ISSN 1039-7205

Agriculture WESTERN AUSTRALIA

MORILLA SWAMP HYDROLOGICAL INVESTIGATION

By R J Speed, E B Lefroy and J A Simons

Agriculture Western Australia
South Perth, Western Australia 6151

February 1997

RESOURCE MANAGEMENT
TECHNICAL REPORT **163**

MORILLA SWAMP HYDROLOGICAL INVESTIGATION

R J Speed, E B Lefroy and J A Simons
Agriculture Western Australia

ISSN 1039-7205
February 1997

CONTENTS

Morilla Swamp Hydrological Investigation

R.J. Speed, E.B. Lefroy and J.A. Simons
Agriculture Western Australia

Introduction

Morilla Swamp is a circular depression approximately 600 m in diameter located within an area of Jingemia Dolomite. Small circular basins are common throughout this geological formation in the northern agricultural region, however, Morilla Swamp is the only one known to contain an isolated population of River Red gum (*Eucalyptus camaldulensis*) (George *et al*, 1996). The others are, or were, populated by York gum (*E. loxophleba*) or *Melaleuca* species.

Increased run-off and rising watertables resulting from extensive clearing of the surrounding district is detrimentally affecting the swamp and adjacent agricultural land. There was no natural surface drainage into or out of the swamp. A 'W' drain constructed in 1989 to alleviate waterlogging on extensive flats north of the swamp now delivers substantial excess surface water into the swamp. There is still no surface water outlet from the swamp.

The swamp is now semi-permanently inundated or waterlogged and severe stress is evident amongst the majority of trees which are possibly a unique provenance of *E. camaldulensis*. The Black Wattle (*Acacia rostellifera*) understorey has been almost completely lost. The only apparently healthy vegetation are scattered Sheoaks (*Casuarina obesa*), however, many of these are falling over probably due to changing soil physical properties brought about by continual saturation such that the soil can no longer support the trees.

Morilla Swamp is an example of remnant vegetation decline as a consequence of a changing hydrological environment in catchments extensively cleared for agriculture. It also raises the issue of protecting genetic diversity. The dark grey to black clay soil in the swamp formed by the decomposition of the Jingemia Dolomite has a pH of over 9, giving rise to the possibility of using *E. camaldulensis* seed stock from Morilla Swamp for industrial waste water disposal strategies. For example, the effluent from some pulp processes is both saline and alkaline, and irrigating a wood lot of *E. camaldulensis* (Morilla) may provide alternative and productive waste water disposal options (George *et al*, 1996).

The aims of the investigation were to assess the cause of the decline of the vegetation, understand the hydrological processes operating within and around the swamp and determine remedial strategies.

Site Description

Morilla Swamp is located 28 km east of Mingenew and 350 km north of Perth (AMG coordinates 6767300 mN, 377000 mE, Zone 50) (Figure 1, inset). The base of the swamp is at an elevation of 290 m AHD.

The swamp is the lowest point within an internally drained 8000 ha topographic catchment. The surrounding catchment is 90% cleared of native vegetation for agricultural pursuits that are dominated by cereal cropping and sheep production.

The climate is Mediterranean with an annual average rainfall of 364 mm, 74% of which falls between May and September (Clewett *et al*, 1994).

The site lies within an area of Jingemia Dolomite, a grey, fine to medium grained, massive rock that commonly displays stromatolites and rudimentary layering fabrics (Baxter and Lipple, 1985). Jingemia Dolomite is a member of the Moora Group of Proterozoic sedimentary rocks that are approximately 1300 million years old (GSWA, 1990).

Evidence of karst features occur throughout the Jingemia Dolomite and numerous closed depressions, of which Morilla Swamp is one example, are believed to be surface expressions of this topography. Hydraulic conductivity is enhanced by secondary porosity caused by dissolution of the rock matrix.

The soil in the swamp is a dark grey to black clay formed by *insitu* decomposition of the Jingemia Dolomite. Soil samples collected from two representative locations in the swamp had pH values of 9.1 and 9.2, indicative of the carbonate parent material.

Morilla Swamp is 3.5 km east of the Darling Fault. Surface drainage east of the Darling Fault is ill-defined, but is well defined west of the fault which is clearly delineated in the region by a scarp and break-aways (Figure 1).

There was no natural surface drainage into the swamp or surface water outlet from the swamp. The swamp is fringed by at least a 2 m rise in elevation. Sandy lunettes fringe the eastern and northern side of the swamp. The southern and western boundaries are shallow to outcropping dolomite bedrock. A 'W' drain, an artificial surface waterway, was constructed in 1989 to alleviate waterlogging on extensive areas of flat agricultural land north-northest of the swamp. The swamp is used as a disposal point for surface water collected in the drain (Figure 1).

A mineral exploration hole, prospecting for diamonds, was drilled in the swamp in 1980 on a magnetic anomaly. The site of this exploration hole coincides with an aerial photographic lineation caused by a dolerite dyke. The hole was partially cased and now discharges artesian water into the swamp, however, the contribution of this artesian flow to the swamp water level is insignificant.

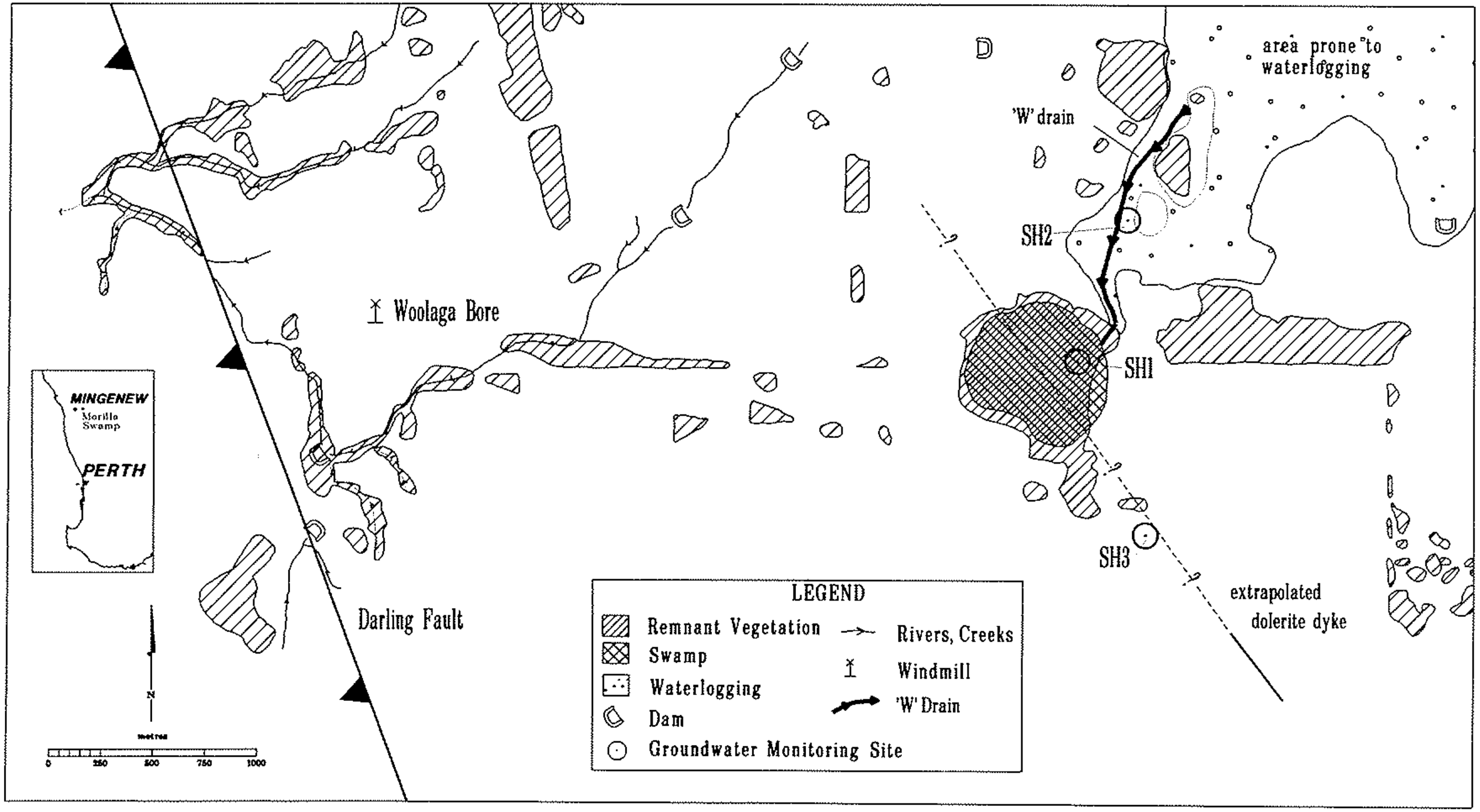

Figure 1. Morilla Swamp site map.

Monitoring Methods

Watertable observation wells and piezometers were established at three sites in a north-south transect in December 1991 (Figure 1), using a Gemco HM12 RAB drill rig. Drill logs and bore construction details are provided in Appendix 1.

Groundwater monitoring began in February 1992.

The transect was surveyed in June 1992 and referenced to the Australian Height Datum (AHD).

Results

The lowest groundwater levels were recorded at the beginning of monitoring in February 1992. The highest levels were in August 1993. Figure 2 displays hydrographs for the three monitoring sites relative to ground surface at the respective sites. There is artesian piezometric pressure at site SH1, both in piezometer SH1D and observation well SH1OB. This is evident from the difference in water level in observation well SH1OB relative to the swamp water level for periods when the swamp was inundated and the water level in the swamp is an expression of groundwater outcrop (Figure 2).

Groundwater salinity has increased by more than 40% at site SH1, from 520 mS/m (Feb 92) to 766 mS/m (Jan 96) in observation well SH1OB and from 540 mS/m (Feb 92) to 772 mS/m (Jan 96) in piezometer SH1D. Groundwater salinity has also increased at site SH2, from 400 mS/m (Feb 92) to 546 mS/m (Jan 96) in observation well SH2OB (36% increase), and 490 mS/m (Feb 92) to 565 mS/m (Jan 96) in piezometer SH2D (15% increase).

In contrast, groundwater salinity at site SH3 has decreased by 25%, from 2810 mS/m (Feb 92) to 2100 mS/m (Jan 96) in observation well SH3OB.

A hydrogeological cross-section is presented for the monitoring date of maximum hydraulic gradient (11 Aug 93) in Figure 3.

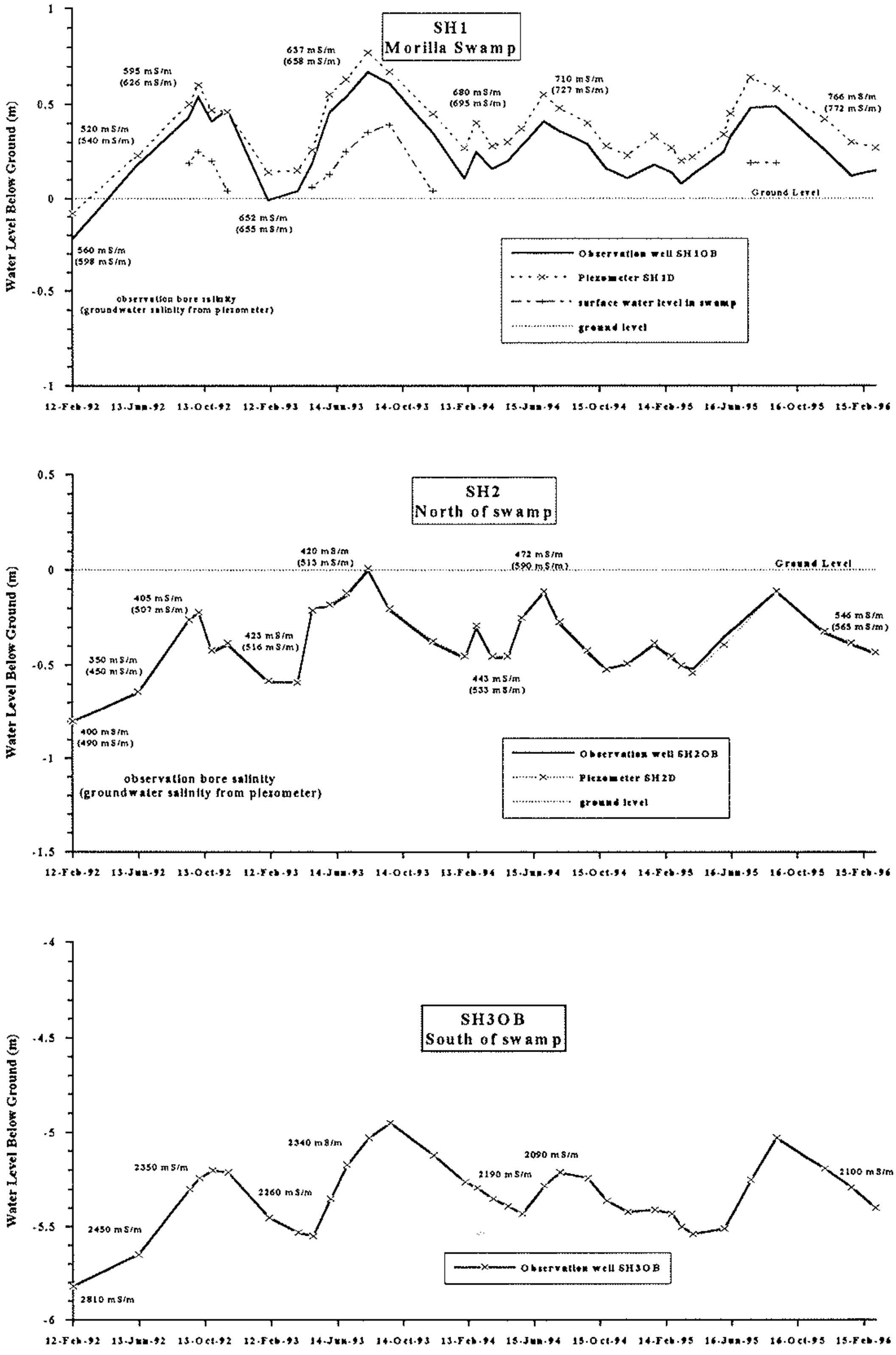

Figure 2. Hydrographs for groundwater monitoring sites.

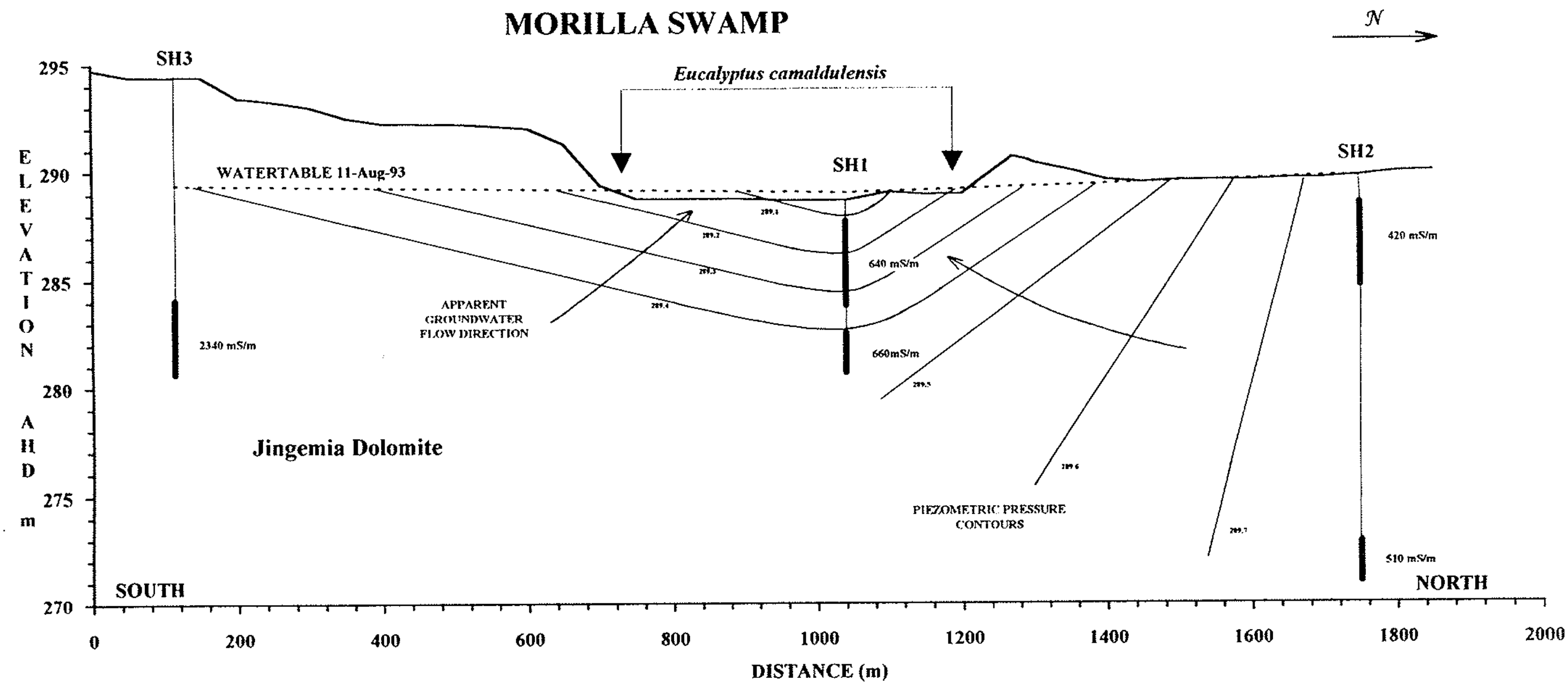

Figure 3. Hydrogeological cross section through Morilla swamp.

Discussion

Morilla Swamp was a 'dry' swamp or depression populated with *E. camaldulensis* and fringed with a pink, ball flowered Melaleuca (L.M. Stone, previous owner until 1979, personal communication, 1995).

It is now subjected to waterlogging and inundation from rising groundwater and increased run-off from extensive clearing of the surrounding catchment. Farm records provided by the Yewers family indicate the groundwater level in Woolaga Bore (Figure 1), drilled into 'mostly limestone', rose 5.94 m from Jan 1961 to Nov 1976 despite supplying the water requirements for a 4050 ha farm carrying up to 11000 sheep and 600 pigs. This represents an average rate of watertable rise of 0.38 m per year.

Morilla swamp is considered to lie within a reasonably homogeneous hydrogeological environment. A dolerite dyke is clearly visible south east of the swamp and can be extrapolated through the swamp as a lineation on an aerial photograph. However, the dyke is not considered to have an impact on the near surface hydrology (< 10 m) although this is not definitely known.

The regional groundwater flow is considered to be westward. Hence the groundwater monitoring transect is across the regional flow direction and therefore in the direction of minimum gradient.

The hydrogeological cross-section (Figure 3) shows a groundwater gradient toward the lake from either side with upward pressure. This is consistent with the convergence zone described by Townley and Turner (1995) for surface water bodies coupled to groundwater. Figure 4 schematically depicts the dynamics of groundwater - surface water interactions within a regional flow system. The cross-section of Morilla Swamp (Figure 3) is across the up-gradient side of the lake.

The larger the lake, the wider the convergence zone, and the stronger the gradient and tendency for groundwater in the vicinity of SH3 to be drawn toward and up into the lake. This is supported by piezometric pressure patterns for different lake levels.

Groundwater in the vicinity of SH3 is considerably saline (> 2000 mS/m) and poses an additional threat to the already severely stressed vegetation in the swamp. The convergence of groundwater from the vicinity of SH3 may explain the observed increases in groundwater salinities in both the observation well and piezometer at site SH1 within the swamp, however, the groundwater quality directly up-gradient (east) of the swamp is unknown.

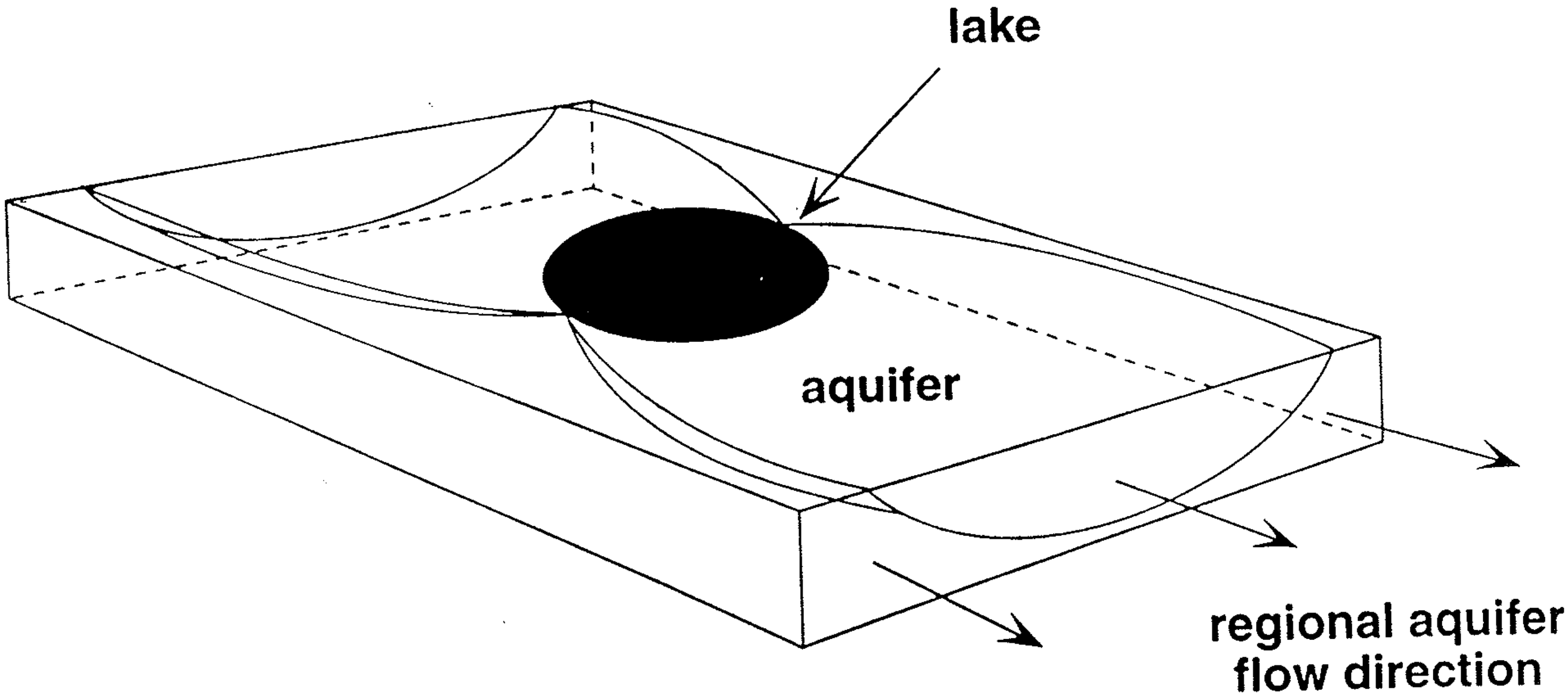

Figure 4. Schematic representation of groundwater capture zone of a surface water body interacting with groundwater (source: Townley and Turner, 1995).

The increase in groundwater salinity in piezometer SH1D and observation well SH1OB is unlikely to be related to evaporation from the swamp because of the upward piezometric gradient at site SH1 and groundwater through flow is likely to move surface water westward rather than allow it to 'sink' through the swamp floor due to density differences brought about by evaporation.

The seasonal peaks related to watertable recharge from rainfall are delayed by approximately a month in observation well SH3OB where the watertable is five or more metres below the ground surface compared to sites SH1 and SH2 where the watertable is within half a metre of the surface. This is indicative of matrix recharge delaying watertable response to seasonal rainfall.

Remedial Strategies

Morilla swamp is beset by a combination of too much groundwater and too much surface water. Too much water gets in and not enough water can get out as groundwater through flow.

The short term imperative is to remove enough of the excess water to alleviate the stress on the trees. *E. camaldulensis* can tolerate short periods of inundation (in the order of a month or so), but are not surviving the conditions of perpetual waterlogging that have been a feature of the swamp for virtually the last four years.

In addition, minimising or removing all the surface water will restrict the convergence zone or de-couple the surface water - groundwater interaction. This would lessen or eliminate the tendency for saline groundwater in the vicinity of site SH3 to be drawn into the swamp.

Closing off the 'W' drain may restrict excess surface water coming into the swamp but would accelerate degradation on the extensive flats north of the swamp and is not considered a viable option in the short term.

Excavating a drain to remove water from the swamp to the west is not considered an ideal option. Such a drain would have to be excavated to a depth of more than two metres through competent dolomite for a distance of about 700 m. This is an expensive option that would be fraught with land degradation hazards, particularly stability of the drain itself over a distance of more than three kilometres required to reach a defined drainage line for disposal.

An option put forward and currently being pursued by the joint owners of the swamp is to siphon the excess surface water out of the swamp to adjust the hydrological balance more favourably toward long term survival of the trees. A defined drainage line suitable for disposal of surface water siphoned from the swamp is located just over three km to the west. This drainage line feeds the Woolaga Creek which is a tributary of the Green Brook which in turn flows into the Irwin River. The distinct advantage of siphoning the excess surface water is avoiding the land degradation hazards associated with excavating a drain.

If the swamp became inundated to a depth of 0.3 m, it would contain up to 85 000 m^3 of surface water. The vertical fall is 20 m over a distance of 3 500 m from the swamp to the defined drainage line.

A 150 mm 'Ultra-Rib' siphon pipe could discharge 1580 m^3 of water per day, or could drain the swamp in 54 days. A 225 mm 'Ultra-Rib' siphon pipe could discharge 4380 m^3 of water per day, or drain the swamp in 20 days (D. Smargiassi, pers comm 1996).

The long term strategy must be to modify or change the current agricultural systems to achieve a catchment water balance with benign environmental impacts. The recommended first step is to establish perennial pasture (e.g. Strawberry clover (*Trifolium fragiferum*)) across the extensive flats north of the swamp. Any improvement in agricultural water use throughout the catchment will ultimately benefit Morilla swamp.

References

Baxter, J.L. and Lipple, S.L. (1985) Perenjori, Western Australia, 1:250 000 geological series - explanatory notes. Geological Survey of Western Australia, 32 pp.

Clewett, J.F., Clarkson, N.M., Owens, D.T. and Abrecht, D.G. (1994) Australian Rainman: Rainfall Information for Better Management, Dept of Primary Industries, Brisbane.

Geological Survey of Western Australia (1990) Geology and Mineral Resources of Western Australia, Western Australia Geological Survey, Memoir 3, 827 pp.

George, R.J., McFarlane, D.J. and Speed, R.J. (1996). The consequences of a changing hydrologic environment for native vegetation in southwestern Australia. In: Saunders, D.A., Craig, J.L. and Mattiske, E.M. (Eds) Nature Conservation 4: The Role of Networks, Surrey Beatty & Sons Pty Ltd, Australia, pp. 9-22.

Townley, L. and Turner, J. (1995) Surface Water - Groundwater Interaction Workshop, Centre for Groundwater Studies, CSIRO Division of Water Resources, Floreat Park, Western Australia.

Appendix 1

Bore construction details
and
Drill logs

Bore Construction details

Class 9, 50 mm PVC. Slots = 0.8 mm					
Bore No.	Depth drilled (m)	Total length of PVC installed (m)	Height of PVC above ground level (m)	Slotted length (m)	Status
SH1OB	5	5.7	1.35	4	observation bore
SH1D	8.1	8.87	1.35	2	piezometer
SH2OB	5	5.91	0.75	4	observation bore
SH2D	19	19.62	0.75	2	piezometer
SH3OB	14	13.91	0.08	3.6	observation bore

Drill log data: SH1

Morilla Swamp 17 Dec 91

Paleo sink hole in Jingemia Dolomite - *E. camaldulensis* province

Depth (m)	General Sample Description
Surface	Dark brown/black peaty earth
0 - 0.8	Dirty grey clay with white weathered dolomite fragments
0.8 - 1	Grey clay
1.0 - 1.5	Brown earthy clay
1.5	White/grey clay
1.6	White clay - decomposed dolomite
1.7	Weathered dolomite with harder bands
2.0 - 5.0	Water injection (2.0 - 5.0m) returned a gritty grey paste, by 4.0m mainly white
	Hard bands prevalent by 5.0m. Quite hard.
5.0 - 8.1	Much less weathered dolomite. No water injection after 5.0m. Prodigious amounts of water by 8.1m. At 8.1 m too hard for blades

Drill log data: SH2

Morilla Swamp 18 Dec 91 Adjacent'W' drain in Barley grass patch	
Depth (m)	**General Sample Description**
Surface	Red alluvial sandy loam
0 - 1	Moist orange/red clay loam
1.0	Dolomite cap rock. Water injected. Changed bit to "rock roller".
1.5	White dolomite
2.0	White dolomite. Making water. Water injection stopped.
2.75	White dolomite clay.
3.0	Added water to clean bit. Changed back to Chevron blade bit.
4.0	White dolomite. Making large amounts of water.
5.0 - 7.0	White dolomite.
7.0 - 8.0	White dolomite with calcite vein.
8.0 - 16.0	White dolomite.
16.5	White dolomite
17.0 - 19.0	White dolomite
19.0	Grey/orange mottled clay

Drill log data: SH3

Morilla Swamp 19 Dec 91 Dolomite outcrop atop a small rise	
Depth (m)	**General Sample Description**
Surface	Red/brown dirt over weathered dolomite outcrop.
0 - 8.5	Decomposed dolomite, quite nodular. Hard bands.
8.5 - 10.0	Decomposed dolomite with brown ironstone nodules with fragments and grey and brown clay cuttings.
10.0 - 14.0	Water injected. Brown silty clay and decomposed brown clays. Dolomite fragments. Hard bands. Same clay underlying dolomite as at SH2 ?