CSIRO

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Feature "thought" :
"The rivers and streams are the report card of our civilisation. If we can't get them right, what hope have we got."
Don Blackmore, CEO, Murray Darling Basin Commission (MDBC)
in ABC Television Program 'Silent Flood.'

Dear Networkers:

SUSTAINABILITY NETWORK UPDATE – No 20E

Water, we are told, will be a crucial sustainability issue for the 21st Century – and so will urbanisation. Consequently, the way we manage water in our cities will assume growing importance from now on. Today, most city dwellers simply accept that "utilities" such as water, electricity and gas, are provided centrally by big corporations, with little individual control other than minor flexibility in how much or how little we use.

In many places, however, these big, centralised supply systems with their expensive, leaky, inflexible, legacy infrastructure are in trouble – especially when faced with population growth and major maintenance expenses. In addition, as social awareness of sustainability issues increases, so too does dissatisfaction with the lack of individual control over how vital resources are used. People are beginning to want to get "off the grid." Down around the foundations of the 'centralisation-and-big-pipes' paradigm the ground is starting to shift. There are signs of a trend to decentralisation, and the appearance of new technologies for distributed systems with increased local control.[1]

The main feature in this Update, from Network Member John Fox of Maleny in South-East Queensland, is important, I believe, because, in looking from the "grass-roots" viewpoint at decentralisation of urban water systems, it introduces us to the deeper underlying issues facing all centralised urban services, and also questions the fundamental patterns of organisation in our modern society.

Water farming – Re-patterning for a sustainable society

*Feature author, **John Fox**, is a civil engineer whose primary interest is the long-term future and how we can improve the chances our species will actually have one. After working for many years with innovative small-scale water technologies and a particular focus on sustainability, he is greatly attracted to the concept of using water, normally simply an engineering and economic matter, as a basis for change – physical, economic, social and spiritual – to a sustainable*

[1] See also, summary of distributed power generation on pp 13-14 of Update 3, www.bml.csiro.au/SNnewsletters.htm

pattern of living. In terms of planning for a long-term future, he sees flexibility as the only way of accommodating the magnitude of accelerating change we are now experiencing.

In the following feature, he introduces us to a new way of looking at urban water resources, based on replacing the existing, highly centralised, 'big-pipes' water supply model with a small-scale, co-operative, layered, 'organic', cellular model. 'Water farms' would harvest local water sources, including rain, and would recycle water and nutrients to enable urban food production.

John sees a myriad of advantages in areas of cost and security, but believes the biggest single outcome could be a new way of connecting human beings directly with a vital life source, leading to a new consciousness of the interconnectedness of things, and a new respect for life and our planet.

You can contact John for discussion at johnfox.maleny@bigpond.com

Big pipes

John Fox

The water industry is very ancient, with remarkable feats of civil engineering extending back thousands of years in regions where city-states and empires were centred. As might be expected, the development of large-scale water transport, storage and treatment technologies started in arid lands and urban areas, where people in developing cities needed to use distant water sources, such as rivers or lakes. Where there was also a system of sewers, this waste was usually dumped into the same rivers and lakes. It was only in the nineteenth century that wastewater treatment became widely used, and even then it was pretty crude.

There have also been available for thousands of years, small-scale technologies for the use of local water, such as roofs with gutters and down pipes, cisterns and tanks, weirs, wells and pumps. When a town is being created, or where people are living separate from a town, they are usually dependent on local water, and in an area of good rainfall or easy-to-access water this is not a problem. Even with quite sparse rainfall it is possible to get a long way with simple technologies, good water storage and careful practices. For many locations, including even some industrial areas, local water would still be sufficient had people retained the paradigm of small-scale local technologies.

Over time, the large-scale, "big pipes", imported-water paradigm was adopted for many areas of the world where local water was abundant, for reasons which initially related directly or indirectly to the large-scale needs of the Industrial Revolution, but then became the "proper," professional (and profitable) way of doing things.

Dams were built in rural areas and large delivery, treatment and reticulation systems were built. The wastewater resulting from this huge water import was collected into a large-scale sewer network, treated, and disposed of, most commonly to a river or the ocean.

Because the rainwater falling on the city was not being stored and used, a stormwater collection and drainage system was built, usually separate, but sometimes combined with the wastewater system. The water from this system was then discharged to creeks, rivers, lakes, or the ocean. As cities grew and became more industrial, this discharge became increasingly loaded with pollutants washed off roofs, roads, parking areas, and industrial sites. Now, in Los Angeles, when it rains they close the beaches, because the water is not safe for swimming.

Why not rainwater?

So, historically, urban water supply planning has usually ignored rainwater as a resource. It almost seems as if people, politicians and technocrats, have forgotten that rain consists of water, which, unless and until it is polluted, is the purest natural form available and arrives free of charge.

So the search continues for more “safe”, politically manageable, catchments and dam sites, more unpolluted, undepleted aquifers, more hilltops for reservoirs, and non-controversial routes for more big pipes to increase the supply of imported water. New sewer systems involve finding the means to dispose of large volumes of water loaded with pathogens and nutrients . . . and nobody wants to live near a sewage treatment plant!

Meanwhile, rainwater, ignored as a resource, is allowed to become a problem, and very little is done to reduce the demand for water or to develop opportunities for water reuse. The conventional reasons given for not using rainwater include issues of water quality, mosquito breeding, cost and aesthetics of tanks and storage ponds, cost of retro-fitting existing systems, availability of space for storage, and the tired old confidence trick of "economies of scale".

As usual with any explanation given to the public by a large corporate entity, there is some validity in these reasons, as long as we don’t look into them too closely. There are powerful commercial, professional, and political vested interests in favour of large-scale systems; they are profitable and controllable but not usually sustainable in anything but a superficial way. And, in accordance with the time-honoured paternalism of government, people are not asked what type of water system they want, or even given the opportunity to object to the system chosen by politicians and technocrats.

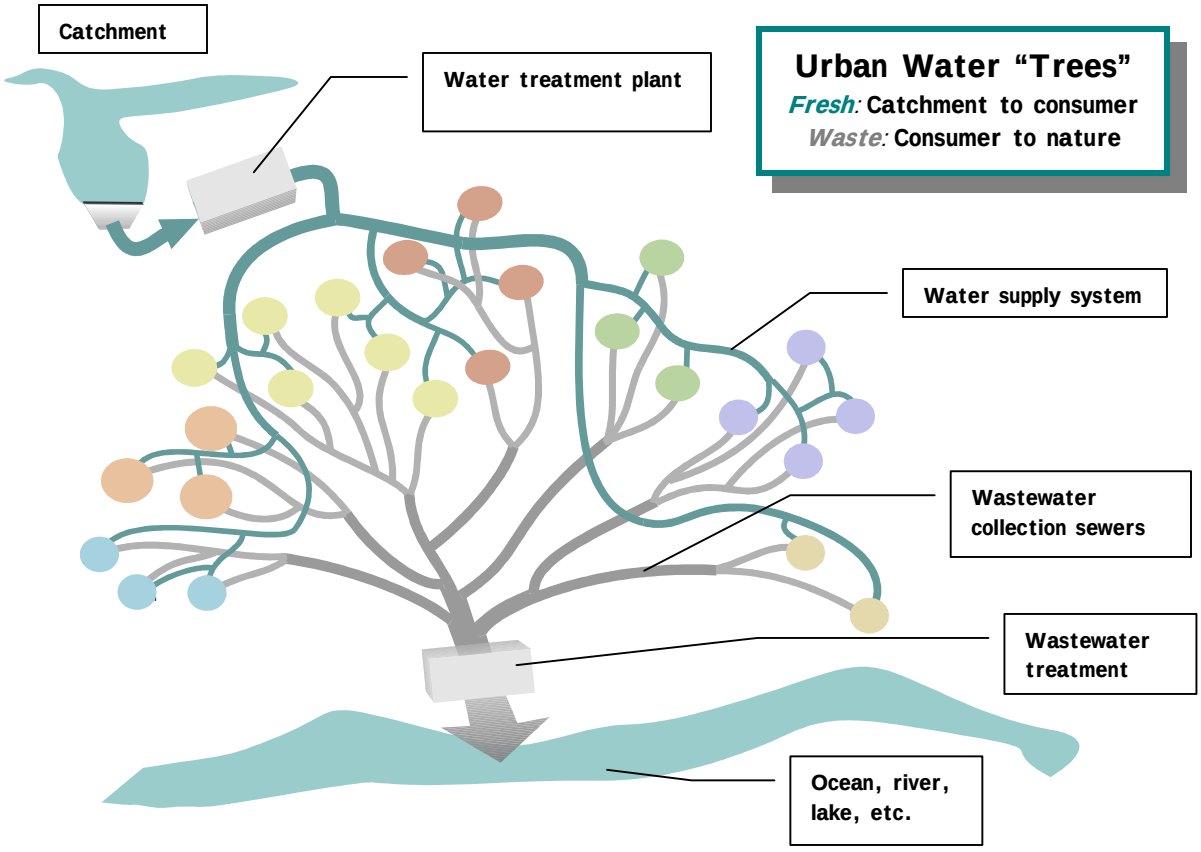
There are many countervailing factors that far outweigh the conventional arguments against rainwater use, but for these arguments to prevail, something has to happen to change the attitude of government that people are incapable of looking after themselves.

It is my view that there is only one valid application for the “big pipes” paradigm – in places where there is inadequate local water, even for very efficient systems. Even then, in places like Southern California, it is only supplementary water supply that should require large-scale infrastructure. Even where rainfall is low, the rain that falls can be captured in tanks, and while it may not be suitable for drinking, it can be treated and used for many other things. "Waste" water can be recycled for non-potable uses in small-scale residential or commercial clusters, reducing the need for imported water, preventing downstream pollution from runoff, and providing water and nutrients to “make the desert bloom”.

> *Phosphate rich soaps and mild cleaning chemicals (grey water) are considered pollutants because they accelerate algal growth in the waterways, which, in turn, leads to oxygen depletion for fish and other marine life forms. The beauty of this "problem" is that these same phosphorus, nitrogen, potassium and protein "pollutants" are excellent sources of nutrition when you reuse grey water for irrigation of fruit trees, landscaping, and gardens.*
>
> http://www.thenaturalhome.com/

The water tree

The pipe systems used for urban water supply and wastewater collection are organised as large-scale, top-down, gravity-driven, hierarchies – “half-tree” patterns of trunks and branches – one for water supply, and another for wastewater collection. Unfortunately in most such systems these two half-trees are not connected — and there is often a third separate, unconnected, big-pipes system for stormwater runoff as well.



Where the hydrological cycle is closed in Nature via evaporation, transpiration, condensation, rain and runoff, the human water cycle has a gap. Human water-use systems can close the gap by recycling treated "waste" water, reducing total throughput of water, and reducing the severity of runoff from the modified catchment. But for centralized "big-pipes" systems this would involve a fourth large-scale, reticulated system, not gravity driven, to pump large volumes of recovered water up from the bottom of a catchment to the top – usually too expensive for old-style economics to contemplate. Even if we could afford the pumping costs, we would still have a problem – nutrients in the waste stream – the result of our presence in the ecosystem in such large numbers, eating food and putting out organic wastes.

So large-scale systems drain water from nature to supply human needs, destroy natural systems to store and transport bulk water, and then let nature absorb human wastes. This is the ultimate in "externalizing" costs: just unload the cleanup task on nature. We do it all the time.

There is another problem with large centralised systems that first distribute fresh water from a point source such as a dam to a large number of users, and then collect variously contaminated wastewater from a large number of users into a single disposal area. Any quality or supply risk to the water source is broadly distributed, and any general lack of care and concern by users is magnified into a big pollution problem at the point of disposal.

Large-scale water systems are socially, environmentally, and economically unsustainable for a whole range of reasons, just one of which is that they are not population-proof; and they cannot be expanded beyond their planned extent without extensive political "management", massive cost and, generally, social disruption as well. Technocrats, and therefore politicians, say "One day we will need another dam". That is not true; it is just a mind-set, driven by fear of losing control.

Society has evolved to a situation where the scale, cost and complexity of centralized systems of any type is so vast, and the alienation of the bulk of users so complete, that there is virtually no recognition, at any level, that the users are in fact part of the system.

In the past, water utilities have been responsive to users' needs in a technical sense only: enough water for "projected demand", in accordance with a "standard" determined by a faceless someone embedded in a political and bureaucratic hierarchy, backed up and protected by statute law. The water is loaded with additives, such as chlorine and fluorine, by political or technical decision, without choices — including whether or not to even connect to the system. Measures to limit demand, and reduce the need for expansion, exist only when a utility is trying to postpone expansion – not when it has just spent a lot of money and needs to sell the water.

An almost total disdain for the detailed needs of water users is possible because people believe that they can do nothing about "the water board": it just "is" — an established fact, an inevitable part of urban life.

In Sydney, a city of 3.5 million, people were told a few years ago that they had to boil the water they were being supplied, due to infestations of the parasites *giardia* and *cryptosporidium*. All over the civilized world where multi-billion-dollar, large-scale water systems are in place, people are paying for bottled water for their own drinking purposes at thousands of times the cost of town water, because they do not like, or do not trust, the town water. This seems to me a major failure of the centralised water paradigm, but at last there are signs of things changing, both in areas where water services are still in their establishment phase and, increasingly, in established areas where there is recognition that man-made systems have a lifetime, and that flexibility is an essential prerequisite for sustainability.

Centralised water systems are not the only candidate for a long hard look at issues of sustainability. Large-scale centralized systems of any kind are vulnerable to widespread, low-level negligence, technical failure of many kinds, natural disasters, and extremist actions. These are all features of society at the beginning of the new millennium. In an age of terrorism, security and surveillance incur huge costs, and are only partly effective in an open democracy. Furthermore, there is certainly no sign that the frequency of natural disasters will decrease in the future.[2]

Major failures have occurred in large-scale systems on many occasions – think of electricity in New York and Auckland (New Zealand), dam failure in Italy, chemical plant failure in Bhopal (India), natural gas explosion in Victoria (Australia) – causing in each case widespread loss, hardship, and death. Interestingly, a few days after the Victorian gas disaster, a letter appeared in *The Australian* newspaper from Prof. Frank Fisher at the Graduate School of Environmental Science, Monash University, from which I quote:—

> "One of the really lovely things Victorians with gas-fired homes are now discovering is that people down the street with electric stoves and solar water heaters are willing to share their good fortune. This discovery will do a lot for us all, as communities and personally." "Instead of striving to build fault-free infrastructure at massive expense, we could build this special social experience into a new way of organizing for emergencies."

From top-down to bottom up

The universe is a system of nested self-organizing systems – of bottom-up patterns – operating in accordance with natural laws. At the planetary scale, Earth's biosphere contains bioregions

[2] See e.g., www.theage.com.au/articles/2002/08/22/1029114162843.html

composed of nested ecosystems. These in turn contain species with a wide variety of patterns of physical and social organization. For species other than humans, habitation of the planet is based on bottom-up patterns. When it comes to humans, however – all 6 billion of us – the planet is now overlaid entirely by our top-down patterns and their consequences.

Reality now includes the "noosphere", composed of the combined intellect of all human beings and the consequences thereof. And, by extension, we can postulate an "egosphere", a global ego, the combined total of the way human beings think they would like their individual realities to be.

This is what we are up against in aiming for sustainability.

My belief is that human habitation of Earth will never be sustainable until it is based on self-organization and bottom-up patterns at all levels – even though we are now dealing with a very different biosphere from that which existed as urbanisation began.

A possible strategy is to identify a component of our "reality" with sufficient importance and relevance to gain the attention of, say, 25% of human beings, and then use this to lead the noosphere and the egosphere to an understanding of what sustainability is, how it might be achieved, and how it will affect life on Earth.

Water is so fundamental to life that a secure water supply is a precondition for human habitation; and water is increasingly on everybody's radar screen at the start of this new millennium. We are told by society's futurists that there will be wars over water – both its quantity and its quality.

There are two contrasting ways of looking at a living organism – we can focus on the whole organism or on the cells that make it up. We can look at a society or city in the same way, either as a single entity to be governed and controlled, or as cellular entity with many "self-organising" properties at the various sub-system and cellular levels.

In our thinking about the nature of urban society, I feel we have tended to focus on the entire "organism" and, in doing so, have missed the essential substance of the object of study. Almost everywhere, we have applied hierarchical, tree-like social and economic structures based on the concept of a single large entity, ignoring or papering over the ways such systems fail to fit aspects of on-ground reality. The only conscious modern application of cellular social structures I can think of is espionage, where that form is chosen for security.

Perhaps it is not surprising we have trouble reconciling the "organism" with the cellular structures that make it up. Even in science, our reductionist methodologies have made it difficult to link the two conceptual scales – to link the whole organism and its behaviour with the minutiae of cellular processes or biochemistry.

To me, it seems we need a change in the way we look at things, a way that accommodates fundamental cellular scales as well as the big-picture. Such a change could be an opportunity to free society from ways of thinking that have restrained us (or at least that sector of society most focussed on wealth and power) from making changes essential for a sustainable future.

So taking a step back from the traditional, centralised, technocratic approach, and considering the city as an organism with intrinsic cellular sub-structure, might be a definitive step in the direction of sustainability.

Much of the water infrastructure needed to supply water equitably to the world's people does not exist yet, and much of the legacy infrastructure that does exist is failing. So, in my view, water seems to be a good place to start a move to sustainability.

I believe our strategy must be to use water, and the myriad other aspects of life that flow from it, to illustrate how humanity's physical, social, and economic structures, systems of governance and justice, concepts of wealth and well-being, and means of day-to-day living, can be made simpler and more comfortable and secure – by being based on bottom-up patterns and made as far as possible self-organizing.

Before human occupation, water moving across the land had patterns of flow which, in quantity, quality and timing, were determined by a wide variety of natural, nested, self-organizing systems. After human occupation water has come to have patterns that are largely determined by human beings and are intended to satisfy their needs. For cultural and "economic" reasons this human-centred pattern typically takes little account of the effects of human occupation on the ecosystem, or of the underlying needs of the ecosystem itself.

A starting point for fundamental change may be the "tree" form that shows up in water and other reticulated systems. The hierarchical tree structure underlies many aspects of "advanced" society, and yet this social and economic form can be both alienating and vulnerable: a deadly combination.

Perhaps the vulnerable tree patterns of society should be replaced by a more adaptable and secure cellular network pattern. In such a network, failure of the systems of one cell need not affect adjacent cells which, as self-contained units, can support and help to repair the damaged cell.

This type of redesign could lead a necessary paradigm shift away from unsustainable, patronizing, large-scale, socio-political and economic structures, towards a more sustainable range of choices somewhere between the cult of the individual and the tyranny of the state.

The water system seems to me to be a good starting point for such a new type of thinking and action, because there is a clear alternative to what is done now – i.e., use of free urban rainwater. Urban water systems could well lead the shift from competition and greed to cooperation and sharing.

Building a large piece of water infrastructure like a dam, for example, involves top-down and bottom-up processes, but the balance lies heavily over on the top-down side.

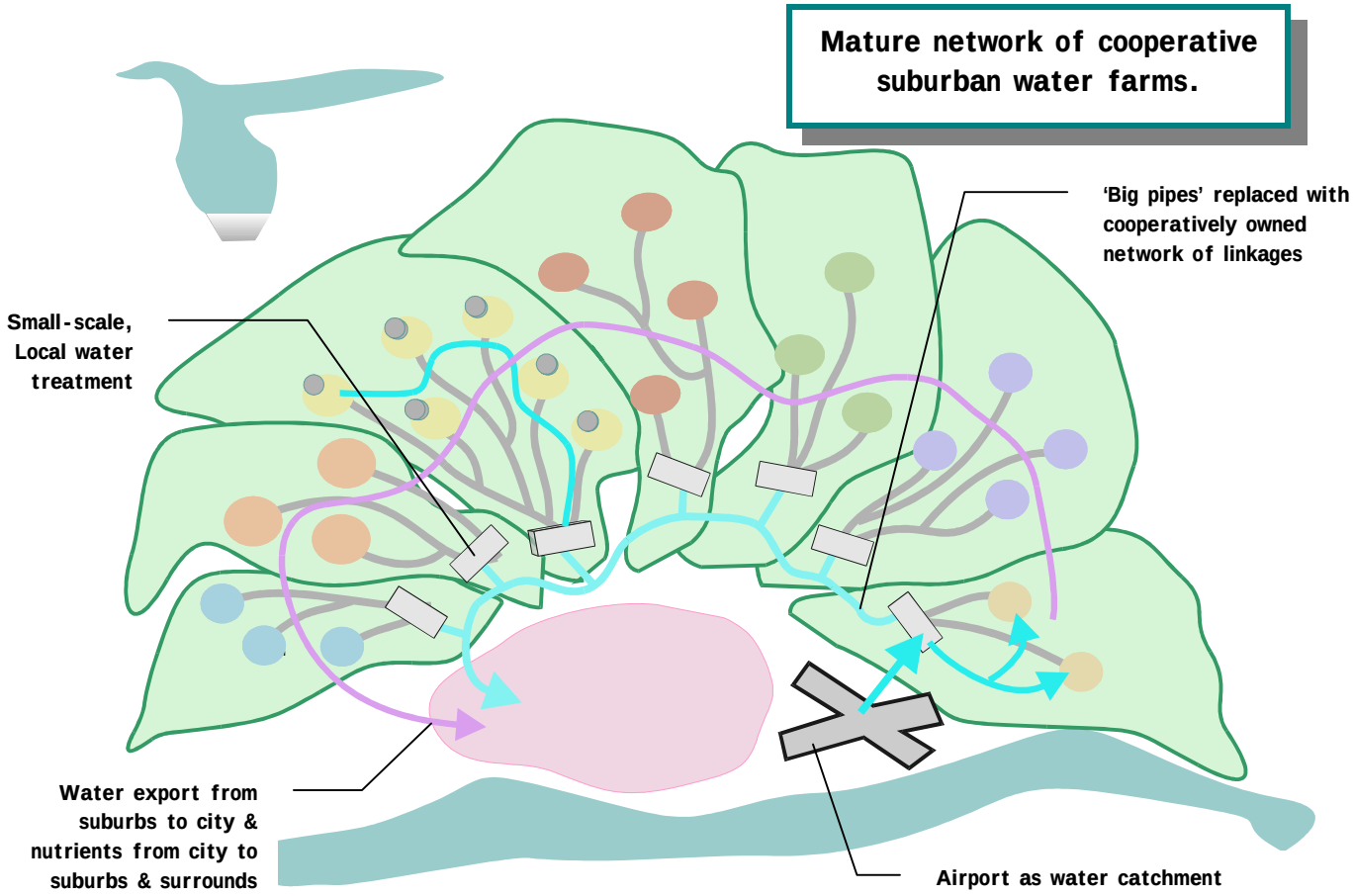
Putting the dam in place involves: identifying potential dam sites (which by their very nature tend to be in places of outstanding beauty), site investigation and geological survey, research, government subsidies, approvals, political softening up, moving people who are in the way, settling claims about eviction from homes and farms, planning, long time delays, design, survey, drafting, quantity surveying, contract administration, purchasing, construction, quality assurance, water treatment, disinfection, system operation, political oversight. Most of these involve top-down patterns and thinking.

On the other side, in the bottom-up category, is the on-site work, where the top-down pattern is subjected to the ultimate test of practicality in the face of local conditions and the minutiae of small-scale, adaptive decision making.

What if we moved the balance between top-down and bottom-up over to the other side – to give a bottom-up water system?

Water farming

My concept is to arrange water systems in bottom-up patterns as small-scale clusters: a network of small catchments, cells, or "water farms", owned and operated co-operatively by the users, and therefore responsive to real needs. The term refers to "farming" water from the urban landscape, to using recycled water-borne nutrients to farm food in urban areas, and to restoring and protecting the environment for the future. Even in an arid place like Southern California, where a large proportion of the water is imported from a long distance away, and where the underground water supplies are depleted, I believe the water-farming concept could be made to work, using imported water much more efficiently and collecting rainwater when it does fall.



A water farm occupies an area of land, on which rain falls and which may include subsurface and/or surface water storage, and subsurface and/or surface streams that may enter and/or leave the area. The area may also include buildings and/or paved areas, and may accommodate a variety of human activities. Some of the water storage and streams in and out may be of human construction and for human purposes.

A system of water farms is a pattern of human occupation which enables continuing human use of land and water while re-establishing and preserving a sustainable pattern of water flows. There are many patterns contained within a water farm which are fundamentally different from those encountered in conventional top-down "tree" systems of social organisation.

Water farming involves the systematic collection of rainwater as an urban water resource from impermeable surfaces such as roofs, roadways, car parks, airport runways, etc. These areas also collect pollutants from spillage and atmospheric fallout. So, because rainfall has the effect of washing both the area on which it lands and the atmosphere through which it falls, early-fall rain tends to be polluted, and the water quality improves as more rain falls. Collected rainwater is therefore best divided by origin into a number of categories for further processing, storage, appropriate use and reuse. Water from other sources may also be available, but the direct use of rainwater as a collective urban resource decentralizes the water infrastructure and distinguishes this as a new paradigm.

Informal classification of water for specific uses

Water class	Sources	Uses	Security
Potable (drinking water)	Late-fall rain, safe underground sources, existing infrastructure.	Human consumption, food processing.	High: health protection.
Body contact (service water)	Early-fall rain, domestic or industrial effluent: treated & disinfected.	Washing (domestic, industrial), recreation, gardening, heating, cooling.	Low: damage avoidance.
High nutrient (landscape water)	Continuously recycled organic effluent: disinfected and blended for specific preferences, locations, crops, and seasons.	Food production (hydroponic, subsoil irrigation).	Moderate: commercial value.
Special purpose	Process effluent and other grades of water: appropriately treated, heated, and managed.	Industrial or medical uses, heating or cooling.	Moderate to high: depends upon type & condition.
Organic waste	Human waste, ground food scraps, fats.	Input to organic waste treatment system.	High: pollution control.
Industrial waste	Wash water, spillage, effluent from industry.	Input to industrial waste treatment or recycling system.	High: pollution control.
Environmentally safe	Excess water from other water classes within the Farm.	Release to the environment.	High: ecological protection.

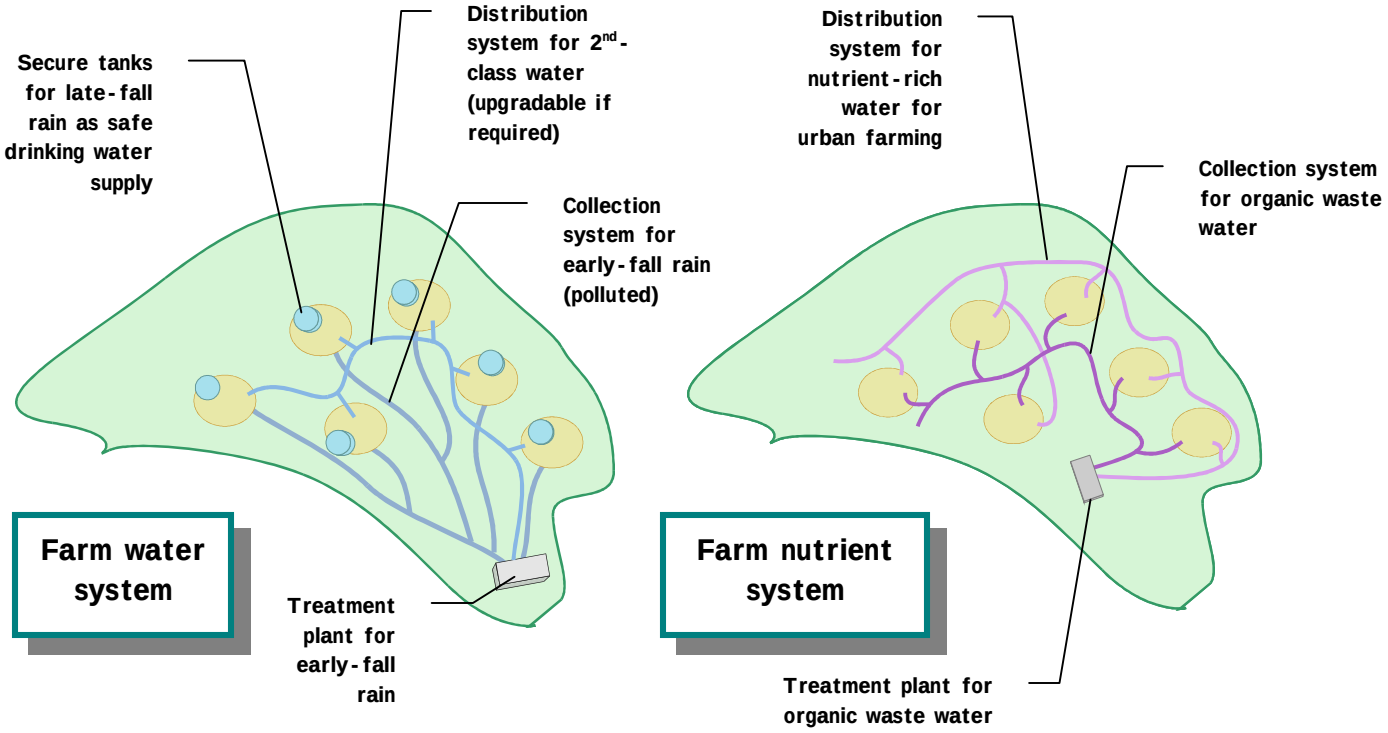
Discrimination of runoff from impermeable surfaces based upon context:—

Condition	Description	Output	Treatment
0	**Stand-by**	No runoff	
1	**Late-fall rain**	Runoff pretty clean	Filtration and disinfection.
2	**Early-fall rain**	Runoff polluted from atmosphere and collecting surface	Pollutant breakdown, filtration, disinfection.
3	**Wash operation**	Runoff polluted with cleaning and other chemicals	Pollutant breakdown, filtration.
4	**Spillage**	Runoff could be anything, but usually predictable for each site.	Return to source, input to secondary use, or suitable treatment.

A water farm would include the following functions:

- Collection of rainwater from impermeable surfaces within a catchment.
- Use of late-fall (clean) rainwater for direct consumption, from roofs or paved surfaces which are not subject to spillage or traffic.
- Use of early-fall (potentially polluted) rainwater for other applications, or for consumption if upgraded to drinking (potable) standard.

- Reuse of suitably treated organic and industrial wastewater for body-contact or non-potable applications, including high-grade industrial uses.
- Recycling of nutrients in water from toilet flushing and food processing to urban food production.
- Collection and storage of excess water to support the water-farm network during shortages or emergencies.



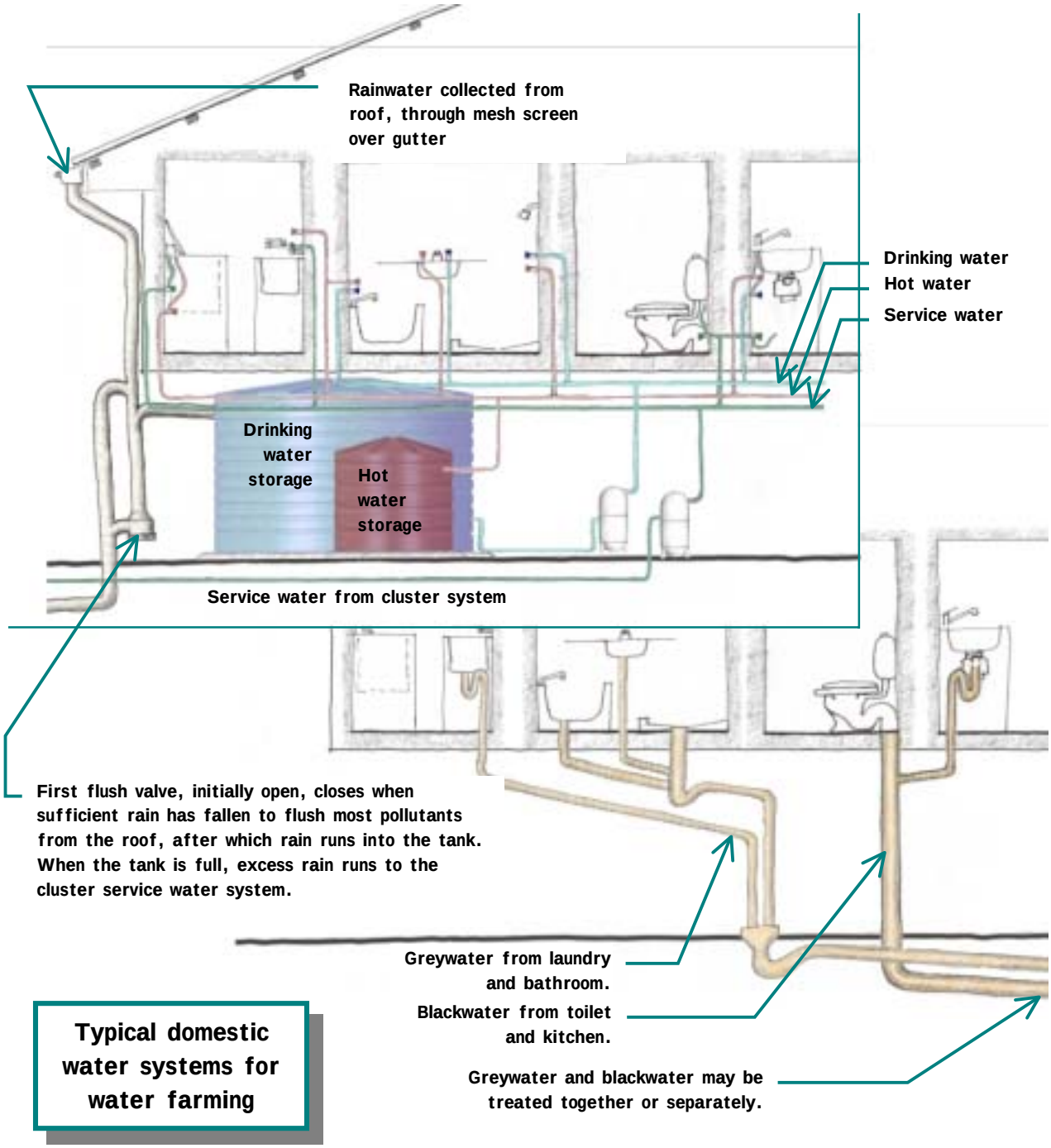
Flexibility

The solution to differing and apparently irresolvable conditions and needs is flexibility — a necessary (though not sufficient) condition for sustainability. As a bottom-up pattern, water farming is automatically adjusted to on-ground reality, with the potential for infinite variety of system arrangement, and huge increases in efficiency and productivity. Water farming is applicable in residential, industrial and mixed areas, and can be extended for direct investment in natural capital by using large-scale water runoff sources such as carparks or airports.

Typically, in a residential area, a water farm would consist of a group or cluster of dwellings, each with a tank for storage of late-fall rain as drinking water. Early-fall and excess rain would be directed into a common storage, treatment and distribution system, for second-class usage: washing, cooling, toilet flushing and possibly gardening. These second-class water systems would be linked from farm to farm, to provide for sharing of excess water.

“Blackwater” from toilet flushing, and other liquid and suspended solid organic waste from food preparation, would be collected into biological treatment facilities, based upon decomposer organisms. The effluent from this system, high in dissolved nutrients, would be disinfected, stored as appropriate, and made available for urban farming, e.g., with high-efficiency irrigation or hydroponics. Such water could also be further recycled and used for toilet flushing after passing through, say, a hydroponic array. This would increase the nutrient concentration, which could be adjusted as necessary to suit prevailing conditions and the type of food to be grown.

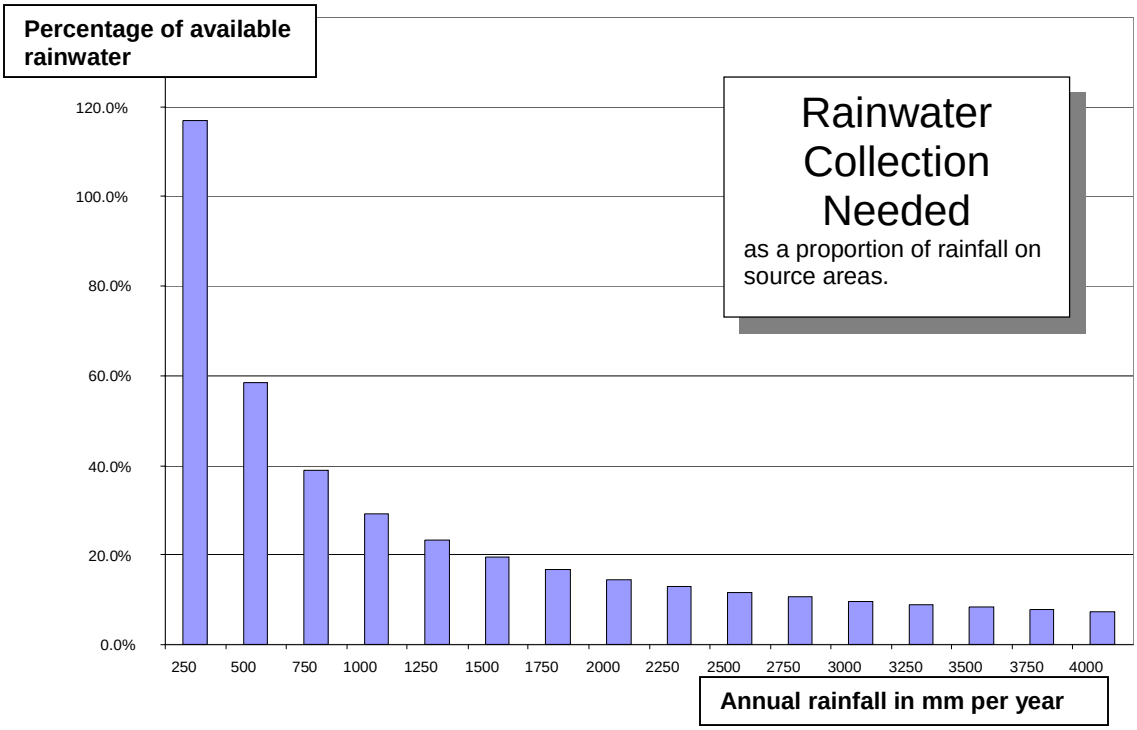
There are still issues to be addressed around hormones, antibiotics, etc. in human waste, and the suitability of recycled blackwater for growing leafy vegetables for food (as opposed to tree fruits where there is a much greater circulatory break between tissues contacted by the water and tissues consumed for food). As a precaution, greywater from other uses, containing soaps, detergents, fats etc, could be treated and reticulated separately from blackwater, and used for food growing, while the treated blackwater is used for landscape irrigation.



Typical domestic water systems for water farming

Water usage

In a modern western-style city, large quantities of treated water are drawn from the reticulated supply, but almost all is used for purposes that do not require the degree of treatment applied. Legal sanctions and political paternalism, plus issues of profitability, ensure that all water is supplied to allegedly high standards, suitable for drinking if you like chlorine.



Figures for urban water usage vary widely, but, for this purpose, I will assume a "typical" 300 litres per person per day. This figure takes no account of water conservation, to reduce demand, or water reuse, to increase the effective supply. If water demand could be reduced 20% by conservation measures, and all water used and then reused once before being returned to the environment, there would be an approximate 60% reduction in the volume of water needed. Making a few assumptions about average population densities etc., it is possible to produce a graph of the proportion of runoff that must be collected against annual rainfall (see figure above). The result suggests that for many cities collected rainwater could easily meet all water supply needs, although for cities in arid climates with rainfall concentrated into small periods of the year, storage becomes a big issue.

Technologies

The following are the general technologies required for operation of a water farm:—

- Runoff management to maintain separation between early-fall and late-fall rain.
- Filtration and ultrafiltration for removal of suspended solids from late-fall rain for direct human consumption.
- Treatment of early-fall and excess rain to body-contact standards for washing and general use.
- Treatment of liquid and solid organic wastes (greywater and blackwater) for water and nutrient recycling.
- Treatment of industrial waste by oil separation, breakdown of chemicals, and removal of heavy metals.

- Real-time computer simulation for control and optimization of water flows, storage, treatment, etc.

In addition, associated technologies for urban food production, such as permaculture, natural-nutrient hydroponics, etc., would allow food to be produced locally, minimising transport inefficiencies for food, nutrients and water.

At least some options for all of these technologies are already available. I have personally been involved with several enterprises in or near Maleny in SE Queensland that have developed, or are working on, biological or natural-energy processes for all these aspects of water-farm operations. And a Sydney house has been equipped for independence from all municipal services – energy, garbage collection, water supply, and sewerage – as well as some food production. This development on a very small inner-city site clearly demonstrates the feasibility of independently providing for fundamental needs in urban living.

Ultimately, the success and sustainability of water farms will depend upon sensitive process design and simple, loving, care and attention from the users.

Water farm networks

The pattern of water farms would reflect both the physical features of an urban area and the pattern of "communities-of-interest" within the population (e.g., bioregion and subculture boundaries). It would not be necessary to define these boundaries precisely, as inter-penetration and overlaying of the different functions of water farms would be possible, reflecting the blurring of functional boundaries in real cities. There would be a multi-layer network of linkages, owned and operated collectively by groupings of water-farm owners. Interconnectivity between farms would be controlled for security of quality and quantity.

Some cellular properties with Water-farm analogies:—

Cells have **membranes**, which selectively control passage of substances in or out:
some substances **diffuse freely**, others are
allowed to flow in **controlled quantities**, or
under **controlled conditions**, or
actively transported **against an energy gradient**.

Some cells have **nuclei** with sophisticated functions; others do not.

Some molecules **cross the nuclear membrane** and/or
flow around inside the cell, but
not beyond the cell membrane.

Some cells have **vacuoles for storage**; others do not.

Between the cells are an **extracellular matrix**,
communicating and occluding **junctions**, and
vascular and nervous **systems**.

I see a strong cellular analogy between the organization of a water-farm network and the structure of living organisms. Viewed as a map, there would be an overlay of "cells" over the existing landscape and community systems, with a variety of types of linkages – quite similar to a photomicrograph of living tissue. A water-farm network would also have a number of the functions of living cells, arranged similarly; and it is interesting to reflect on how a cellular organism is able to resist and repair damage by virtue of the very high level of duplication and redundancy inherent in the system.

An organically organized cellular water system would be highly resistant to disaster or attack, and if the individual farms and the linkage network were operated appropriately, with people clearly acknowledged as part of the system, the network would be effectively self-adapting and self-repairing.

To follow the organic analogue further would be to explore, among many other things:

- the degree to which the system could use biological and natural-energy technologies,
- the type and level of "intelligence" that would be required for control at the various levels,
- the distribution and organization of that intelligence.

The many potential benefits of water farming

One obvious immediate benefit of water farming would be the reduced need to produce food and water in one location and transport them to another for use. As another example: – where at present many people pay someone to mow their lawns, there could be an industry of people with green thumbs growing much of the food for city families on-site. Many skilled, creative, rewarding jobs would result, together with opportunities for sharing and exchange of food: co-operation, not competition.[3]

Water-farm entities would be in a good position to deal with solid wastes, undertake environmental restoration, and provide other lateral benefits, including nourishing a non-competitive people-oriented approach to enterprise and employment.

These small water entities would avoid huge capital outlays, and hence borrowings and compound interest. The future of global economics is not looking very bright – and certainly not the prospects for the capital needs of poor countries with huge urban populations. Even many "wealthy" countries have huge populations with poor living conditions and insufficient capital even to adequately maintain existing legacy systems.

One of the biggest advantages of the small-scale cluster model for water infrastructure is that the process of introducing it to replace large-scale centralized systems is very easy, potentially depending on very simple, comparatively inexpensive decisions. Because of the nature of the bottom-up pattern, it can be introduced gradually as a means of removing load from existing water and sewerage systems. There is no need for large, controversial political processes or huge billion-dollar financial commitments: all that is needed is the willingness to move from centralized control and accept that small is beautiful. It just needs a little more faith in people.

I believe that empowering people to provide for themselves some of life's fundamental needs will put them back in contact with deeper realities – the knowledge that they can take control of their own lives, and an understanding that they are independent and interdependent parts of the greater planetary system. Being part of a group of people who cooperate in providing for themselves the fundamental needs of life is nourishing experience. A planetary network of networks of such groups of people, with an enormous range of linkages (including water linkages), would be an extremely resilient form of civilization, in the literal sense of that word.

> *"Don't be loath to discard your 'beautifully complex' solutions and substitute them with your undramatically simplest solutions. And do that again and again until it looks so obviously simple that everyone will say, "Anybody could design that!"*
>
> Buckminster Fuller

*An additional point that struck me on reading John's feature is the **major business opportunity currently being missed by 'big-pipes' water corporations** – that of providing technologies and even maintenance services to those seeking to establish water farms, either individually or in community groups, within our cities. Citizens seeking to harvest rain and recycle 'greywater'*

[3] i.e., a 'partnership' rather than 'dominator' pattern of living – see the feature by Network member Andrew Gaines in Update No.19 at www.bml.csiro.au/SNnewsletters.htm

and 'blackwater' are faced not only with a maze of inhibiting legislation and discouraging disincentives, but also a lack of appropriate outlets for purchase and maintenance of water-farming technologies.

Governments, water corporations, inventors and retailers need to recognise the trend and capitalise on it. As distributed water systems gradually gain momentum, there will be a great need among those involved for the first time in water farming, for knowledge and technical options. If the visionary leader of an oil company can recognise writing on the wall and move the business "beyond petroleum" to solar energy, where will we find an equally visionary business leader to move "beyond dams-and-big-pipes"? E.G.H.

New Government and CSIRO thinking supports 'water farming' concepts

Report of the Senate Inquiry into Australia's Management of Urban Water

www.aph.gov.au/senate/committee/ecita_ctte/water/report/index.htm (The site gives access to the Report in PDF format – either as a single file (1.39 MB) or as a series of 16 chapters and appendices.)

Dr Peter Dillon - Peter.Dillon@csiro.au - Leader, Water Reclamation Research Team, CSIRO Land & Water, comments on the outcome of this important inquiry:

The Inquiry Report released on 5 December by the Chair of the Environment Committee, Senator Lyn Allison, reflects the overwhelming view of Australian water managers that we need a change in the way we do water business in urban areas. The report found :

- Urban water pricing fails to cover the true cost of water
- Lack of coordinated research on water conservation and reuse
- Components of urban water managed by different institutions, often without coordination
- Aging assets mostly continue to dominate spending decisions for water infrastructure in spite of technology changes

There are several symptoms of malaise in urban water management. Australia has the world's second highest per-capita rate of domestic water consumption (after USA), and urban consumption is in competition with rural users and the environment. This is profligate considering that all Australian capitals discharge even more stormwater and effluent than the volume of water they draw from their catchments. Cities such as Canberra, Melbourne and Perth are on water restrictions, and with population growth, climate variability, and capped catchment yields, it is clearly time for change.

The report says that solutions are at hand. Water-use efficiency gains through low-flow showerheads, mulching gardens and watering at night with timer taps, increased capture and use of rainwater and stormwater, use of greywater on gardens, water recycling in industry, and water reclamation and non-potable reuse are possible. Auditing and mandating water-use efficiency in public buildings, use of efficiency-rated appliances, water-sensitive urban design, and specified targets for reduced water-consumption, stormwater retention, and effluent reuse, are all means of moving forward. These actions need to be supported by well-informed planners, developers, builders, and plumbers (such as GreenPlumbers – www.greenplumbers.com.au), health regulators, environmental regulators, spppliers of products and services, backed by a research knowledge base and monitored demonstration sites to give confidence on the sustainability of new interventions.

The barriers that prevent implementation of these solutions need to be addressed. These include current water pricing regimes, assurance of public and environmental health protection, and the need for greater commonwealth support for coordination and integrated research.

The report acknowledges that while water management is a State responsibility, the Commonwealth has a role in leading and coordinating. It is proposed that providing foundations for the sorts of solutions listed above is the next stage of implementation of the COAG water-reform agenda. This program has delivered pay-for-use water pricing in urban areas, but has yet to make urban consumers pay the real

costs associated with mains water, wastewater, stormwater and groundwater. Neither has it yet aligned (by economic, regulatory, or educational means) the goals of consumers, utilities and State governments with best water-conservation practice.

Cities are outside the research charter of Land and Water Australia and excluded from the National Land and Water Audit. Environment Australia ceased funding the Urban Water Research Association of Australia in the early 1990's, and there is no Australian Cooperative Research Centre (CRC) with responsibility for more than a fraction of stormwater and water-reuse research needs. NHT funds are tied to specific projects rather than the essential basic research to underpin change.

CSIRO researchers strongly support recommendations for setting State targets for urban water management, such as an increase of 30% in water-use efficiency over 10 years (including water conservation, rainwater harvesting, and/or stormwater harvesting), and increasing reclamation and reuse of sewage discharges to 30% within 15 years. For new housing, such targets could apply within 12 months, backed by conditional home grants and building approvals. In new subdivisions and industrial estates, measures such as mandatory provision of pipes for reclaimed water and adequate open space around creek lines for stormwater harvesting, should be implemented to achieve the same types of targets. The recommendation that commonwealth buildings be audited for water use efficiency is applauded, and it is proposed that this subsequently be rolled out to all large users of water.

Clearly there is need for institutional reform at city level, or at least for coordination mechanisms to ensure that potable water, sewage, stormwater, groundwater, and reclaimed water are priced to cover the true cost of water (removing currently hidden subsidies). Increased State revenue should be allocated to supporting the restructuring of water management – e.g., to (1) development of national guidelines for rainwater, stormwater, greywater and reclaimed water use or reuse, (2) support of private-sector innovation, and the training of regulators, planners, engineers, builders and plumbers, (3) educational programs for urban dwellers, new home buyers, and affected industry participants, (4) improved triple-bottom-line reporting in water management, and (5) nationally coordinated research in water conservation and reuse.

In conclusion, CSIRO water researchers agree with the Report that the chronic problems with Australian urban water management require an urgent solution in which Commonwealth government leadership is needed to progress the COAG reform agenda and ensure consistency between States. The benefits of getting this right are estimated by CSIRO to be (1) 500 GL/yr of 'new' water available for the environment and agriculture, (2) the underpinning of small-to-medium businesses (SMEs) in a growth industry for water conservation and reuse products and services estimated at $300M pa in Australia alone, and (3) timely development of Australian capacity to service a $60B pa international market in similar products and services. Acting now will prevent our own problems getting worse, and will prime Australian innovation to help provide relief for the one-third of the world's population that will have critically short water supplies this century.

A call to save water:

Dr Peter Dillon, – Peter.Dillon@csiro.au - has called for a national effort to save water by more efficient urban water management. In a recent press release, Peter pointed out the bizarre fact that Australia, the World's driest continent, currently wastes 92% of city runoff and 86% of effluent water. The amount of water going to waste is huge – constituting a loss to industry and the environment, inhibiting development and adding to pollution. Peter has called for collection of rainwater and stormwater, and re-use of greywater, blackwater, and treated industrial discharges. He sees the main barriers to water re-use as issues of public confidence, health, the environment, reliable treatment, storage, economics, lack of relevant regulations, lack of regulatory and funding support, poor integration in water resource management, and simple lack of awareness. Although the nation's poor record on water reuse is slowly changing, with effluent reuse doubling to 14% in the last four years, this remains a tiny proportion of the total water running to waste.

*See Peter's press release at: **www.csiro.au/index.asp?type=mediaRelease&id=waterbid&pf=yes** or go to **www.csiro.au** and type 'water bid' into the search facility.*

Other CSIRO sites and contacts relevant to urban water issues:

CSIRO Urban Water: www.cmit.csiro.au/research/urbanwater
This multidisciplinary group of researchers, led by **Dr Andrew Speers** of CSIRO Manufacturing and Infrastructure Technology – Andrew.Speers@csiro.au - looks at improving the efficiency, suitability and ecological sustainability of urban water management in the light of economic, social and climatic changes. Their work integrates engineering, modelling and social aspects, to explore both new technologies and the context in which they will be applied. The website accesses researchers, published papers, a newsletter, press releases, and details of research projects.

Geoff Syme, Research Director, Water Security for Sustainable Communities, CSIRO Land & Water: Geoff.Syme@csiro.au

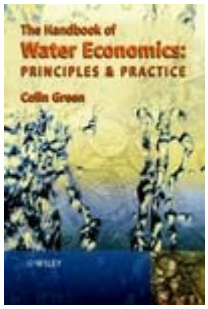
Australian Research Centre for Water in Society – **www.clw.csiro.au/research/catchment/arcwis**
Entry point for enquiries on social-science aspects of water management.

Policy and Economics Research Unit (PERU) – www.clw.csiro.au./research/agriculture/economic/
Has a number of urban-water-related documents listed under 'Publications'.

Program on underground storage of stormwater and treated effluent:
www.csiro.au/index.asp?type=mediaRelease&id=Prwaterbug or go to **www.csiro.au** and type 'buried dams' into the search facility. This particular work on "water banking" was awarded the inaugural UNESCO International Water Prize for Innovation in Water Resources Management in Arid and Semi-Arid Areas in 2001. (See: www.csiro.au and type 'buried water prize' into the search facility.) For more information, contact Dr Peter Dillon of CSIRO Land & Water - Peter.Dillon@csiro.au

Other Information Resources

WATER – Book
"The Handbook of Water Economics: Principles and Practice" – by Colin H. Green



Water is vital to social and economic development whilst both arable land and water are scarce. Managing water is highly capital intensive, and capital is also scarce. Simultaneously, there are environmental consequences to any intervention in the water cycle whilst the economy depends on the environment. Therefore, for an integrated catchment, economic analyses must be undertaken on the analysis of the impacts of the proposed scheme upon the catchment as a whole. This book starts with the Dublin declaration for defining sustainable water management and sets out the economic framework needed to support the implementation of its requirements. It covers the nature of choice and decision-making, considering social and policy issues for water and resource management; and provides the practical tools for economic evaluation of water needs, use of economic instruments and cost-benefit analysis.

To be published by Wiley, February 2003. ISBN: 0-471-98571-6. Information and orders at:
www.wileyeurope.com/remtitle.cgi?isbn=0471985716

WATER – Technical Articles
Safeguarding our water – discussion from *Scientific American*
www.mindfully.org/Water/Every-Drop-Count.htm
A powerful set of four discussion papers on of some of the potential ways forward to reduce pressure on water – developing new resources, reducing demand, and recycling.

"Making Every Drop Count" - Peter H. Gleick of the Pacific Institute for Studies in Development, Environment and Security describes the magnitude of the world's pressing water problems in terms of skyrocketing usage and ominous limits to the known supplies.
"Safeguarding our Water" - Sandra Postel of the Global Water Policy Project looks at irrigation, the single largest use for freshwater, and at the prospects for improving this vital agricultural technology. This paper is also available as **"Growing More Food with Less Water"** from:
www.clt.astate.edu/asurockdoc/downloads/sci13.pdf
"How We Can Do It" – Peter H. Gleick and Diane Martindale consider the available and potential technical options for staving off water shortages.
"Where Will the Water Be?" – Peter H. Gleick looks at issues of conflict and water availability.
[Thanks to Network Member Simon Buckley of AusAID – Simon_Buckley@ausaid.gov.au - for the alert via his "Water Thematic Newsletter".]

WATER – Technical Reports

Waterways Scientific Services of the Queensland EPA

www.epa.qld.gov.au/environment/science/water/publications.html
An extensive list of regional water-quality documents downloadable in PDF format or available on request to the EPA. *[Thanks to Raymond Williams of QEPA for the alert.]*

POPULATION & RESOURCES – Critical discussion

Ted Trainer looks at the CSIRO "Future Dilemmas" Report

In a previous issue of this newsletter (No 18) we referenced the above major CSIRO Technical Report to the Federal Department of Immigration, Multicultural & Indigenous Affairs by Network members Barney Foran and Franzi Poldy of CSIRO Sustainable Ecosystems. [See: www.cse.csiro.au/futuredilemmas] On publication, the Report gained significant attention in the television and print media, principally for its conclusion that the high, medium and low population scenarios tested were all physically feasible out to 2050 and beyond. Network member, Ted Trainer, while questioning little of the factual content of the Report, argues that it significantly underestimates the seriousness of the problems set by commitment to affluent living standards and economic growth, and does not give sufficient consideration to the claim that our consumer-capitalist society is grossly unsustainable. Find Ted's Critique at:
http://www.arts.unsw.edu.au/tsw/D68.CSIROreport-crit.html

TECHNOLOGY & SUSTAINABILITY – Paper

Robert M. May (2002) Sustainable development on a finite planet, *Trans IChemE* 80(B):87-92

(Lord Robert May of Oxford is Professor of Zoology at the University of Oxford, and President of the British Royal Society)
Scientific advances over the past century have improved most people's lives, in both developed and developing worlds. But increasingly we recognize that many of these benefits have not been produced in a sustainable way, particularly as human populations continue to grow. The focus of this paper is on some of the consequent problems of sustainability, on some of the possible technical advances that might alleviate the problems, and on the social difficulties inherent in acting today on behalf of a seemingly distant future. The paper is the written version of Lord May's Third John Collier Memorial Lecture to the Royal Society London. It highlights issues and roles of relevance to industrial chemists and chemical engineers. *[Thanks to Lord May for personally making a reprint of his paper available to our Network. If you do not have easy access to the journal, I can send you a photocopy. Send name and mailing address to Elizabeth.Heij@csiro.au]*

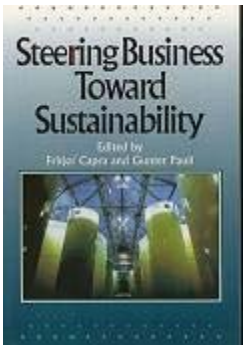
RENEWABLE ENERGY – IEA/OECD Report

Renewables Information 2002: IEA Statistics

Addressing the growing need for accurate data on how renewable energy markets are developing in response to policy supports, this volume presents comprehensive information on use of renewables and wastes in the OECD region. It takes a by-country perspective, but also analyses each of the various types of renewable energy and power generating capacity. Available FREE from the IEA Bookshop at books@iea.org or download information as a PDF at: **www.iea.org/stats/files/Ren2002.pdf** (878 Kb).

BUSINESS SECTOR – Book

Steering Business Toward Sustainability



Originally published in 1995, this book remains radical and thought-provoking. Sustainability, in its ecological and social components, poses businesses an inescapable challenge: without sustainability there will be an end to profits, Hence, business people have a strong self-interest in minimizing the ecological damage of their operations. In this book, business executives, economists, ecologists, and other thinkers outline new practical approaches that businesses and society must take to meet this challenge. Of interest to look at how these concepts stand seven years on. Available from the United Nations University through their online shop. Go to **www.unu.edu** Click on 'Publications', 'UNU Online Shop' and plug the book title into the 'Search' facility. ISBN: 9280809091; Stock number: 70012. *[Thanks to Carol Murray of CSIRO Black Mountain Library for the alert.]*

Other Web Sites of Interest:

Alternative Technology Association (ATA) – www.ata.org.au

Established in 1980, ATA is a non-profit community group that aims to use and promote environmentally friendly technology. The group is interested in renewable energy sources such as the sun, wind and water; building with natural materials and conserving energy. ATA has around two thousand members across Australia, conducts regular meetings, workshops and courses, and produces a range of educational publications. Even if you don't join the group, the website has a great range of live links to useful technological information. This is a first-class example of how technology can empower both small business and the community directly.

The Australian National Centre for Sustainability – www.sustainability.org.au

This site brings you in contact with, and allows you to contribute to, development of a new kind of public organisation. The theme of the Centre is *healthy people on a healthy planet* expressed through the arts and sciences. The Centre will celebrate diversity and the understanding that there are many pathways to achieving a *sustainable Australia*. The Centre proposal, currently undergoing a national feasibility study, will involve construction of a national facility in Canberra to provide:

- display space for the best examples of sustainability practice, products and ideas
- a centre for both formal and informal sustainability education
- a place to participate in local, regional and global sustainability research, management or design
- a forum for exploring, discussing and developing possible pathways to sustainability
- an opportunity for active collaboration between community, industry and government to further national action towards a sustainable world, particularly through the Australian Sustainability Network

Opportunity to Comment on Draft Policy

TRANSPORT

The total amount of freight carried around Australia is forecast to double in the next twenty years, with interstate freight almost tripling and container traffic expected to increase by 66%. Clearly something needs to be done now to deal with the implications for traffic congestion, the environment, and public safety. Submissions in response to the Federal Government's Green Paper, "Auslink: Towards the National Land Transport Plan", are invited and need to be submitted by Friday 7 February 2003. Auslink is the Government's vehicle for developing and funding an integrated national land transport infrastructure network. It is intended eventually to develop into a comprehensive National Transport Policy body. Information about Auslink and a copy of the Green Paper can be obtained from the Department of Transport & Regional Services (DoTaRS) at its website: **www.dotars.gov.au/transinfra/auslink.htm**

A bouquet – and a rare one at that!

The Federal Government gets a lot of stick from all directions, but this time plaudits are in order for the newly released National Research Priorities. Top of the list is **"An Environmentally Sustainable Australia."** Well done – to our political leaders for assigning top priority where it really matters, and also to all the important individuals who informed and lobbied behind the scenes. (Now it will be very interesting to see the types of projects to which actual funds are allocated! Will it be more bouquets – or more "stick"?)

[The other three priority areas are: 2. Promoting and Maintaining Good Health, 3. Frontier Technologies for Building and Transforming Australian Industries, and 4. Safeguarding Australia. Find further information at www.dest.gov.au/priorities/]

Events of interest (2003)

ISOS Online Conference – "In Search of Sustainability"
February – November 2003. An innovative and progressive Internet Conference open to Australians from all walks of life. Jointly managed by Australia 21 Ltd, Nature and Society Forum Inc, & Sustainable Population Australia Inc, in association with The Australian Collaboration. Information: www.isosconference.org.au

Water Conferences listed by the International Water Association (IWA):
See: www.iwahq.org.uk/template.cfm?name=events

Third World Water Forum
Kyoto, Japan, 16-23 March. Information: http://www.worldwaterforum.org/eng/index.html

Efficient 2003 Conference – Efficient use & management of urban water supply
Tenerife, Canary Islands, Spain, 2-4 April. Information: www.iwatenerife2003.org

Innovations in Water - Ozwater Convention
Perth, 6-10 April. Information: www.awaozwater.net or http://www.enviroaust.net/

Eco-Innovation & Sustainable Development -- Professional Development short course
Canberra, 28-30 April. Information from convenor, Dr Janis Birkeland: Janis.Birkeland@canberra.edu.au or by phone on (02) 6201 2693.

National Landcare Conference - Respecting Values - Working and Learning Together
Darwin, NT, 28 April –1 May. Sponsored by NT Dept Infrastructure Planning & Environment and the Tropical Savannas CRC. Pre-registration at www.landcareconference.nt.gov.au and information from the secretariat at: dcem@desliens.com.au

Inaugural national workshop of the Economics & Environment Network at ANU (ANZSEE Affiliate)
Canberra, 2-3 May. Information: Wendy.Proctor@csiro.au, http://een.anu.edu.au or http://een.anu.edu.au/eennationalworkshop_callforpapers.pdf

Sustainable Development Indicators in the Mineral Industries (International Conference)
Aegean Island of Milos, Greece, 21-23 May. Information: www.heliotopos.net/conf/sdimi2003/

International Society for Industrial Ecology – 2nd International Conference
Ann Arbor, Michigan, USA, 29 June – 2 July. Information: http://css.snre.umich.edu/isie2003/

Ninth International Conference on River Research – sponsored by the CRC for Freshwater Ecology
Albury, NSW, 6-11 July 2003. Information: www.conlog.com.au/NISORS/overview.html

Integrative Modelling of Biophysical, Social and Economic Systems for Resource Management Solutions – the MODSIM 2003 International Congress on Modelling and Simulation
Townsville, Qld, 14-17 July 2003. Information: http://mssanz.cres.anu.edu.au/modsim2003.html or David.Post@csiro.au

Rangelands in the New Millennium – VII International Rangelands Congress
Durban, South Africa, 26 July – 1 August 2003. Information from : delegates@sbconferences.co.za or www.ru.ac.za/rgi/irc2003/IRC2003.htm

GIN2003: Innovating for Sustainability – 11th International Conference – The Greening of Industry Network
San Francisco, 12-15 October. Information: www.greeningofindustry.org/gin2003.htm

International Conference on Water-Saving Agriculture & Sustainable Use of Water & Land Resources
Yangling, Shaanxi, P.R. China, 26-29 October 2003. Working language, English. Information from local Australian contact: Lu.Zhang@csiro.au

And Finally – Notes and Reminders

Check out our web site at www.bml.csiro.au/sustnet.htm
The site is being upgraded over time by Lyndon Hirst at CSIRO's Black Mountain Library. Your suggestions are welcome.

- **Find back issues of Network newsletters directly at: www.bml.csiro.au/SNnewsletters.htm**
- **Pass it on!** The Sustainability Network is intended to be inclusive rather than exclusive. If you know someone who might be interested in this newsletter, by all means forward it to them or give them our web address.
- **Want to make contact with scientists?** If you can see an application for the science featured in these newsletters and need to contact the scientists involved, let me know by email.
- **Want to see a particular area of sustainability science featured?** If there is a particular area of sustainability-related science that you would like to see featured as a "spot" in a future newsletter, send me an email or call me by phone to discuss it.
- **Give me your feedback.** I would be interested in your comments as to whether these newsletters are interesting, useful, and pitched at the right level for your particular purposes. Do you have suggestions? Thanks to all those who have already sent in comments and alerts.

Milestone: Our Sustainability Network now has over 480 members.

That's it for this update.

Sincerely,
Elizabeth G. Heij
Network Facilitator

Next Newsletter: We take a look at the interface between sustainability and human perceptions of risk.