Initial Investigation of the Cause of Salinisation of Dam Water Supplies and their Management, at the Bodhinyana Buddhist Monastery, Serpentine, WA.

A Report

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Report on Visit to Bodhinyana Buddhist Monastery, Kingsbury Drive, Serpentine

21Jan98

by

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1. Introduction:

Dr. Bill Scott, Mr Theo Bazen, Mr. John Rich and Mr. David Williamson visited the property owned by the Bodhinyana Buddhist Monastery on 21 January 1998. We were hosted by Abbot Ajahn Nyanadhammo and Mrs Sue Towler.

The purposes of the visit were:

1. to initially assess factors causing salinity in the dams used as a water supply for the monastery;

2. to outline a student project for further studying the problem; and

3. to provide advice to the Monastery about possible solutions to the problem of salinity of the water resource.

2. Information Available:

- Plan of the development of the Property showing buildings, roads, dams, and topographic contours;

- Copies of locality maps (as below)

- Analyses of water sampled from the 3 dams for a limited number of dates since 1990 (table at end);

- Reports from Water Corporation related to problems with corrosion of pipes and associated iron content of water, and associated reports;

- Correspondence related to the proposal for establishment of a gravel pit in the headwaters of the catchment in which the monastery exists.

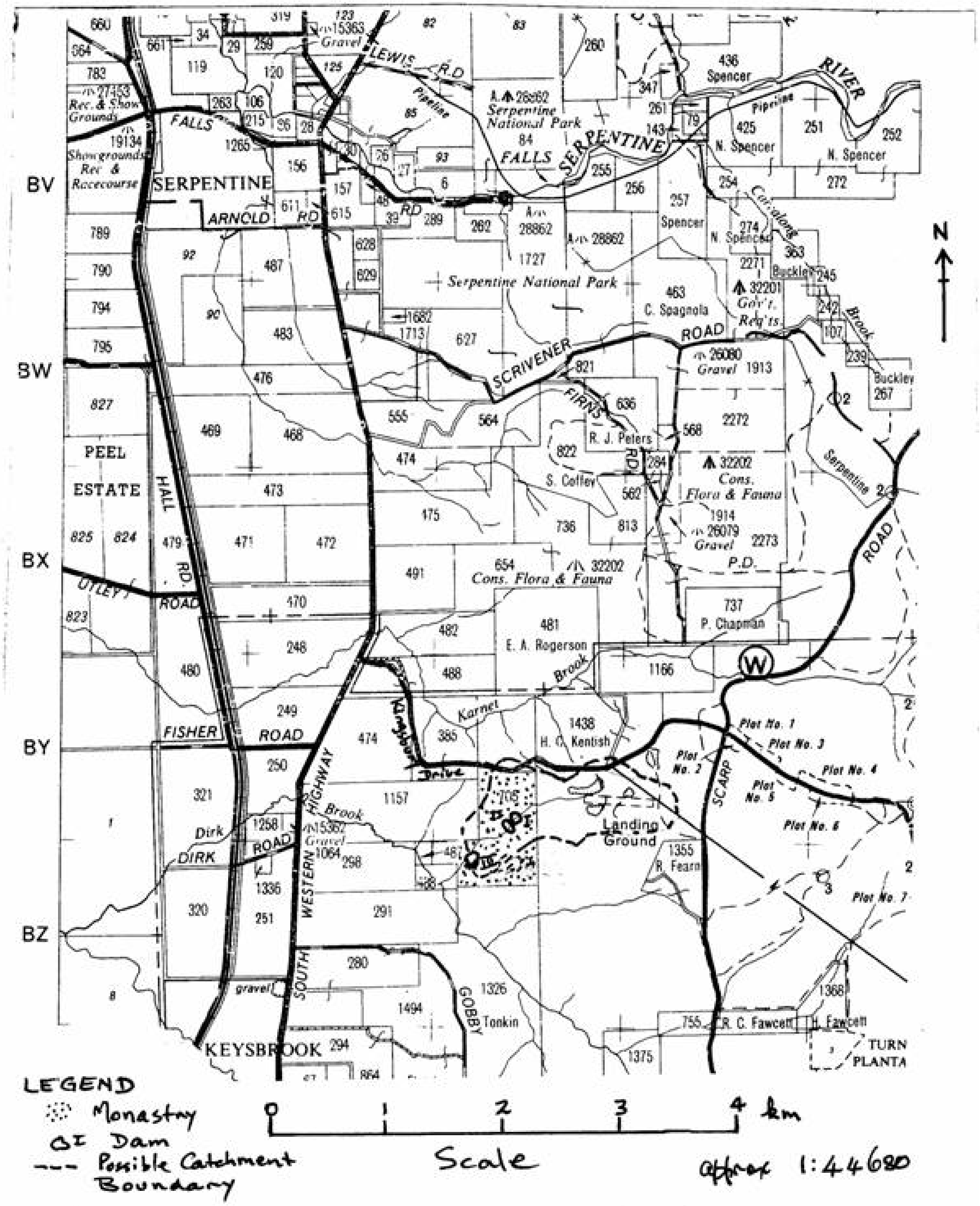


Figure 1. Location of the Catchment for the dams at the Bodhinyana Monastery, Serpentine. (Map Ref: Gleneagle 80 - Forests Dept., 1973)

3. Inspection:

3.1 Catchment: The location is shown on the attached map (Figure 1). The area is estimated to be about 1 km^2 (100 ha). By driving along Kingsbury Drive it was found that the catchment was primarily a logged forest area with a landing ground in the upper reaches, 40 metre wide and about 600 metre long, the only area of cleared land. CALM maps (prepared in 1973) show gravel pits located north and south of the western end of the landing ground, but field inspection suggests that these were rehabilitated with tree plantings over 10 years ago. It was confirmed that the area of the catchment east and upslope of the monastery site is Crown land managed by CALM. The catchment is a narrow one with quite step slopes, typical lateritic soils and frequent exposures of granite rock. The lower boundary of the monastery property is virtually on the escarpment of the Darling Scarp.

3.2 Dams: The Top Dam (see I on Figure 1 and picture below) existed when the property was acquired for the monastery in 1983. The Middle Dam (II on Figure 1), downslope but adjacent to Top Dam, was constructed by the Monastery in April 1993 to receive the winter overflow from the Top Dam. It has been observed that the water level in the Top Dam does not appear to decline as might be expected as water is removed.

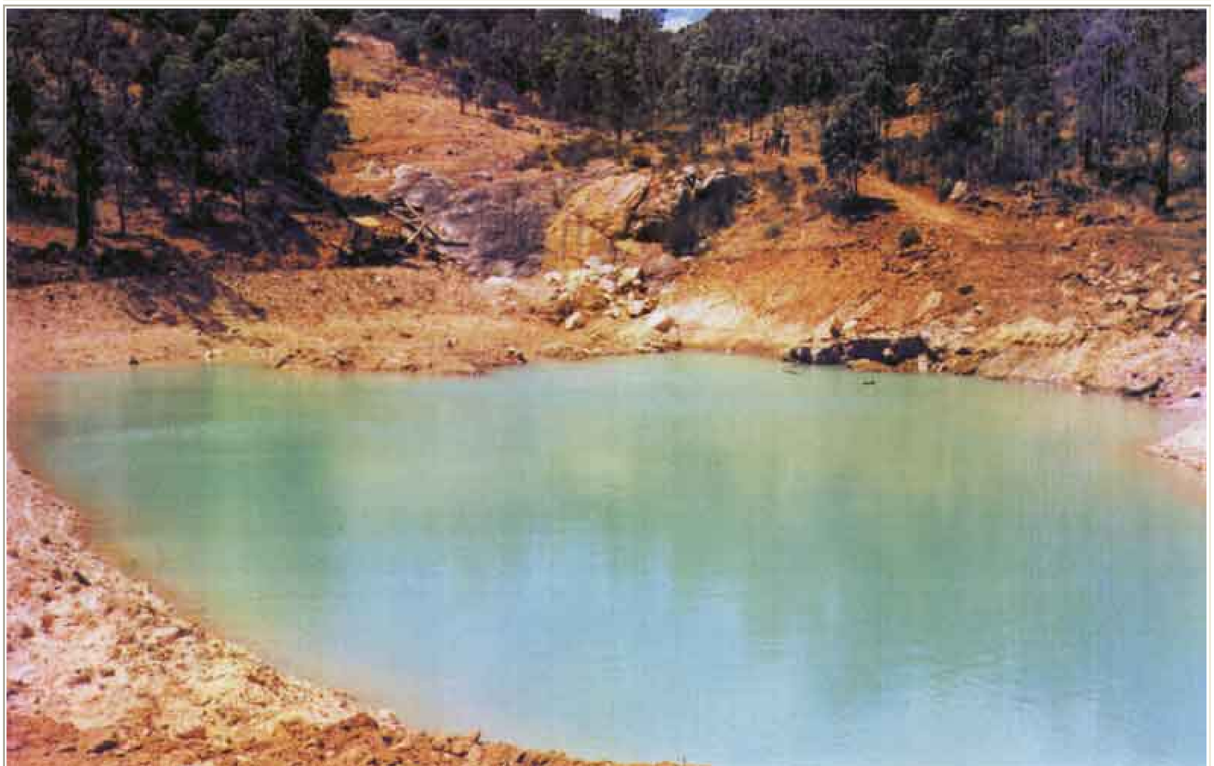
Bottom Dam is a new dam built in June/July 1997 about 200 metres down the valley from Top Dam and Middle Dam. Within a fortnight of completion of construction the dam filled to overflowing. The site has a vertical granite face on the northern side into which the earthen wall of the dam is butted. As would be expected there is seepage coming from the interface of the dam wall and the granite face. On the eastern side of the dam there is another vertical granite face above the level of the dam where flow in the creek forms a waterfall into the dam. Problems with scouring during overflow of the dam are being attended to, and further earthworks undertaken to correct the problem of inaccurate levels at the top of the dam wall. It was recommended that a concrete and rock spillway be designed and constructed to handle the overflow from this dam and to avoid the potential damage to the dam wall by scouring during overflow. Professional engineering advice should be sought on this matter to avoid a catastrophe.

The available data for salt content of the water in the dams showed the quality to be marginal to brackish for all dams depending on the time of the year. See the analysis of water from the dams (appended in a table at the end). Presumably, if analyses were available for the water quality following refilling of the dams during winter, the quality at the end of the winter would be in the potable range (that is, less than 500 mg/L total soluble salts or an electrical conductivity of less than 850 micro Siemens per centimetre (µS/cm) depending on the units used). Water used from the dams is aerated in a tank before being pumped to storage tanks to reduce the high iron content. The water is classed as hard with the potential to cause corrosion problems in pipes, hot water systems and appliances.

3.3 Groundwater in the catchment:

As the salinity issue will be inevitably linked to groundwater flow into the dams and groundwater discharge at the soil surface, indications of seepage were sought. Signs of seepage into Top Dam were found immediately up-slope of the present water level in the dam, with areas of salt inflorescence observed (see Salt Scald below). Reeds, usually associated with areas of groundwater discharge, were also present. There was an exposure of granite rock associated with the wall of Top Dam suggesting that there could be a granite rock bar across the valley which would act as a barrier to groundwater flow in the valley at the location of Top Dam. This would explain the groundwater discharge at the surface at the dam location. Middle Dam was located on an area known to be a wet seepage area. To the south-east of the dam an area of moist dark coloured soil was observed which identified an area of groundwater seepage. There was no information available, and no wells or dug holes available, to determine the salinity of the groundwater in any of the observed seepage locations.

Salt Scald above the Top Dam Looking East	 photo by Theo Bazen, 1998
Top Dam Looking East	

	photo by Theo Bazen, 1998
Middle Dam Looking West	 photo by Theo Bazen, 1998
Bottom Dam Looking East	 photo by Theo Bazen, 1998

4. Assessment of Information provided and Observations during visit.

4.1 The salinity level in each dam is the consequence of the dam receiving discharge of saline groundwater. The source of the groundwater would be from aquifers within the topographical catchment for the dams.

4.2 The catchment for the dams is degraded due to the historic logging of timber, but the vegetation present throughout the catchment is adequate to avoid the classic scenario for salinisation where groundwater levels rise due to increased recharge caused by land clearing. Even in this high rainfall location (estimated to be about 1100 mm per year) groundwaters can contain high salt content associated with the restriction to natural groundwater flow caused by geological barriers cutting across the valleys in catchments. There is good evidence of both the barriers and the impact on groundwater flow (as seen in the seepage zones) in the catchment where the dams are located.

The high rainfall in this location provides the potential for a reasonable quantity of groundwater recharge to occur in these lateritic soils which could sustain the wet areas observed even under the present or previous forested condition of the catchment. From data presented by Stokes et. al. (1980), the salinity of the groundwater could be in the range of 1000 to 2500 mg/L total soluble salts, and the total quantity of salt stored in the catchment could be in the range of 100 to 200 tonnes per hectare. An estimate for annual discharge of salt from the catchment is about 50 kg/hectare, though this may have been increased to as high as 100 kg/hectare due to the effect of logging for millable timber and an associated increase in the discharge of groundwater from the catchment.

4.3 The observation of the fairly constant water level in Top Dam suggests that there is a significant volume of groundwater seeping into the dam. This would carry salt into the dam and allow an increase in salinity following the refilling of the dam with runoff water during the winter months. Evaporation would contribute to the increase in salinity, but with a smaller impact than the seepage of saline groundwater into the dam.

4.4 All 3 dams are subject to salt input via the groundwater seepage, though there may be indirect flow into Middle Dam. To predict the future trend of salt input to the dams and, consequently, the trend in the salinity of the water in each dam, would require a detailed study of the hydrological system which maintains the water resource in the dams. This requires quantifying the input and output components for both salt and water. Further comment on this follows.

4.5 There is no perceived advantage in supplementing the existing vegetation in the catchment to try to reduce recharge to the groundwater as is the objective for managing salinity in the agricultural regions. The area of the landing strip is less than 5% of the total catchment area and would not have significance through any additional recharge produced in the overall situation of the mobilisation of salt in the catchment. There is no rational or economic means of determining where there may be significant enhancement of recharge in the catchment which might be modified by intensified tree planting or by engineering methods. Nevertheless it is reasonable to seek to maintain the existing vegetation, though additional plantings could only be justified for aesthetics rather than recharge management.

5. Management of the problem of high salinity in the water supply.

The existing management of water requirements is very appropriate. It is understood that, in general, personal water needs are obtained through rainwater tanks and other needs are met from the dam supply. The cleaning out of gutters and the periodic cleaning of rainwater tanks is carried out, and this is highly commended for managing quality of rainwater.

Other options which could be considered include:

1. Subject to the results of appropriate testing of the water quality of dam water (microbial content especially), an option is the conjunctive use of roof runoff water and dam water (particularly during the immediate post winter months) in domestic supply tanks. The ratio of each would depend on the salinity of the dam water and the desired salinity of the water required for domestic use.

2. Moving even further toward a dual water supply system with 'low grade' piped to toilets, clothes washing, garden use, and possibly bathing provided, for the latter case, that the microbial content is below acceptable standards for human use. The high iron content and hardness of the dam water would require careful consideration of the use of this water in hot-water systems. This has already been recognised in previous consultations with the Water Corporation.

Preventing or reducing the groundwater seepage into the dams is a logical consideration. The constraints are primarily ecological and economic.

1. **Ecological Option:** As mentioned earlier, our opinion is that increased tree planting in the catchment would not have a noticeable impact on the volume or salinity of the groundwater seeping into the dams. The seepage areas in which Top Dam and Bottom Dam have been located are typical of the forested catchments in the Darling Range. The reliability of winter rainfall means that, in the pristine forested situation, accumulation of salt at the soil surface due to seepage during the summer period is washed away in streamflow in the early winter months.

2. **Engineering Option:** The engineering option would require interception of the groundwater flow upstream of Top Dam and Bottom Dam using a number of low yielding groundwater pumping bores (or a large sump type well) and piping the effluent to the downstream side of Bottom Dam. It may even be possible to use a siphoning system as an alternative to the periodic pumping of the bores or sump well, though the siphons would need to be re-established using a pumping system. However the major constraint to such a system is the statutory requirement for groundwater effluent disposal. It is unlikely that permission would be given for the effluent water to be pumped into a stream.

6. Potential for Scientific Project:

The opportunity for a scientific project would be focussed on the prediction of the future salinity of the water in the dams. Fundamentally, this would be a water and salt balance study to produce a model of the hydrological system. The study would aim to provide a prediction of the salinity trend for each dam and establish a working model which could be used by the Monastery to continue monitoring the situation.

The project would:

1. Estimate the flow of groundwater and salt into each dam through a suite of wells/bores upslope of the dam

2. Establish the capacity of the dams and monitor the changes in salinity through the autumn and winter period.

3. Estimate the surface flow into the dams and other water and salt balance parameters needed to model the system.

4. Develop a model to predict the future salinity of the dams based on synthetic rainfall data.

5. Recommend a management approach for sustainable water supply.

A conceptual diagram of the field system is given in Figure 2, below.

Resources would be needed to make the necessary observations and installations at the Monastery site. These could include installation of groundwater wells/piezometers, water level gauges (and possibly data loggers) for dam water and groundwater level monitoring, raingauges, analyses of water samples for salinity and microbiology, and surveying to determine the shape of the dams. An estimate of evaporation from the dams would be required, probably using meteorological data available from the Meteorological Station at Karnet.

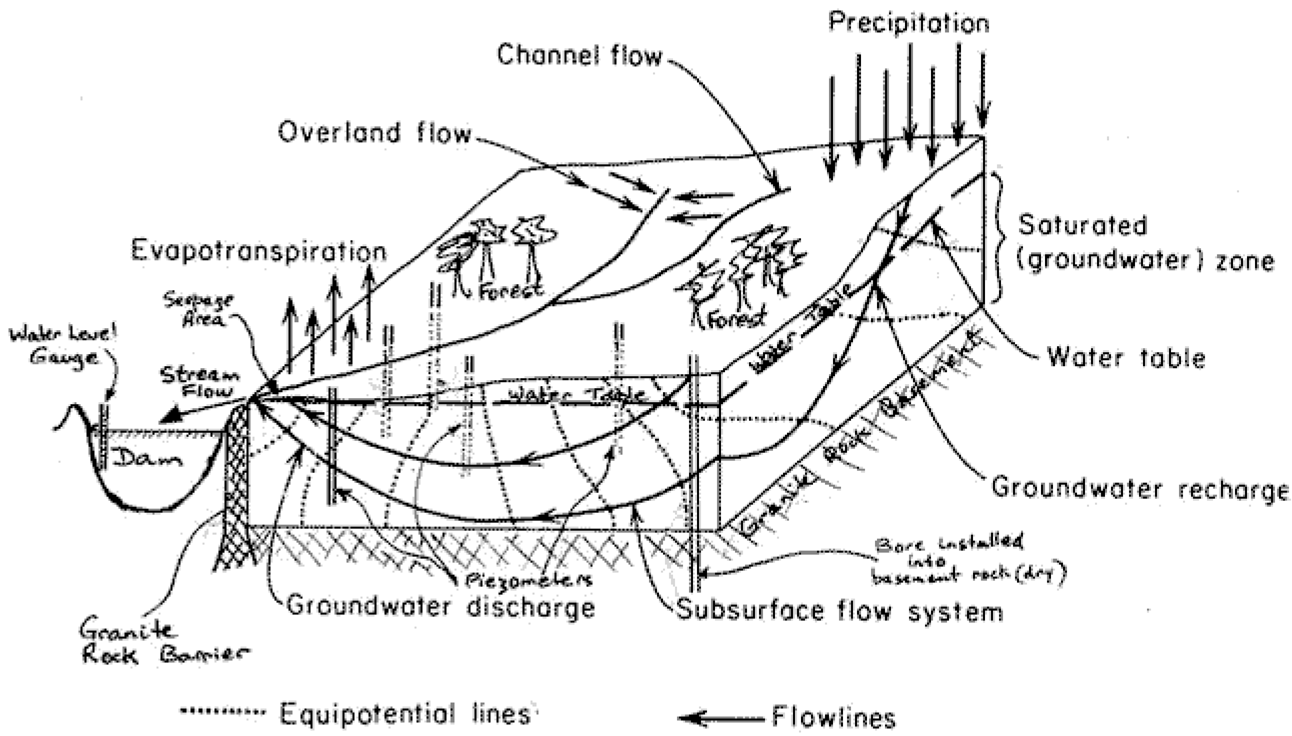


Figure 2: Schematic representation of the hydrologic cycle for the monastery catchment.

7. Acknowledgment:

We acknowledge with thanks the interest and hospitality of the Monastery in involving Murdoch University in this problem and for providing copies of the information already obtained in previous investigations by various agencies. We are encouraged by the interest in supporting a student project.

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from original report prepared 23 January 1998

File: MonastryDamSalt1998.doc (D.R. Williamson)

Australian Environmental Laboratories Client: Bodhinyana Monastery Our Reference: 37573 Project: Dam Waters Laboratory Report					
Your Reference Our Reference Date Sampled Type of Sample	Units	Method	Top_Dam 37573-1 19/12/97 Water	Middle_Dam 37573-2 19/12/97 Water	Bottom_Dam 37573-3 19/12/97 Water
pH	pH Units	PEI-001	4.4	5.5	5.9
Electrical Conductivity@25^{o}C	µS/cm	PEI-032	2300	1500	1300
Total Dissolved Solids (calc)	mg/L	PEI-032	1500	960	830
Iron, Fe (soluble)	mg/L	PEI-001	<0.05	<0.05	0.10
Sodium, Na	mg/L	PEI-001	520	240	220
Potassium, K	mg/L	PEI-001	3.8	2.1	2.2
Calcium, Ca	mg/L	PEI-002	9.3	6.7	6.7
Magnesium, Mg	mg/L	PEI-002	36	28	23
Chloride,Cl	mg/L	PEI-020	890	450	420
Carbonate, CO_3	mg/L	PEI-006	<1	<1	<1
Bicarbonate, HCO_3	mg/L	PEI-006	<5	<5	5
Sulphate, HSO_4	mg/L	PEI-020	63	39	43
Nitrate, NO_3	mg/L	PEI-020	0.8	<0.1	<0.1
Sum of ions	mg/L	Unassigned	1530	766	720
Cations/Anions % difference		Unassigned	-0.57	-3.42	-0.57

[-] Stokes, R.A., Stone, K.A,. and Loh, I.C. (1980) Summary of soil salt storage characteristics in the northern Darling Range. Water Resources Branch, Public Works Department W.A., Technical Report No. WRB 94.