 glass of tap water, eye dropper and yellow food colouring.

Consider:

Add one drop of the food colouring to the glass of water. Ask the students what differences, if any, they notice (It should make no visible difference).

Ask each student, one at a time, to add just one drop to the glass. After all the drops have been added, check how the water looks. Discuss the results.

Analysis:

Students compare this to water quality impacts. If one individual person makes a small impact, it may not have any noticeable effect on the waterway. But if many people in the community do just that one small activity, it can add up to a big impact.

Make a class list of small individual impacts that one person can make on waterways (eg: throwing rubbish onto streets or into waterways, tipping pollutants down stormwater drains).

Ask students what happens in each case listed above. What is the physical or chemical effect on the river of one person doing that activity, as opposed to many people?

Draw a flow diagram to show the consequences on the waterway of one of the actions listed.

The same principle applies to small individual actions that help look after waterways. Discuss this positive scenario. Ask students for ideas on what individual people can do to help look after our waterways. Develop a class list. The class could refer to this list when developing their action plan for looking after their local wetland or waterway (Often extensive damage requires a substantial initial effort by many people. For example a group of residents collect the accumulated rubbish from the river then place notices in local letterboxes and newspapers explaining how residents can to look after the river by not putting rubbish down storm drains).

Students write a short essay about an imaginary river that became polluted by many small individual actions. In it they describe how the river was cleaned up and stayed clean.

The Story of a River

B3

(Adapted from Waterwatch Victoria and Barwon Water and Swan River Education Kit 1999 Water and Rivers Commission)

Activity 26

Curriculum Links:

SOSE Environments / Natural Systems Env 3.3

Science Concepts and Context / Life and Living CC 3.2

Focus Question:

- **How can human use of catchments affect catchment health?**

Aim:

To participate in a role-play or debate about an issue relating to river management.

Main Idea:

- This activity is an excellent introduction to the issues relating to water quality and river management. Observing the impact of pollution on a simulated catchment can introduce some causes of water pollution.

Need:

The Story (below).

1 clear container such as a punch bowl or small fish tank filled with water (4-5 litre capacity)

17 film canisters (available from most photo labs), each filled with one of the following:

Vinegar, fertiliser, mud, salt, toilet paper, nylon line, vegetable oil, litter, soil, detergent, red and yellow food colouring.

Consider:

There are 16 land uses identified in the activity story. Labelled each film canister according to its land use.

Place the clear container of water centrally in the room and explain it represents the ‘river'.

Distribute the canisters among the group. Remind them not to open them until their character emerges in the story, then they are to empty their canister into the river.

Read the story in a dramatic way, stopping at the end of each section when a character/land use is mentioned. Remind participants to come forward and empty their canister.

Analysis:

You may wish to do some simple testing (eg. salinity, turbidity) or have students make observational recordings, describing what happened and the changes that resulted.

Students work in pairs to rank the significance of different causes of water pollution based on their own experiences and knowledge. The class can discuss the impacts and significance of each. Identify which issues may exist in your catchment.

The Story:

Briefly introduce the concept of Australia being the driest inhabited continent and discuss that water is so precious yet many ecosystems are under threat of pollution.
All of us living within water catchments contribute directly or

indirectly, significantly or not so significantly to the degradation of our waterways, often without realising the extent of the impacts made.
This is the story of the travels of a very special river -our river- through its catchment. It begins in the higher parts of the catchment where the rain runs off the slopes and begins its long journey to the sea.
In the valley below there is a power station which generates electricity for the region. It burns large quantities of coal and releases pollutant gases into the atmosphere.These pollutants combine with moisture in the atmosphere to produce acid rain. Rainfall carries these acids back to the Earth's surface and can pollute the very source of the river **(add vinegar).**

The water gathers momentum as it descends the slopes. The river continues towards the sea through farming country where, recently, some crops were fertilised. Afterwards they were watered and the run-off into the river has brought with it some of the fertiliser (**add fertiliser**).

The neighbouring farm is a piggery. Some of the manure from the pig pens washes into a drainage pipe, which then empties into the river.

On the other side of the river are grazing lands. There are very few trees remaining and in some of the lower parts of the pasture, the water table has risen because the trees are not using the water any more. This water brings the salts in the soil up to the surface making the land unusable. It also means that run-off from the land is salty and this threatens the freshwater organisms and animals in the river (**add salt**).

A grazing herd of cattle feed on the vegetation on the banks. When heavy rains arrive the banks collapse into the river (**add mud**).

The coal mine, which supplies raw mineral for the power station, pumps water out of the river to clean its equipment and flush out some of the waste. This includes various acids which all drain back into the river (**add vinegar**).

Slowly the river starts to wind its way through the outskirts of a major town. Out here there are a number of hobby farms. Their houses here are not connected to a sewerage system but have their own septic tanks. Occasionally these tanks overflow and untreated sewage seeps directly into the river (**add toilet paper**).

There are a number of people making use of the river around the bend. Someone is fishing on the banks. Unfortunately their line gets caught around a rock and is left in the water (**add nylon line**).

Other people are water-skiing. Their boat needs a service and in the meantime its engine is leaking oil directly into the river (**add oil**).

Another group of people is enjoying a picnic at a park overlooking the river. A gust of wind blows some of their rubbish off the table and down into the water (**add litter**).

Further downstream the river is being utilised for tourism. A charter boat is giving some people a scenic tour of the river. Drinks are for sale on board but not everyone uses the bins that are provided (**add litter**).

The river now starts to meander through the suburban part of the town. A new subdivision is being developed. Many of the trees have been removed and when it rains, the top layer of soil is eroded and contributes to the silting up the river (**add soil**).

Most houses in the developed parts of the town have a garden. To keep those nasty bugs away the gardeners use a range of pesticides. At the end of the

day the sprinklers are turned on to water the plants. The pesticides wash off into the storm water drains and enter the river (**add yellow food dye)**.

People who have spent the day at work are now starting to drive home. The roads are choked with traffic. Oil drips out of many of these cars and sometimes they brake in a hurry leaving traces of rubber on the road. Every time it rains these pollutants are carried into the stormwater drains and straight into the river (**add oil**).

There is still some industry along the river here. It uses detergents to keep its production equipment clean. But sometimes, the dirty water is hosed out of the factory into the gutter where it disappears into a storm water drain. Once again, however, this water flows straight into the river (**add detergent)**.

Redevelopment is occurring on the opposite bank. Demolishers have discovered a few drums of something mysterious. They won't be able to sell these as scrap. The waste is released into the river, to the detriment of all the organisms and animals living in it (**add red food dye**).

With one final bend the river finally arrives at its mouth and flows into the sea. But look at what flows out with it!

What can we do with our river? A heavy rainstorm would help. The fresh supply of river water from rain can help flush out many pollutants. Indeed, rivers can be a major way of flushing and cleaning ecosystems. However this only moves the problem to a coastal area where other ecosystems will be affected.

We must reduce the amount of pollution that is entering the river.

Note: The title of the river in the story has been left open so that you may include the name of the local river, which runs through your catchment, if you wish.

After some discussion create a definition of the term 'pollutant' – this may be done by combining several individuals suggestions.

Discuss which of the pollutants could be measured – if pollutants are measurable it is possible to objectively establish levels of pollution.

investigate sources of pollutants by finding out more about the types of land-use activities in the catchment.

Discuss factors other then chemical pollutants that effect water quality, eg: processes that remove vegetation, allow water to overheat, change water flow regimes or destabilise the banks.

Construct a table that relates land uses to their potential pollutants.

Decide who is or should be responsible for preventing rivers from being used as drains.

Imagine a time when there was little or no water pollution of waterways. Suggest what could have been done back then to make a difference now (if students rely on regulatory solutions ask them to consider other alternatives as well).

Extension:

As a class design a large mural or collage to depict the various land uses in the hypothetical catchment.

Alternatively you may like to re-write the story to reflect local catchment uses and impacts on nearby waterways.

Produce an environmental impact map showing areas of degradation, eg: weeds, erosion, rubbish, pollution.

Pollution and Macroinvertebrates

B3-B5

Activity 27

Curriculum Links:

SOSE Environment/ Environmental Awareness and Care Env 3.2 / Natural Systems Env 3.3

Focus Question:

- **Can macroinvertebrates be used to assess catchment health?**

Aims:

1. To sample and sort macro-invertebrates in order to assess the health of the sample site.
2. To correlate waterway health to surrounding or upstream land uses.

Main Ideas:

- Water pollution occurs when waste products or other substances such as litter sewage, contaminated runoff change the water quality.
- Pollutants are carried over the land and into waterways from land used for urban, rural or industrial purposes. They can also be leached through soil into the groundwater.
- Many macroinvertebrates are sensitive to the condition of the water. Measuring their presence or absence is one way to measure water quality.
- Pollution tolerance refers to the tolerance of macroinvertebrates to various pollution types. For example, most mayfly families are intolerant of pollution, whilst worms are more tolerant. Only pollution tolerant animals will be found in polluted waterways

Need:

Macro sampling equipment and the 'NT guide to macroinvertebrate sampling' provided in Education Kit.

Consider:

As a class students recall what they know about the uses of land in their local catchment. List the land uses.

Obtain a catchment map for your area and map the land uses onto it. Depending on your area there may be land use maps available from DIPE.

Using you map select sample sites which may potentially be affected by pollution. Students hypothesise about what they may find at the sites chosen.

Analysis:

Students then sample at the sites chosen and compare their results to what they predicted – this may be a once off or frequent exercise.

Consider the affect of sample timing on the results (time of day, season, pre or post pollution event).

If poor water quality was found, students discuss what they should do with this information.

Reflection:

How difficult or easy was it to predict waterway health from identifying the land uses across the catchment?

EXCURSION

Litter Survey

B1-B3

Activity 28

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env 2.2 /Natural Systems Env 3.3

Focus Question:

- **How has human use of the catchments affected catchment health?**

Aim:

To gain insight into the cumulative impacts of litter generation in waterways.

Main Idea:

- Litter can obstruct flow, which may then lead to waterway erosion.
- Litter can potentially be ingested by animals feeding within the waterway;
- Litter increases in bacterial activity involved in the breakdown of organic litter, eg: food scraps – this consumes dissolved oxygen required by other organisms;
- Litter can be toxic if it contains oil/pesticide/heavy metal residues; and
- Litter can cause health risks to humans who may wish to swim/fish from the area.

Analysis:

Students visit a water body on an excursion (this can be at the same time as they do their water monitoring). They pick up any litter which may be in and about the stream.

Discuss the impacts of this litter on the sites ecology. Students then:

- classify the litter according to types (eg. plastic, paper, glass etc);
- in the classroom draw a graph of the various types of litter;
- to determine how the litter reached the collection point;
- consider ways in which the litter problem could be solved; and
- apply these techniques to reducing the litter problem in their school.

Reflection:

Consider the role of packaging of products and how production of litter may be reduced in the first place.

EXCURSION

Algal Blooms

B3-B5

Activity 29

Curriculum Links:

SOSE/Environment/Natural Systems/Env 3.3

Focus Question:

- **How has human use of the catchments affected catchment health?**

Aims:

1. Students become aware of the potential for algal blooms to become a problem in the environment.

2. Students can identify potential areas of risk in their local environment and what actions can be taken to reduce the risk.

Main Ideas:

- Human activities and use of catchments can contribute to excessive algal growth.
- Algal blooms, can cause a number of problems that can threaten the commercial, recreational and environmental values of a waterway:
- The growth of algae is strongly influenced by water salinity levels, temperature, light, water movement, sedimentation and importantly nutrient availability.

Need:

Student Sheets on the following pages: Algal growth flow diagram and Algae ecology.

Consider:

Review and discuss the student sheets.

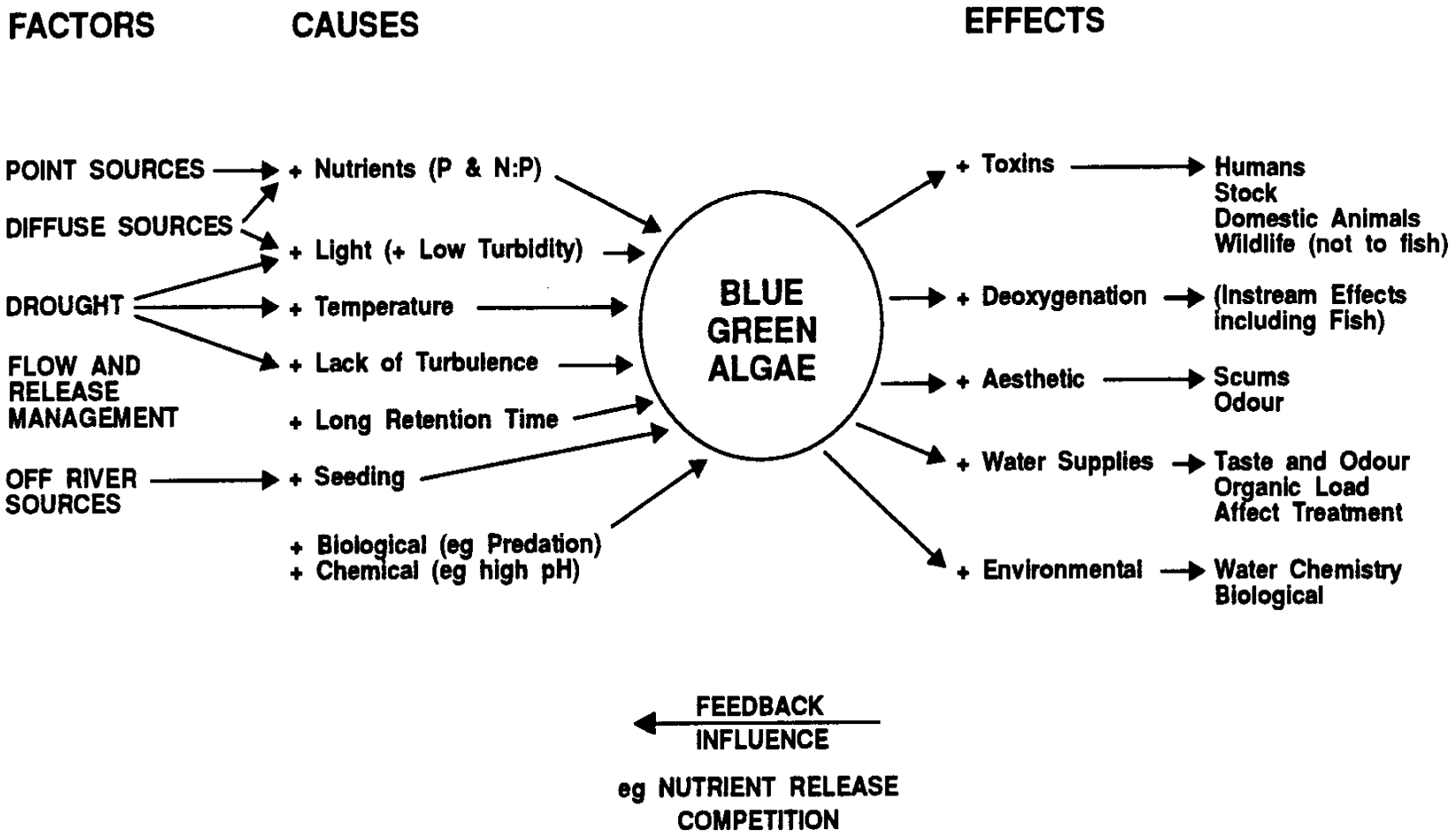
Analysis:

Complete Student Sheet 4.6 (below).

Reflection:

What can you and your family do to prevent algae outbreaks in your area?

Student Sheet 4.6
Algal Growth and Ecology



Algae are naturally occurring aquatic plants that form an important part of the aquatic food chain.

Algae like slow flowing water, warm temperatures and lots of light.

1. Where in the catchment are we most likely to find large quantities of algae:

In the middle of fast moving rivers	YES / NO
At the edge of a slow moving river	YES / NO
In a sunny lagoon or rockhole	YES / NO
In a creek in Summer / dry season	YES / NO
In a creek in Winter / wet season	YES / NO
In a sunny position of a slow flowing river bank	YES / NO
In the shade of a fast flowing creek	YES / NO

2. What role does algae play in an aquatic ecosystem?

Provides food for fish and crustacae	YES / NO
Produces oxygen during the day and uses oxygen at night	YES / NO
Traps the suns energy, turning it into food	YES / NO
Traps and uses nutrients	YES / NO
Provides nutrients when it dies	YES / NO
Supports bacterial life	YES / NO
Reduces light within the water column	YES / NO

3. Circle the conditions that promote algal growth

High turbidity,	Low turbidity
Low nutrients	High nutrients
High temperatures,	Low temperatures
Low flow of water,	Fast flow of water
Lots of light,	Few hours of light/day

4. How do humans promote algal blooms?

Conduct a study of your home environment, what chemicals in the house and garden are used that may then be washed into our waterways? What alternatives are there to reduce the amount of these chemicals used? Discuss this with your family.

5. What impact does an algal bloom have on water quality and other aquatic species?

Take an excursion with your Regional Waterwatch Coordinator and look for algae – what is a normal amount of algae, where is it normal to occur? Where are there occurrences of algae that are either too many in number or in an unnatural location? Trace back an unnatural occurrence upstream to see what might be the cause

6. What can humans do to reduce algal blooms?

Some suggestions for community education and awareness about algae:

- Make a poster about how the chemicals we use can contribute to algal blooms in the catchment and ask the shopping centre for permission to display these outside supermarkets.
- In your local shopping centre ask permission to set up a display about algae and how the products we use contribute to its growth in the catchment. Collect examples of packaged products that contain chemicals that promote algal growth and add these to your display.
- Create a simple brochure, about how the products we use contribute to algal growth in the catchment, for letterbox dropping in your neighbourhood.
- Put a story or poem about algae into the school newsletter.

Conflicting Uses of Water Resources B3-B5

(Adapted for the NT from the Swan River Education Kit)

Activity 30

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env 4.2 / Natural Systems Env 3.3

Focus Question:

- **How do we use water in the catchment?**

Aims:

1. To recognise that there are conflicting land-use options in catchments.
2. To explain why cooperation between people and groups is needed for resolution of conflicts that may arise between competing land uses.
3. To identify various interest groups and their stances.
4. To find a resolution to a catchment care dilemma.

Main Ideas:

- The diversity of landscapes across a catchment can provide for a variety of uses.
- Some land uses can impact on others as water flows through the catchment area.
- Without some system of rules being put in place, these factors lend themselves to conflicting land use and associated competition for land and water.

Need:

The associated hypothetical character cards board for recording meeting outcomes.

Consider:

Students identify various stakeholders involved and recognise the conflicts that need to be resolved through cooperative effort.

Prepare character cards and organise a suitable venue within the school for a meeting.

Step 1

Using one or both of the hypotheticals outlined below, explain the catchment dilemma to the students.

Top End Hypothetical:

Horticulturalist Eric Woolridge has purchased a property in the horticultural protection zone, adjacent to the rural living zone of the Darwin River catchment basin. He is considering clearing about 50 hectares of native vegetation so that he can then sell horticultural produce in the near future. Eric is not sure if this will affect other people in the catchment area. He discusses his concerns with neighbours and with people in the nearby township. The local Landcare representative suggests that a community meeting be called. Eric agrees and hopes this meeting will resolve any potential problems. The Landcare representative organises the meeting.

Central Australia Hypothetical:

Pastoralist, Jenny Hume approaches the local Landcare officer about people entering a leased property, which she uses for cattle and sheep grazing. These people do not keep to the vehicle tracks but are entering via the river system - eroding the river banks. She wants to ban unauthorised visitors from the lease but doesn't know how to control the many fence lines and gates leading on to the property. She asks the Landcare office to

assist. As this is a common problem in the area, the Landcare officer suggests that a community meeting be called. Jenny agrees and hopes this meeting will resolve any potential problems. The Landcare representative organises the meeting.

Step 2

Provide role cards for each character. Students (or groups of students) choose a character and then pin on the corresponding character card. The cards give details about the characters, their personalities and their concerns. (In some cases students can decide what the personality of the character is like.)

Step 3

Students should spend some time discussing and developing the characters.

Step 4

Conduct the Meeting: The chairperson calls the community meeting to order. He/she ensures that all characters have an opportunity to present their cases. At the conclusion of the meeting, several options will be available. The whole class should vote on which option to choose.

Reflection:

Reflect on the processes and outcomes of the meeting:

- Who were the characters and what different types of personalities did they display?
- Which characters were best able to put forward their point of view and why?
- What were the conflicts identified?
- What did you learn about the interrelated effects of changes in the catchment?

Character Cards – Top End Hypothetical

1. Chairperson

Personality: You are very fair and want everyone to have an opportunity to present a case. You must be strong to prevent some people from 'taking over' the discussion.

Case: You need to control the meeting so that a consensus decision can be reached. Ask people to explain their statements clearly and summarise the ideas presented. At the end of the meeting, you must re-state the options available to Eric (write a list on the blackboard or on butcher's paper) and arrange for the whole group to vote on the issue.

2. Horticulturalist – Eric Woolridge

Personality: You are open to suggestions and willing to compromise. You are able to explain your case clearly.

Case: You are considering clearing 50 hectares of native vegetation to increase the value of the property and so that you can sell horticultural produce in the near future.

3. Grazier – Eric's neighbour

Personality: You are quite assertive and very opinionated.

Case: You've been in the district all your life. Many of the properties in the area have been recently cleared, at least for rural living. You have a few places on your property that are obviously eroded. Being downstream from the property, you do not want siltation of your drainage lines and associated fencing.

4. School teacher

Personality: You do tend to be outspoken but you are prepared to listen to others.

Case: You moved to the area a year ago. One of the reasons you moved was because of your love of native vegetation in the area and the need to stay away from herbicides and pesticides. Previous experience in living in horticultural areas have caused many allergies.

5. Conservationist

Personality: You are a bit domineering.

Case: You believe the area should be left with its native vegetation cover for a number of reasons, including the protection of native animals and some unusual plants. There has been very little study done on many of the plants and animals of the area, so nobody really knows exactly what damage may occur to habitats if the area is cleared. You know that macroinvertebrates will suffer from resulting increased turbidity and this will affect the food chain.

6. Soil Conservation Officer

Personality: make one up
Case: You've worked in the NT Government Natural Resources Department for years, and know a great deal about the prevention and control of soil erosion. You believe that at least 10% of the vegetation should be left uncleared in the productive area and that no vegetation in the drainage lines and swampy areas should be cleared - fruit trees could be planted on the remaining areas.

7. Water Quality Officer

Personality: You are a good listener but still feel that maintaining good water quality is the highest priority.

Case: Treating erosion requires staff and money. Your Department is often criticised for waterway erosion and sedimentation, but you have limited resources for dealing with erosion outbreaks.

8. Landcare Representative

Personality: make one up

Case: You appreciate the need to increase productivity while maintaining unique flora and fauna and allowing for sustainable production. You believe that at least some pockets of trees should be left behind to allow a source of seed for revegetation if required. You are wary of erosion problems, invasion by weeds and decline in water quality. You point out that clearing waterways and swampy land is not going to be of great value to the land holder in the long run. Productivity could be increased by taking better care of smaller pockets of fruit trees than by expanding the total area ie by better use of water and fertiliser so to reduce overall costs and increase profit margins.

9. Shire Councillor

Personality: make up one

Case: You believe that productivity of rural industries, especially horticulture, is vital to the Shire and to maintaining business in the local town. If rural income decreases any further, unemployment will increase rapidly and local businesses will become bankrupt.

10. Town Resident

Personality: You are well educated and well spoken.

Case: You believe strongly in human rights and freedom. If the horticulturalist wants to clear their land, that's fine as long as it doesn't harm other people. You perceive the main problem in the river to be pollution by farm chemicals.

11. Local Fisherman

Personality: You are quietly spoken.

Case: You make a living by fishing near the mouth of the estuary. The fish population has started to decline. You think this is due to the estuary silting up and algal blooms caused by excess nutrients finding their way into the estuary. If the fish numbers decrease further, you will be forced to fish somewhere else further away.

12. National Parks Officer

Personality: make up one

Case: Your concern is the protection of the habitat for endangered native animals. You worry that clearing trees would isolate these animals in small pockets of remaining vegetation, and they would soon die out. You believe habitat corridors must be maintained as a minimum standard for the sustainability of local fauna populations.

13: Student

Personality: make up one

Case: you do not want a horticulture industry near your school as you are prone to allergies.

Your school has been specifically set up to be away from air and water pollution.

Character Cards – Central Australia Hypothetical

1. Chairperson

Personality: You are very fair and want everyone to have an opportunity to present a case. You must be strong to prevent some people from 'taking over' the discussion.

Case: You need to control the meeting so that a consensus decision can be reached. Ask people to explain their statements clearly and summarise the ideas presented. At the end of the meeting, you must re-state the options available to Jenny (write a list on the blackboard or on butcher's paper) and arrange for the whole group to vote on the issue.

2. Grazier – Jenny Hume

Personality: You are open to suggestions and willing to compromise. You are able to explain your case clearly.

Case: You are considering banning unauthorised visitors from the lease but don't know how to control the many fence lines and gates leading on to the property.

3. Grazier – Jenny's Neighbour

Personality: You are quite assertive and very opinionated.

Case: You've been in the district all your life. Many of the properties in the area have been subject to trespassing and associated damage to fences, tracks and fires. You strongly support Jenny's call for a ban.

4. School teacher

Personality: You do tend to be outspoken but you are prepared to listen to others.

Case: You like to take your holidays locally by going out bush to camp. You respect the pastoralist's leasehold and the purpose for which it is dedicated. Why should you be banned because of a few irresponsible 'outsiders'.

5. Conservationist

Personality: You are a bit domineering.

Case: You believe the pastoral leases should be better managed and that stock should be kept out of the creeks and river beds, they are causing as much erosion and water quality decline as the tourists in the 4WD's. You would like to see a combined solution to the problems such as better management of stock and education campaigns for tourists located in strategic locations.

6. Soil Conservation Officer

Personality:

Case: You've worked in the Government Natural Resources Department for years, and know a great deal about the prevention and control of soil erosion. You believe that at least 80% of the erosion is caused by the short time tourists are on the property and the remainder by stock over a longer time period. Vegetation should be left uncleared particularly in the drainage lines and swampy areas, that fruit trees could be planted on the remaining areas.

7. Water Quality Officer:

Personality: You are a good listener but still feel that maintaining good water quality is the highest priority.

Case: Treating erosion requires staff and money. Your Department is being criticised constantly for waterway erosion and sedimentation, but you have limited resources for dealing with erosion outbreaks.

8. Local Government Representative

Personality: make one up

Case: You believe that both the pastoral and tourist industries are vital to maintain businesses in the local town. If rural income decreases any further, unemployment will increase rapidly and local businesses will become bankrupt.

9. Traditional Owner

Personality: make one up

Case: You believe strongly in human rights and freedom. If the tourists want to get access to leasehold land they should be allowed to as long as it doesn't harm other people. You do not want to see tourists hanging around sacred sites, you want tourists banned from these locations.

10. Local tourist operator

Personality: You are quietly spoken.

Case: You make a living by taking tourists to remote areas for camping trips. You are a responsible operator and feel that commercial operators like yourself should be exempt from the ban on 'trespassers' on lease hold land.

11. National Parks Officer

Personality: make one up

Case: Your concern is the protection of the habitat and endangered animals. You are concerned about soil erosion and water quality decline that can effect the health of the flora and fauna. You also are worried about damaging uncontrolled fires. You believe something must be done about the inappropriate use of 4WD's on leasehold land and feel that a cooperative approach is needed.

12. Student

Personality: make one up

Case: you do not want to be denied access to local leasehold land as that is where your family spend time exploring in the holiday breaks. Can't something else be worked out?

River Uses Compatibility Survey B3-B5

(Adapted from the Swan River Education Kit Water and Rivers Commission WA 1992)

Activity 31

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1 / Environmental Awareness and Care / Env 4.2

Focus Question:

- **How do we use water in the catchment?**

Aims:

1. To understand co-existence of complementary activities at river sites.
2. To discuss the views of all user groups.
3. To explain why the potential environmental impact should be the primary consideration in determining the use of a site.
4. To prepare reports.

Main Ideas:

- The diversity of landscapes across a catchment can provide for a variety of uses.
- Some land uses can impact on others as water flows through the catchment area.
- Without some system of rules being put in place, these factors lend themselves to conflicting land use and associated competition for land and water.

Need:

Transport to a local river site where there are a variety of users and uses. Student Sheet 4.7 (below).

Consider:

Brainstorm the uses of public access areas along our rivers. Then consider the potential for conflict when areas are used by groups of people with incompatible needs.

At the site:

After observing the site, fill in the Student Sheet, list likely river use activities in the numbered grids, both down and across (eg: boating, fishing, seed collecting, harvesting native produce, kayaking, educating, scientific research, bird watching, walking).

Then, students form user groups, each one representing a different use of the river. Discuss the following aspects:

(i) needs, in terms of facilities, access and environment (eg. clean water);

(ii) possible rules and regulations that their activity requires; and

(iii) how each of the other groups may affect them.

Analysis:

Use the sheets provided to organise and record ideas. Students then decide the degree to which activities interfere with each other and complete the Student Sheet grid, using the key down the left-hand side as a guide.

As a whole-class activity, students brainstorm and discuss all the possible solutions to potential conflicts. They devise a set of guiding principles couched in general terms, eg: ‘uses that degrade the banks should be discouraged’, ‘uses that contribute to health and fitness should be encouraged’, ‘families should be encouraged’, ‘frogs should be protected’, etc.

Students assess each of the ‘interfering uses’ marked on their student sheet to decide if there is a solution that would allow both activities to continue. If not, they then use the guiding principles to decide which of the activities should be discouraged. They should try to find win-win solutions – those that allow the best balance of uses while protecting the environment at the site. Students can then present a list of activities that should be encouraged at the site, along with any special conditions that need to be applied.

Extension:

Students representing user groups produce written and oral presentations to demonstrate the solutions they have devised to allow compatible uses of the river environment to co-exist.

Students investigate what land use guidelines exist already in the NT.

Reflection:

Who and how do you think guiding principles to land use should be devised in society?

Student Sheet 4.7
Land and Water Use Compatibility

Key	
o	slight or no interference
oo	complementary activities
x	some interference
xx	major interference

Instructions

When you have decided on your uses for the site, list these both across and down the chart. The example 'fishing' has been entered. Using the grid, consider how each use would affect other uses and rate their compatibility using the key. Choose the appropriate symbols in the key and mark them in the empty boxes.

USES	**1 fishing**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1 fishing									
2									
3									
4									
5									
6									
7									
8									
9									

Please fill in the following:

Name of group and student representatives

…….

…….

River site activity

…….

……..…

Needs of your group	**Effect on other groups of your use**	**Compatibility rating from survey sheet**
	access	
	facilities	
	other	
Conflicts that need solving: conflicts		
Possible solutions: solutions		
Rules for using the site harmoniously: rules		

Needs Auction

B3-B5

(Adapted from the Swan River Education Kit, Water and Rivers Commission WA 1999)

Activity 32

Curriculum Links:

SOSE Environments / Place, Landforms and Features Env 3.1

SOSE Environments / Environmental Awareness and Care Env 4.2

Focus Question:

How does the way society values water resources affect the way water is conserved or used?

Aim:

To recognise the difficulties of accommodating environmental, social and economic values in waterway management.

Main Idea:

Individuals and organisations have various interests in river environments. Accessibility to riverine resources is influenced by different levels of power and financial resources.

Need:

Student Sheet 4.8.

Consider:

Students assume the role of a character with a vested interest in the river site and bid for their needs at an auction (ideas are given in the box opposite).

- Students adopt the character of an animal or person who needs the resources of the river.
- Students are each given the student sheet and are allocated an equal amount of 'money' (eg: $1,000) with which they can plan to buy their resource needs at an auction.
- Students consider and select the items they most need for survival. Decide which needs they will bid for and how much they can afford to spend on each.
- The auction then begins under the control of an auctioneer, who sells each item to the top bidder.
- At the conclusion participants state what they have bought and what they missed out on.

Extension:

Repeat activity varying the amount of starting money. Discuss whether equal resource distribution is the fairest way of solving access issues and if indeed it is possible.

Reflection:

Discuss the value of sharing resources equitably.

Possible characters:

Animals: Brolga, frog, barramundi, water monitor, pelican, spangled perch, crocodile, greater bilby, freshwater prawn dragonfly, shield shrimp.

People: camper, angler, food gatherer, motorbike rider, birdwatcher, artist, writer, photographer, nearby pastoralist, tour operator, feral pig hunter, mining operator, road builder, pest controller for mozzies.

Student Sheet 4.8
Auction Bidding Sheet

Items (Needs)	Available	My top bid	Actual top bid	Purchaser
A rubbish-free environment				
Friendly, fun-loving tourists and visitors				
Good facilities (picnic tables, toilets, etc.)				
An attractive natural environment				
Wide grassy areas				
A big, efficient drain that flows into the river				
A major road with river views				
Pollution-free river water				
Healthy natural vegetation to protect river banks				
Plenty of eating-sized fish in the river				
Shallow water at the river's edge				
Lots of reeds and sedges at the river's edge				
Unrestricted rights to use water for irrigation or industry				
Plenty of parking				
Total				

Decisions, Decisions!

B1-B3

(Adapted from the Swan River Education Kit, Water and Rivers Commission WA 1999 and Great Barrier Reef Marine Park Authority, 1988.)

Activity 33

Curriculum Links:

SOSE Environments / Environmental Awareness and Care Env1.2, Env 2.2

Focus Question:

- **How does the way society values water affect the way it is conserved or used?**

Aims:

1. To discuss the different ways in which people perceive the environment.
2. To describe how the community can share the responsibility of looking after river environments.

Main Idea:

- Clean water is a resource that many people take for granted. Its availability is being threatened by the high demand for catchment resources and by environmental degradation.
- Integrated Catchment Management involves the whole community, including local government and state agencies, industries in managing the natural resources in a catchment.

Need:

Two copies of Student Sheet 4.9 (below) for each student.

Consider 1:

Provide an explanation of any of the thoughts or statements on the student sheet if required.

Students complete one copy of the Student Sheet before the river visit. They should carefully read each of the fifteen statements in the left-hand column and tick the column that most closely matches their level of agreement or disagreement.

Tally the responses of all students against each of the fifteen statements on the work sheet.

Summarise and report on the findings.

Analysis 1:

Take an excursion to a suitable local wetland or waterway. Using the second copy of the Student Sheet, students repeat the exercise.

Once again, tally the responses for each statement. Compare the pre and post-visit responses.

Ask students who changed their minds to explain their reasons.

Consider 2:

Discuss how positive values and attitudes towards the river might be demonstrated by environmentally responsible behaviour.

Analysis 2:

Students could then list examples of environmentally responsible behaviour.

EXCURSION

Student Sheet 4.9
Decisions, Decisions!

Thoughts and decisions	Strongly agree	Mildly agree	No opinion	Strongly disagree
1. People who fish for recreation should be allowed to catch as many fish as they wish.				
2. I can learn more about the river by reading a good book about it than by visiting it.				
3. Weeds look better than native plants so there is no need to get rid of them.				
4. It's okay for stormwater runoff from roads to drain into the river because there is nowhere else for it to go.				
5. Some parts of the estuary should be protected and used only by fish and birds, not humans.				
6. Powerboats should be banned because they cause erosion of the banks.				
7. Rubbish is not a very serious pollution problem compared to chemicals because chemicals can get into the river through drains.				
8. More picnic areas and boat ramps should be established to give a greater number of people a chance to enjoy the river.				
9. People who own houses and businesses near the river have a responsibility to find out if what they do affects the river in some way.				
10. Only people who have an interest in studying some aspect of the river should be allowed near it because ordinary use creates too much damage.				
11. People should be able to use the river in ever way suits them.				
12. We need environmental police to control people who pollute and degrade the river.				
13. If people knew more about the river, they would choose not to harm it and would do more to care for it.				
14. It's better to learn about this river than some other place we can't visit.				
15. Nothing I do could harm the river in any way.				

Extension:

Write some poems of your own that relate to management of water quality. The examples below are poems by Meredith Bellette

I have a little doggy,
Who does what doggies do.
Whenever we go walking,
He needs to find a loo.

I take a little plastic bag,
And turn it inside out.
I put my hand inside it.
The laws I will not flout.

And then I pick up doggy doo,
And place it in the bin,
So environmentally,
We won't commit a sin.

****

Butts come in all sizes.
It really is bad taste.
See them lying everywhere.
It really is a waste.

The waste goes down the gurgler,
And ends up in the sea.
It fouls up all the water.
Butt out! Think smart! Breathe free!

Simulated Catchment Crawl

B3

Activity 34

Curriculum Links:

SOSE Environment / Natural Systems Env 3.3

Focus Question:

- **How has human use of the catchment affected catchment health?**

Aim:

To make links between land use and health of the catchment and changes to water quality.

Main Ideas:

- Human use of land and water has implications on catchment health and water quality.
- Previous scientific studies have determined various cause/effect relationships between land use and catchment health.
- This knowledge has allowed computer modelling to be created to simulate similar events and the consequences of those events.
- Computer simulation models allow students to learn from others experiences without further damaging the environment.

Need:

Computer access with a CD-ROM drive/ Internet; Mission Australia/Landcare catchment package and Exploring the Nardoo, access to the site: www.cwmb.sa.gov.au/kwc/interactive/wetland/index.htm

Consider:

The Mission Australia/Landcare CD ROM is suitable for primary school from the end of Band 2. Exploring the Nardoo is suitable for Band 4 and beyond. All these resources run students through the consequences of various land use activities on catchment health and water quality.

Analysis:

Follow the CD ROM prompts.

Human Influences on the Water Cycle

B3-B5

Activity 35

Curriculum Links:

Science/Concepts and Contexts/Analysing Parts/ CC 3.1, CC 4.1

Science/ Concepts and Contexts/Interaction and Change/ CC 3.2, CC4.2

Science/Science and Society/Communicating scientifically/ScS 3.1, ScS 4.1

Focus Question:

- **How have humans influenced the water cycle?**

Aim:

To gain a greater understanding of how human development has the potential to significantly alter the water cycle.

Main Ideas:

- Recent human activity has increased the level of solar energy absorption and therefore heat retention in the Earth's atmosphere.
- This phenomenon has occurred as a result of higher concentrations of certain gases, termed 'greenhouse gases', including, carbon dioxide, methane, chlorofluorocarbons (CFCs), nitrogen oxides and ozone
- It has been predicted that the Earth's mean temperature will rise by between 2 and 6° C within the next century.
- Landform changes such as vegetation clearance can also alter the global water cycle.

Need:

Internet access.

Consider:

The class does a retrieval chart of what they understand of global warming and land clearing.

Investigate:

The class then uses the Internet to investigate further and to determine current impacts on the global water cycle.

Reflection:

Look into the future, what could happen to the global water cycle if no actions are taken to slow down global warming and land clearing?

Suggested sites:

- http://www.greenhouse.gov.au/pubs/gwci/furtherinfo.html
- http://www.uic.com.au/nip24.htm
- http://www.cap.nsw.edu.au/teachers/global_warming/global_warming_workshop.htm
- http://www.csiro.au/index.asp?type=faq&id=GreenhouseEffect
- http://www.brs.gov.au/publications/ccn/

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