Water Resource Planning in Rural Residential Developments

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Water Resource Planning in Rural Residential Developments

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SUMMARY Water resources management may be incorporated in long term planning under the legislative control of the NSW Environmental Planning and Assessment Act, 1979. As part of a Local Environmental Plan, Local Government Councils may implement strategies for the development and conservation of those resources. The Uralla Shire Council on the New England Tablelands has adopted policies to protect surface and groundwater resources while adopting guidelines for rural residential water supplies. As part of the latter a computer model of catchment/storage and consumption has been used to indicate suitable combinations of those three elements for a reliable supply. In adopting these policies and guidelines, the Council is acting positively to encourage long term self reliance in water resource management.

1 INTRODUCTION

The New South Wales Environmental Planning and Assessment Act, 1979 gives local government councils prime responsibility for establishing policies and priorities in land use planning, zoning controls and environmental protection. The interaction of the elected representatives with the general public in formulating a Draft Local Environmental Plan (LEP) is seen as one of the benefits of ensuring that the community's values are safeguarded. In the preliminary stages, the Council, either by its own resources, or through consultants, prepares a Local Environmental Study (LES). The LES is an inventory of the physical, environmental, historical, cultural and socio-economic resources of the Shire from which policy direction and priorities may be derived.

The Local Environmental Plan for the Uralla Shire is used as an example in this paper. The Shire, situated in the New England Tablelands, has an area of approximately 3200 square kilometres, comprising highland tableland landscape (1100 m ASL) fringing the eastern scarp country, while the western extension reaches into slopes at altitudes of 600 metres ASL. Rainfall, having a mildly 'summer dominance, averages 808 mm per annum decreasing to 650mm to the west.

The water resources recognised within the Study included surface water storages, natural river and creekline characteristics, associated flooding patterns where documented, reticulated water systems and groundwater availability. The specific local requirements for domestic water, outside the areas of reticulated supplies, are often overlooked in considering the welfare of rural residential dwellers. The Uralla LES investigated the water resources with respect to residential development and the Draft LEP has addressed the problem by introducing development control plans specific to domestic water. The requirements for rural residential water can be categorised as: internal domestic water; water for gardening and landscaping; water for animals; and a water reserve for bushfire fighting. Each has a specific requirement based upon expected lifestyle of the dweller and the land area available.

This paper examines the means by which the water resources may be incorporated in long term planning. As part of that plan the development of a rainfall catchment/storage model has been prepared to determine the combinations suitable for a range of internal domestic water consumption rates.

2 PLANNING REQUIREMENTS

The monitoring and analysis of domestic use of water has been carried out by researchers such as Heeps (1977), while the collection and storage parameters have been investigated by Perrens (1975) and Patterson (1985). Australian literature currently available does not indicate how findings such as these have been incorporated into our daily lives, or more specifically have been used to relieve the plight of the rural residential dweller.

The problems for Uralla are compounded by its proximity to the City of Armidale and the development of hobby farms in this area. Within the Uralla Shire, the subdivision of land, while only accounting for a small proportion of the total Shire area, involves almost half of the total number of ratepayers as detailed in Table I. The low residency rate and the large number of smaller properties may suggest that the resources of the Shire, both physical and social, have yet to meet a full residency requirement and fulfil the expected needs of the people. Thus the development of priorities and policies must address those expected needs, one of which is a reliable domestic water supply with the protection of the Shire's groundwater and surface water resources.

TABLE I

URALLA SHIRE RURAL LAND SUBDIVISION AND RESIDENCY FACTORS (after RES, 1985)

Holding (ha)	Number	Residency (%)	% of Shire
0-2	324	50	23
3-5	213	46	15
6-10	101	46	7
11-25	117	56	9
25-100	168	56	12
101+	458	72	33

During periods of low rainfall, rural residents are confronted with inadequate domestic water supplies, aggravated by small catchments and high consumption rates. When all the stored water has been consumed the only option is to purchase water in 6000 litre loads for up to $60 per delivery. The costs during extended dry periods becomes a drain on both individual and community finances. Perrens (1975) used a consumption rate of 200 l/p/d while Patterson (1985) used values 73 to 350 litres averaging 165 l/p/d. The variation occurs because of the differing attitudes to water conservation and the ability to pay for carted water. There is a temporal variation in water consumption depending upon the seasonal conditions and stored water volumes. When the season is abnormally dry consumption rates fall while low stored volumes reduce consumption to an absolute minimum. For Uralla the costs of providing water to outlying rural residents during droughts places a burden on the town's reticulated supply while adding significantly to the heavy traffic using minor roads. A well recognised problem is that in the advent of bushfire (droughts and bushfire seasons are co-incident) the rural dweller has little reserve to protect private property.

3 SURVEY

3.1 General

The authors, as consultants undertaking the Local Environmental Study, collected primary and secondary water resource information with respect to surface water, groundwater, water storages, farms dams, flooding, bushfire requirements while investigating the requirements for rural residential dwellings. The aim of the project was to implement into the Draft LEP mechanisms for protecting the environment, but also protecting the resources from exploitation, while providing guidelines for efficient use of all resources. The following sections indicate the expectations for applying water resource data to an LES, particularly as it applies to the provision of a reliable and adequate domestic water supply.

3.2 Groundwater

The standard series 1:25000 topographic maps document known wells, bores and springs. Further information was provided by the NSW Water Resources Commission in relation to licenced groundwater extraction. The latter information was described in terms of: location description, current depth, standing water level, drawdown rate, pumping rate, aquifer depth, salinity and rock type at bottom of the hole. When this information was related to the geological survey map, the greater proportion of bores extract water from basaltic material. There was little documented evidence of water from the granitic material which covers 90% of the Shire or of salinity levels. The implications to planning are that the groundwater resources of the Shire are poorly documented and that it is not possible to suggest areas where the reliability of a potable groundwater resource is high. Thus, any reliance upon groundwater for domestic consumption would have to be based upon specific surveys. The Uralla Shire Council has adopted a policy which reflects this uncertainty.

The average cost of tapping a groundwater resource is in the vicinity of $2000 and may result in water of varying quality with yields as low as 300 litres per hour. However, the cost of failure to tap groundwater can result in up to $1500 per hole drilled.

3.3 Town Water Supplies

The Uralla town water which is drawn from Kentucky Creek 15km south of the town supplies water to 2000 of the 5200 Shire residents. The catchment, of approximately 150 km^2, is farming and grazing country with a high proportion of improved pasture. Less than 5% of the catchment is tree covered, the remaining open grassland with isolated woodlands and individual trees. Uralla has no alternate source of town water within the Shire and has to protect that catchment. The protection requirements will include controls on development, subdivision and intensification of agricultural activities. Present runoff rates must be maintained to satisfy the demand for water, however, control of sedimentation is a major concern in the yellow podzolic and yellow solodic soils of the catchment.

3.4 Farm Dams

The use of on-farm water storages to provide water rural dwellings cannot be considered a satisfactory option. Patterson and Perrens (1985) showed that storages less than 1ML and 3 metres deep are highly unreliable because of insufficient storage at depths greater than average evaporation losses. Hobby farms, with the typical 1 ML storage are struggling to maintain a stock water supply over an 18 month period of low rainfall, without the added incumberance of domestic usage. The poor quality of the stored water, saline in the solodics and highly turbid in the basalts, precludes use within the home except for toilet water. Thus, farm dams on small holdings are not seen as a substitute for other domestic water resources.

While farm dams may, depending upon topography, provide adequate second grade water (for toilets), the strategic location of all farm dams is encouraged under the LEP. Presently farm dams are designed and planned after the subdivision has been made and usually after dwellings have been constructed. There appears to be little co-ordinated development of farm dam networks to maximise the catchment potential. Under the Plan, approval for the construction of all dams will be based upon maximisation of surface hydrology in relation to the 'catchment.

3.5 Bushfire Requirements

The NSW Bush Fire Council has recently issued guidelines for the on-site storage of water for rural residential buildings, recommending 10 kilolitres (kL) of stored water to be dedicated for fire fighting. These guidelines impose further requirements for water storage additional to domestic use and have been amended in the Plan to allow farm dams, swimming pools and independently powered bore pumps to substitute for tank storage. This was seen as a relief upon the provision of expensive tank storage and the need for catchment expansion.

3.6 Domestic Water

The potential number of dwellings on rural small holdings less than 25 hectares is 755 (Table I). The provision of reticulated water to that number of houses spread across many thousands of hectares is economically prohibitive while access to adequate groundwater resources is both geologically dependent and financially unattractive. The poor quality of farm dam water precludes its use for domestic use other than second grade water. The options for domestic water at a reasonable price are limited to rainwater collection from the roof of the dwelling and out buildings and storage in steel or concrete tanks. The present strategy for catchment/storage combinations is based upon the misbelief that the larger the storage the more reliable the system. The roof area is limited by the dwelling size, while the storage is based upon either dollars in choosing one or two 22 kL storages or by maximising storage with one 110 kL tank.

The computer model described below was used to indicate a combination of variables for collection and storage of rainwater, matched with variations in consumption to derive a suitable standard for the Uralla Shire. While a standard is applied to all new dwellings, the occupant may satisfy Council of water conservation measures to be adopted, or dual plumbing to use second grade water in appropriate fixtures. The Council is then able to assess the reduced consumption of water on catchment area and storage volumes. This may present a substantial saving to the occupant in capital expenditure while fulfilling the objectives of Council in optimising reliability of rural residential water supplies.

3.7 Water Saving Options

Various water saving options are available for the modern rural residence without the loss of amenity. The authors are currently undertaking research on reducing the domestic water consumption by the use of water conserving fixtures. Significant savings are available by reducing water pressure, using dual flush, low volume toilet fixtures, low flow shower heads, dishwashers and by choice of suitable washing machines. It has been shown that by reducing pressure from 220 kPa to 80 kPa, internal water consumption may be reduced by 45%. Low flow shower heads are available which reduced flow from 11 litres per minute to 4 litres per minute whilst providing a suitable shower spray.

4 COMPUTER MODEL FOR DOMESTIC WATER

4.1 Selection of Computer Language

The computer model was written in the relatively new 'Turbo Pascal', a computer language which has many advanced features when compared with FORTRAN, COBOL and the original PASCAL developed in the early 1970's. The selection criteria favoured 'Turbo Pascal' for its ease of use, commonality with PL/1 and Algol, flexibility and compactness of data storage, extremely fast compiling, and portability between most MS-DOS based computer systems. BASIC, BASICA and CBASIC were also considered, but were unacceptably slow, of relatively complex structure for solving detailed problems and relatively inefficient in data storage.

4.2 Computer Model Structure

The computer model comprises two main portions, namely:

(a) daily or monthly rainfall data for up to 10,000 individual entries; and
(b) specification of analytical criteria, including the storage capacity, area of contributing catchment, commencement volume, consumption rate, plus the absolute increments for each of tank volume, consumption rate and catchment area.

The model requires less than 20K bytes of programme memory while the rainfall data is stored in a compact format by Turbo Pascal at 2 bytes per entry. The model allows either daily or monthly rainfall data to be used for up to 10,000 individual entries or over 27 years of daily data. Ten such long term data bases can be stored on the programme disk. Alternatively, the programme enables operators to save or access data files from other disk drives. The operational speed of the model processes 252 months of rainfall data for each of the 125 criteria in about 36 seconds, or about 500 times faster than GW BASIC. All data output is printed as a 125x5 matrix via the parallel printer port.

4.3 Collection and Consumption Variables

The computer model estimates the quantity of available water given the following constraints:

- the volume of the water storage unit;
- initial water storage volume;
- area of the contributing catchment;
- the estimated water consumption; and
- estimates of future trends based on long term historical data.

Data relating to catchment, consumption and storage can be entered by the operator on menu type prompts as may the absolute quantities for incrementing those base quantities. Storage was varied from 20k to 140k litres. Patterson (1985) found that storages averaged 59kL while 31% of the residences studied had 22k-45kL and 29% had 45k-90kL storages. Consumption rates were varied because of the differing habits of households due to occupancy rates and conservation strategies at various periods of the year.

In the same study Patterson (1985) showed that the average roof area for rural residences in the Armidale region was 238 m^2 with a standard deviation of 90 m^2. This range of catchments was used in the model, while the variation in area was used to illustrate the need for maximising the relationship of storage to catchment. This segment of the analysis is essential for determining the economics of expanding catchment and/or storage facilities compared to the usual alternative of purchasing water on a periodic basis.

4.4 Assumptions used by the Model

The main assumptions used in the model are:

(a) that consumption (usage) is constant for any given data set;
(b) water consumption is not correlated to prevailing rainfall patterns;
(c) water is purchased when the volume of stored water drops to or below 1000 litres; (this assumption may be varied if required);
(d) that failure can only occur once within the defined time interval (i.e. only once per day for daily data, or once per month for monthly data).

Analysis may account for a landscaping component via the usage variable if such consumption characteristics are required. For the purpose of this paper, both landscaping and firefighting requirements are ignored to avoid unnecessarily complicating the principle of the model.

4.5 Model Predictions and Sensitivity

The model was run on monthly data for the period

1960–1985, average monthly data for two years and daily rainfall data for 1977 and 1985. Because the model recognises only one failure in a single time period, the monthly data may result in many individual failures within that month but overall not fail. Thus daily data show failures in any one day. The differences are significant for individual catchment/storage combinations but confirm the sensitivity of available water to catchment area and not stored volume. In all cases, the consumption of more than 500 litres per household per day created unreliability. The model does not account for the ability of the household to alter water use according the weather conditions or stored water volumes.

A starting volume equivalent to a delivered load of water (5kL) was used at the commencement of the modelling. There was an insignificant difference for a 20kL litres starting volume.

The availability of water, measured by the number of purchases (equivalent to failures) required for each storage/catchment/consumption combination, was sensitive to catchment areas as detailed below in Tables II and III. Storage only influences reliability where catchment is sufficient to provide the input to storage. For the 15kL rate (500L per household per day) a nine fold increase in storage at 200 m^2 catchment only reduced failures by 30%, however at 300 m^2 the reduction was from 52 failures to 1. At the 30kL consumption, the household required 500 m^2 catchment an a minimum 100kL storage to meet a once-per-year failure strategy. At 15kL per month only 250 m^2 catchment and 80kL storage was required. In economic terms, the usage of 30kL per month would be hard to justify.

TABLE II

FAILURES FOR CATCHMENT STORAGE COMBINATIONS FOR 15kL PER MONTH CONSUMPTION FOR 26 YEARS OF MONTHLY RAINFALL

Storage (kL)	Catchment (m^2) 100	150	200	250	300	400	500
20	262	188	125	80	52	26	15
60	262	183	88	35	11	2	1
80	262	183	83	26	5	1	1
100	262	183	82	23	1	1	1
140	262	180	79	20	1	1	1
180	262	180	79	20	1	1	1

TABLE III

FAILURES FOR CATCHMENT STORAGE COMBINATIONS FOR 30kL PER MONTH CONSUMPTION FOR 26 YEARS OF MONTHLY RAINFALL

Storage (kL)	Catchment (m^2) 100	150	200	250	300	400	500
20	311	300	278	252	221	166	118
60	311	300	278	245	207	124	66
100	311	300	278	245	206	106	42
140	311	300	278	245	206	98	32
180	311	300	278	245	206	96	28

The Tables above have not addressed the overflow situation. When the storage is full, overflows may occur because of insufficient storage. These events decrease with increased storage and increased consumption. Table IV indicates the purchase/overflow situation for three tank sizes and three consumption rates. While increased catchment decreases the number of purchases, it also increases the overflows. As catchment is increased there would be opportunity for periods when water use could be considered a luxury, for if not consumed, it would be lost. However, since all waters used within the home then become the product for septic tank disposal, there is a secondary need for water conservation.

TABLE IV

PURCHASES AND OVERFLOWS WITH CATCHMENT AND STORAGE COMBINATIONS OVER 26 YEARS AT 15kL AND 30 kL CONSUMPTION PER MONTH

Storage (kL)	Area	15kL Pur.	15kL O'flow	30kL Pur.	30kL O'flow
20	100	262	0	311	0
20	300	52	199	221	31
20	500	15	206	118	95
100	100	262	0	311	0
100	300	1	65	206	0
100	500	1	202	42	46
180	100	262	0	311	0
180	300	1	59	206	0
180	500	1	94	28	24

5 BENEFITS OF WATER RESOURCE PLANNING

The benefits of using the model for assessing the catchment storage parameters for domestic needs relates to the economics of providing a reliable water supply. The present strategy of building one's dream house and adding the largest tank or that which better fits the remaining finances is false economy. The reliable supply is a close correlation between conservation strategy and catchment/storage, not storage alone. The benefits of larger storages, as seen in TABLE II and III are few, except that together with larger catchment, the opportunity for occasional extravagant use may be possible.

The community benefits of requiring a minimum catchment storage relation for each dwelling is that the town water resources are not overtaxed during droughts and the cartage of water does not create transport and haulage problems. The individual benefits are reliable domestic water supplies and self reliance, while avoiding the high cost of purchasing water and the necessary severe conservation requirements that financial burden incurs. It also reduces the attempt to exploit the groundwater resources during extended dry periods. There must be an economic assessment of the relationship of the number of failures per year to the individual and social costs of preventing those failures. The farm dam design problem for use as second grade domestic water is not new, but to many "hobby farmers" the farm dam has to be guided into its appropriate place in the planning scenario.

The poor information registered of the groundwater resources is a result of insufficient number of boreholes to allow identification of potential aquifers and water quality. The situation for Uralla is not unique and will be more pronounced in other areas where once marginal farming lands are subdivided for rural residency. The Council has recognised the paucity of this information base and requires all subdividers, who wish to use groundwater to overcome the rainwater catchment storage limitation, to prove the resources before subdivision is approved. Thus, the expense of individual search for groundwater will be reduced.

6 RECOMMENDATIONS

6.1 Draft Local Environmental Plan

The Council has adopted the policies on water resource development to be implemented within the Draft Local Environmental Plan. The policies advocated are radical for current LEPs but are seen as a protection of the Shire's water resource base. The effects of unreliable domestic supplies upon the lifestyle of the rural residents have repercussions through all sectors of the community. Damage to minor roads by water trucks, increased use of minor roads and overtaxing of town water supplies are some of the community disbenefits.

The Uralla Shire Council has adopted the following policies into the Draft LEP (RES, 1986b) and specifications under the Development Control Plan will ensure those policies are implemented in all future development.

(a) Groundwater:

(i) protect the quality and quantity of groundwater resources within the Shire; and
(ii) regulate the impact of further demand on existing groundwater users.

(b) Land resources

(i) to protect the quality and yield of water supplies whilst ensuring an acceptable degree of drought resistance through better management practices.

(c) Rural domestic water supplies

(i) that water using appliances and fixtures be based upon the application of appropriate technology to minimise water usage;
(ii) that adequate rainwater collection and storage capacity be provided consistent with domestic and bushfire fighting requirements; and
(iii) that the Council may accept an alternative means of complying with the requirements above provided satisfactory evidence is provided to support that alternative.

6.2 Development Control Plan

The three sub-sections above are legally enforceable under the Environmental Planning and Assessment Act, 1979. The specifications in the Development Control Plan give the Council the details under which they can assess each development application. An example of the detail in that document (RES, 1986a) in relation to domestic water is given as:

(a) Groundwater: "Any development utilising groundwater resources must demonstrate that such usage will not adversely affect existing groundwater users or detrimentally affect either the supply or quality of groundwater. A certificate from the Water Resources Commission or a qualified consultant, confirming suitability, availability and extraction rate is required as proof of the groundwater resource."

(b) Domestic Water: "Where the household is to rely on rainwater for domestic uses a minimum of 290 m^2 will be connected to a minimum of 70kL of storage for up to and including a 3 bedroom residence. Each additional bedroom will require 60 m^2 additional catchment and 15kL of additional storage."

7. CONCLUSION

The Uralla Shire Council has taken positive steps to implement sound water resource management policies in the Draft Local Environmental Plan. The benefits to the community in the long term will be in the protection of vital town water supplies, groundwater and surface water resources and efficient and reliable rural residential water supplies. The controls over development have been prepared to allow supplementing rainwater catchment with surface and groundwater without constricting those residents with a sound water conservation strategy.

Guidelines produced for and by the Council will provide sound conservation techniques for use in rural residential developments. In this way current research may be passed on for the benefit of the community.

8. ACKNOWLEDGEMENTS

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