SALINITY PROBLEMS IN THE BARWON RIVER SYSTEM

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Victoria"

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INTRODUCTION

This paper is based upon an investigation carried out on behalf of the Geelong Waterworks Sewerage Trust and the Geelong Regional Commission titled "Barwon River Water Management - Preliminary Study".

The study arose from two trends in water management in the Barwon. Firstly a steady growth in domestic and industrial consumption for water from the Geelong area has been placing substantial demands upon the Trust's existing Barwon River supply headworks. The Trust is therefore anxious that further use of the water resources of the river is not foreclosed by any deterioration in its quality - especially salinity. Secondly a large number of the many rural consumers of Barwon River water - for domestic stock and irrigation purposes - have in recent years reported increases in salinity in the water to the extent that it has affected stock and made it impossible to successfully irrigate crops as in former years. The interests of these diverters are substantially represented by the Geelong Regional Commission - the joint sponsor of the study.

The area subject to study was the Barwon River upstream of its confluence with the Moorabool River (Fig 1).

DESCRIPTION OF THE PRESENT SITUATION

Data

By comparison with, say the River Murray, the Barwon River is not well documented as regards salinity and flow data. Fig. 2 shows the location of stations which record streamflows and which are regularly sampled for at least salinity (conductivity) determination. The stations are few in number and many have less than ten years record. Consequently during the six months study a number of data collection surveys were carried out at monthly intervals. At each of forty locations, samples were collected for analysis, and
flows at time of sampling determined. Water quality determinations included salinity (conductivity) at all locations and at various others - colour, turbidity, phosphate and orthophosphate. Figures 3 & 4 show typical salinity values recorded at times of low flow and high flow respectively in the Barwon River.

The figures also show by means of the width of the arrows the total salt loads emanating from the various tributaries and eventually combining in the main stem of the river.

Figure 5 is an assemblage of the principal historical data and portrays average salt load over the period 1972-78. This enables the identification of the principal sources of salt as follows (expressed as % of salt load reaching Moorabool confluence)

<table>
<thead>
<tr>
<th>Location</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birregurra Creek</td>
<td>24%</td>
</tr>
<tr>
<td>Upper Barwon River</td>
<td>17%</td>
</tr>
<tr>
<td>Warrambine Creek</td>
<td>17%</td>
</tr>
<tr>
<td>Leigh River</td>
<td>15%</td>
</tr>
<tr>
<td>Other tributaries</td>
<td>27%</td>
</tr>
</tbody>
</table>

PRESENT WATER MANAGEMENT REGIMES

From the above and from discussions with local councillors and farmers the prevailing salinities in the three main reaches of the river and the uses to which the water is being put have been assessed.

Upper Barwon (headwaters to Birregurra Creek)

Salinity varies from 100-1000 mg/L with a mean of 140 mg/L
Suitable for irrigation domestic stock purposes - all year
Suitable for potable supply - winter and spring only
Middle Barwon (Birregurra Creek to Warrambine Creek)

Salinity varies from 200 - 3000 mg/L with a mean of 500 mg/L
Suitable for stock except in summer
Suitable for irrigation and domestic purposes in winter and spring only
Suitable for potable supply - wet springs only

Lower Barwon (Warrambine Creek to Moorabool River)

Salinity varies from 500 - 5000 mg/L with a mean of 800 mg/L
Suitable for irrigation domestic and stock purposes - spring only
Unsuitable for potable supply without desalination.

SOURCES OF SALT

Despite the limited data available the principal sources of salt have been able to be identified.

Upper Barwon

Salt contained in Upper Barwon flows emanates mainly from a number of small saline springs and swamps in the area downstream of Forrest. This salt in turn is considered to have been leached from the older basaltic rocks. The appearance of these saline flows so far upstream may also be attributable to the widespread clearing of the catchments in this area in the past one hundred years.

Middle Barwon

The substantial additional salt entering between Birregurra Creek and Warrambine Creek originates in part from additional inputs from low lying swamp areas but predominantly from Birregurra Creek. This watercourse received most of its flow from a drainage scheme first constructed in 1953 and then
enlarged in 1961-66.

Called the Lake Colac/Lough Calvert Drainage Scheme the works consist of a control structure at the north-east corner of Lake Colac (average salinity 1500-2000 mg/L) discharging excess lake water to a channel running north east then south east and picking up surplus flows from the two lower Loughs Calvert (2000-5000 mg/L) via control structures and from a lake known as The Sanctuary (2000-5000 mg/L). It is proposed in the future also to take occasional discharges from Middle Lough Calvert (approximately 15000 mg/L) and Eurack Swamp, but not Upper Lough Calvert (approximately 25000 mg/L).

The capacity of the scheme to discharge into Birregurra Creek and thence the Barwon River is a nominal 250 ML/d with a practical limit without overtopping of 170 ML/d. This compares with a mean daily flow in the Barwon at this point of 350 ML/d.

This scheme enables Lake Colac to be maintained at a depth which is either not too shallow so as to prohibit recreation or not too high so as to flood surrounding grazing land. Similarly, drainage from Lough Calvert minimises the flooding of grazing land in its vicinity.

Currently, the drainage of saline floodwater from the Lake Colac/Lough Calvert system takes place normally from 1st May to 30th September, provided its release does not increase the salinity of the Barwon River at Winchelsea beyond 1000 mg/L.

Since records have been kept (1959 to date), substantial flows (> 5 ML/d) have occurred in Birregurra Creek as follows:
In some years, significant proportions of the flow would have originated from local runoff as distinct from controlled release from Lake Colac/Lough Calvert.

The salinity of the water reaching the Barwon via Birregurra Creek is normally about 2000 mg/L, increasing to 3000 mg/L as the release period ceases, and residual water backed up in The Sanctuary enters the Creek.

The five water bodies able to be or proposed to be drained into Birregurra Creek are listed below in increasing order of salinity:

- Lake Colac
- Lower Lough Calvert
- The Sanctuary
- Middle Lough Calvert/Eurack Swamp (occasionally)

In the years of little late spring/early summer flow in the Barwon, limited flushing of the river takes place and the water released last down Birregurra Creek represents a significant proportion of water being consumed by diverters downstream in early summer. Therefore, some benefit would accrue to these diverters if the last water to be released down Birregurra Creek was the freshest available. With the lack of control over The Sanctuary, this is difficult to achieve at present.

Works proposed in a recent report by SRWSC (Ref 1) to considerably upgrade the drainage system would enable The Sanctuary to be isolated from the channel flows to Birregurra

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<tr>
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<tbody>
<tr>
<td>1959 4½ months</td>
<td>No</td>
<td>1968 3 months</td>
<td>No</td>
</tr>
<tr>
<td>1960 8</td>
<td>Yes</td>
<td>1969 1</td>
<td>No</td>
</tr>
<tr>
<td>1961 7</td>
<td>No</td>
<td>1970 3</td>
<td>No</td>
</tr>
<tr>
<td>1962 ½</td>
<td>No</td>
<td>1971 6</td>
<td>Yes</td>
</tr>
<tr>
<td>1963 3½</td>
<td>No</td>
<td>1972 6½</td>
<td>Yes</td>
</tr>
<tr>
<td>1964 6</td>
<td>Yes</td>
<td>1973 5½</td>
<td>Yes</td>
</tr>
<tr>
<td>1965 4½</td>
<td>No</td>
<td>1974 5</td>
<td>Yes</td>
</tr>
<tr>
<td>1966 2</td>
<td>No</td>
<td>1975 7</td>
<td>Yes (6 mths)</td>
</tr>
<tr>
<td>1967 0</td>
<td>No</td>
<td>1976 9</td>
<td>Yes (9 mths)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1977 4</td>
<td>Yes (2½ mths)</td>
</tr>
</tbody>
</table>
Creek, thus providing an improved degree of control. The works also provide for the future occasional drainage of the very saline Middle Lough into the system and the timing of these flows would need to be carefully considered.

In very wet years, e.g. 1975-6, there is carryover water outside the normal May-September release period. In such a situation, when flows in the Barwon are relatively low, the interests of diverters downstream would be best served by delaying further releases from Lake Colac/Lough Calvert until the following May, i.e. avoiding the normal irrigation season.

The optimum pattern of release to least affect Barwon River diverters would be in the following sequence:

1st  carryover water from all lakes
2nd  Middle Lough when required
3rd  The Sanctuary
4th  Lower Lough
5th  Lake Colac

If the volumes of water concerned require it, Lake Colac could be released in conjunction with the others, provided it was the last to be cut off (making allowance for its travel time to the Barwon).

In some years, it could be possible to pre-release from Lake Colac early in the May-September period such that if a drier than average winter and spring occurred, no release would be required from July onwards. Such an arrangement would be of considerable benefit to any proposals by Geelong to divert water from the Barwon during the period July to October.

The control of the scheme would be enhanced by more continuous records of salinity levels, river and channel flows and lake levels. This would aid in the forecasting of correct release strategies, hence overcoming the lag time in the outlet channel, and enable the changes in salinity of the various lakes to be observed.
Lower Barwon

A considerable quantity of salt enters the lower Barwon from the Leigh River and Warrambine Creek which drain much of the northern area of the Barwon basin. Some of the salt originates from natural or man assisted leaching resulting in the formation of springs and swamps. A substantial amount of salt enters Warrambine Creek from the Woady Yaloak diversion channel. This scheme was constructed in 1958/59 by forming a 40 km long, 500 ML/d capacity channel from Cundare Pool to Warrambine Creek. The channel diverts excess floodwater from the Woady Yaloak River so as to reduce the rise in level of Lake Corangamite, the latter being the normal ultimate destination of Woady Yaloak flows. The mean daily flow in the Barwon at the confluence with Warrambine Creek is about 400 ML/d.

This 40 km long, 500 ML/d capacity channel is operated throughout the year to minimise rises in the level of Lakes Corangamite (salinity approx 25 000 mg/L), Gnarpurt and Martin so as to reduce the area of grazing land flooded in those areas. The salinity of flows in the channel since its inception has generally been in the range 2000-5000 mg/L. The constraints on operation (established in 1961) of the 500 ML/d capacity channel are the following salinity (TDS) levels, which are not to be exceeded at Geelong:

<table>
<thead>
<tr>
<th>Month</th>
<th>TDS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>November-April</td>
<td>1500</td>
</tr>
<tr>
<td>May</td>
<td>1500</td>
</tr>
<tr>
<td>June</td>
<td>3500</td>
</tr>
<tr>
<td>July-August</td>
<td>4500</td>
</tr>
<tr>
<td>September</td>
<td>3000</td>
</tr>
<tr>
<td>October</td>
<td>2000</td>
</tr>
</tbody>
</table>

This system permits relatively high salinities and also takes no account of the travel time from the control gates to Geelong (a distance of about 80 km). Consequently,
salinities in the Barwon from Inverleigh to Geelong could rise too high before the necessary adjustments are made at the gates. It is considered that closer control would be possible by taking account of salinity at Winchelsea, allowing for travel time to the Barwon and measuring salinity at Inverleigh to check the salinity of the mixed flow.

THE CREEPING LAKES

To elucidate the background to the raison d'etre of the two saline floodwater diversion schemes requires firstly a consideration of events in the Quaternary-Pleistocene geological period.

Currey (Ref. 2) has postulated that the Barwon and Leigh Rivers originally flowed to sea via what is now Thompson's Creek emerging at Bass Strait at Breamlea (Fig. 6). He further proposes that lava flows 6-7 million years ago blocked this flow path resulting in an accumulation of water in a vast inland sea covering 1800 km² from west of Camperdown to Winchelsea and from Colac to Cressy. Currey refers to this as the former extent of Lake Corangamite (present area 250 km²). Eventually the rising water level reached a low point near Inverleigh and the resultant channel cut through follows the present path of the Barwon to Barwon Heads. The formation of this new outlet steadily lowered the water level resulting in a number of stranded closed lakes such as Corangamite, Colac, the various Loughs Calvert, Gnarpurt, Cundare (Martin) and many others. A number of these are currently the subject of study by Gutteridge, Haskins & Davey (Ref. 3).

Since that time the lakes have fluctuated in level in accordance with variations principally in rainfall, runoff and evaporation and to a lesser extent groundwater inflows and outflows. They have rarely overflowed. Accordingly they have acted as large evaporimeters with increasing salinity in dry periods. The lakes display marked differences in salinity and can range from slightly brackish e.g.

- 8 -
Lake Colac (1500 mg/L) to highly saline e.g. Upper Lough Calvert (25000 mg/L). (Seawater salinity is about 30 000 mg/L). This variation is due in part to catchment geology and soils but more importantly to the ratio of catchment area to lake surface area and the frequency of occurrence of outflow be it surface or subsurface. Lake Colac has a large catchment area as well as a surface outlet whereas Upper Lough Calvert has a relatively small catchment and rarely overflows at all.

Fig. 7 shows the variation in annual rainfall at Birregurra since 1904. Both at Birregurra and Camperdown further to the west, the average annual rainfall since 1950 has been significantly higher than in the years to that time. The average at Birregurra from 1904-50 was 650 mm., and since 1950 710 mm. At Camperdown during 1898 - 1950 annual rainfall averaged 750 mm, increasing to 840 mm since that time. Since lake evaporation in the area is of the order of 1000 mm a change of 100 mm in average annual rainfall is very significant from the overall water balance point of view.

It was in this period of lower average rainfall that the land surrounding the various lakes - Corangamite, Colac, etc, was alienated from the Crown and put to agricultural pursuits predominantly. However with the onset of the wetter period since 1950, much of the land previously well above high water became inundated owing to the large volumes of rainfall and runoff entering the closed lakes and the generally flat terrain - resulting in large areas being flooded by relatively small rises in level.

A number of reports (Refs. 4,5,6) were commissioned by the State Government in order to investigate the alleviation of the flooding being experienced by landowners in the vicinity of the lakes.

These resulted in the construction of the two schemes
described previously - the Woady Yaloak River diversion and the Lake Colac/Lough Calvert drainage system. Both schemes are overviewed by the S R W S C which authority also operates the former scheme whilst the Lough Calvert Drainage Trust operates the latter.

POSSIBLE SALINITY ABATEMENT MEASURES

General

Several proposals have been suggested over the years to reduce the salinity in the Barwon to levels acceptable for the various demands endeavouring to be made upon it. Some were suggested at the time of initiation of the two flood mitigation/drainage schemes, others have been proposed subsequently amidst the deteriorating saline situation, and still others have been developed during the present study.

Headwaters Storages

The only major storage in the Barwon system (excluding the Moorabool) is West Barwon Dam which unlike the Hume Weir on the River Murray is operated primarily for urban water supply purposes. Thus there is minimal release in summer—mainly for riparian purposes — and no provision for release to maintain a certain salinity downstream. To maintain a salinity of say less than 500 mg/L at Winchelsea would require a substantial proportion of West Barwon's 21 000 ML capacity to be dedicated each summer to dilution releases. This would significantly reduce the safe yield of the Geelong water supply.

However there are a number of potential storage sites (see Fig. 8) on the various other tributaries in the Otways able to harness areas in the range 10-35 km² compared with the West Barwon Dam Catchment of 50 km² (the latter albeit of higher mean annual rainfall). For a moderate capital cost but substantial unit cost, construction of reservoirs of capacity 1500-1700 ML on some of these tributaries would permit the storage of winter-spring runoff for later release for salinity control and also for guaranteed minimum flow...
purposes. Alternatively the storages would enable additional yield to be harvested by the Geelong water supply scheme based on the Wurdiboluc inlet channel.

Abstraction at Times of Low Salinity

Whilst there are no suitable storage sites in the middle and lower Barwon it is possible given a knowledge of the prevailing salinities to abstract suitable water from the river during winter and spring. Immediately upstream of Birregurra Creek approximately 12 000 ML could be pumped into Geelong's Wurdiboluc system even in a moderately dry year. The water would average 500 mg/L salinity and would require shandying with fresher water to produce a more potable quality (Fig.9).

Further downstream at Winchelsea similar abstraction of 23 000 ML/a would average 2000 mg/L salinity and at Pollocksfords 18 000 ML/a of 1000 mg/L salinity water could be obtained. (Fig.10) In both these cases desalination (preceded by conventional water treatment) would be required to produce a potable supply.

Smaller scale consumers, such as domestic and stock diverters, could make more effective use of the Barwon supply by storing the lower salinity winter/spring flows for consumption during summer. This could be via pumped or gravity diversion into off river storages.

Diversion to Corio Bay (Fig. 11).

This scheme was first conceived by Horsfall almost 20 years ago. It would consist of a channel to divert Lake Colac/Lough Calvert drainage to the 'Noady Yaloak Diversion Channel and then a 45 km channel of 750 ML/d capacity to Cowies Creek which drains into Corio Bay at Geelong. It would be a substantial construction task with three major siphon crossings of the Barwon (twice) and the Moorabool (once) Rivers. Whether such a large channel would be permitted
on environmental grounds in such an aesthetically attractive area is doubtful in this day and age. At today's prices it would cost about $18 million and would benefit 21 irrigators, 7 domestic, stock and dairy diverters, one industrial user—(and possibly also Geelong) by enabling them to draw lower salinity water from the river.

Diversion to Bass Strait (Fig. 11).

This scheme was also described in Horsfall's reports and has been modified by a number of investigators since. It would connect Lake Corangamite to Lake Colac by channel and thence drain excess from both lakes by channel towards Birregurra followed by a syphon under the Barwon and then a further channel to a point south of Winchelsea. There, a 250 ML/d pump station (or alternatively a tunnel) would lift the water over the range to the Anglesea River for conveyance to Bass Strait.

The scheme would benefit a similar number of users as the previous scheme but at some penalty to the water quality of the Anglesea River. It would cost today about $22 million.

Miscellaneous Schemes

As referred to previously, the timing of release of saline flows down both Birregurra Creek and the Woady Yaloak diversion channel is rather crudely programmed at present. In addition there are insufficient control structures in the former scheme to provide effective control over the different lakes contributing to the salt load. It is considered that some reduction in salinity peaks in the Barwon could be achieved by a more sophisticated set of operating rules for both schemes.

Groundwater resources are copious and of good quality in the Upper Barwon and are currently being developed for the Geelong supply. However downstream of Birregurra it is only available in quantities sufficient for domestic and stock purposes and even then not in all areas.
Disposal of saline water by evaporation (as used along sections of the River Murray) is not considered feasible owing to the large quantities of water involved and the fine balance between rainfall (700 mm) and evaporation (1000 mm) in the area.

FURTHER STUDY

The study upon which this paper has been based is and was intended to be preliminary in nature. It has barely scratched the surface, but has identified a number of areas worthy of further investigation.

In particular these are the headwaters storages, schemes for abstraction at times of low salinity and improved operation of the existing drainage schemes.

For all these schemes to be fairly assessed a considerable expansion in the data base will be required. And a recommendation of the study already being put into effect is the establishment of extra water quality sampling stations extra stream gauging stations and one or two continuously recording salinity (conductivity meters).

CONCLUSION

The salinity problems being experienced in the Barwon River originate from natural phenomena but have been considerably exacerbated by man's use of the land and works constructed to maintain his use of the land. It is considered that the problems can be overcome at least in part by more detailed data collection and study leading to actions designed to modify the manner in which the river system is currently managed.

Inevitably the alleviation of the salinity problems will involve the resolution of a number of conflicting interests. An obvious example is the apparent incompatibility of the
need to prevent saline lake water flooding rural land which is met by delivering the water into the Barwon, and the desire to keep the salinity of the river low enough for at least irrigation and preferably potable purposes.

Acknowledgement

The author would like to thank the Geelong Waterworks and Sewerage Trust and the Geelong Regional Commission for their assistance during the study and their approval for the presentation of this paper.

REFERENCES


3. Gutteridge Haskins & Davey. Environment Protection Policy for Western District Lakes; Environment Protection Authority (to be published later this year).


7. Other References - approximately fifty other reports papers and files were examined during the study upon which this report was based.
BASS STRAIT

LEGEND
A EXISTING STREAM GAUGING STATIONS
A* DISCONTINUED STREAM GAUGING STATIONS
SALINITY SAMPLING STATIONS
oS B.R.W.R.C.
0G G.W.R.T.

BARWON RIVER WATER MANAGEMENT STUDY
STREAM GAUGING STATIONS AND SALINITY
SAMPLING STATIONS AVAILABLE FOR STUDY

FIGURE No. ~
Figure 7.
Annual Rainfalls for Birregurra P.O.
BARWON DAM SITES IN BARWON HEADWATERS.

LEGEND

ROADS

RIVERS

CHANNELS

APPROXIMATE BARWON RIVER

EXTENSIONS/CONTINUATION

LEGEND

EXISTING DAM

POSSIBLE FUTURE DAM SITES.
Figure 9.
Pumping from Conn's Lane to Wurdiboluc
Reference No. 5080 01
Figure 10.
Supply Scheme
Pumping from Winchelsea to Wurdiboluc
Reference No. 5030 v1