Water For Australia

Barry Dunn (Chairman WfA) P O Box 2010 Peakhurst NSW 2210 (02)9534 1194 barry@growmax.com.au	Laurie Hogan (Principal) Civil Engineer & Inventor Bulladelah (02)4997 4862 glhogan@bigpond.com www.wfa.com.au	Robin Gaskell B.Agr. Writer of Submission 61 Laurence St Lithgow NSW 2790 (02)6352 2334 drought-breaker@pacific.net.au

Ms Roxane Leguen

Committee Secretary
Senate Rural and Regional Affairs and Transport References Committee
Parliament House
Canberra ACT 2600

Dear Ms Leguen,

Inquiry into Water Policy Initiatives

Please accept this submission for the Inquiry from the Water for Australia group: we will be pleased to submit further details, as required by the Committee, and are prepared to attend Committee hearings to answer questions from the Committee.

Yours Sincerely,

Robin Gaskell
(for Water for Australia)

Water for Australia

Submission to Senate's Inquiry into Water Policy Initiatives

CONTENTS

Water for Australia – Submission

Introduction

The Water for Australia group offers a comprehensive plan for the management of Australia's water. It treats the water that falls on the continent as a national resource, which can be harvested and supplied, equitably to users, both city-dwellers and agricultural producers. The WfA Project combines the benefits of desalination with those of water recycling to create sustainable agriculture serviced by salt-free country towns.

The Present Senate Inquiry

This inquiry seeks factual information relating to the management, use and supply of water under different categories. Although these categories give the impression that participants are going to suggest making the best of a deteriorating situation through shoring up one aspect of the water story, or another, the Water for Australia concept does not fit neatly into any of the categories: it presents a pro-active, total approach to water management in Australia.

The WfA initiative, with its plan for the introduction of eastern and western Water Grids capturing water, redistributing it, and desalinating it where necessary, would, if implemented, represent a major innovation that would ensure the effective husbanding of the nation's most precious resource. To say that the range of innovations comprising the Water for Australia project make up (c) "farming innovation" would be understating the situation entirely.

Not taking a fragmented approach to the various problems of water use, but, instead, putting all of the pieces together to ensure both the maintenance of a clean water supply and its equitable distribution, the Water Grid concept shows that a total approach can be taken to water in Australia. By combining desalination – the solution to salinity – with afforestation – the cure for desertification – the WfA scheme demonstrates an overall approach to the upgrading of water management in Australia. Extending the piping of water across farm and state boundaries maximises utilization of the planned salt factories and averages out the collection and distribution of water on a geographical scale.

(a) the development of water property titles
This is an extremely divisive concept, which tends to commodify water, virtually ensuring that the richest farmers receive more water than others.
Through use of a water grid, available water can be distributed equitably according to a property's ability to produce crops, the supply being limited only by a farmer's choice not to use their share.

(b) methods of protection for rivers and aquifers Within a Water Grid area, rivers would be protected through having forested wildlife corridors along their banks; irrigation water would be delivered to cropland via the Grid, and not extracted from rivers. Subterranean water will be added to the Grids only in exceptionally dry years from aquifers and artesian basins; the rate of extraction would not exceed the rate of recharge.

(c) farming innovation
Innovations which are within the WfA plan have been used elsewhere individually, but not, as here, all together:

- Forest strips covering 50% of a property.
- Rotation of cropping strips with forests when the forest trees are harvested.
- Use of either subsoil, or drip, irrigation at night, pre-dawn.
- Water Flow Collectors (covered dams) located at the lowest points of each Grid square - collecting run-off during rain.
- A bore-pipe in each 1 sq. km Grid pumps groundwater to the Collector maintaining a low watertable and removing salt from the soil.
- Irrigation water is pumped from Collectors to crops and forests through buried pipes.
- Water that is too salty for irrigation use is piped to the nearby salt factory.
- Saline water is desalinated (reverse osmosis at Water Flow Collector and/or processed at salt factory) with recovered water being recycled for irrigation.
- Electricity for bore pump, reverse osmosis and to move water through the Grid is produced in solar power generators on roofs of Collectors.

(d) monitoring drought and predicting farm water demand
Traditionally, both predicting drought and gauging the amount of water a farmer needs have been guessing games. The result at any one time has been the division of available water allocation among farmers, and this has been hard to adjudicate. Use of a Water Grid to redistribute water to farmers will be computer-controlled; and, such a system, as well as being suitable for the calculation of equitable distribution, is ideal for record-keeping – leading to a reliable prediction of future demand.

At present, drought and fluctuations in supply – ‘demand’ being the wrong word when no water is available – are extremely regional, and depend on local rainfall. As such, future predictions of water availability and farm allocations are very difficult to calculate.

Alternatively, with efficient water usage being a condition of the use of Grid water; with forest strips moderating the environment of field crops; and, ultimately, the feeding of Carpentaria water into the Grid, the supply of water into a Water Grid system will tend to be averaged over the whole system, and will balance out to being noticeably more than is available to the average farmer now.

(e) the implications for agriculture of predicted changes in patterns of precipitation and temperature

Considering that tendencies towards drought and rising temperatures are caused largely by the human action of reducing vegetation cover – resulting in the reduction of transpiration and its associated rain cycle – a reversal of this harmful action seems a more sensible response than an acceptance of its results.

A continuation of deleterious monoculture will exacerbate the observed negative climate changes: this implies that a radical change away from monoculture is indicated.

A re-establishment of partial eucalypt forest will moderate climate, ensure a permanent ground cover, reduce the water-table, and provide a protected environment for field crops in the non-treed areas between the strips of forest.

The WfA scheme, through the innovation of the Water Grid with its associated desalination phase in the irrigation cycle, would, in fact, “drought-proof” the agricultural areas in the Grid, ensuring a regularity of water supply.

Rationalisation

The present piece-meal system of water usage in Australia has reached the end of its cycle, having developed obvious shortcomings: rivers have become salty drains; dryland farming areas, denuded of trees, are becoming salty deserts; irrigated soils are filling with salty water; and inland towns are crumbling as salt rises with the damp.

The common denominator in the deterioration of both water quality and soil productivity is salt. Any successful water regime in Australia must take account of the fact that the bedrock of the continent was formed in salty seas; hence, for agriculture to become sustainable, this salt component must, in future, be factored into the way we manage the water cycle.

How the Water Grid Works

The Water for Australia proposal has taken all of the necessary factors into consideration. Water, falling as rain, is harvested in covered, sealed dams, called Water Flow Collectors; water from these Collectors is piped to irrigate strip forests alternating with strip cropping; bore-pipes draw groundwater into the collectors, and maintain a water table of approximately six metres; and, if the water from run-off or underground is too salty for irrigation, it is piped, not to the fields, but to a salt factory for desalination.

In salted and desertifying areas the installation of these Water Flow Collectors, on a grid pattern of one kilometer, will keep the rainfall available locally, while the associated bore-pipes, by lowering the water-table, will increase the amount of non-saline moisture to the root-zone for both forests and crops. This recycle/desalination system sweetens the soil by removing salt from the root-zone, brings salinated land back into production, and increases the productivity of the land. The harvesting of salt – to be used as an industrial resource – is simply a bonus, which will bring chemical industries into the previously exclusively agricultural landscape.

In summary, installation of a desalination Water Grid will ensure a regularized water supply in areas that had previously made a single use of naturally-occurring water prior to its entry into aquifers or into the surface river system. Water will be pumped from areas of collection to areas of need, and this water will not become unusable through pollution with salt owing to the desalination cycle built into the Water Grid.

In Detail

Three Water Grid systems can be developed: one Grid in the eastern states – from Queensland through New South Wales and into Victoria; the second Grid in the Western Australian wheat belt, serving farms, forests and mining requirements; and the third serving the Northern Territory and South Australia.

Water can be fed into a fully-developed Eastern Water Grid from the high-rainfall area around the Gulf of Carpentaria; this would reasonably be equivalent to approximately two inches of additional rainfall spread over the three states' gridded areas.

The use of worked-out minesites plays an important role in the Water Grid scheme: the water stored in them will not become contaminated, because it will be separated from the base-rock by impervious plastic. Storage lakes in open-cut sites will support an aquiculture industry, and also provide tourist attractions; they will also be called upon as a back-up to the Grid.

Each Grid square would have its Water Flow Collector connected to the Water Grid by buried PVC pipes; they would carry water to the irrigated fields or to the salt factory. These pipes – one for each direction – would be laid in shallow trenches with a 1km by 1km grid pattern; in these trenches, together with the pipes, would be the necessary wiring for the control systems that directed the water around Water Grid. Such a grid pattern can be extended progressively, over time, by digging more trenches, laying pipes, and building new Water Flow Collectors.

The suggested starting unit is a 10km by 10km Pilot Project: this would be sufficient to demonstrate the viability of the system over a grid pattern of a hundred squares; also, it would provide the nucleus from which a sustainable Water Grid could grow.

The electrical power that drives the system – pumping water around the Grid, powering bore-pipes, and applying pressure for Reverse Osmosis – will come primarily from a solar power system (which is in development) on the roofs of the Water Flow Collectors. Electrical power running the salt factory and other administrative buildings will come from solar power units on the roof of the salt factory.

Forestry

For the sake of stimulating the water cycle as well as the lowering of the water table, the WfA project includes a 50% forest cover. This will not detract from crop production as there will be more water available for crops, and the associated forests will moderate the environment of the crops.
Half of the width of a 1sq.km grid square would be under forest: these forests would be five kilometers long, then they would alternate to avoid formation of wind tunnels.
Hybrid halophytic eucalypts, developed by Saltgrow company, would be used as the timber crop: they are quick-growing and salt tolerant; growing in parallel with field crops, after twenty to twenty-five years they would be felled, and this would allow a rotation between fieldcrops and forest.

The cutting of a forest plantation represents the time that a Water Grid goes into profit: after the first forest is harvested the Water Grid area will be permanently in credit. As well as primarily rationalizing the provision of water for agriculture and country towns and secondarily providing the salt for new chemical industries, a Water Grid development would stabilize the economy of the area it traverses.

Implementation Framework

While the concept of installing engineering work across broad areas of farmland sounds expensive and invasive, the alternative to major innovation in water services to the salinating, desertifying areas is a continuation of the present degradation of land and water.

It is suggested that the installation of Water Flow Collectors, salt factories and the pipe grid that links them, be perceived as the innovation of a broad national utility: the analogies are water reticulation services in cities, and the national electricity grid. By starting with an "experimental" Pilot Project of a hundred grid squares (100 sq. km) - in an area that has become unworkable agriculturally through drought and salinity - there would be pressure from surrounding farmers to have the grid extended as soon as the gridded land came back into production.

Although the concept of Public Private Partnerships is currently popular with governments, the innovation of a first Water Grid, even though based firmly on known technology, would be unlikely to receive investor support, because its return on investment depends the time it takes for a forest to grow – even though it is of fast-growing, purpose-bred eucalypts. For this reason, the introduction of a first Water Grid is proposed as a publicly sponsored national utility.

While farmers and country towns would be required to pay a levy for the provision of the service plus a relatively small rate for water used through the system, this would be far outweighed by the increase in productivity of the land together with the reliability of the supply of water.

It is further envisaged that, owing to the extreme urgency of the problem of managing water on this continent, financing for such a project be given the highest priority, and that, once the feasibility study is done, publicly-created credit be provided – as has occurred during previous national emergencies – for the development of Water Grids.

Salt Extraction and Water Recycling

Considering that in Australia the base-rock is salty, and that this salt becomes dissolved in groundwater, the treatment of salinity is integral to the rational management of water here. For this reason, the removal of salt from agricultural water is an essential aspect of the irrigation cycle; as is observed at present, surface water drawn for irrigation from rivers, or from the subsoil, becomes progressively saltier with successive re-use. The only way that water can be successfully recycled for irrigation – on the same land, or along the course of a river – is for the removal of accumulated salt during the irrigation cycle.

While artesian water can have a sufficiently low level of salt for it to be used for irrigation, relying on this deep, slow-flowing water for Australia's agricultural future is not the answer to our water shortfall, because the artesian supply is finite, and levels continue to fall with increasing use.

In the WfA scheme, salinity of water is reduced at two points: firstly, at the Water Flow Collector, the saltiness of run-off and of water from deep bores is monitored, and, where deemed too saline for direct use on crops, it undergoes Reverse Osmosis – with the brine-off from this process being pumped to the salt factory; secondly, at the salt factory, using electrical separation, salt is harvested from the water as salt crystals or brine solution, while the water yielded from the process is pumped back to the fields.

In a Water Grid, there are two pipe systems: the narrower, 150mm, pipes carry saline water to the salt factory; and the wider, 300mm, pipes distribute water from the salt factory, to Water Flow Collectors and to crops and forests for irrigation. The pumping pressure maintained in each system is 40 psi.

By introducing this desalination phase into the irrigation cycle, the WfA scheme converts low-quality saline water into two valuable resources: industrially usable salt and potable water; this permits the recycling of irrigation water on one property a number of times.

The electrical power, which is needed to drive the removal of salt in Reverse Osmosis and electrolysis, comes from a form of solar power that is generated on the roofs of the Water Flow Collectors and salt factories, respectively.

Feeding the Grid

A water grid that is set up for the transfer of both salinated and fresh water can have its water content topped up by either/or both sea-water and tropical rain. In Australia, most of the rain falls in the tropical north, and for this reason, with suitable earthworks, a part of the summer rain that floods the land in the Gulf of Carpentaria region can be captured and pumped towards the center of the continent rather than being allowed to run into the Arafura Sea.

It has been estimated that such an input to an eastern Water Grid would provide the equivalent of an additional two inches of average annual rainfall over the entire Grid area. By the same logic, sea-water can be introduced to the southern ends of Water Grids – being pumped to a salt factory prior to being used for irrigation.

Why a Water Grid system should be introduced in Australia, particularly, is simply the fact that this continent, unlike others, has no large rivers carrying great volumes of water through the continent, nor does it have large snow-fed catchments permanently feeding regular river-flows. Optimisation of a Water Grid system would need an input greater than that delivered by the irregular rainfall, and this can be supplied readily from the excess of fresh water falling in the north during the Tropical 'Wet Season'.

A National Water-Grid

Assuming that such an innovation proves its worth – starting with a single Desalination Unit and associated grid – soon, farmers, in other salinity-prone areas, would also press for having the insurance of their own water purifying and recycling systems, and demand their own salt factories.

Depending on the right blend of political will and common sense, the application of desalination technology would prove to be both a necessity for farmers and a successful experiment for agriculturalists. Scientific monitoring would discover that areas, which, prior to desalination, were losing production, had, after joining a water grid, turned their economies around.

After some desalination systems have been installed overseas, and the remaining unconnected Australian pastoralists have realised that, in the face of encroaching salt, they have no alternative but to become part of a desalination water grid, the nation's agricultural land will be covered by a small number of large, regional water grids.

The extent of a Water Grid is limited by the distance that saline water can be pumped to a salt factory. The maximum distance is calculated as 300km; an optimum distance is approximately150km. However, with a number of salt factories located within a Grid system, its extent is limited by the availability of suitable soil and climate for the growth of crops and forests. Installation of a Water Grid, with its 50% forest cover, would tend to ameliorate the regional weather and reverse the trend of climatic deterioration in the Grid area.

Decentralisation of Industry and Population

Salt produced by the salt factories will provide a reason for the development of chemical industries in parts of Australia that are far from the coast, and currently solely agricultural. New workers, drawn to these more remote, inland areas will enrich the culture of the countryside and boost the economy of rural areas.

With an increase of forestry in former dryland farming areas, the weather will be moderated, people will be attracted to living, and working, in the hinterland as the climate becomes moister and cooler, and, importantly, the economy will be boosted by the production of hardwood timber for which there is a growing world demand. The result of new salt and timber industries will be a renewed decentralization of population plus an increase in GNP from these developing rural industries.

Desalination Applied to New Inland Urban Centres

Although most of the Water Grid concept concerns agricultural production, the WfA group has prepared plans for the reduction, and ultimate elimination, of salinity from rural cities. Water that is pumped from the subsoil of towns within Water Grid areas will be put into the Grid, and pumped to the nearest salt factory. Considering that new towns are anticipated, for chemical workers and foresters who move into Grids, these new towns will be built with suitable drainage sumps and pumping stations to prevent rising water-tables from developing beneath them.

Science/R&D/Testing/Application/Engineering

Considering that the problem of progressive salinity is not succumbing to the traditional methods of science, it is time to widen the search, to seek solutions beyond the basic disciplines of biology, soil science and geology. With the problems of an excess of groundwater and high concentrations of salts in this groundwater, the twin solutions, of the removal of water and the removal of excess salt from this water, will yield to engineering methods rather than to agricultural ones. At the same time that engineering methods are being applied to these processes of removal, full consideration must be given to the regenerating soil, both to the ecology above the surface, and to the microbiology below it.

Sustainability

Salinity, like the reduction of fertility in farmland, is a sign that Australian agriculture is out of the pioneering, exploitative stage, when the productivity of land was simply assumed. Now, two centuries after the beginning of European style farming, the imbalances of an exploitative phase of farming are becoming clearly apparent: if farming practices suited to the unique Australian environment are not researched, then soil fertility will continue to fall, and salinity will continue to spread through areas that have a water imbalance. Without development of a maturity in agricultural methods – including replacement of elements removed in farm produce, practices that maintain a deep water table, and maintenance of a rich microbial life in the soil – Australian farming will continue to deteriorate.

Of concern to the Senate Committee's present inquiry – if Agriculture is to be continued – at the same time that water tables are being returned to pre-European settlement levels, fundamental changes must be made in our approach to using the continent's low fertility soils, which are underlain by saline bedrock.

Species

Once salinated soils have had their water-tables lowered to agriculturally-feasible levels, agricultural research into crop species, and tree varieties, which will maintain a sustainable environment, is essential.

Trees in the forestry strips would need to be fast-growing, hardwood species; they would be chosen for suitability to their environment and would probably be selected from the range of hybrid halophytic eucalypts produced by the *Saltgrow* nursery in Queensland.

Rotations

The strips of trees and field crops would be rotated every twenty to twenty-five years, depending on the time it took for the timber to reach millable size. In the cropping strips between these long-term forests, cereals, field crops and pasture would be rotated as in present mixed farming**.**

Irrigation

Water would be applied to crops using drip or subsoil irrigation methods, and this would occur usually before dawn. The amount of water applied would be monitored constantly to ensure that the water-table did not rise unduly.

Life of the Soil

WfA would promote the use of methods that were conducive to the growth of microbes and worms in the soil: this would cause an accumulation of humus in the topsoil, ensuring retention of moisture in the root-zone. These conditions would be created through regular irrigation, subsoil ploughing, the growing of green manure crops, and ensuring that there was a reasonable plant cover cooling the soil at all times.

Economics

Digging Water Flow Collectors, installing pumps, laying pipes, and building salt factories to establish the WfA, complete desalination system would be costly at the start. However, L. Hogan has estimated that a typical system would reach the break-even point after eight years; and that after the first crop of timber was harvested (20 –25 years), installation costs would have been covered, and a particular instance of the WfA grid system would go into profit.

Engineering Work

A civil engineer with an extensive career, Laurie Hogan, has considered throughout his working life how he might apply his engineering knowledge to finding a solution to Australia's problems of water supply and salinity.

He has refined a system that involves the recycling of irrigation water, comprising desalination and re-use of ground-water plus the efficient collection of run-off from rainfall; the final result, which incorporates these factors, involves the redistribution of water through a selected inland area via a Water Grid that ensures equitable water distribution for irrigation. Reafforestation with commercially usable hardwood, of half of the agricultural area assures a low water-table and a long-term profitable investment.

The setting up of a small WfA grid is probably beyond the resources of a single farmer, or group of farmers; it is also probably outside the operating plan of a multinational corporation.

The construction of Water Flow Collectors, laying and burying of pipes, erection of pumping stations and, of course, the installation of a salt factory are all cost intensive activities, which are not likely to be justified by any private agricultural enterprise – or, even, a consortium of farmers.

For this reason, it is foreseen that public sponsorship would be the only way that effective desalination systems could be installed – both for single units and for the co-ordination of single grid systems, which will be amalgamated to form larger grids containing two, or more, salt factories.

Prior to the setting up of a first water grid, it would be necessary to tool up for the making of special-purpose 300mm PVC piping, and for the solar-powered electrical generators to be built into Collector roofs. This would also need considerable seed capital, which would most likely come from a government source.

Operational Costs

Considering that agriculture in Australia must be changed to become sustainable – or otherwise have large parts of the nation's farmland become salty deserts – turning the tide on salinity is, in fact, a national emergency, and there is, in the Constitution, provision for the government to step in, in such cases.

Energy for Desalination

Discovery of a low-cost process for the desalination of saline groundwater is a valid subject for research. It is likely to involve reverse osmosis, but, if so, the method of creating the electric power for this process is open to investigation: it would probably involve some way of converting solar energy to electricity

Replacement of Minerals taken from the Soil

A vitally essential part of a sustainable agricultural system involves maintaining the fertility of the soil, and, in large part, this means replacement of elements that leave the property in produce. With implementation of the Water for Australia system – involving the recycling of water on a farm, and a greater intensity of agricultural production – the maintenance of long-term soil fertility would require considerable investment in ensuring the replacement of minerals that were removed in crops.

To be certain that desalinated farmland did not suffer 'mineral-mining' as a result of the inadequate application of mineral fertilizer, crop analysis combined with the provision of financial assistance – to ensure a suitable level of fertilizer application – would probably be an essential part of farming within a water-gridded, desalinated area.

Monitoring of Soil Chemistry and Water Levels

As well as analyzing the levels of minerals leaving a farm in trees, crops and stock, the actual soil of such farms would need regular monitoring for changes in the levels of its minerals. Such testing, because of the use of recycled water, together with the associated replacement of minerals lost, would be an essential requirement in using the WfA system – ensuring that it did not accelerate the depletion of minerals.

Ongoing Research

Implementation of the WfA system, would be a new step in sustainable agriculture in Australia, and hence, a 'work in progress.' For this reason, an additional cost in the innovation process would be ongoing research, which monitored the system for unexpected changes in the soil, such as changes to the organic matter content, or deterioration of soil structure. Of course, on the positive side, some additional research costs would involve attempts to further maximize plant and animal husbandry in water-gridded areas.

Balance Sheet – Installation of the Water for Australia Scheme

While there are costs associated with the running of desalination plants and the pumping of water, the overall benefit of using recycled water via Water Grid systems is all in the positive.

Hardwood Timber

Planting the newly developed, fast-growing hybrid eucalypts, and watering them judiciously, Australia will produce, sustainably, a valuable product that is in demand and produced elsewhere primarily from native forests: hardwood timber.

Increases in Productivity and Value of Land

Farmland that uses water recycling and which maintains a deep watertable, while benefiting from irrigation, is decidedly more profitable than the same land which formerly supported only dryland farming, and depended for its moisture only on rainfall.

The value of land incorporated into a water-grid will rise in value considerably, and this will offset the expense occurred in having the Water Flow Collectors, pipes and salt factories installed.

Industrial Development from Recovered Salt

Salt recovered from groundwater is rich in minerals, and does not contain only sodium chloride. Thus, an industrial complex will grow around an initial Desalination Unit; and, within these surrounding commercial concerns a number of elements will be extracted while other salt products, such as pool salt, will be refined. A valuable resource, which currently drains to the sea, or fills agricultural land, will be recovered and utilized for profit.

Water Grid

Throughout a water-grid system, it will be possible to redistribute water to make up for irregularities in natural rainfall. This will make agriculture in these areas much more predictable and reliable. Owing to the recycling of water and to the fact that trees make up fifty percent of crop production in gridded areas, the climate in these areas will improve. The installation of water grids, with their associated forests, is probably the best method of drought-proofing Australia, while also ensuring the national food supply.

Input of water to the Inland via the Water Grid

Up to now, water has been the limiting factor in the development of inland Australia. With the existence, however, of a system based on the pumping of water, it is only sensible to use this capacity to take in additional water as required. This could just as easily be sea water as tropical rainwater.

A Water Grid installed not far from an ocean, such as in southern South Australia or near the southern coast of Western Australia, could, with the laying of additional piping, draw seawater into the grid. This would add water, for irrigation, to farms within the grid, and supply the chemical complex with salt additional to that yielded from groundwater. Such a link between the ocean and a Grid, or alternatively, between tropical rainforests and a Grid, would buffer Australian agriculture against seasonal fluctuations in rainfall.

Projected Break-even Point and Profitability

While the costs of tooling-up for, and installation of, a water grid and its associated salt factory, are high, correspondingly, the profitability of crops and stock grown in areas using such recycled water are similarly high. This means that the time taken for the profit on agricultural products to cover installation cost is relatively short: the estimation of time taken to reach the break-even point, where profit covers initial cost, is approximately eight years. After that, profitability rises quickly and the system becomes fully profitable with the harvesting of the first timber crop: this is in the range of twenty to twenty-five years depending on the environment and the type of hardwood timber grown.

After the first cut of timber, the system should be fully paid-for, and generating wealth.

Progressive Funding

While the cost of setting up a Pilot Project would be high, it would start making some profit within the first years, and this would continue to grow over the first two decades. However, it would not be until the first timber crop was cut that the full establishment cost would be covered. As soon as the first salt factory was established the grid could be extended without excessive cost. Economies of scale would apply to Grid growth, and the profitability of extended areas would be greater than that of the initial project. As a public utility with a small profit built into its charges, the Water Grid's income would soon cover the cost of its expansion. After the first timber stand was cut, the establishment cost of additional Grid squares would be covered progressively by revenue from users of the system.

Administration

Owing to the fact that the efficient management of Australia's water is a matter of national survival, it would probably be best for a Water Grid system to be administered by a publicly accountable statutory authority rather than a profit-driven private corporation. Salt factories, being vitally essential to the successful operation of Water Grids, would probably also be best retained in public ownership.
The satellite chemical industries making use of the salt products of the factories, however, would probably be most successful as private concerns.

A Statutory Body

Who runs a Water Grid? The administrative body operating a Grid would be responsible for its growth and development, and, as such, would be responsible for making the decisions about where to procede with the installation of new Water Flow Collectors, pipes, and additional salt factories. Such decisions would need to be in line with the good of the nation, and hence, the authority making them ought to be above matters of private profit-making.

A Pilot Project

The place to start would probably be with a unit small enough to be a controlled experiment, but large enough to be self-contained. The WfA designers suggest that such an initial Water Grid be a salinated area of farmland that is out of production, and of 100 sq. km. Would it be possible to set up a pilot project to test the scheme?

Ownership

Considering that in a dry continent like Australia, water can be equated with life, it would seem risky for government to sell to private interests a utility designed for the equitable distribution of water in arid areas. For reasons of national security, it would seem that the equity of a national Water Grid should remain with the people.

Conclusion

If there really is a catastrophe in Australian agriculture, and land really is being permanently lost to production – and possibly converted to desert, then can government rationally ignore the Water for Australia proposal, which presents a scheme for the sustainable management of water in threatened agricultural areas?

Robin Gaskell B.Agr.,Dip.Ed..

Inclusions

Water Grid

Artist's representation of Water Grid
Operational flow chart of Water Grid
Schematic map of National Water Grid
The Water Grid Transfer System
The National and Environmental Plan

Water Resources

The Transfer of northern Australian Tropical Run-off
Groundwater Resources of Australia – map
Surface Resources of Australia – map

Salinity

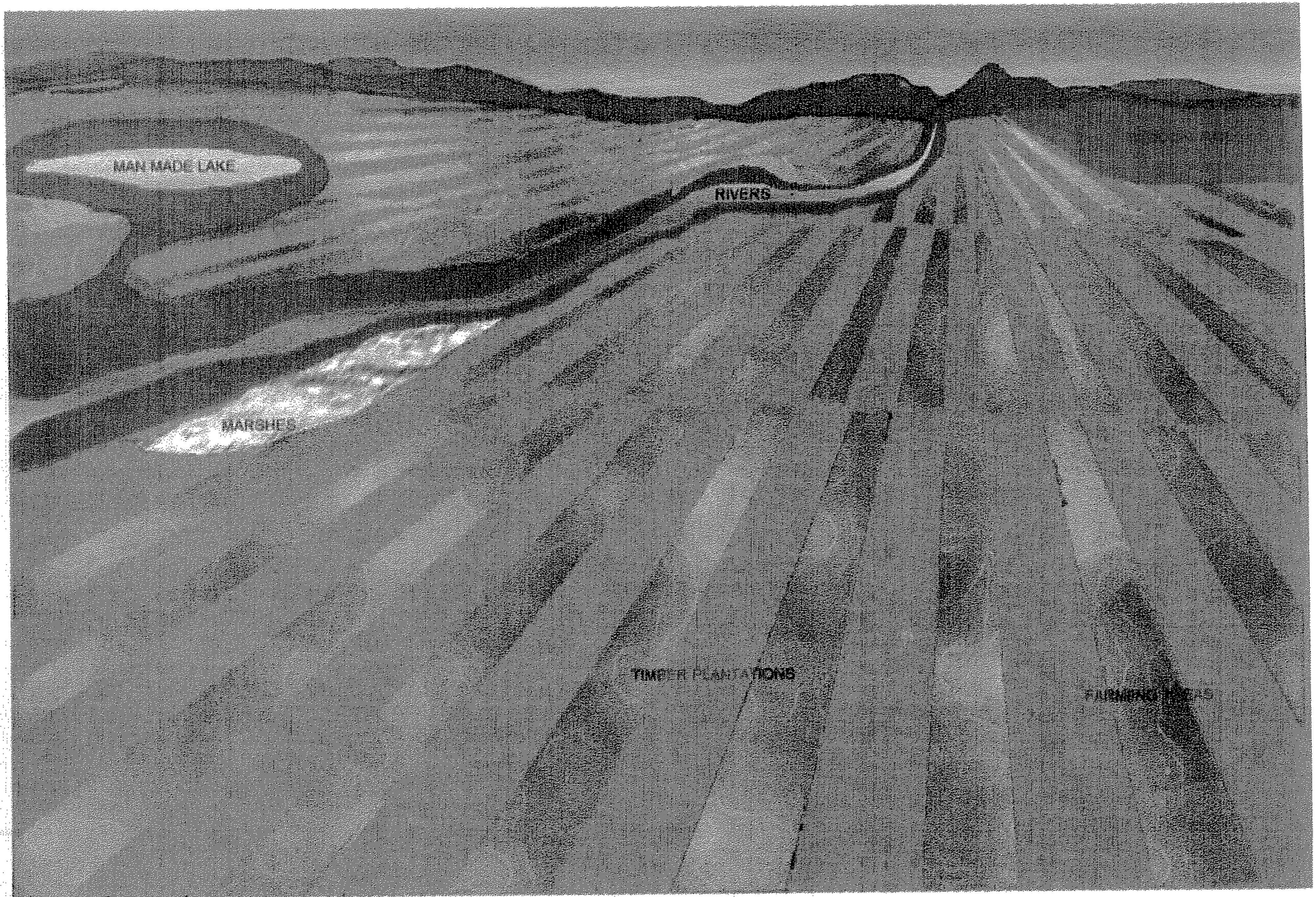
Groundwater Salinity – map
Monitoring the White Death **– Chemistry in Australia**
Salinity 'fortunes for taking' **– The Land**

100 sq. km Pilot Project

Pilot Study – plan
Setting up a Trial Area to Evaluate Proposed use of the Water Grid System
Pilot Project – supplementary information
Pilot Study – Critical Path Analysis
Pilot Study – Management Cash Chart

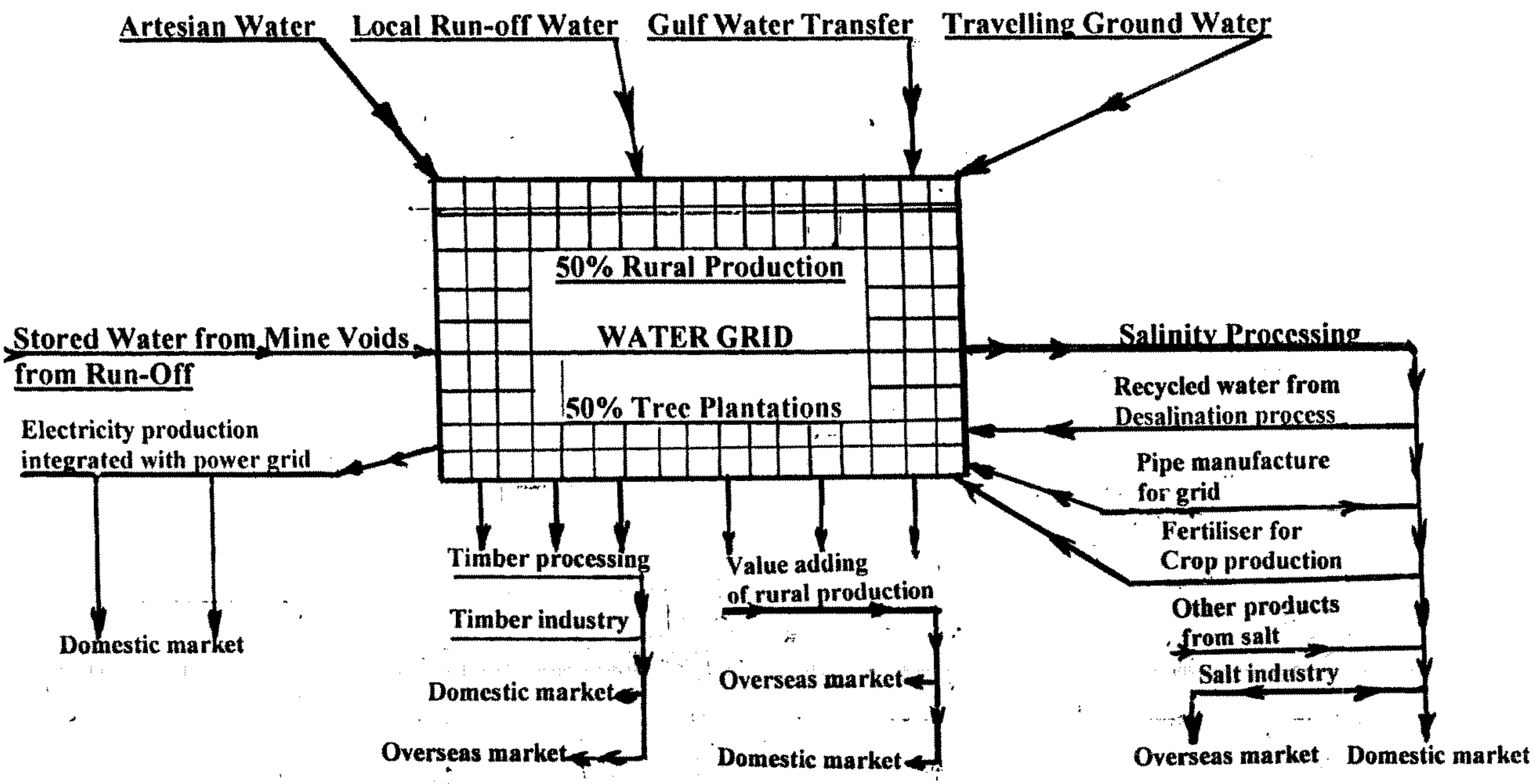
Supplementary Information

Saltgrow Hybrid Eucalyptus
Timber Values Forecast
WfA Measurements and Facts


MAN MADE LAKE
RIVERS
MARSHES
TIMBER PLANTATIONS

WATER FOR AUSTRALIA

Explanation of Grid Operational Flow Chart



AUSTRALIAN
MINING INDUSTRY COUNCIL

Mining and mineral processing activities are widespread across the Australian continent. From the days of the first mineral discovery - coal in NSW in 1796 - explorers have searched the length and breadth of the continent for the riches hidden beneath the surface.

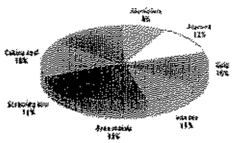
The gold discoveries of the 1850s and later gave this search added impetus, and encouraged people to move out of the main centres of population further and further into the interior.

The mineral riches won from the earth led to the establishment of many of Australia's major cities, such as Ballarat, Broken Hill and Kalgoorlie, and in more recent times new centres such as Mount Isa, Roxby Downs, Karratha and Newman.

The resource industries today produce the bulk of Australia's exports. In the year to 30 June 1991 mineral resources exports, including oil and gas, totalled $27,034 million - about 53 percent of Australia's merchandise exports and about 43 percent of all exports, including services.

In that year Australia's biggest export by value was black coal, both for steelmaking and for power generation, which earned $6,452 million. Other major mineral exports were bauxite, alumina and aluminium, $4,895 million; gold $3,884 million; iron and steel $2,826 million; and crude oil $2,004 million.

The Composition of Australian Mineral Exports 1990/91



- Mine being developed
- Mine
- Deposit
- Smelter
- Refinery
- Export port

- Coal producing area
- Individual operating mine
- Large deposit

- Oil and/or gas fields
- Individual (producing) oil and/or gas field

KEY TO MINERALS

- Al Aluminium
- Cu Copper
- Fe Iron
- Pb Lead
- Ni Nickel
- Sn Tin
- Zn Zinc
- Au Gold
- Mn Manganese
- Ag Silver
- W Tungsten
- D Diamonds
- Op Opals
- Ge Other Gemstones
- Sa Sapphires
- A Asbestos
- Gy Gypsum
- Ka Kaolin
- Ls Limestone
- Mg Magnesite
- MS Mineral Sands
- P Phosphate Rock
- RE Rare Earth
- Sa Salt
- Si Silica
- T Talc
- U Uranium

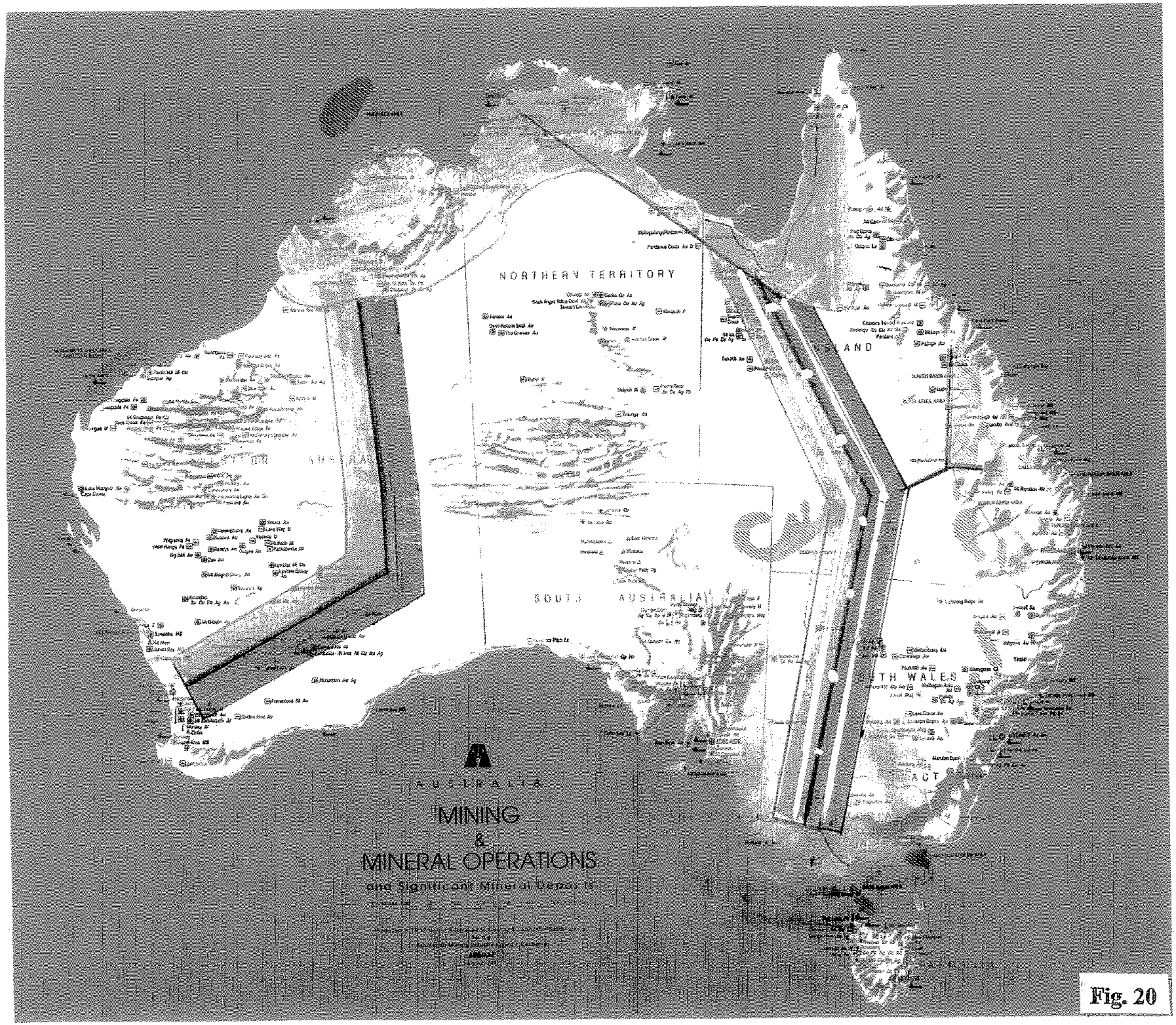


Fig. 20

COAL

QUEENSLAND

Blair Athol
Blackwater
Collinsville
Cook
Curragh
German Creek
Oaky Creek
Peak Downs
Saraji
South Blackwater

NEW SOUTH WALES

VICTORIA

Anglesea
Loy Yang
Yallourn

GOLD

Big Bell
Boddington
Kalgoorlie

WATER FOR AUSTRALIA

The Water Grid Transfer System

What is a Water Grid?

The water grid is a series of buried pipe mains, forming a square pattern of catchments, one square kilometer in area. This configuration can be changed to suit the topography of an undulating land surface, maintaining the one square kilometer catchment area.

Each catchment has a Water Flow Collector (WFC), situated at the lowest outfall point of the catchment boundary. Each WFC has a storage capacity of 10 megalitres of water. In times of crossland flows, including flood, the WFC is filled, and the flow proceeds into the next catchment, filling that catchment's WFC. This is repeated until the flow is diminished, or all the WFCs are filled and ready to draw on for grid transfer or irrigation needs.

The Function and Benefits of the Water Grid

Water grids are designed to harvest, store and distribute water evenly over a given area, to be used for sustainable farming activities and to supply the water needs of large-scale tree plantations.

The establishment of water grids would provide a tool to control salinity, at the same time creating profitable salt and timber industries to fulfil domestic and overseas markets.

The grid harnesses water from all the sources shown on the grid operations flow chart.

The small catchments allow for fast collection of precipitation before the clouds that brought the rain leave the area. This reduces loss from evaporation and soak that now occurs from the very large catchments that now exist.

The bore adjacent to a WFC supplies traveling ground water and artesian water. A grid allows the repeated use of traveling ground water for irrigation. Some losses will occur from evaporation and plant transpiration, before the water is returned to the ocean outfall.

The energizing of the water grid system is provided by solar power generated by a specially designed WFC roof. (The patent application has been lodged). The water grid's electricity supply could be integrated with the power grids, on an exchange basis, pumping in off peak time would make this an attractive proposition.

Water grids are designed to be centrally controlled by the use of power activated valves that are between slice and gate valve design. The system can be over-ridden by hand in times of emergency or special maintenance.

Water grids are designed to suit the irregular and scattered rain and weather patterns to collect and distribute the water where required in this low profile continent of Australia.

,The National Water and Environmental Plan

Laurie Hogan and Barry Dunn

The idea of developing a plan to find a sustainable water solution for this low profile, dry island continent of Australia started in 1953. Since then until now, the national water grid and environmental plan has been painstakingly researched and developed.

Australia will not reach its true potential until we solve the water and salinity problems that inhibit long-term sustainability.

Water for Australia has produced a practical plan including cost benefit analysis. The plan has been formulated by using a holistic overview and lateral thinking, taking all of the presently foreseeable problems into account and finding answers to each.

There have been many good ideas put forward during the long investigative period of the WfA plan. We have selected five, which would work in harmony with the Water for Australia plan, to be applied where best suited in the fight against the flood, drought and salinity syndrome. They are as follows:

- The slitting and forming of earth to form a microcosm environment; this is an excellent method to restore depleted soils back to fertility.
- The Peter Andrews system, using plants to cleanse the river or creek flows and a series of detention weirs and canals to allow water to pass though topsoil of selected areas improving the soil profile.
- The old man saltbush system, to be used as a stock feed in dry marginal areas that are not gridded and are frequently drought stricken.
- The catch soak drains running in level contours around slopes, this is a well known system that allows water to soak through the top soils slowing down the run off and improving water conservation.
- No till farming, which is suitable for special soil types and for use in areas where it is necessary to reduce the cost of grain production.

These systems all require water to function, coupled with the Water for Australia plan would ensure the water required which would enable Australia to overcome most of its water, salinity and environmental problems.

Australia's total average annual water run-off (as per Civil College technical report inventory for the 90s) is in the order of 397 million megalitres. Given a rate of $200 per megalitre, the total value would be ninety seven billion dollars. We divert approximately 25% of the total run-off. This diverted amount is small by the developed world standards. This 25% represents 99 million megalitres, at a rate of nineteen billion dollars.

Water for Australia's aim is to increase the amount of diverted water from 25% to 50%. This would produce an extra water value of nineteen billion dollars per annum and make available extra storage of 99 million megalitres. We harvest this water by collecting run-off from small design catchments, by the re-use of traveling ground water, plus water from desalination of lowering water tables. In addition, we would use some of the excess of our northern cyclonic wet seasons, and when necessary, desalinated ocean water. This additional water would be stored or reticulated on to the rural zones by the use of water grids. This water would be metered and applied to the crops by drip or subsoil irrigation.

P2...

Water Grids
The design of the water grid system is harvest water from where it is in excess and transfer it to where it is needed.

WfA first promoted piped water grids in the 80s — when no one appeared to listen. Then a Queensland property piped water from a bore, serving its drinking troughs. This was followed by the WimmeralMalley piped water scheme; and, Richard Pratt started replacing some open channel irrigation with pipes all of which provided substantial water savings. The obvious success of these projects has proved the value of the water grid system. Water grids substantially reduce losses from evaporation and soak and the resulting salinity.

The pipe grids are made up of 300 millimetre ID plastic pipes, energised by gravitational flows through drive heads, and pressure from the artesian basin. Solar powered pumping would operate at each water flow collector.

This arrangement maintains a pressure of 276 Kpa (40 lbs per sq.inch). These pipes form a I square kilometre grid pattern, laid in a 1 metre deep trench for long life and ultra violet protection. A 10 megalitre water flow collector (water storage facility) is constructed in the corner of each square catchment, or in a depression in the low side of the catchment. This pattern will be used in low profile country, changing shape to suit the topography, in undulating areas zoned rural.

The enclosed water grid system allows water to be transferred long distances with minimal contamination compared with flood waters, which pick up faeces, dead animals and also spread fly and mosquito-borne diseases. One of the main benefits of the water grids is the rapid collection of water in the small designed catchments. This run-off is harvested before most of the cloud cover that delivered the precipitation leaves the area. This helps prevent huge losses that now occur from evaporation and soak in the very large catchments that now exist. Not much of the soak water ends up in the river systems, but journeys to the ocean along the impervious layers within the decayed mantle.

A bio-stabilisation system incorporated into the grids allows for desalination of the topsoil to suit the intended crops by stenlising, scrubbing, adding organic matter, correcting and balancing minerals and adjusting the pH as the particular soil requires. This soil rehabilitation could not take place without the water grids, salt factories or bio-stabilisers. Combining the grid with biostabilisers will return our depleted soils back to high fertility production, and will guarantee the water that is needed to drought proof the selected rural zones.

The grids' operational functions are to harvest run-off water, ground water, and desalinated water, that is stored or reticulated for use in classified rural zones and for other national use. The grid operations are computerised and operated from central control stations. This is made possible by using solenoid slice or gate valves to direct water through the grids. Salinated water would be piped from farm collection dams on salt affected properties to the closest salt factory for treatment via 100 millimetre ID plastic pipes running parallel and in the same trench as the 300 millimetre ID fresh water mains. This would allow continuous operation in both salt reduction and water transfer.
All water grid pipe mains are buried along with computer control and electricity supply transfer cables.

P3...

The selection of PVC plastic pipes are made for the following reasons:

- Plastic is light to transport.
- Flexes with ground movement.
- Smooth bore reduces friction.
- Has a long life when buried.
- The main component of the pipe manufacture is our problem salt.

Land Zoning
It would be ideal to introduce land zoning of the non-urban areas of Australia. This should help settle down much of the debate by the stakeholders within each category and prevent overlapping in management of the various zones. The following is a suggested framework for the zoning:

Environmental Zone
National Parks, native forests, wetlands, lagoons, rivers and sanctuaries, native title and heritage areas, and archaeological sites, ecological corridors and reserves for protected species.

Rural Zone
All types of farming, including salt resistant tree plantations, and rural support industry.

Mining Zone
Underground, open cut mining and quarry extraction areas, designed to leave behind water storage facilities.

Forestry Zone
Land set aside for natural forests and forestry support industries.

Special use Zone
Government use, defence, water storage, utility easements, (portions of native title could be considered for rezoning to any one of the groups, at the initiative of the Aboriginal people) and areas set aside for future use.

Tourism Zone
Selected areas for tourism, which can occur in all zones.
As non-urban zoning would require much debate and long preparation for legislation to be effected, discussion should start as soon as the first grid project is on the drawing board.
Once zoning is legislated, it should help reduce the arguments between the environmentalists and other interests.

Salinity
It is now well known that the mishandling of the salinity problems in ancient Mesopotamia caused the present deserts of Iraq. Australia has used much the same open channel and flood irrigation practices as they did some 4,000 years ago in that once fertile agricultural country. Land degradation from the same causes is happening in Australia and the same deserts will result if the old practices continue, It is useless to contemplate any long-term irrigation, without putting in place a method to reduce salinity on the topsoils.

P4...

That is why WfA has placed the importance of the establishment of 10 salt factories and the use of bio-stabilisers. We will be using modern technology as necessary to reduce salinity by four million tonnes of fossil salt per annum.

These salt factories would produce all of the pipes and fittings needed for the water grid, using 57% salt and derivatives of oil or coal to produce the plastic pipes of PVC (polyvinyl chloride). There would also be a range of salt products for domestic and overseas markets. This salt industry would be both profitable and sustainable adding billions of dollars to the GDP. There are critics of PVC piping, and we have taken a balanced approach with its selection.

Mining

With our current open cut mining, Australia is missing out on a great opportunity by backfilling open cut mines. We need the foresight to mine to a hydraulic design. Each one of the often very large excavations produced by current mining practice, represents a potentially high capacity safe reservoir, which would be incorporated into the national water grid plan. This is a vital component of the plan and backs up the operation of the water grid projects. This would not create a great outlay for the mining industry, when the cost of reclamation is taken into account.
The result would be pristine lake water storages, which can be used for aquaculture, surrounded by parklands and native vegetation for the benefit of recreation and tourism.

The problems associated with acid and leachate have been dealt with in the design criteria of the WfA plan. There are seven operational mines within Queensland's Bowen Basin.
If the largest open cut mine in the basin is worked to a hydraulic plan, it would produce a void when mining operations cease and after lining, capable of holding four Sydney Harbours of back up water.

Tree Plantations

Tree Plantations are an important segment of the National Water and Environmental Plan. These proposed plantations would be grown in 50% of the rural zoned areas. The plantations would be set out in a north/south configuration, half a kilometer east/west and five km. north/south. They are offset as shown in the plan. This design allows for fire protection access, some wind protection for crops, while allowing sufficient sunlight for crops and farm animals. These plantations help bring back fertility by returning leached nutrients to the soil from bark and leaf litter.
The trees also maintain lowered water tables thus helping prevent salinity. The role these plantations play is important in the sustainability of the plan. They also assist in reducing global warming and preserves native forests.

The harvesting of these tree crops will support a very large timber industry, providing several thousand jobs in the country, where they are needed, and will add substantially to the Nation's GDP.

Each plantation is composed of a monoculture of fast growing native trees selected for straight trunks and salt tolerance. Overall there would be a variety of types or species of native trees used in different plantations. Some may be fire resistant or enrich the soil or be useful in other ways.

P5...

Going back some thousands of years to the ancient Middle East, examples may be found that prove the importance of native trees to survival (From Ronald Wright's 'A Short History of Progress')

"A small civilization such as Sumer, dependant on a single ecosystem and without high ground, was especially susceptible to flood and drought Such disasters were viewed, then as now, as acts of God (or gods). Like us, the Sumerians were only dimly aware that human activity was also to blame. Flood plains will always flood, sooner or later, but deforestation of the great watersheds upstream made inundations much fiercer and more deadly than they would otherwise have been. Woodlands, with their carpet of undergrowth, mosses and loam, work like great sponges, soaking up rainfall and allowing it to filter slowly into the earth below; trees drink up water and breathe it into the air. But wherever primeval woods and their soils have been destroyed by cutting, burning, overgrazing, or ploughing, the bare subsoil bakes hard in dry weather and acts like a roof in wet. The result is flash floods, sometimes carrying heavy loads of sift and gravel—like liquid concrete."

<u>The Environment</u>

The plan is in balance with the environment. In fact, it improves the river systems in the following ways: it provides most of the water for rural production by collecting water as stated earlier. Without the plan this water would not be available. The grid water lessens the rural demand now taken from the river flows.

The environmental part of the plan is to protect the running rivers and creeks by gradually installing fenced wild life corridors between 20 and 50 meters either side of the riverbanks. The make up of this bush filter plan would be of native trees, shrubs and grasses. This allows wildlife to access National Parks and habitat areas by the river routes.

The riverside growth acts as a filter for farm chemicals and nutrient run-off. These fenced corridors protect riverbanks and the extra shade provided by the trees plus the increased river flows, helps to reduce toxic algae growth. The protecting tree and shrub cover on the banks also reduces flood damage.

In times of long, intense drought, the plan provides the river systems with some water to maintain a low flow.

Tree plantations are another environmental improvement. They supply the timber industry's needs, without destroying old growth forests. The salt tolerant plantations are grown in harmony with the farming operations by protecting the soils and crops, and reducing salinity by controlling water table levels. The timber crops are rotated with the farm crops when a plantation is harvested. This rotation procedure, using mainly organic fertilizers and chemicals if needed, guarantees sustainability in our future farming practices.

Ten salt factories also benefit the environment by gradually reducing the salinity problems of Australia.

The footprint of the grids is not as big as one might think when first hearing the plan unfold. The rural production zones are the only areas where the gnd system would be laid, apart from some single pipe easements, bringing in water from some of the storages.

P6...

Surely there is sufficient balance provided in the plan for the adoption and construction of the national water and the environment plan.

We should cease the rhetoric and construct a rational future plan using a blend of modern technology and common sense. The mistakes of the past are there for us to see so that we can now overcome thousands of years of the sad history of land abuse by people not understanding the consequence of their actions.

Financing the Plan

The Water and Environmental Plan is broken up into eight segments. They are as follows:

1/ Construction of the pipe grids and water flow collectors, including energising and running costs, funded by governments.

2/ Construction of major back-up mine storage, funded by governments and miners.

3/ All work associated with river restoration and environmental matters, funded by governments and part of the allocations to the following instrumentalities; the environment, National Parks, tourism, Landcare and private donation of work or cash.

4/ Soil restoration and tree plantations within the rural zones will take place, funded by governments, forestry, farmers and the timber industry.

5/ Salt factories would be funded, owned and managed by farming co-operatives and private investment.

6/ Access roads and public utilities, funded by governments.

7/ Area bio-stabilisation, funded by farmers with help from governments by way of interest free loans.

8/ All other parts of the plan funded by government and stake holders.

All expenditure will be returned to government with a profit over a reasonable time span by the following cash flows and expenditure savings:-

- The sale of 196 million megalitres of water per annum equals thirty eight billion dollars. The return on this water would be from rural activities which ultimately would.be returned to the Government
- A reduction of government funding for drought and flood relief.
- An expected doubling of rural income from rural production.
- Income from newly established manufacturing industries created by the plan.
- Income from growing our timber industry to be one of the largest in the world.

P7...

- Income from a large salt industry producing billions of dollars per annum.
- Income from the increased tax take.
- A large increase in gross domestic product.
- The projects will breathe life back into the declining inland towns and cities.
- Create hundreds and thousands of new jobs, over time.
- Stop the population drift to the coastal cities.
- Rebuild our depleted topsoil and improve our environment
- The new industry of area-rehabilitation, for our now unproductive agricultural land.

The Council of Australian Governments is quite capable of funding this nationbuilding project.

It is vital to build this infrastructure now, while the economy prospers.

The plan should remain intact; no part of the plan should be removed; only input into the improvement of the plan should be considered.

The Transfer of Part of the Northern Australian Tropical Run-off

This proposed transfer would supply the water grids of the three Eastern States. It is both practical and affordable and though it may appear a large infrastructure undertaking, it would be an essential asset to secure Australia's future.

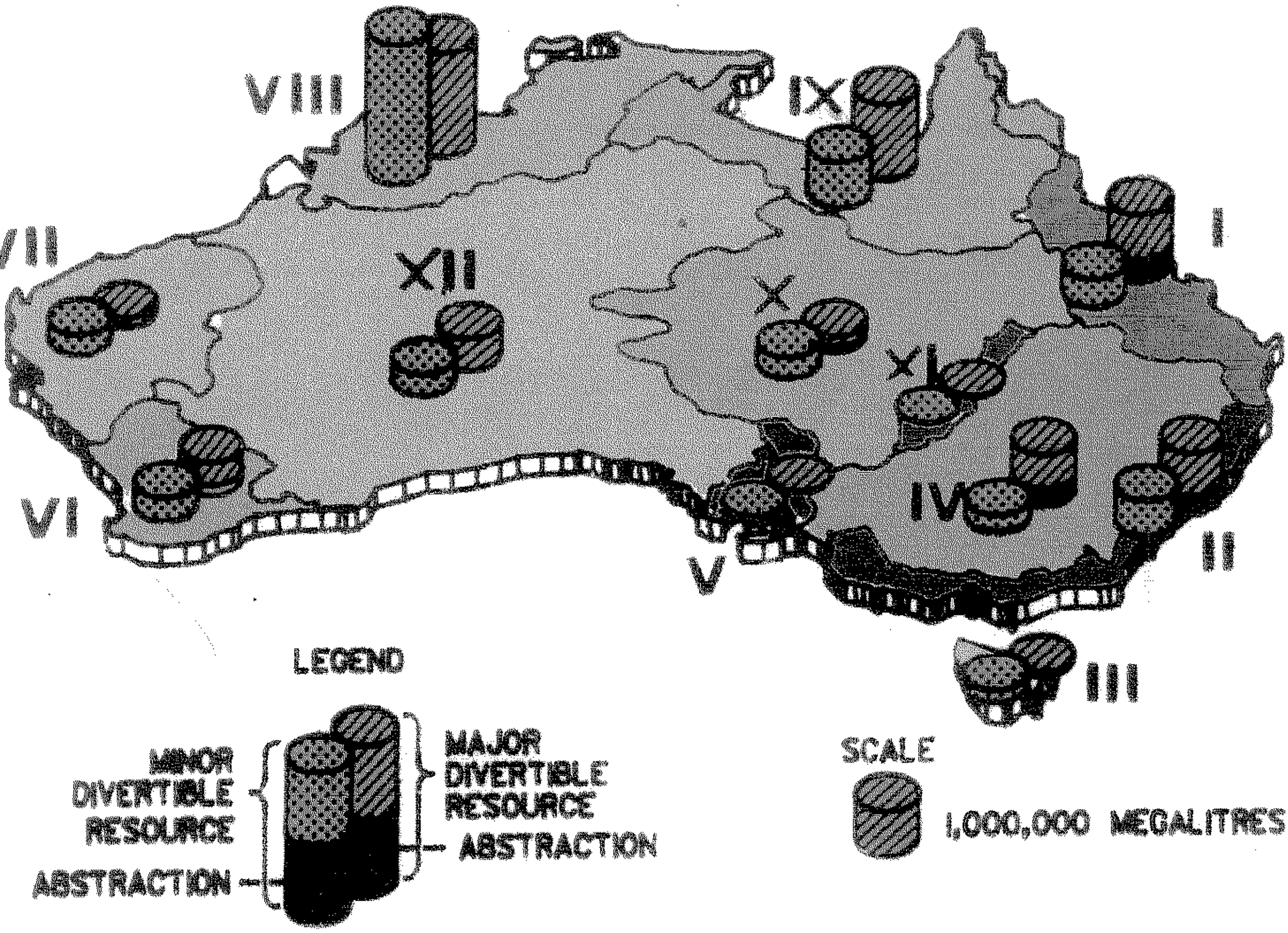
The Northern Gulf of Carpentaria's mean annual run-off is in the order of 92,500,000 million megalitres per annum, which takes place in the wet season.

The plan requires the collection and pumping of 32,472,000 megalitres from this source over 300 days. As the wet season last approximately 90 to 120 days, it will require lake type storages sited along the catchments with a total storage capacity of approximately 75,000,000 megalitres. This storage is in excess of requirement but allows for evaporation and local use, also allowing for poor wet seasons.

The grid system provides the opportunity for the north/south transfer of part of the tropical rainstorms occurring in the Gulf of Carpentaria regions of water at 6,780 megalitres per day, which equals 2,034,201 megalitres per annum. The balance of the transfer is by 2 culvert tunnels, each to be designed using grade and pressure to have a flow velocity of 600 cubic meters per second. This water takes 6.7 days to reach the southern extremities of the grid, including the rainfall within the grid area. The sum total of all this storage capacity plus the artesian groundwater and traveling groundwater, and desalinated water from lowering water tables, would provide sufficient water for an estimated 660,000 square kilometres of very productive rural activity.

Taking excess water from this region should not create a damaging effect on the fish breeding mangrove area as the water disturbance created by the dramatic high tide effect running in and out provides similar conditions to land flows. The exception is the flood plumes that carry some food, but these flood flows also rip out precious soils and the plumes destroy coral reefs. In balance, taking all the relevant evidence into consideration, it could be said that reducing the amount of flood discharge along the Northern Australian coastline is an environmental improvement.

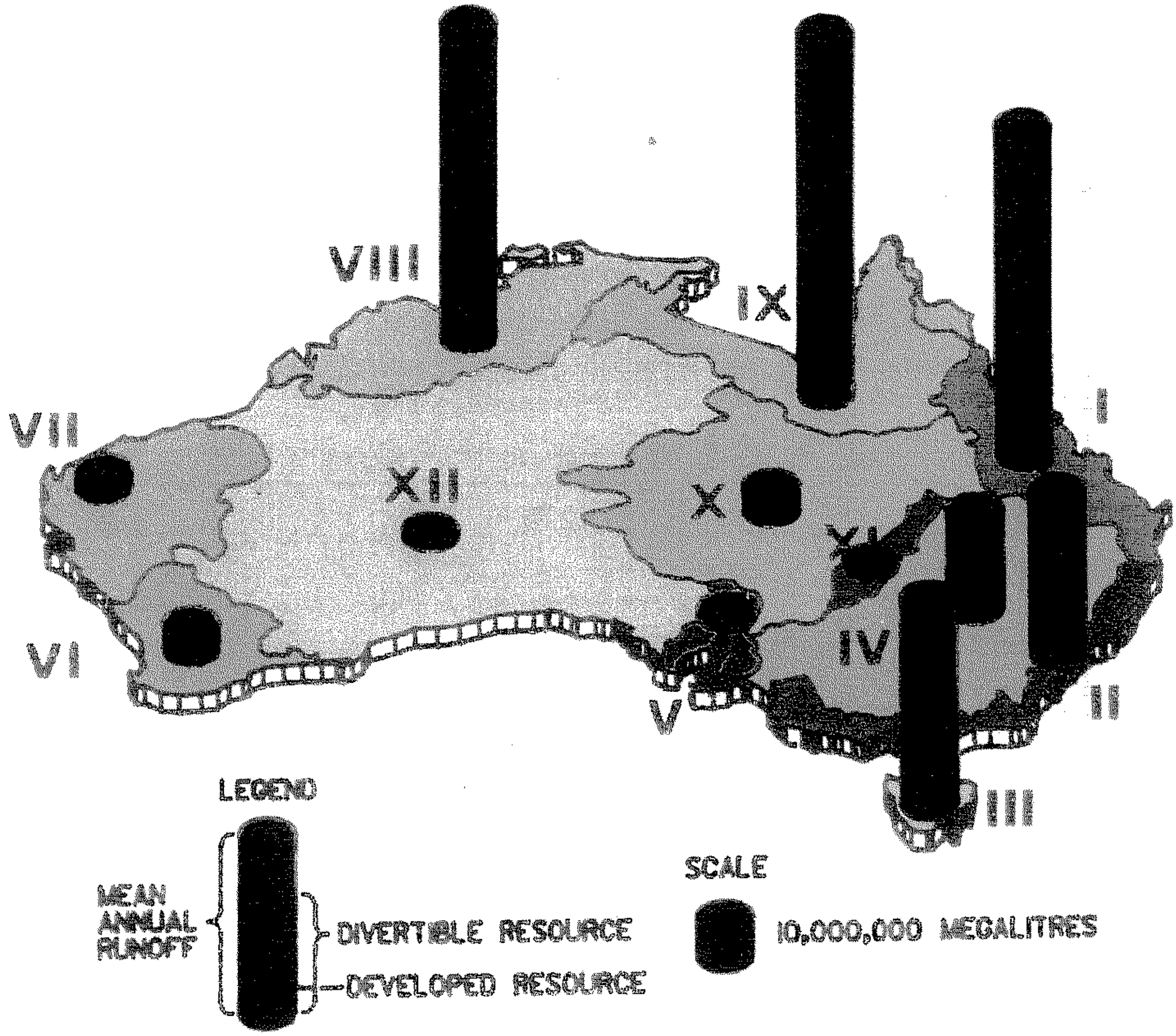
It is certainly incomprehensible to let the greater part of 92,500,000 million megalitres at a value of $18.5 billion dollars, run into the sea and then to desalinate the ocean water at great expense to both the environment and taxpayer. The grid is the answer to using the excess of the precipitation from the seasonal tropical downpours. This excess water should be used to help irrigate the drought stricken land, where farmers are trying to survive and many towns and cities are now short of water.



GROUNDWATER RESOURCES OF AUSTRALIA

(Fresh and Marginal Quality Water)

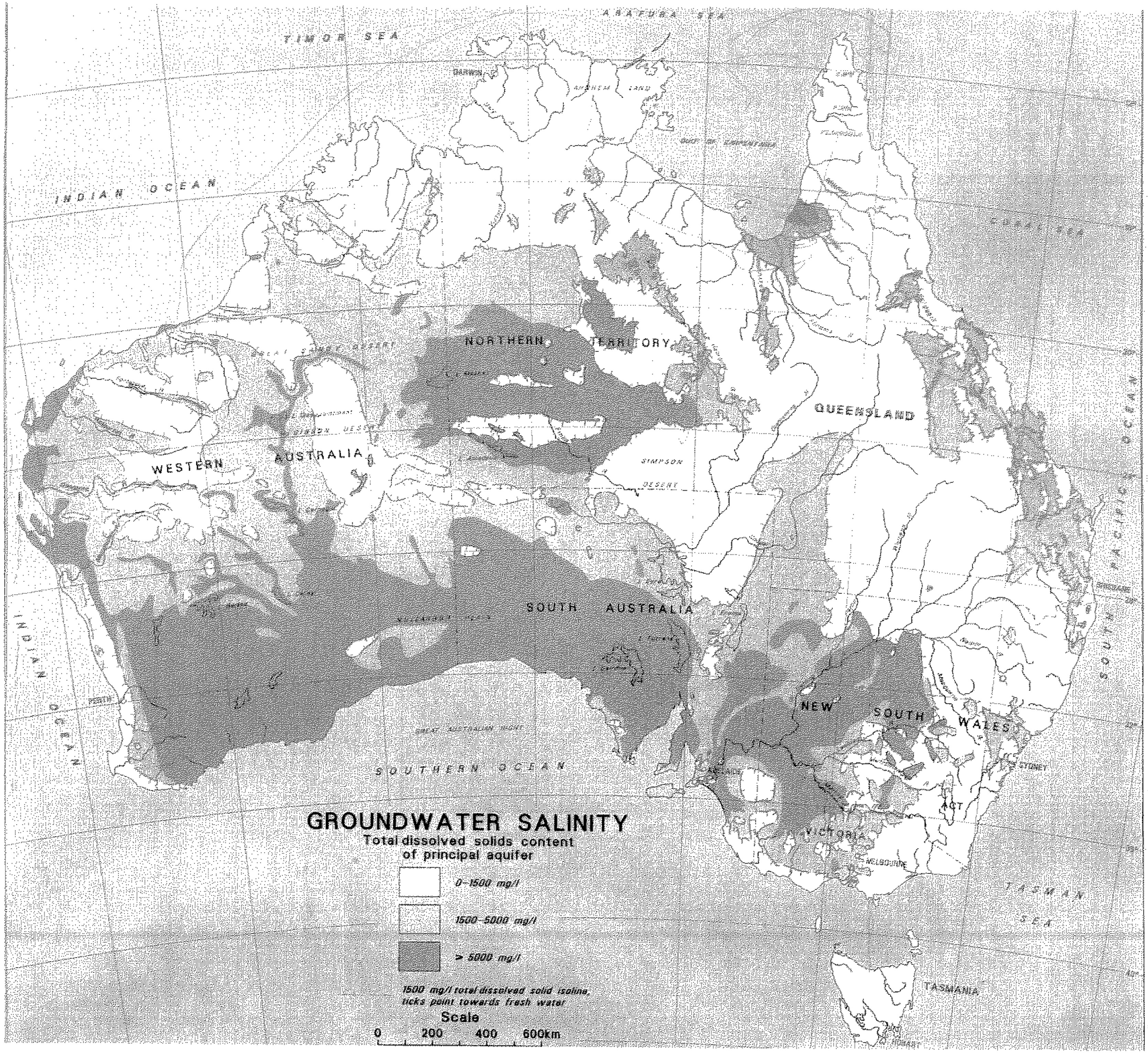
SOURCE : 1985 REVIEW OF AUSTRALIA'S WATER RESOURCES AND WATER USE



SURFACE WATER RESOURCES OF AUSTRALIA

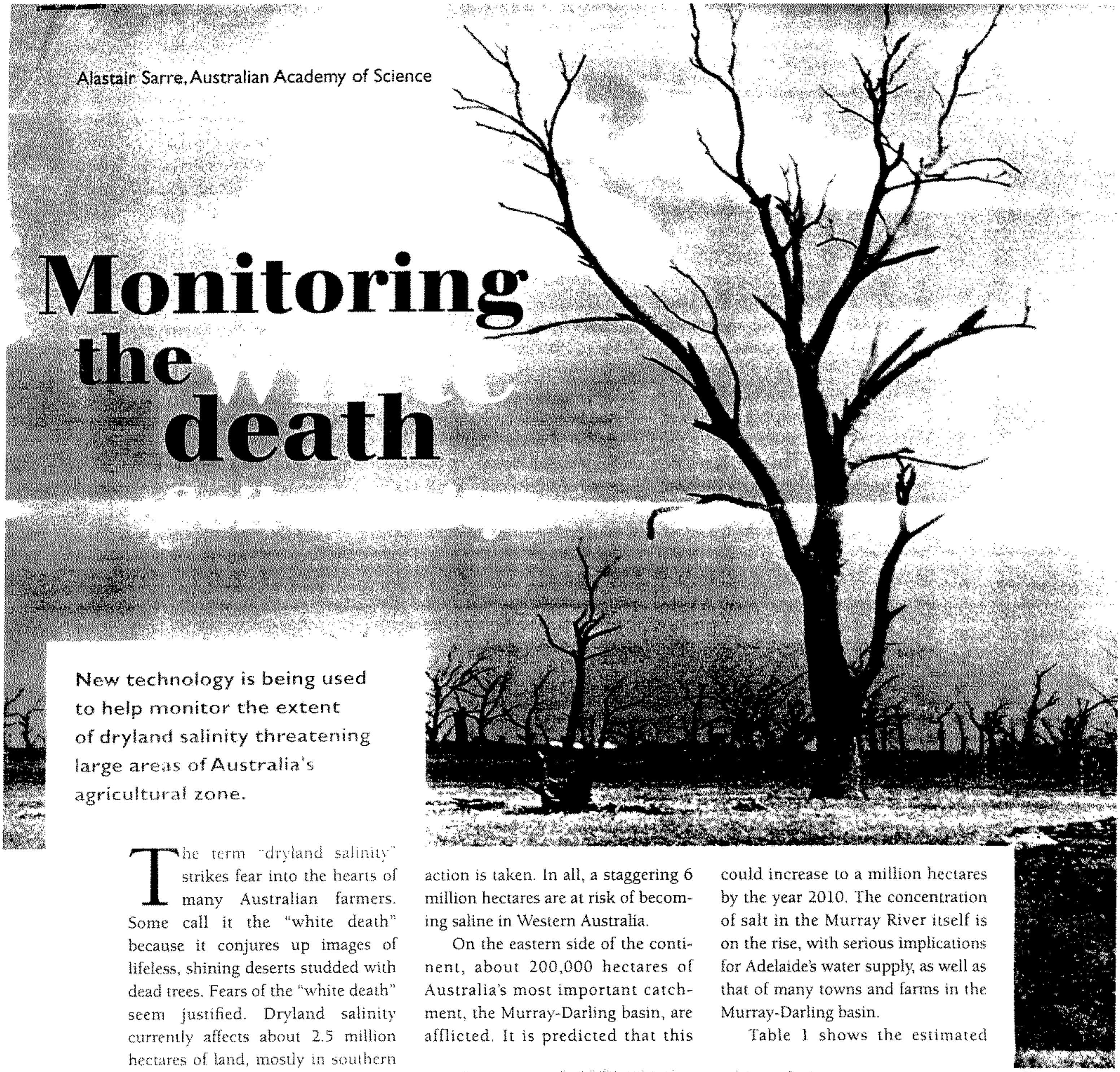
(Fresh and Marginal Quality Water)

SOURCE : 1985 REVIEW OF AUSTRALIA'S WATER RESOURCES AND WATER USE


GROUNDWATER SALINITY
Total dissolved solids content of principal aquifer
0–1500 mg/l
1500–5000 mg/l
> 5000 mg/l
1500 mg/l total dissolved solid isoline, ticks point towards fresh water
Scale
0 200 400 600km
TIMOR SEA
ARAFURA SEA
INDIAN OCEAN
SOUTHERN OCEAN
SOUTH PACIFIC OCEAN
TASMAN SEA
CORAL SEA
GREAT AUSTRALIAN BIGHT
DARWIN
ARNHEM LAND
WESTERN AUSTRALIA
NORTHERN TERRITORY
QUEENSLAND
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
ACT
TASMANIA
SIMPSON DESERT
PERTH
ADELAIDE
MELBOURNE
SYDNEY
BRISBANE
HOBART

Alastair Sarre, Australian Academy of Science

Monitoring the white death



New technology is being used to help monitor the extent of dryland salinity threatening large areas of Australia's agricultural zone.

The term "dryland salinity" strikes fear into the hearts of many Australian farmers. Some call it the "white death" because it conjures up images of lifeless, shining deserts studded with dead trees. Fears of the "white death" seem justified. Dryland salinity currently affects about 2.5 million hectares of land, mostly in southern Australia and causes damage totalling $270 million each year.

Dryland salinity is widespread across Australia's agricultural landscape, but it is worst in the medium-to-low rainfall areas of southern Australia. Salinity "hot-spots" include the Liverpool plains of northern New South Wales, the Yass River valley around Canberra, the upper south-east of South Australia, Kangaroo Island, the Victorian mallee and Western Australia's wheatbelt.

This last is the worst affected: authorities there estimate that 1.8 million hectares in the region currently suffer from salinity. Worse still, they think that this area could double within the next 15 to 25 years if no action is taken. In all, a staggering 6 million hectares are at risk of becoming saline in Western Australia.

On the eastern side of the continent, about 200,000 hectares of Australia's most important catchment, the Murray-Darling basin, are afflicted. It is predicted that this could increase to a million hectares by the year 2010. The concentration of salt in the Murray River itself is on the rise, with serious implications for Adelaide's water supply, as well as that of many towns and farms in the Murray-Darling basin.

Table 1 shows the estimated

Photo: Robert Kerton

Table 1. The estimated number of hectares of Australian farm land affected by salt in 1996 and the number of hectares that could be affected if no solutions are found.

	Hectares salt-affected (1996)	Hectares at risk*
Western Australia	1,804,000	6,109,000
South Australia	402,000	600,000
Victoria	120,000	unknown
New South Wales	120,000	5,000,000
Tasmania	20,000	unknown
Queensland	10,000	74,000
Northern Territory	minor	unknown
Total	**2,476,000**	**>11,783,000**

* Includes areas already affected.

Source: Land and Water Resources Research and Development Corporation, which manages the National Dryland Salinity Research and Development Program on behalf of involved stakeholders and agencies.

number of hectares of Australian farm land affected by salt in 1996, and the number of hectares that could be affected if no solutions are found.

What is dryland salinity?

There are two kinds of soil salinity: dryland salinity (occurring on land not subject to irrigation) and irrigated land salinity. Both describe areas where soils contain high levels of salt. Usually, plants and soil organisms are killed or their productivity is severely limited on affected lands.

Much of Australia's landscape is naturally saline – think of the great salt lakes in our interior. Many of our agricultural lands also contain vast reservoirs of salt, but normally these are held deep within the soil profile where they don't affect plant growth. The problem occurs when this salt is brought to the soil surface by rising water tables.

Surprisingly in such a dry continent as Australia, salinity occurs when there is too much water. To understand why salinisation occurs, you need to understand ground water.

Usually, at some distance below the surface, the soil is saturated with water. It is not quite like an underground lake – the water is most commonly held within the soil profile rather than in some vast underground cavern. The top surface of the ground water layer is called the water table.

Ground water recharge is the amount of water being added to the ground water. If this is higher than discharge, which is the amount of water lost from the ground water, then the water table rises. As it does, the water dissolves salt held in the soil profile, and the salt becomes more and more concentrated as the water moves upwards. If the salty water keeps rising, it eventually reaches the surface and subsurface layers of the soil. The water evaporates, leaving the salt behind.

Why is the ground water rising?

In our quest to prepare Australian soils for agriculture, we cleared trees by the billion. Yet trees played a crucial role in maintaining the water balance in our ancient soil profiles. It was our success in clearing trees that has led to the development of dryland salinity. (Irrigated-land salinity is caused by a similar effect – the application of excess water to land causes the water table to rise. The problem is made worse if the irrigation water itself is also saline.)

Trees help control ground water levels in two ways: by decreasing recharge and by increasing discharge.

Decreasing recharge

Most ground water recharge is supplied by rainfall (except in the case of irrigated-land salinity), and more of it reaches the ground water when trees are cleared. This is because trees develop extensive root systems to trap the water, which is then used for tree growth or returned to the atmosphere by evaporation and transpiration. The amount of water that percolates below the root zone of crops and pastures is estimated to be 10 to 100 times the amount percolating below trees.

Increasing discharge

Trees also play a role in discharging ground water. The roots of many Australian tree species reach down deep into the ground, often making contact with the water table. During drought, such trees use this water in order to survive and keep growing.

Solving the problem

If salinisation is caused by the removal of trees from the landscape, it seems logical that putting them back will solve the problem. Farmers throughout the country, including those in zones most affected by salinisation, have embarked on a massive tree-planting campaign, giving hope that the rural landscape will recover from its many ailments, including salinisation. The ability of trees to reduce salinisation is still not fully known, although they have been shown to lower water tables in some areas.

In the meantime, programs such as the Joint Venture Agroforestry Program have produced guidelines to ensure that any trees planted have the maximum positive benefit. For example, healthy, highly productive trees will be more effective than less productive trees in lowering water tables because they will use more water. Some farmers may be tempted to plant trees on the salty areas, but unless these are specially adapted to saline soils they may not grow well and therefore not play much of a role in solving the salt problem. In some situations, trees planted higher up in the catchment, in areas of high recharge, may be more effective. And, in general, the more trees planted, the more impact they will have on water table levels.

Tree-planting is just one of many strategies that show promise in the fight against salinity. For example, deep-rooted perennial crops such as lucerne lower water tables and may often be a viable alternative to trees. In places where soils are likely to remain saline for some time, salt-tolerant species such as saltbush – which can be eaten by sheep – have had some success. Scientists and agriculturalists are working to enhance the salt tolerance of other plant species through breeding programs.

Innovative farmers are experimenting with other possible solutions. For example, driven by the knowledge that salt is a potentially valuable product, some farmers are pumping their saline ground water into evaporation ponds. The salt harvested from these ponds can be sold as a raw material in the production of sodium carbonate and sodium hydroxide, or as table salt.

Monitoring the problem

In the past, farmers estimated the extent of salinisation on their properties in response to questionnaires issued by the Australian Bureau of Statistics. This method is thought to have underestimated the extent of salinisation, partly because the definition and recognition of salinisation varies between farmers. Nor do such methods provide maps of where the salinity is, where it is spreading to, or the rate at which it is spreading.

In recent years, new techniques have been developed for monitoring salinity. Most involve what is known as remote sensing. This is the collection of data using devices fitted to an aeroplane, satellite or some other craft located above the Earth's surface. Such technology can be used to gather a range of information related to salinity. Often remote sensing involves cameras that can record electromagnetic radiation – particularly visible light and infrared light – reflected from the Earth's surface.

Different parts of the electromagnetic spectrum provide information about the Earth's surface that may be useful for the detection of salinisation.

A number of techniques to collect and analyse electromagnetic information have been tested. For example, colour infrared film can be used to take photographs from aeroplanes. Different colours (corresponding to different wavelengths within the infrared band) will show vegetation under varying levels of stress, which can then be related to the degree of salinity. Dark-green vegetation produces a bright red image, light-green foliage a pink image, barren saline soil a white image, salt-stressed vegetation a reddish-brown image. If such photographs are taken of the same area over different years, changes in the pattern of salinisation can be monitored.

Another airborne electromagnetic technique makes use of the fact that electrical conductivity increases with increasing salinity. It involves an aeroplane flying low over the ground. Mounted on board is an electromagnetic transmitter and trailing behind on a cable is a receiver. The transmitter sends out pulses of electromagnetic radiation. When these hit the ground, they induce a magnetic field in the ground that is proportional to the ground's conductivity. This induced magnetic field is recorded by the receiver trailing behind the aircraft.

Increasingly, scientists are also using satellite images to analyse salinity patterns across large areas. Most images are supplied by a series of scientific satellites known as Landsat. These orbit the Earth, recording information about the electromagnetic radiation reflected by the Earth's surface.

In Landsat satellites, an instrument called a thermatic mapper makes regular observations in bands ranging from the visible to the thermal on each area of the Earth's surface, sending the information back to Earth. Many scientists consider that data produced in this way can be used effectively for the detection and monitoring of salinity, and experimental results support this view. In a recent study carried out by CSIRO Mathematical and Information Sciences, a remote sensing technique in three study areas in Western Australia was trialed. At one study site, salt-affected land was mapped remotely at an accuracy of almost 100 per cent. Accuracy was lower at other sites, but refinement of the techniques will continue to improve results.

Predicting where salinisation will occur next

A number of factors determine the vulnerability of sites to salinisation. These include:

- the position of a site within a landscape – generally the lower it is, the more likely it is that the water table will reach the surface and cause salinisation;
- soil type;
- management – such as the extent of clearing;
- rainfall.

Combining information on these and other factors could allow the prediction of sites vulnerable to the saline menace. This is where a geographic information system (GIS) can play a role. GIS is a computer application that involves the storage, analysis, retrieval and display of data that are described in terms of their geographic location. The most familiar type of spatial data is a map – GIS is really a way of storing map information electronically.

A GIS has a number of advantages over old-style maps. One is that because the data are stored electronically they can be analysed readily by computer. In the case of salinity, data on rainfall, topography, soil type – indeed, any spatial information that is available electronically – can be used to first determine the combinations most susceptible to salinisation, and then to predict similar regions that may be at risk.

To understand why salinisation occurs, you need to understand ground water.

Much information is already in a form that can be used in a GIS, and more is being added continually – including that produced by Landsat. As the databases and prediction techniques improve, farmers and land management agencies will be better placed to wage an assault on salt.

Predicting and preventing the advance of salinity

The knowledge gained from the new monitoring techniques, along with that generated by decades of painstaking field research, is offering many insights to the causes of salinisation.

Importantly, this is aiding in the development of methods to predict sites most at risk of salinisation so that preventative measures such as tree-planting can be taken. Armed with the information such methods will provide, a coordinated community response could succeed in combatting the white death, before it eats out our agricultural heart.

For more information see the NOVA web site at www.science. org.au/nova/. NOVA is an Australian Academy of Science project.

THE LAND Regional

Salinity 'fortunes for taking'

By ALAN DICK

IMAGINE a scheme where products worth hundreds of millions of dollars are extracted from Murray-Darling basin salt in a way that helps provide a long-term solution to basin salinity woes, and townships with new sources of fresh water.

That's what Dr Hal Aral, of CSIRO Minerals, has in mind, and small demonstration scale projects are already underway, or in the wind, to help bring it about.

Dr Aral says substances dissolved in the salty groundwater can be used in a wide range of processes.

They include making fertilisers, light metals, plastics, industrial chemicals, oil refining, pesticides, glass, fibre glass, ceramics, bleach, soaps, detergents, dyes, inks, sewage treatment, sugar refining and alcohol brewing.

And that, he says, is just the short list.

Some chemicals extracted from salt could be also used in processing titanium from the huge deposits of mineral sands the CSIRO has identified in an area stretching from Horsham in Victoria, north to Broken Hill in NSW and edging into South Australia.

Dr Aral said if nothing was done about salinity Adelaide's water would be undrinkable in 20 years, and in 50 years the river water would be toxic to most crops.

"By 2100 the whole system will be carrying 10 million tonnes of salt a year."

He said moves to store saline water in evaporation basins were likely to prove only a temporary solution, because they would leave a million tonnes of salt a year that over time would leach back into the groundwater.

"Plans to pump saline water into the sea require costly pipelines, high energy and constant maintenance, and are throwing away a lot of useful substances."

His plan involves setting up a network of solar powered desalination plants at evaporation ponds (where saline irrigation tailwater is collected) to extract a range of chemicals.

One by-product could be fresh water for use by nearby towns, and some chemicals extracted could be further processed on site into other useful industrial products.

Dr Aral said once common salt — sodium chloride — was extracted, the water, known as "bittern," still contained magnesium, potassium, sulphates, boron, strontium, bromine, iodine and other useful compounds.

According to program leader industrial minerals with CSIRO Minerals, Dr Graham Sparrow, an industry in value-adding Murray-Darling basin salt on the basis of a "back of an envelope" calculation could be initially worth about $200 million a year.

He said the CSIRO was working with a company called SunSalt at Mildura to extract magnesium compounds left after common salt (sodium chloride) was extracted.

Magnesium sulphate was used in making fertiliser and magnesium chloride to suppress dust.

He said magnesium sulphate cost about $400 a tonne to import and the idea was to produce it more cheaply locally.

Other possibilities included using the higher temperatures at the bottom of evaporation ponds, where salt was more concentrated than near the surface, to produce electricity.

Photo: Liz Bull

Wakool salt industry

WHEN the Federal and State Governments chipped in $30 million in the early 1980s to develop a saline ground water interception and disposal scheme in southern NSW, officials perhaps didn't realise how effective it would be in reducing naturally high water tables in the area.

Set on 2100ha, the Wakool Tullakool Sub-Surface Drainage Scheme, west of Wakool in the western Riverina, has 54 Tubewell pumps across 21,000ha which suck saline water 10 and 20 metres below the soil surface.

So effective are the pumping and evaporation basins that the scheme has had a positive effect on the water table across 55,000ha of farmland, keeping the water level more than 2.5m below the soil surface.

Manager of Sub Surface Drainage for Murray Irrigation, Karl Mathers (pictured), said the saline water, which ranged from 2000ec to 130,000ec, was pumped into a gravity system of evaporation basins ranging in size from 20 to 40ha, which gradually fed into a basin which held the hyper saline water.

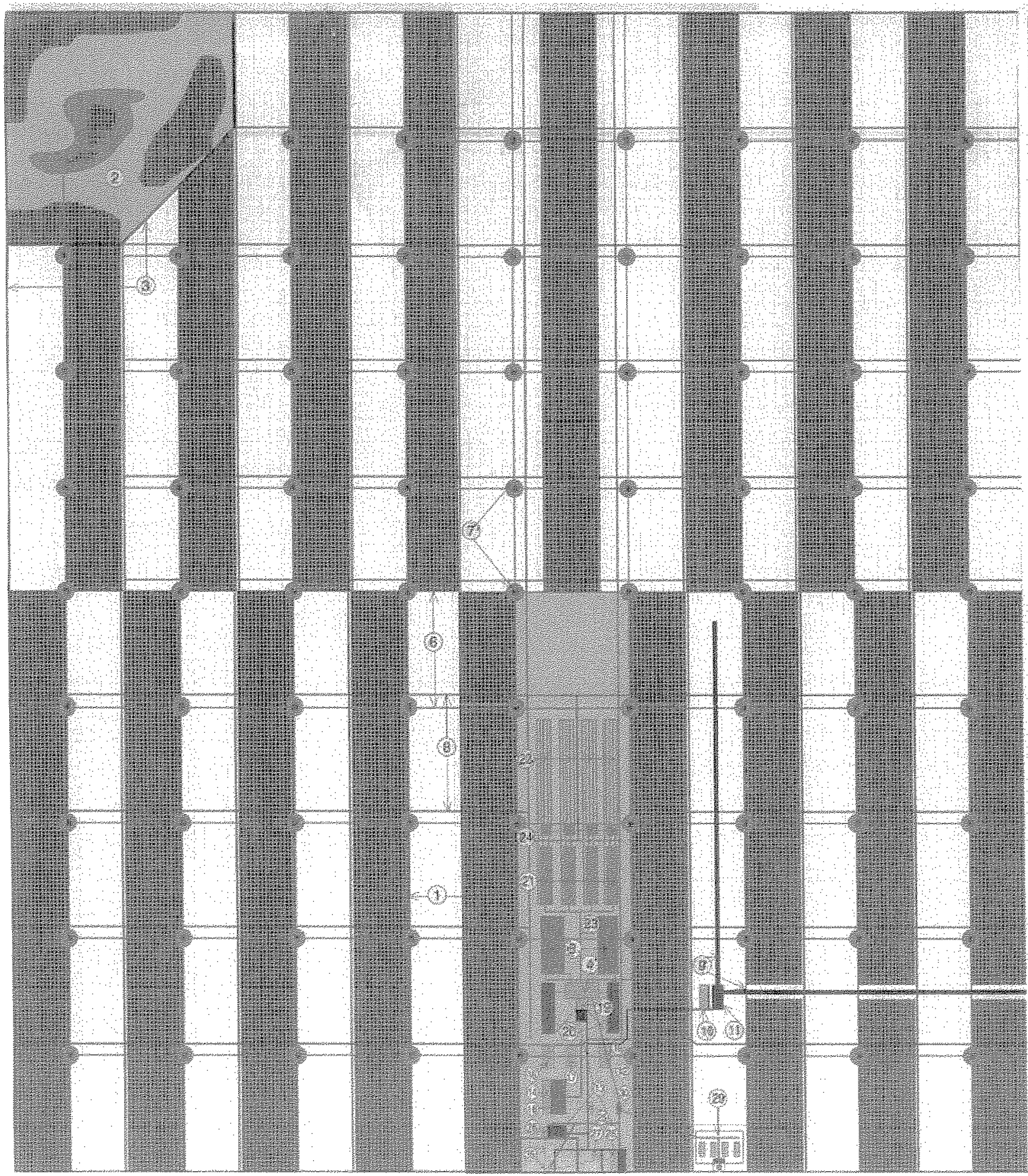
This is transferred into crystallising bays where it is harvested and used in various industries, such as stock feed, hide salt, or for chemicals.

The scheme pumps between 10,000 and 14,000 megalitres of water each year, with the product now being researched for its mineral properties.

As well, an aquaculture program is about to begin to raise snapper, mullaway and tiger prawns.

— LIZ BULL

10



No.	Description
1	Tree plantation
2	Wild life sanctuary area
3	Boundary Fence 2.4M chain wire 8 gates
4	Salt product factory
5	Solar ponds 2x100,000 M^2
6	Pipe grid mains
7	Water Flow collector site
8	Formed fire access roads
9	Two air strips, one east west, one north south
10	Hanger for aircraft and reception building
11	Air craft hard stand for parking
12	Sealed roads
13	Car park areas
14	Trades workshop building
15	Fish hatchery building
16	Plant unsealed hard area
17	Farm product packing shed
18	General store and farm requirements building
19	Power station building and plant
20	Solar stills
21	Fish breeding ponds
22	Hydroponics gardens
23	Water supply
24	Crustacean ponds
25	Fire and Ambulence building
26	Lecture area and classrooms
27	Administration building
28	WFA motel building
29	Caravan and temp accommodation area
30	Sewage treatment works and mains
31	Plant and equipment - (Not Shown)
32	Electrical installation - (Not Shown)
33	(Not Shown)
34	(Not Shown)
35	Nursery & Service Station complex

SETTING UP A TRIAL AREA TO EVALUATE THE PROPOSED USE OF THE WATER GRID SYSTEMS TO COMBAT THE FLOOD, DROUGHT AND SALINITY PROBLEMS.

Water for Australia's people present this additional information to the Senate's Inquiry into the extent and economic impact of salinity: we hope to give the Senators an idea of how we would go about setting up a trial area if sufficient funding was made available for the project.

An area that would be suitable for the 100 square kilometre (10km x 10km) evaluation site would be reasonably flat, salt-affected, and have a high water-table; it would also be an area of land that had become useless for agriculture. There are several suitable sites in the Darling basin. The Water for Australia team would be ready to go into action once the site had been chosen, the go-ahead given, and the funding in place.

The attached information presents a broad outline of what would be required to implement the construction of an up-to-date evaluation facility for Water for Australia's plan; it covers the broad range of segments to be evaluated. When the education facility was fully established, it would showcase Australia's sustainable approach to rural science: it would attract not only students, but also people who are searching for sustainable answers to the flood/drought/salinity cycle; as well as that, it would draw in people seeking new ideas for farm production. The construction of the evaluation facility would not only serve to assess the Water for Australia plan, but would also provide an ongoing educational, and hands-on, laboratory for the assessment of research in the many areas that are crucial to the finding of improvements, which contribute to rural industry's progress.

List of documents;
1/Plan and description of the facility.
2/Construction critical path.
3/Cost to set up and operate. Note 1997 costing. A $
4/Support letter for tree plantations.
(Engineering planning and costings by L. Hogan)

Water for Australia
Submission to the Rural and Regional Affairs and Transport Committee
Senate Inquiry into Water Policy Initiatives

Supplementary information
Concerning the Establishment of a Water Grid Pilot Project

Robin Gaskell

Pilot Project

The Critical Path Analysis and Financial Flow Chart were prepared by Laurie Hogan, Principal of the Water for Australia Project, and they follow a sequence of events starting with:

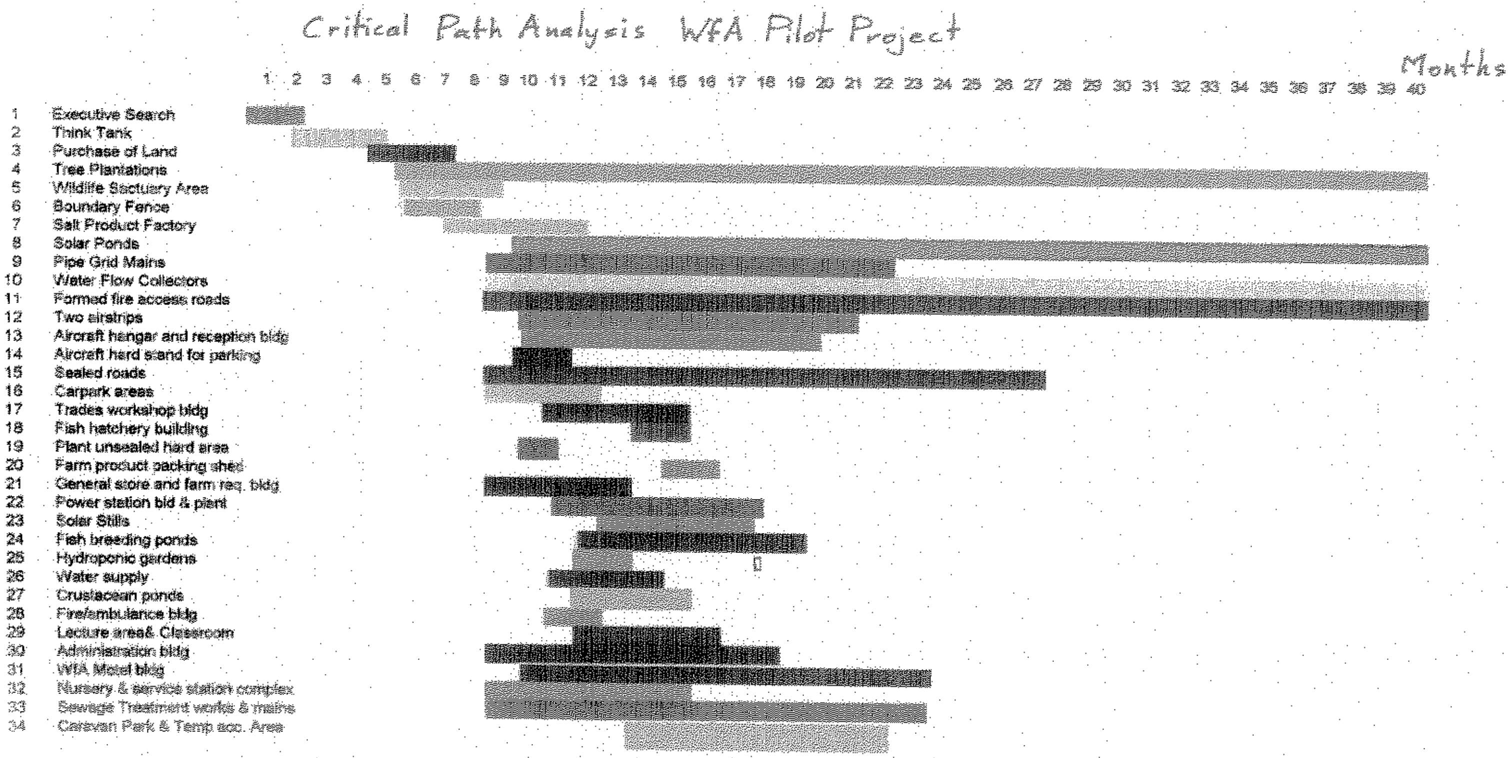
1. Search for suitable 10km x 10km parcel of salinated land
2. Collecting together a key team of WfA participants
3. Discussions with major governmental stake-holders
4. Purchase of land
5. Fencing the Project area
6. Establishing site for Salt Factory, and start of building
7. Area allocated as wildlife sanctuary and suitably fenced
8. Tree planting commenced
9. Laying of Water Grid pipes commenced
10. Construction of Water Flow Collectors commenced
11. Solar ponds sited, and construction started
12. (etc)

The full sequence of events is given in the Critical Path Analysis and Flow Chart. The cost estimates are given as year totals, and a cumulative figure is not given because of the difficulty with combining costs from different years.

While the first major income will follow the first harvesting of timber, there will be crop, animal and some timber yields prior to this; the Flow Chart conservatively shows the first major rotation between trees and crops at thirty-five years; however, it could even be ten years prior to this. The inclusion from the timber expert, John Gwalter, suggests a faster growth of forest; and, to this effect, the use of quick-growing hybrid Saltgrow Trees is mentioned in our submission.

A significant factor in the economy of WfA's desalination plan is the production of electric power within the Water Grid, and, here, the roofed Water Flow Collectors play a major role. While the design for the solar generators on the WFC roofs has been patented, and will supply the necessary power - for water pumps, bores and reverse osmosis - the technology of this power production process needs further development research.

A research grant to bring this low-cost, solar power system to fruition will ensure that the Water Grid concept can be shown to be fully feasible, economically. While The WfA group has had a long history of presenting the scheme to official inquiries, it has not, as yet, sought grant money to finalise its power production system. The solar power unit that is developed for Water Flow Collectors will also be suitable, in terms of roof dimensions and power output, for supplying electricity to remote homesteads.


Critical Path Analysis WfA Pilot Project
Months
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
1 Executive Search
2 Think Tank
3 Purchase of Land
4 Tree Plantations
5 Wildlife Sactuary Area
6 Boundary Fence
7 Salt Product Factory
8 Solar Ponds
9 Pipe Grid Mains
10 Water Flow Collectors
11 Formed fire access roads
12 Two airstrips
13 Aircraft hangar and reception bldg
14 Aircraft hard stand for parking
15 Sealed roads
16 Carpark areas
17 Trades workshop bldg
18 Fish hatchery building
19 Plant unsealed hard area
20 Farm product packing shed
21 General store and farm req. bldg
22 Power station bld & plant
23 Solar Stills
24 Fish breeding ponds
25 Hydroponic gardens
26 Water supply
27 Crustacean ponds
28 Fire/ambulance bldg
29 Lecture area& Classroom
30 Administration bldg
31 WfA Motel bldg
32 Nursery & service station complex
33 Sewage Treatment works & mains
34 Caravan Park & Temp acc. Area

Planting

The trays of Saltgrow trees should be soaked prior to planting, and then planted into the mounds, ensuring that the root ball is in contact with moist soil. The crackpot plastic insert MUST be removed prior to planting. The soil around the plant should be pressed firm to ensure good contact. If no follow up rain occurs, watering in may be required to achieve optimum establishment. For detailed planting times, refer to the table below or ask for Saltgrow's "Australian forestry planting times", brochure. Any gaps in the plantings should be filled in within 2-3 months.

Ongoing Management

As with any crop, ongoing nutrition, pest, weed and disease management is essential for optimum results.

Thinning

At 3-4 years the stand should be thinned to around 300 trees per ha, to ensure suitable growth of the individual trees. Small diameter logs may find a market as firewood, or be treated for use as fence posts, grape trellises, fencing timber etc.

Pruning

After 3-4 years, all limbs should be pruned to a height where the stem has a diameter over bark of more that 7cm. no more than 40% of the green crown should be pruned. Within 5-6 years, pruning up to 6m should be carried out. This pruning will minimise the knots in the timber, and thus maximise the value of the timber.

Harvesting

A commercial thinning at 8-12 years will be required, and clear felling of the stand at 20-25years. The timing of harvesting should be discussed with your local forestry and timber experts to ensure that the timber suits your target market.

John Gwalter B.Sc.(for.)

Forestry & Scientific Consultant E-mail http://www. hydinnov@midcoast.com.au Telephone (065) 834003

25 Bellevue Drive
PORT MACQUARIE
NSW AUSTRALIA 2444

WATER FOR AUSTRALIA

I have examined the timber values forecast in WATER FOR AUSTRALIA and find that the result is highly pessimistic regarding returns to the community.

The Basic calculations are:

AREA	= (4000 X 4000)/10000 ha X **50%**	= **800 ha**
Increment	= 6.5 m^3/ha/annum	= 5,200 m^3/annum
Rotation length	= 30 years	
Total harvested volume (log volume)		= 156,000 m^3 Log
Recovery	= 50% sawn/round	= 78,000 m^3 Sawn
Value @ $1,500 m^3		= **$ 117,000,000**

20% of this could be expected to be returned to the producer as Royalty at stump,
(50% of 20% @ $1500 m^3 Sawn = $150/$m^3$ Log) or **$ 23,400,000**

The balance would be manufacturing cost, harvesting costs and haulage costs, all of which benefit the community, thus the value to the community is $ 117,000,000

This would have to be discounted at a suitable rate to the present day

The Present Worth of these sums is given below for various interest rates

Table of Present Worth @ **30 yr** discount

Discount rate	End Worth 117,000,000	End Worth 20% of 117,000,000
1%	86,804,984	17,360,996
2%	**64,592,296**	**12,918,459**
3%	48,202,452	9,640,490
4%	36,073,284	7,214,657
5%	27,071,160	5,414,232

17

At Government cost discount rate of 2%, the project would be estimated to be worth approximately $64,500,000 in timber generated value to the community or approximately $13,000,000 in timber value to the producer.

The CSIRO report presented at *Plantations and Farm Forestry* 9-12 Sept 1996 indicates that growth rates **__greatly__ in excess of 6.5 m^3/annum can be expected.**

COMMUNITY RETURNS

A Growth rate of at least 18m^3+/ha/annum, or three times that used in the estimate of value to the community could be expected. thus a total value return to the Community of **$ 351,000,000** ($194,000,000 present worth @ 2%) for 800 ha over 30 years is reasonable .

GROWER RETURNS

It is normal for a grower to receive 20% of the **wholesale** price in sawn cubic metres, in cubic metres log volume. Assuming that the figure of $1500/$m^3$ sawn is retail price. then the value return to the grower of $23,400,000 would be only $ 11,700,000 (100% mark up to retail) @ 6.5 m^3/ha/annum .
However at 18 m^3/ha annum a return of **$35,100,000** ($19,400,000 Present worth @ 2%) is reasonable @ 30 years on 800 ha.

INTERMEDIATE YIELDS

The Value of Thinnings has not been taken into account. Thinnings for pulp and poles would greatly enhance the present worth value of the project and have minimal effect on the end worth.

MULTIPLIER EFFECT

A multiplier of 4-5 should be applied for those supported by the timber industry, reflecting employment in services. Such benefit would be directly attributable to the timber industry. This benefit has not been taken into account.

SUMMARY

I find that the Timber returns estimated in the WATER FOR AUSTRALIA report are conservative in terms of Community value.

John Gwalter

JOHN GWALTER B.Sc.(for.) 29/1/97

Water for Australia Project * Measurements & Facts

Water Flow Collectors:-
20/25m wide, 92m long, 10m deep, 10 megalitres capacity
660 000 Collectors projected for Qld/NSW/Vic Water Grid
Electricity production on roof - patented solar power

Water Grid — Two major systems projected: Eastern & W.A.
10 new towns planned for the Eastern Water Grid
Pipe to Salt Factory: 300km max. 150km av.

Individual grid units 1 sq km (side 1km)
Water Flow Capacitor @ lowest point

Forest strips — 0.5 km wide, 5 km long
First thinning 15 yrs, harvested 20 – 25 yrs
Average rotation Forest/Cropping 25 yrs

PVC Water Pipes — 300mm to Irrigation Site; 150mm to Factory
Pressure **40** lb/sq in

Salt Content — Irrigation water < 1000 ppm; Ocean 35 000 ppm
When > 1000 ppm → Reverse Osmosis
_ Brine-off → Factory

To compare: Sydney water supply = 200-250 ppm

Salt Factories — Receive brine-off from Reverse Osmosis @ WFC
Concentrate brine to solid salts and industrial brine
Extracted water back to WFCs and irrigation sites
Produce 400 000 tons of salt per annum (10 in East)

#Service trench — All sides of 1km grid unit
1 m deep ; 600mm wide
300mm PVC pipe carries water to Cropping
150 mm PVC pipe carries water to Factory
Copper power cables
Electronic control line to Water Flow Collector
Voice-phone line to Collectors

People 300 to operate one factory; 1.8 million total in Eastern Grid