Open Channel Seepage & Control

Vol 1.2 Current Knowledge of Channel Seepage Issues & Measurement in the Australian Rural Water Industry

An ANCID initiative funded by the Murray Darling Basin Commission, the Land and Water Resources Research & Development Corporation & the Rural Water Industry

August 2000

AUSTRALIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

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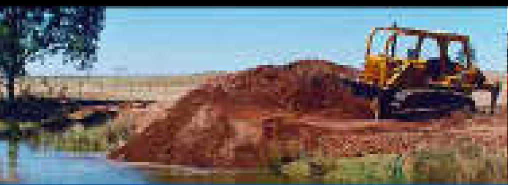

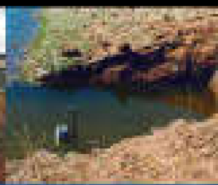
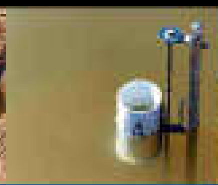


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This report is the first in a series detailing the outcomes of a three stage project investigating the measurement, remediation and associated decision making for channel seepage.

Acknowledgments

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Goulburn-Murray Water
Land and Water Resources Research and Development Corporation
Murray Irrigation
Murrumbidgee Irrigation
Southern Rural Water
Sunraysia Rural Water
Wimmera Mallee Water

In addition, ANCID also wishes to acknowledge the significant input made by the many Rural Water Authorities who responded to the survey which now forms the basis for this Report.

There has also been wide interest in this study and significant input has been provided by a wide and diversified range of interested people for which ANCID is very appreciative.

This document has been prepared on behalf of ANCID by Sinclair Knight Merz Pty Ltd.

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Foreword

In response to concerns over the lack of information available on seepage from open channel supply systems, in October, 1998, the Australian National Committee on Irrigation and Drainage (ANCID) conducted a two-day Workshop. The Workshop was held at Moama in southern New South Wales and had major support from the Murray Darling Basin Commission, the Land and Water Research and Development Corporation, the Commonwealth Department of Primary Industries and Energy and 16 other industry organisations. The Workshop brought together 90 stakeholders and experts in the field of channel seepage from throughout Australia.

The key outcomes from the Workshop were a suite of recommendations seeking new and extensive investigations aimed at improving the level of knowledge about channel seepage.

In response to the recommendations, ANCID formed an industry Task Force to advance the investigations. It has developed a three-stage project designed to implement the recommendations.

Each stage of the project is briefly described as follows:

Stage 1 – This project will investigate best practice, easy to use standards to be used in identifying, measuring and quantifying channel seepage.

Stage 2 – This project is aimed at providing best practice procedures and processes involved in undertaking remedial work to seal channels suffering from seepage.

Stage 3 – This project is designed to target the Decision Support Systems needed to assist industry in making decisions on whether or not to undertake what is often very expensive remedial works on seeping channels.

The three stages will run over four years and will involve a total expenditure of close to $2.5 million. Stage 1 is now well under way and Stage 2 is scheduled to commence in October, 2000.

The major outcomes from each of the Stages of the project work will be in the form of reports and Best Practice Guideline Manuals. This report is one of the suite arising out of the project. It summarises the outcomes of a survey of 41 authorities representative of the rural water industry in Australia. The objective of the survey was to assess the current status of channel seepage identification and quantification techniques within Australia. In addition, information was compiled on the estimated volume of seepage loss, confidence in seepage estimates, importance of channel seepage issues to rural water authorities and the perceived cost of seepage. A significant effort has been involved in its preparation and I commend the contents to you and am sure you will find it interesting and informative.

I would like to also acknowledge the significant support and funding provided to this project by the Murray Darling Basin Commission, the Land and Water Resources Research and Development Corporation, several Water Authorities and Natural Resource Management Agencies. Without their valued support and interest, the project and this report would not have been possible.

Stephen Mills
Chairman
ANCID

Contents

Executive Summary

The Australian National Committee of Irrigation and Drainage (ANCID), in conjunction with the Murray Darling Basin Commission (MDBC), have initiated a project to investigate channel seepage measurement. This report summarises the outcomes of a survey of 41 rural water authorities (RWAs) representative of the rural water industry in Australia (24 of the 41 surveys were useful for analysis purposes).

The key outcomes from the survey are summarised below.

Water Supply, Size of Channel

- The majority of rural water authorities surveyed supply less than 100 GL/yr.

Network and Seepage Rates

- On average, 17.5% of released water is lost through unaccounted for processes.
- On average 4% of total water supplied by all RWAs surveyed is estimated to be lost via seepage.
- An estimated 320 GL of water is lost each year from the authorities surveyed.
- The average length of earthen channel per GL of water supplied is 3.85 km. This result is skewed, however, by one RWA which has 54 km channel / GL supplied. When this result is removed the overall average drops to 1.45 km / GL water supplied.

Significance of Channel Seepage

- Two-thirds of all authorities surveyed have a reasonable or higher confidence in their estimate of seepage.
- Of the authorities surveyed, 42% rate channel seepage as a high or very high priority.

Channel Seepage Costs & Issues

- Measurement of channel seepage is most commonly considered the area where additional resources need to be applied.
- 25% of authorities have undertaken assessment of seepage at 3 or more sites.
- 50% of authorities have undertaken no on ground seepage measurement works at all.
- Extensive seepage investigations are generally only undertaken by water authorities delivering greater than 160 GL/Yr.
- There is a weak correlation between increased investigation and higher confidence in channel seepage estimates.
- The priority given to channel seepage appears dependent mostly on the perceived cost of the impacts of channel seepage
- Loss of water is considered the most significant cost consequence of channel seepage
- It is estimated that 46% of authorities do not know the extent of land degradation associated with channel seepage. A further 25% believe it to be less than 1 Ha.
- Of the authorities surveyed, 16% indicated that they

- are spending more on channel seepage identification, measurement and remediation than the estimated cost of water lost and other impacts of seepage from the channel.
- The average expenditure on channel seepage identification, measurement and remediation is approximately 60% of the estimated cost of water lost and other impacts of seepage from the channel
- Remediation works accounts for 61% of the monies spent on channel seepage, with monitoring and investigation contributing 35%.

Channel Seepage Measurement Techniques

- Cost and speed are considered the most important criteria in channel seepage assessment.
- Technical accuracy is considered of lesser importance.
- Seepage identification (visual, piezometers) rather than quantification techniques dominate channel seepage assessment methods.

Channel Seepage Remediation

- The majority of authorities do less than 5 km of remediation works per year.

Demand for Guidelines

- The majority of authorities believe that there is insufficient information and/or expertise on techniques for seepage identification and measurement.
- There is a strong demand for guidelines on channel seepage identification and measurement

A significant feature of the survey results was the apparent inconsistencies within and between surveys. This suggests that understanding of channel seepage issues and the approach to addressing them is ad-hoc for many authorities. Perceptions of seepage loss rates were often unsupported by seepage assessment studies. In addition a significant number of authorities who were undertaking assessment were finding that their assessment was not improving their confidence is seepage estimates. This suggests a lack of direction in the application of assessment methodologies.

Channel seepage remediation projects are often undertaken without quantitative analysis of seepage. The failure to clearly establish cost-benefit aspects of remediation contradicts the priority that the value of water lost is the major motivator for channel seepage investigations. The reliance on qualitative techniques such as visual inspection and piezometric surveys confirms this inconsistency. This is further supported by 70% of RWAs who acknowledge that there is insufficient information and expertise to assess channel seepage. However a clear outcome of the survey was the desire of RWAs to overcome these knowledge gaps and develop a more systematic approach to channel seepage assessment.

1. Introduction

The Australian National Committee of Irrigation and Drainage (ANCID), in conjunction with the Murray Darling Basin Commission (MDBC), have initiated a project to investigate channel seepage measurement. The main objectives of the study are to:

1. Assess the current status of channel seepage identification, measurement and quantification techniques;
2. Trial and document a range of seepage identification, measurement and quantification techniques; and
3. Prepare and publish guidelines on the best practice techniques for identifying, quantifying and monitoring channel seepage.

The first of these objectives is to be met by a combination of a literature review of available information in conjunction with a survey of 41 Rural Water Authorities (RWAs). This report summarises the RWA survey information.

1.1 Groups incorporated into survey

Information was gathered from a representative group of rural water management authorities

The survey was sent to 41 different Rural Water Authorities or Irrigation Districts / Areas across Australia. The list of authorities was supplied by ANCID and is considered to be representative of rural water management authorities providing water for irrigation purposes.

Figure 1.1 shows the majority of surveys were sent to Rural Water Authorities in the eastern States, broadly reflecting the distribution of surface water resources within Australia (**Figure 1.2**).

1.2 Information gathered in the survey

The questions within the survey were designed to compile information on the following areas:

- Total water supplied by the RWA;
- An estimate of seepage losses in the channel distribution systems, and total system losses, ie unaccounted for water;
- Effect of seepage losses (monetary loss of water and land degradation);
- Importance of channel seepage issues to the RWA;
- Accuracy of (ie, confidence in) seepage estimates;
- Criteria by which the Authority select a seepage measurement technique;
- Estimate of money spent addressing channel seepage issues; and,
- Seepage measurements techniques (techniques used, perceived accuracy, cost and satisfaction with outcome).

A copy of the survey is presented in **Appendix A**.

Figure 1.1: Survey Return Rate by State

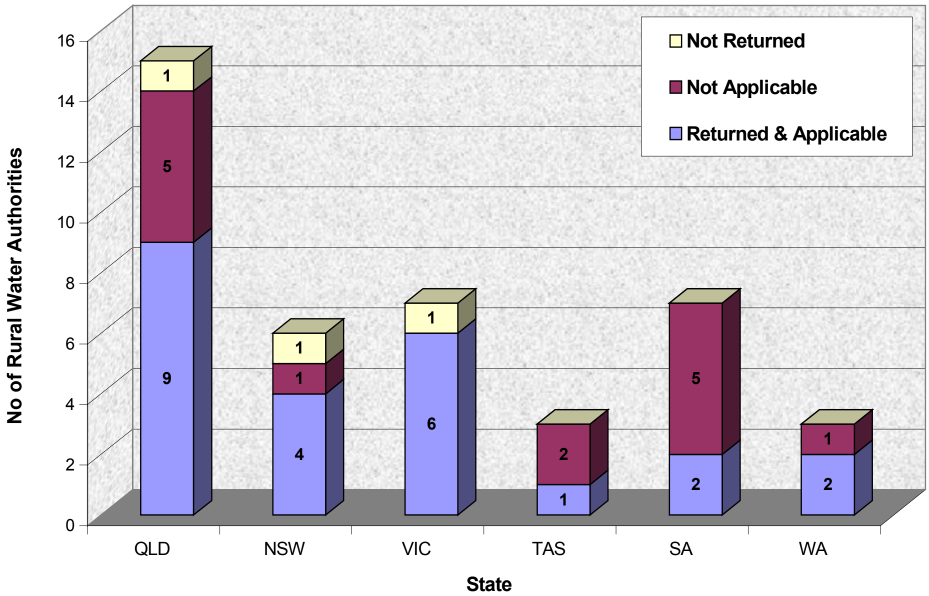
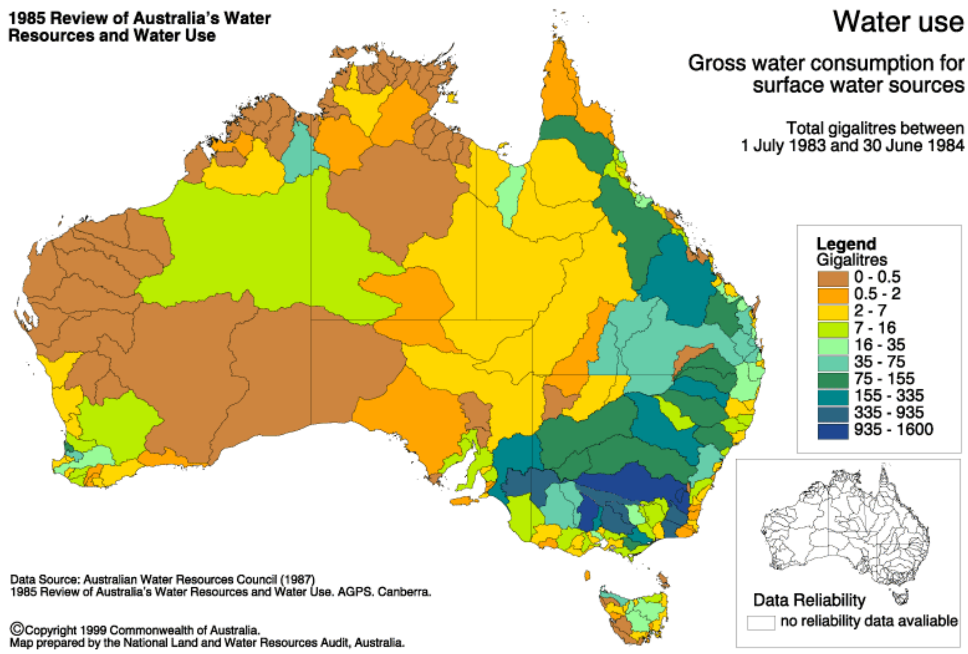


Figure 1.2: Distribution of Surface Water Use in Australia



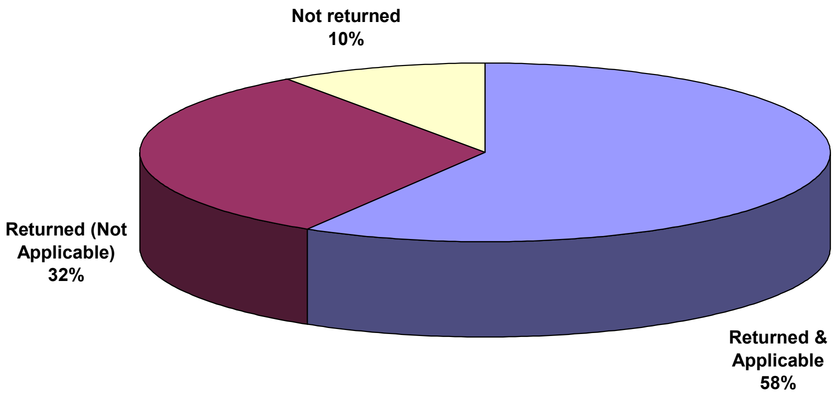
Note: Source of diagram – Review 85, National Water Resources Audit

1.3 Response to the survey

Of the surveys forwarded to the representative Rural Water Authorities, 90% were returned (**Figure 1.3**). The survey was not seen as applicable to 32% of the RWA's as channels did not form a significant part of their distribution network. As a result, of the 41 surveys sent out, 24 (58%) provided information on channel seepage from earthen channels. The majority of these were from the eastern States (**Figure 1.1**), reflecting the distribution of water resources within Australia.

Of the surveys issued, 90% were returned. However only 58% contained the relevant information.

Figure 1.3: Survey Return Rate



1.4 Discussion of the Survey results

Discussion of the survey results is divided into six sections. For each section, a summary of the applicable survey questions and the section of this report under which the results are discussed is provided in **Table 1.1**.

Table 1.1: Analysis of Survey Results

Section	Title	Relevant Survey Questions
3	Water Supply, Size of Channel Network and Seepage Rates	Q1 - Q6
4	Significance of Channel Seepage	Q7, Q12, Q13
5	Channel Seepage Costs & Issues	Q8 – Q11
6	Channel Seepage Measurement Techniques	Q14 – Q 19
7	Channel Seepage Remediation	Q20 – Q22
8	Demand for Guidelines (and Additional Comments)	Q23 – Q24 (Q25)

2. Characterisation of rural water supply

The initial section of the survey (Questions 1 to 6) was designed to characterise the nature of water distribution among the representative rural water management authorities. This included an assessment of the volume of water distributed, the length of channel in the distribution system and the understanding of losses from the distribution system. Each of these aspects is discussed in the section below.

2.1 Water Supply

Figure 3.1 illustrates the size of the RWAs surveyed, based on the approximate quantity of water delivered each year by the Authorities. The most common size is in the 100 – 500 GL/yr range, accounting for eight authorities / irrigation areas, followed by the 50 – 100 GL/yr range which represents six RWAs.

The majority of rural water authorities surveyed supply less than 100 GL/yr.

Figure 2.1: Size of RWAs Based on Annual Volume of Water Supplied

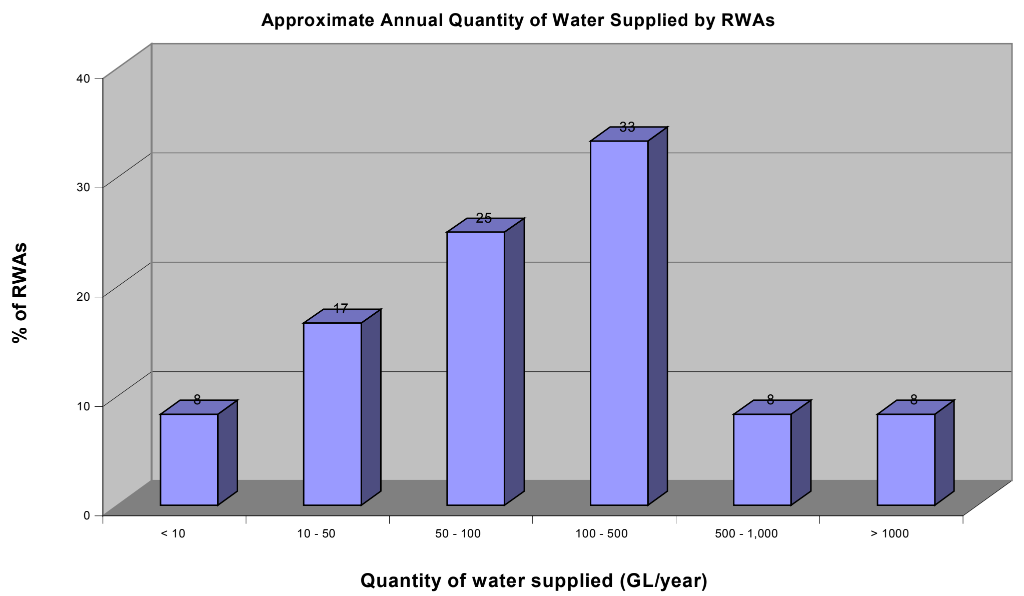
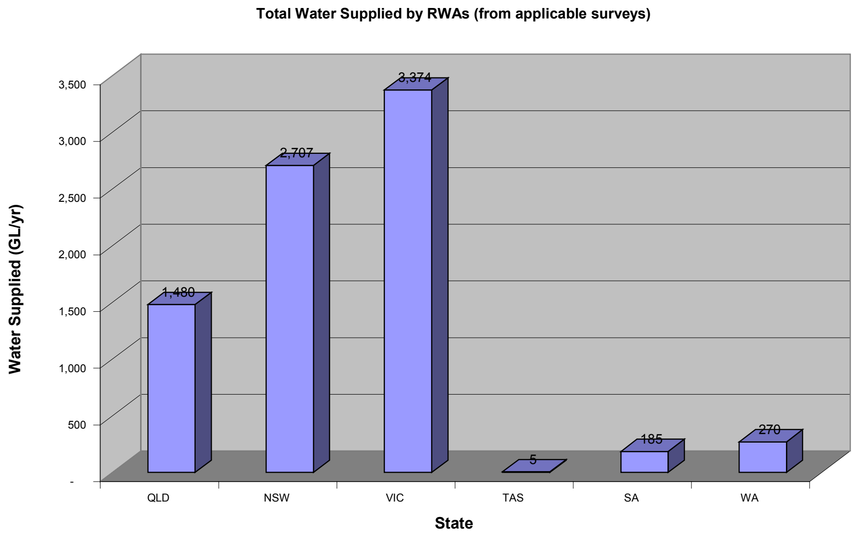


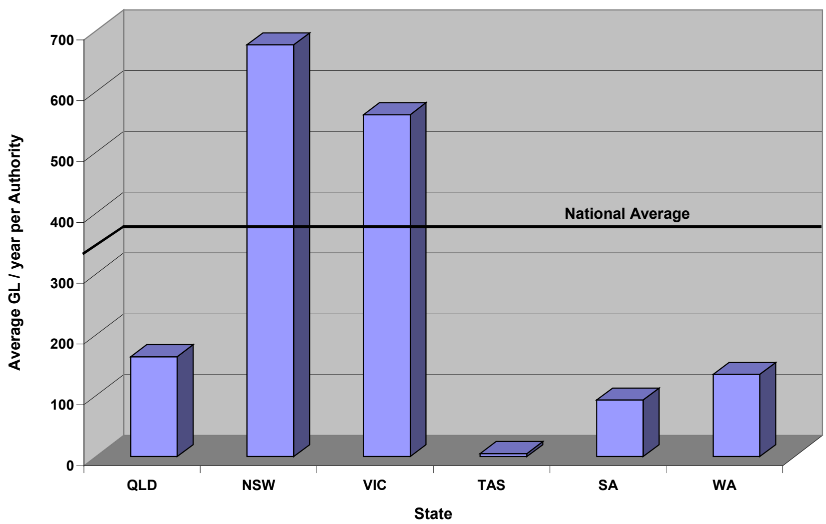
Figure 2.2 presents the annual total volume delivered by the 24 RWAs on a state by state basis. The bulk of the water delivered represented by this survey comes from the east coast states, Queensland (1,480 GL/yr), New South Wales (2,710 GL/yr) and Victoria (3,370 GL/yr). This reflects the overall distribution of surface water resources within Australia. **Figure 2.3** shows the average annual volume delivered per RWA. New South Wales is shown to have the largest average Authority based on water supplied.

Figure 2.2: Water Supply on State by State Basis



The average volume of distribution of the Authorities surveyed is 341 GL/yr. However a more accurate picture of the distribution size of a 'typical' RWA is the median, which is 80 GL/yr. In general the distributed volume of authorities in Victoria and NSW is significantly higher than the National average. This in part is a reflection of the distribution of surface water resources and the current water management structure of each of the States.

Figure 2.3: Average Size of RWA By State



2.2 Size of Channel Network

Figure 2.4 provides an indication of the typical length of the earthen channel network within each of the RWAs surveyed. The most common length of channel within an RWA was less than 100 km, accounting for nine authorities. Two authorities had no earthen channels, only concrete lined channels, and two authorities contained more than 5000 km of earthen channel.

Overall the National average for the length earthen channel per GL supplied is approximately 3.85 km / GL water supplied. (However this result needs to be treated with some caution as one Authority within Victoria reports 54 km channel / GL supplied. When this result is removed the national average drops to 1.45 km / GL water supplied.) Based on the authorities surveyed, the length of the distribution systems per GL supplied is significantly longer in Victoria and NSW than in the other States, as depicted in **Figure 2.5**. Again, note that the high result in Victoria is largely due to the effect of one RWA.

Figure 2.4: Distribution of Lengths of Channel Network

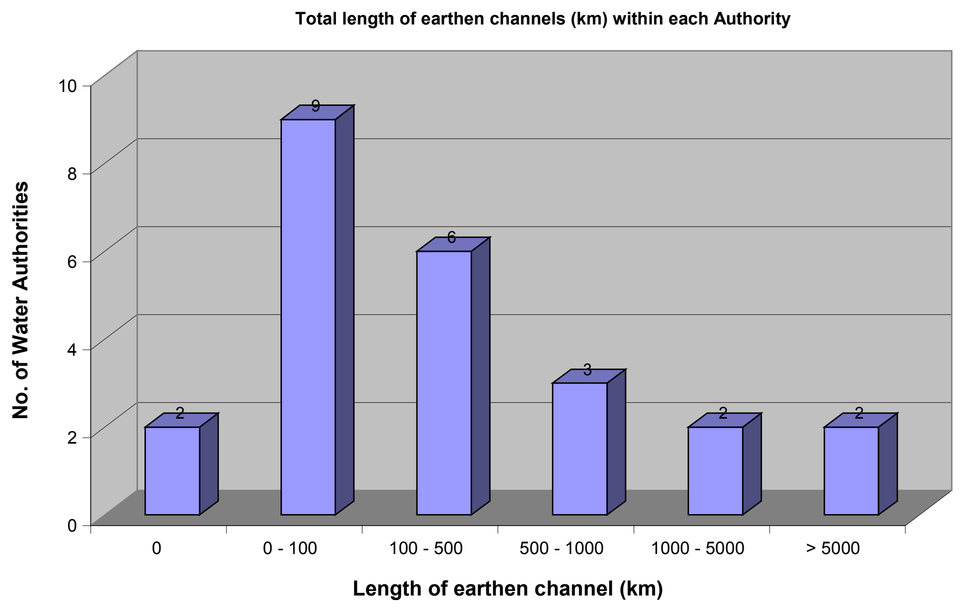
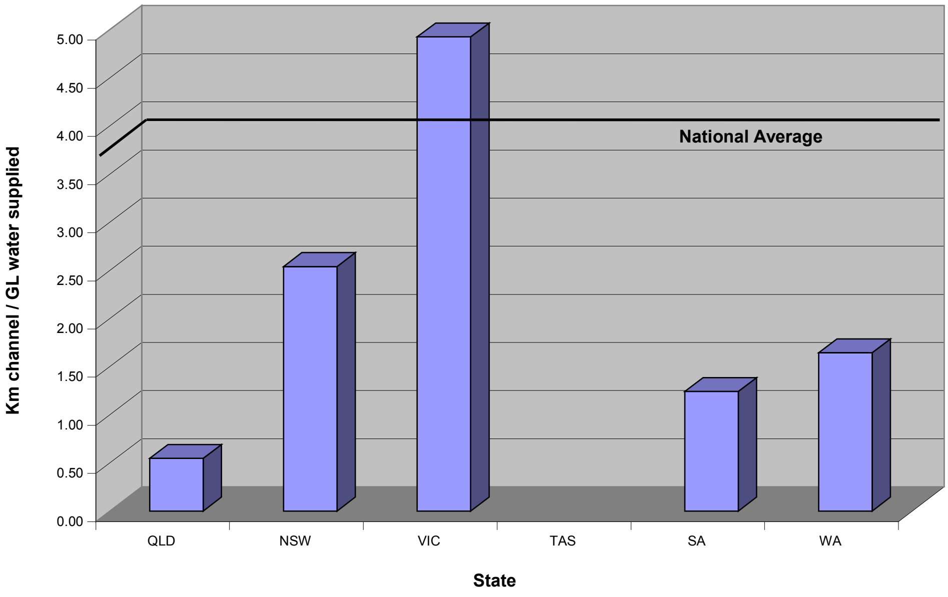


Figure 2.5: Total Earthen Channel Length by State

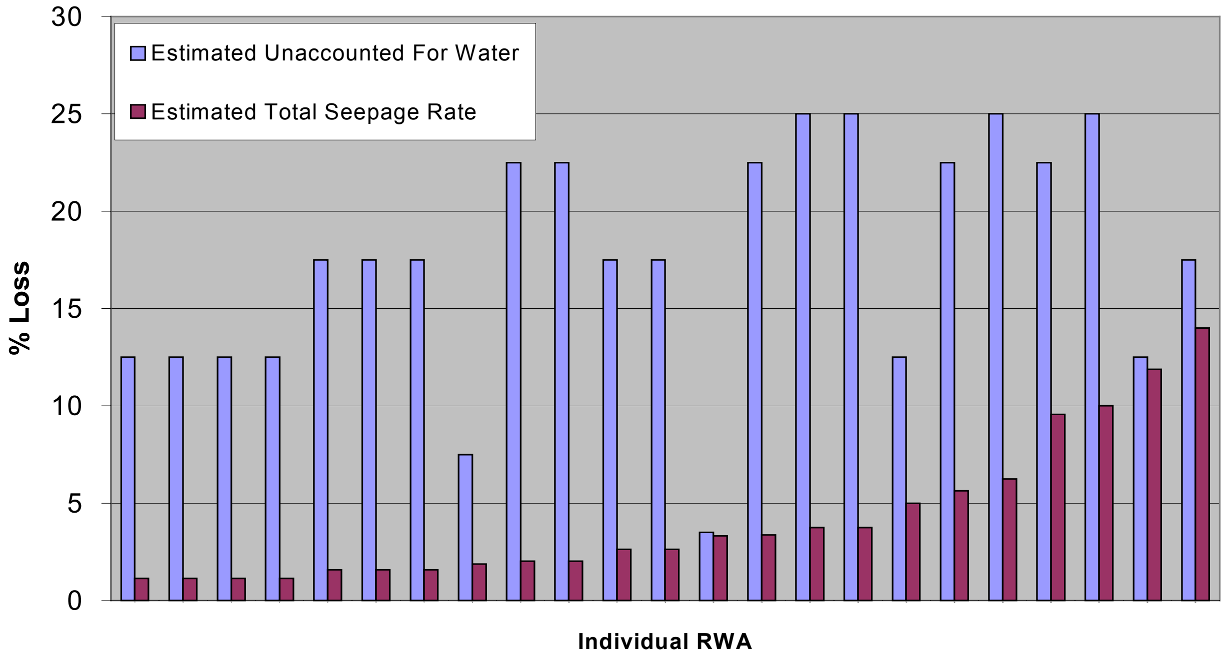


2.3 Seepage Rates

Questions four and five of the survey aimed to gain an understanding of how much water the RWAs estimate they are losing to seepage.

Figure 2.6 presents data for all of the 24 RWAs, showing unaccounted for water (evaporation, seepage, measurement errors, unaccounted diversions etc) and seepage losses as a percentage of total water delivered by the Authorities. The data has been presented in ascending order of seepage rate, to help depict the range and distribution of the estimates.

Figure 2.6: Unaccounted for Water and Seepage Loss Rates



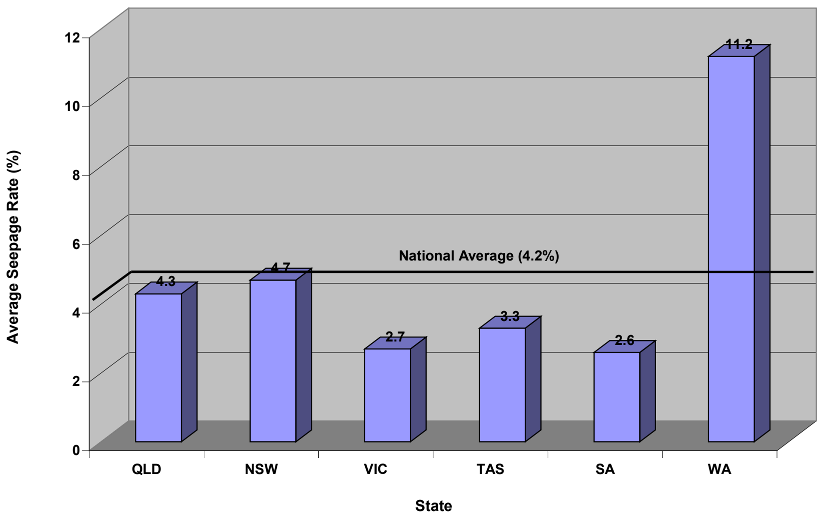
On average, 17.5% of released water is lost through unaccounted for processes. On average 4% of water is lost through seepage.

Figure 3. indicates the estimates of unaccounted for water ranges from 3% to 25% (average 17.5%) of total delivered volume. Seepage is estimated to represent from 1% to 14% (average 4%) of total delivered volume. The correlation between overall system loss and seepage loss is poor. This suggests seepage is more a product of local conditions within each authority than as a consistent percentage of total system losses. Contributing to this is the possibility that the way the estimates of seepage loss are made varies from authority to authority. An example of this can be gauged by the difference in seepage losses for two authorities adjacent to each other with similar size and landforms. One authority estimates a seepage loss of 2% of total delivered water as compared to 10% in the adjacent authority.

An estimated 320 GL of water is lost each year from the authorities surveyed.

Overall for the authorities surveyed, a total of approximately 320 GL/yr of water is lost to seepage from the distribution network. This represents 4.2% of all water delivered. On a State by State basis, the percentage of seepage of the total delivered volume is summarised in **Figure 2.7**.

Figure 2.7: Average Seepage Rate by State

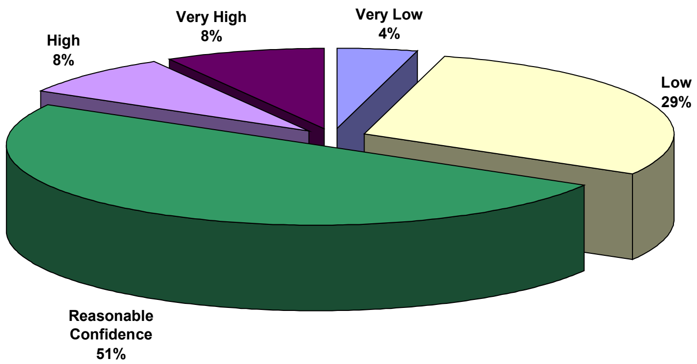


2.4 Confidence in Seepage Estimates

Question 6 of the survey ascertains the level of confidence the Authorities have in their seepage estimates. **Figure 2.8** presents the results of this question. Of the authorities surveyed, 67% have a reasonable or higher confidence in their estimates.

Two-thirds of all authorities surveyed have a reasonable or higher confidence in their estimate of seepage.

Figure 2.8: Confidence in Seepage Estimate



3. Significance of Channel Seepage

Part of the survey (Questions seven, twelve and thirteen) was designed to assess how significant an issue channel seepage is to rural water supply authorities.

3.1 Importance Assigned to Channel Seepage Issues Within the Authority

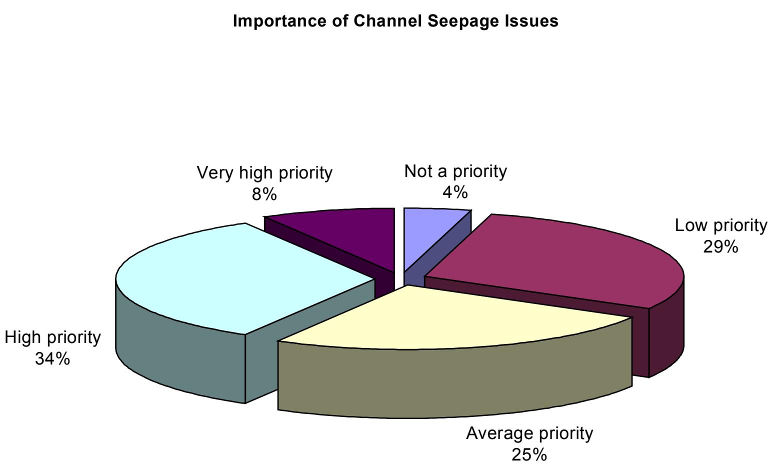
Figure 3.1 presents the responses to question seven regarding how importantly channel seepage issues are regarded within the Authority. The definition of priority used in the survey is explained in the table below:

Priority	**Definition**
Not a Priority at all	Not an issue facing the organisation
Low Priority	Within top 20 issues facing the organisation
Average Priority	Within top 10 issues facing the organisation
High Priority	Within top 3-5 issues facing the organisation
Very High Priority	Top 1-2 issues facing the organisation

One third of the respondents indicated channel seepage was either not a priority or a very low priority (defined as being within the top 20 issues facing the organisations). One quarter of the respondents regarded channel seepage issues as being of average priority, which was defined as being within the top ten issues facing the RWA. A further third of Authorities regard channel seepage issues as being a high priority, and within the top 3-5 issues facing the company / organisation. Two of the RWAs regarded channel seepage issues as being among the top two priorities of the Authority.

Of the authorities surveyed, 42% rate channel seepage as a high or very high priority.

Figure 3.1: Importance of Channel Seepage Issues within Authority

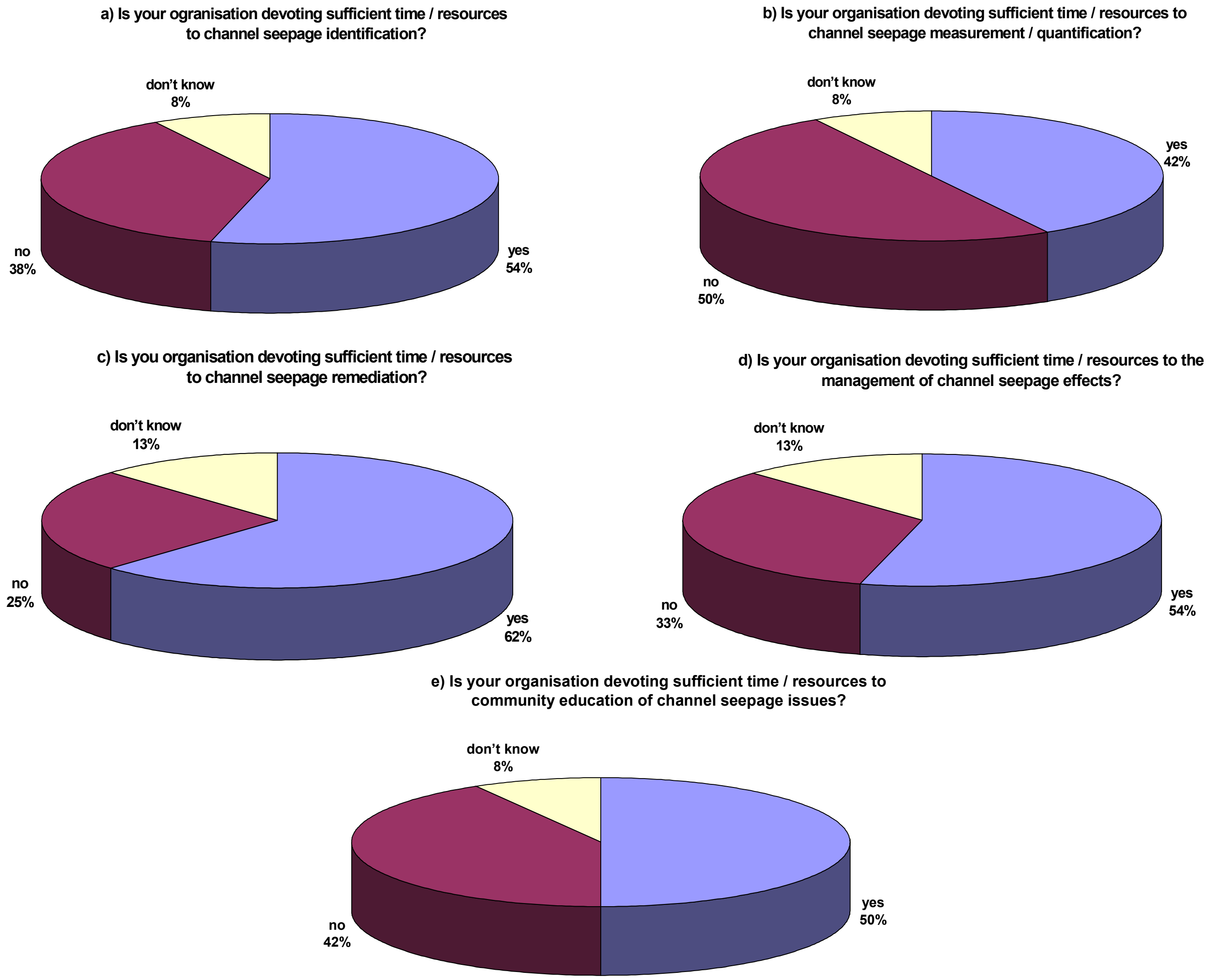


3.2 Time and Resources Devoted to Channel Seepage Issues

Question 13 of the survey asked if, in the opinion of the respondent, the organisation is devoting sufficient time and resources to the following channel seepage issues. The responses are presented in **Figure 3.2**.

a) Channel Seepage Identification,
b) Channel Seepage Measurement / Quantification,
c) Channel Seepage Identification,
d) Management of Channel Seepage Effects, and
e) Community Education with respect to Channel Seepage Identification.

Figure 3.2: Time and Resources Devoted to Channel Seepage Issues



Measurement of channel seepage is most commonly considered the area where additional resources need to be applied.

In order of importance, the issues that are currently considered as not getting sufficient resources are:

1) Seepage measurement (50% believe insufficient resources/time allocated);
2) Community education of channel seepage issues (42%);
3) Identification of seepage areas (38%);
4) Management of seepage impacts (33%); and
5) Channel seepage remediation (25%)

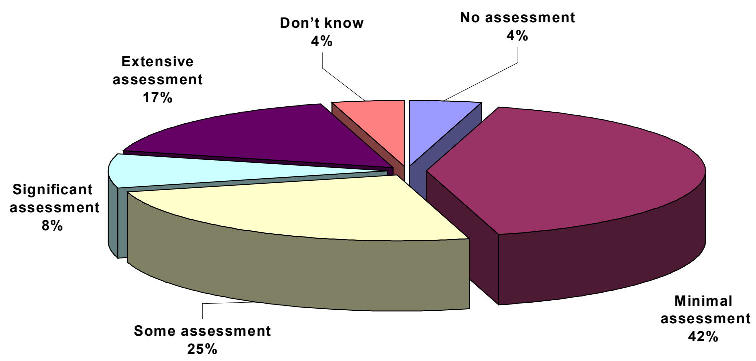
3.3 Work Undertaken to Assess Channel Seepage Issues

Question 12 of the survey asked how much work had been undertaken in the past ten years to assess channel seepage issues. The definition of how much work was 'significant' assessment is outlined in the table below and the results are presented in **Figure 3.3**.

No Assessment	Minimal Assessment	Some Assessment	Significant Assessment	Extensive Assessment
No assessment made of channel seepage losses	Estimates of channel seepage system losses based on records	1 - 3 site specific seepage studies undertaken	3 – 5 site specific seepage studies undertaken	More than 5 site specific seepage studies undertaken

25% of authorities have undertaken assessment of seepage at 3 or more sites, however 50% have undertaken no on ground works at all.

Figure 3.3: Work Undertaken by RWAs in Past Ten Years to Assess Channel Seepage Issues

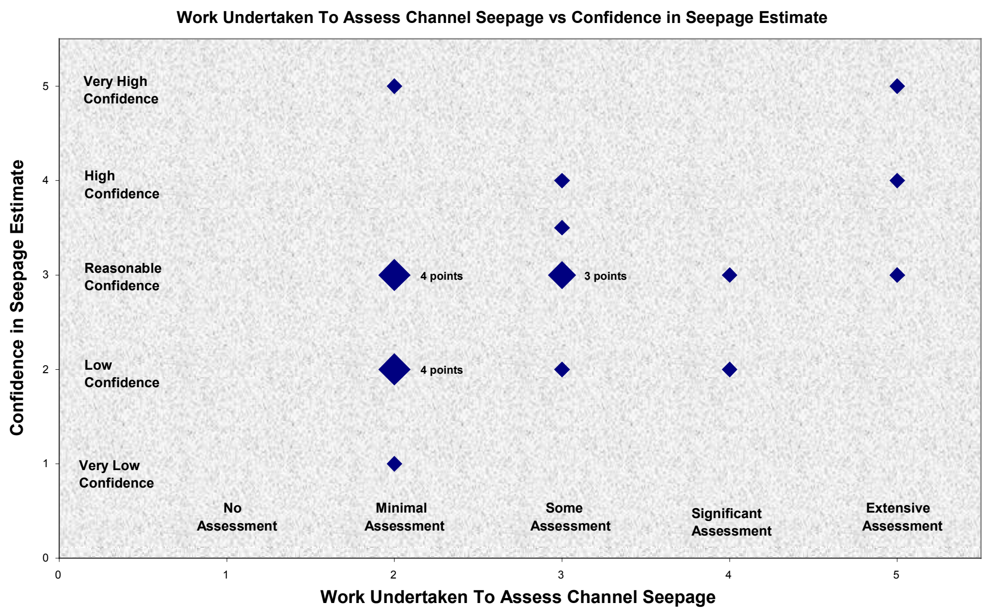


The results of this question reveal that the majority of RWAs have done no on-ground works to assess channel seepage. 42% of Authorities indicated that minimal assessment only had been conducted, that is, channel seepage estimates are made based on records rather than on-ground works. One quarter of Authorities (six) have undertaken some assessment (1-3 site specific seepage studies), while a further six have undertaken significant or extensive assessment. The six in the 'significant' and 'extensive' assessment categories were all from Queensland, New South Wales and Victoria. All but one were supplying more than 160,000 ML/yr.

Extensive seepage investigation is generally only undertaken by the larger water authorities.

A comparison was conducted between the results of question 6, regarding confidence in seepage estimates, and question 12, regarding the amount of work conducted to determine seepage losses. The results of this comparison are plotted in **Figure 3.4**. (Note that some points contain more than one result – illustrated by larger dots).

Figure 3.4: Work Undertaken to Assess Seepage Against Confidence in Seepage Estimate



There is a weak correlation between increased investigation and higher confidence in channel seepage estimates.

The results show that the amount of work undertaken on channel seepage assessment is only weakly correlated with the confidence of the Authority in their seepage estimate. There is a general trend to higher confidence with more investigation, but the range of confidence in that band is fairly wide. For an example of inconsistencies in the trend, one RWA has very high confidence in their seepage estimate, yet has done only minimal assessment. Another, despite having conducted extensive assessment has only reasonable confidence in their seepage estimate. The fairly flat line of best fit applied to the data tends to indicate that an increase in the amount of work undertaken does not result in clear gains in an understanding of seepage rates. Only five RWAs had greater than a reasonable confidence in their seepage estimate.

3.4 Trends Related to Importance of Channel Seepage Issues with Authority

Analysis was conducted to further explore why some Authorities place channel seepage issues as a higher priority than others. This was achieved by plotting the results of question seven (importance of channel seepage) against other characteristics of the Authority, including:

- Seepage rate;
- GL supplied per year;
- Volume lost to seepage; and,
- Estimated cost of seepage.

Table 3.1 summarises the key finds of this analysis. The associated graphs are contained in **Appendix B**.

Table 3.1: Results of Analysis of Importance of Seepage Issues

Characteristic of Authority	Comment on Correlation (refer to Appendix B for graph)
Seepage Rate (Figure B.1)	A weak correlation is observable between the two variables. For example, there were no RWAs who assigned seepage issues as being of low priority with a seepage rate above 4%. However, the converse is not true, with five Authorities with a seepage rate below 4% but indicating seepage issues to be a high priority within the organisation. This shows that while a low seepage rate is more likely cause an Authority to not regard seepage issues highly, there are others factors at play. These may include the volume of water lost to seepage (ie a fairly low seepage rate but multiplied by a large volume amounts to high absolute losses), environmental issues or issues of public perception.
GL supplied / Yr (Figure B.2)	Again only a weak correlation is observed between the two variables, with many exceptions to the general trend. In fact a strong trend between these variables would not generally be expected. It would be assumed that stronger trends would exist between the seepage rates and relative amounts of water lost, than simply the size of the Authority. One hypothesis for larger Authorities (greater delivery volumes) placing a higher value on channel seepage issues is that they can afford to, where a smaller Authority may not have the resources to give channel seepage the priority they may wish to. Further, larger Authorities may feel more public pressure to be pro-active about channel seepage and want to be seen to giving it a high priority.
Volume Seepage Loss (Figure B.3)	A slight correlation is observed between total seepage losses and the importance of channel seepage issues. However there are many Authorities whose attitude to channel seepage cannot be explained by this model. Two RWAs estimate seepage losses below 1,000 ML/yr but place a high priority on seepage issues, and three RWAs with losses between 3,000 ML/yr – 22,000 ML/yr place only a low value on channel seepage. The second largest loser of water to seepage (estimated 55,000 ML/yr) regards channel seepage issues as being only of average importance.
Estimated Cost of Seepage (Figure B.4)	A weak to moderate trend is observed. With the exception of one RWA, those Authorities who incur high costs associated with channel seepage (> $100,000 / yr) give it a high priority. Aside from the high end of the cost range there is no correlation observed between the two variables.

The priority given to channel seepage appears dependent mostly on the perceived cost of the impacts of channel seepage.

The key outcomes from this analysis include:

- Authorities which believe channel seepage to be of low priority all think that seepage represents less than 4% of supplied water;
- A high priority for seepage appears independent of estimated % seepage loss;
- Priority of channel seepage shows weak correlation to actual volume lost;
- Of the six Authorities that estimated the cost of seepage to exceed $100,000, five rated channel seepage as a high priority.

In summary, the analysis conducted in this section has shown at best only moderate trends between how importantly RWAs view channel seepage and other key variables, such as seepage rates, volume of water lost and cost of seepage. These results indicate that either:

i) The factors that influence an RWAs perception of channel seepage is multifaceted and cannot be summarised by single variate analysis.

ii) The survey has been filled out inconsistently.

Given that in answer to a question later in the survey concerning the problems associated with channel seepage, the number one response was "financial loss to the Authority", it is somewhat surprising that a better correlation was not observed between the cost of seepage and the importance of seepage issues to the RWA. The lack of a fine enough scale to accommodate answers regarding the importance of channel seepage (Q7) may also have contributed to the absence of definitive trends uncovered in the analysis.

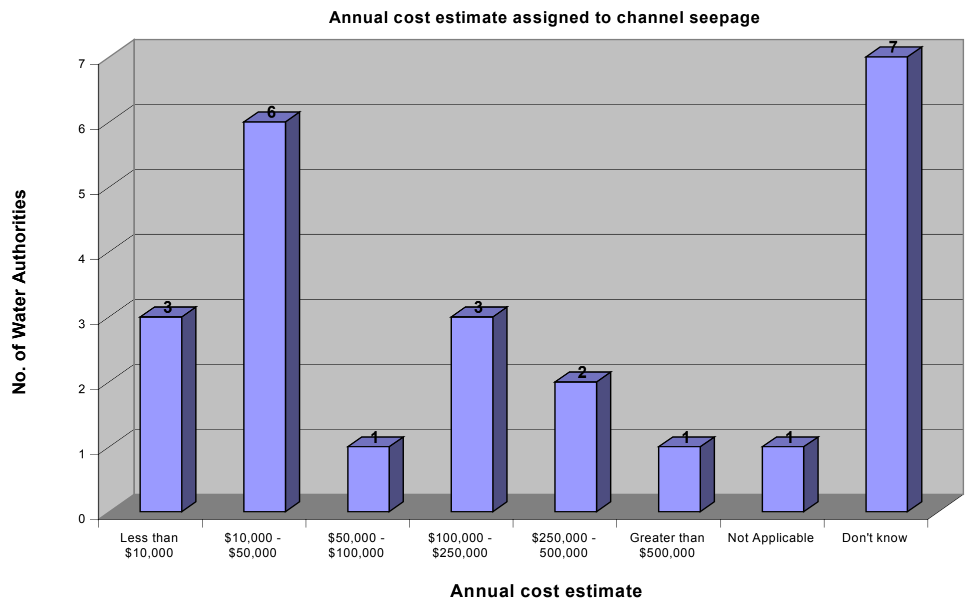
4. Channel Seepage Costs and Issues

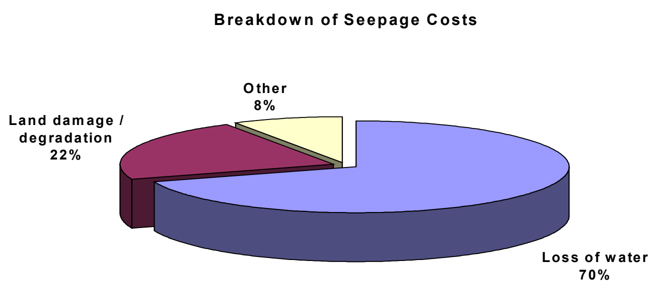
This section is based on Questions 8 – 11 of the survey and is focussed on the costs of seepage and the main issues of concern caused by channel seepage.

4.1 Channel Seepage Costs

Figure 4.1 presents the results of Question 8 of the survey, part A of which asked for an annual cost estimate of channel seepage within the Authority. Part B of the question, asked for a breakdown of the costs, providing an option of loss of water, land damage / degradation and 'other'. The column chart in the figure below address part A and the pie chart summarise the results of part B.

Figure 4.1: Costs of channel seepage





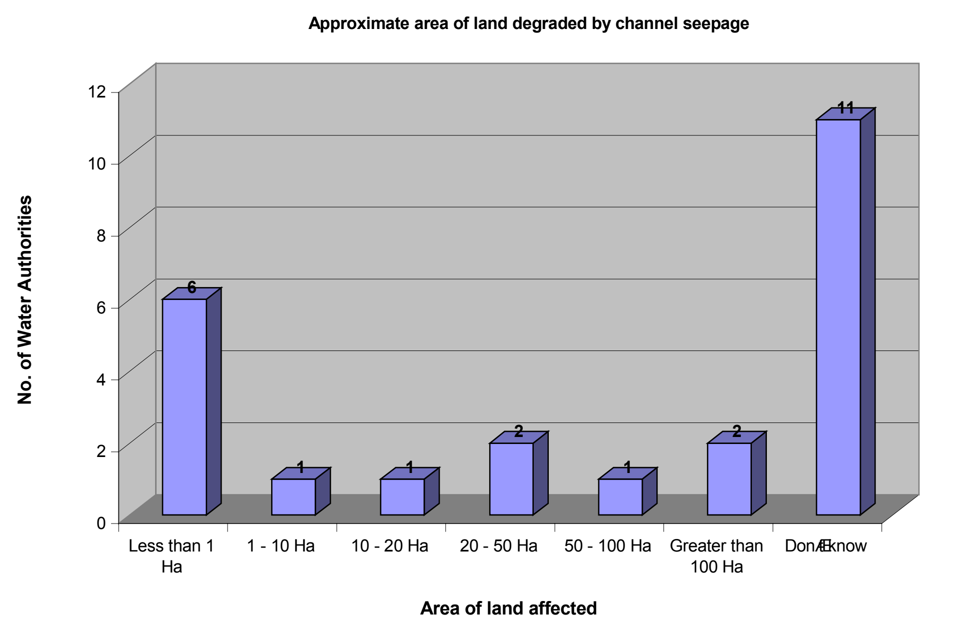
Perhaps the most apparent observation to be made is the relatively large number of Authorities (seven) which were not able to estimate the costs of channel seepage. Apart from this category, the most common estimate of seepage costs was in the $10,000 - $ 50,000 range. The remainder of the results were well spread. Three Authorities indicated costs exceeded $250,000 per year, with one of these estimating costs above $500,000 per year.

Loss of water is considered the most significant cost consequence of channel seepage.

The breakdown of the costs reveals loss of water to be the dominant cost associated with channel seepage issues, comprising 70% of total costs. **Figure 4.2** presents the results to Question 9 regarding the amount of land estimated to be *directly* degraded by channel seepage (ie waterlogging or salinisation). Again, the most notable feature of the results in the large number of Authorities (11) which were not able to estimate the area of land degraded by channel seepage. This included Authorities across the range of sizes, including several of the very large suppliers. Apart from this result the dominant estimate was that channel seepage was causing minimal or no degradation of the land (< 1 Ha). Only five Authorities estimated land damage to exceed more than 20 Ha.

It is estimated that 46% of authorities do not know the extent of land degradation associated with channel seepage. A further 25% believe it to be less than 1 Ha.

Figure 4.2: Land Directly Degraded by Channel Seepage



Of the authorities surveyed, 16% indicated that they are spending more on channel seepage than the estimated cost.

Figure 4.3 plots the estimated annual cost of channel seepage against annual expenditure. The dashed line indicates the scenario where expenditure perfectly balances cost. Only four points lie above this line, indicating the majority of RWAs are spending less on channel seepage issues than they estimate channel seepage is costing them. In fact, the solid line of best fit shows that on average, RWAs are spending only around 60% on channel seepage of the costs incurred by the problem. **Figure 4.4** presents similar results but at a State level. On a State by State basis the annual cost of channel seepage compared to the annual money spent on channel seepage is presented. NSW and Victoria are shown to be spending approximately the same amount of money on channel seepage as the costs incurred, Queensland and WA indicate some significant differences.

The average expenditure on channel seepage is approximately 60% of the estimated cost of the seepage.

Figure 4.3: Cost of Channel Seepage vs Annual Channel Seepage Expenditure

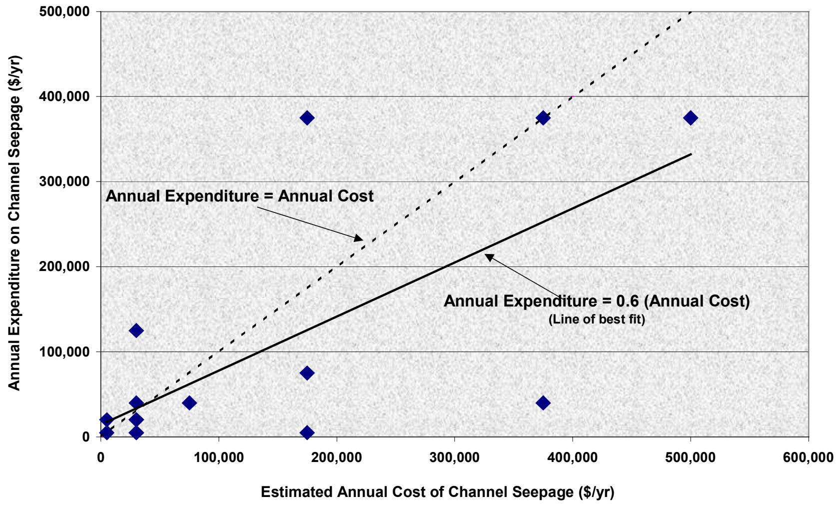


Figure 4.4: Annual Total Cost of Channel Seepage Compared to Expenditure on Channel Seepage

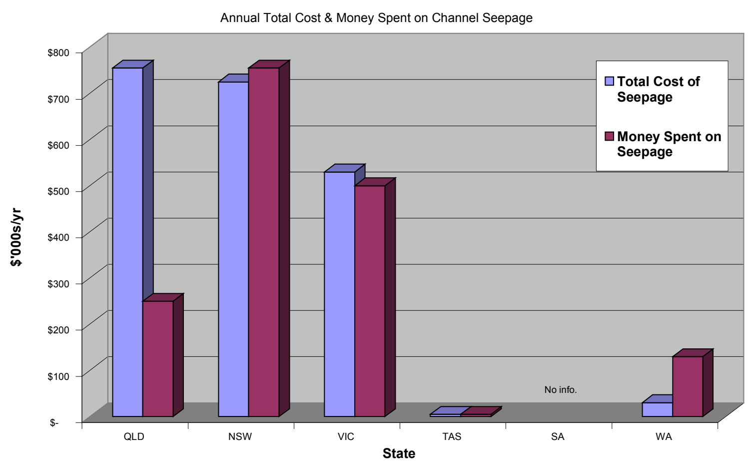
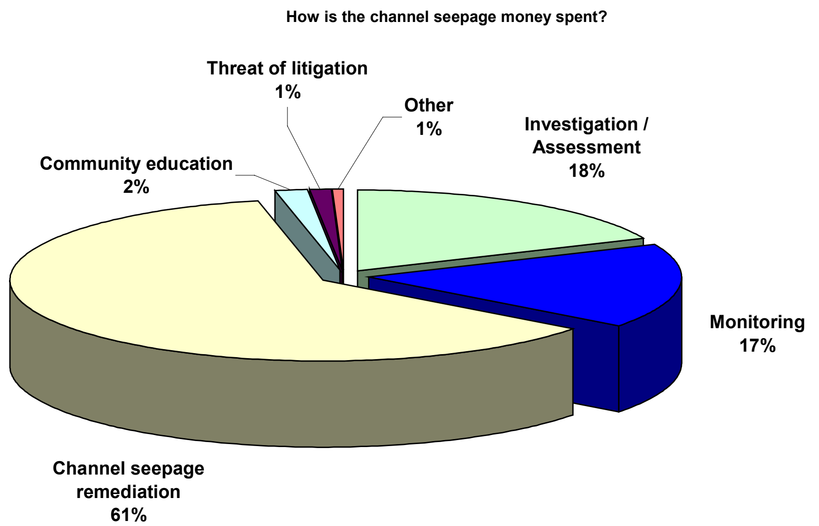


Figure 4.5 illustrates how the money spent on channel seepage issues is divided. On average, sixty percent of an Authority's channel seepage expenditure is consumed on channel remediation works. Investigation-

assessment and monitoring are the only other two significant areas where funding is used, at 18% and 17%, respectively.

Remediation works accounts for 61% of the monies spent on channel seepage, with monitoring and investigation contributing 35%.

Figure 4.5: Division of RWA Channel Seepage Expenditure



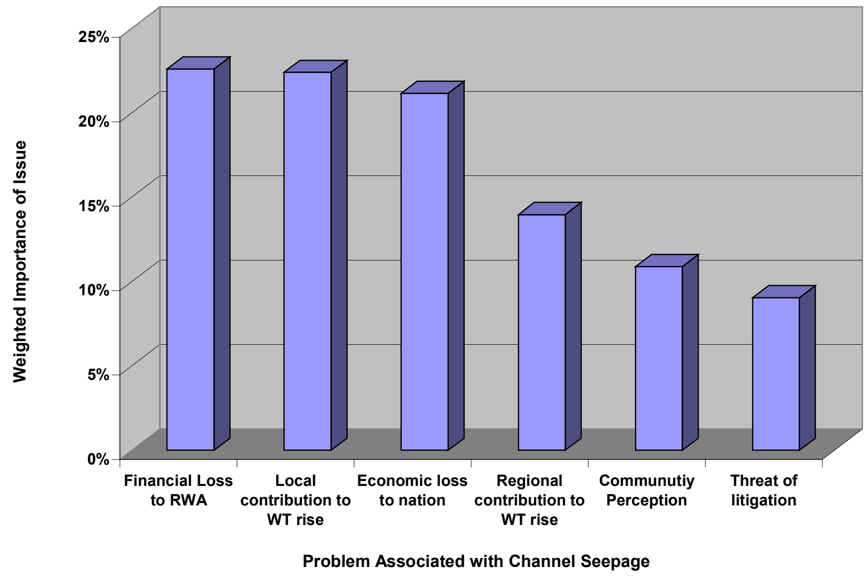
4.2 Problems Associated with Channel Seepage Issues

Question 11 of the survey asked respondents to rank in order of importance the problems associated with channel seepage. The six options were:

- Financial loss to Authority
- Economic loss of commodity to community/state/nation
- Regional contribution to watertable rise
- Local contribution to watertable rise and land salinisation / degradation
- Community perception
- Threat of litigation

These results were assigned a weighting and the results summarised in **Figure 4.6**. This chart illustrates the three issues which were highlighted as having virtually equally high importance associated with channel seepage, including: financial loss to Authority, local contribution to watertable rise / land degradation and economic loss of commodity to the community. The fact that the local contribution to watertable rise was identified as one of the most important issues was somewhat surprising given the relatively low estimates of area of land locally affected by channel seepage in question 9. This suggests that Authorities were either deliberately underestimating the area of affected land by local watertable rise, or are concerned about future problems associated with local watertable rise that are yet to be manifested. Threat of litigation was regarded as the least important issue associated with channel seepage.

Figure 4.6: Weighting of Problems Associated with Channel Seepage



5. Channel Seepage Measurement Techniques

This section presents the results of those questions dealing with channel seepage measurement techniques, including Q17-Q19.

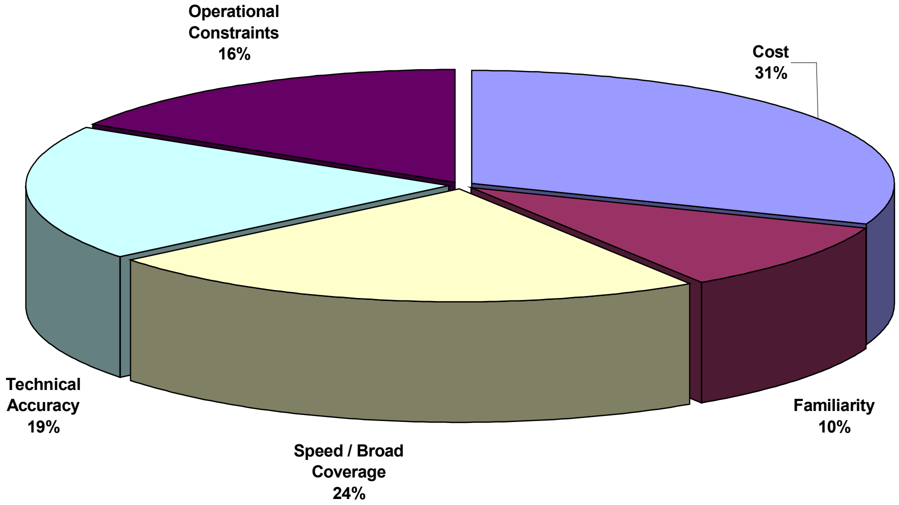
5.1 Criteria for Technique Selection

Question 17 of the survey asked Authorities to rank the criteria used in selection of a channel seepage measurement technique. Fifteen of the twenty-four respondents answered this question. The five criteria provided were cost, familiarity, speed / broad coverage, technical accuracy and operational constraints. Respondents were required to rank these criteria (1 - most important and 6 - least important). To summarise these results, a no. 1 ranking was assigned 10 points, a no. 2 ranking as 6 points, a no. 3 as 4 points, a no. 4 as 2 points and no. 5 as 0 points. These were then added for each criteria and the percentage results are presented in Figure 5.1 below.

Cost and speed are considered the most important criteria in channel seepage assessment. Technical accuracy is considered of lesser importance.

The most important criteria identified was cost, and the least important was familiarity with the technique. Speed, or the ability of the technique to cover large areas rapidly, was ranked as the second most important criteria. Technical accuracy and operational constraints were weighted almost evenly as the third most important criteria to consider when selecting a technique. The priority placed on cost and speed suggests that identification of where channels seep rather than quantification of the seepage loss are the driving forces behind current seepage investigations.

Figure 5.1: Main Criteria Used For Selection of a Channel Seepage Measurement Technique



5.2 Techniques Used By RWAs

Question 14 was one of the most significant questions in the survey with respect to the survey's main goals, which asked respondents to indicate the techniques previously and currently used by the Authority to quantify / identify channel seepage, and to indicate the accuracy, cost and satisfaction of using the technique. Three of the 24 respondents did not answer this question. **Table 5.1** presents the results of the question. The number in columns 2 & 3 indicate the number of Authorities who have used / use the technique. The results are presented in descending order of the most popular current techniques. The remaining columns tabulate the percentage breakdown of responses concerning perceived accuracy, relative cost and satisfaction.

Table 5.1: Techniques used By RWAs for Channel Seepage Measurement

Technique	No. of RWAs Which Used in Past	No. of RWAs Which Currently Use	No. of RWAs			No. of RWAs			No. of RWAs		
			Perceived Accuracy			Relative Cost			Satisfaction		
			Low	Med	High	Low	Med	High	Not Sat.	Sat.	V. Sat
Visual Inspection	15	18	5	10	2	17	1	-	6	9	2
Estimated from Records	11	11	9	3	1	10	1	1	7	5	-
Piezometric Survey	6	9	-	7	2	-	4	5	-	8	1
Inflow – Outflow Studies	5	7	3	4	1	4	2	-	3	4	-
Aerial Photographs	6	7	4	5	-	4	4	1	3	4	1
Pondage Tests	4	6	1	3	2	1	2	2	1	4	-
Groundwater Bores & Water Chemistry Analysis	4	6	-	2	4	-	4	2	-	6	-
Soil Mapping	4	4	2	-	-	2	-	-	3	-	-
EM31	3	3	1	1	1	1	3	-	1	1	1
Idaho Seepage Meter	5	-	2	1	1	1	-	2	4	-	-
EM34	2	1	1	1	-	1	1	-	1	1	-
Constant Head Permeameter	1	-	-	1	-	-	1	-	-	1	-
Sentec ???	1	1	-	1	-	-	1	-	-	1	-
Measurement of Flow Through Pipe[1]	1	1	-	1	-	1	-	-	-	1	-
EM38	1	1	1	-	-	-	1	-	1	-	-
Channel Seepage Modelling / Mathematical Equations	1	1	-	1	-	-	-	1	-	1	-
Dig Slits in Channel Bed	-	1	-	-	1	1	-	-	-	-	1
Indicator Plants	-	1	-	-	1	1	-	-	-	-	1
Seismic	1	1	-	-	-	-	-	-	-	-	-
EKS	1	1	-	-	-	-	-	-	-	-	-
Test Hole Measurement	1		-	-	-	-	-	-	-	-	-

1. Definition provided in survey by RWA: Leak confined to drain or pipe and flow measured

5.2.1 Visual Inspection

Table 5.1 indicates that visual inspection is the most popular means of identifying channel seepage, with 18 of the 21 RWAs currently using this as an assessment tool. Approximately 60% of Authorities believe this to be a reasonably accurate means of identifying seepage, 30% perceive it to have low accuracy while 10% believe it to be a highly accurate means of identifying channel seepage. As expected, the vast majority of RWAs recognised this as a low cost means of channel seepage assessment. The percentage split indicating satisfaction with the technique virtually matched their perception of the technique's accuracy. That is, those Authorities who believed the technique to have low accuracy were not satisfied, those who thought it was highly accurate were very satisfied etc. Some of the different comments on visual inspection noted that: is was easy because it was obvious, useful for qualitative purposes only and useful when combined with other techniques.

5.2.2 Estimation from Records

While estimation from records was the second most popular technique of channel seepage assessment, 70% of those RWAs who use it perceive it to be of low accuracy, and 58% are not satisfied with this as a technique, despite the relatively low costs. Comments on this technique were negative, indicating that it was a 'waste of time', 'not comparable with (other) seepage measurement techniques' and the accuracy is low as 'other causes of losses are significantly greater than seepage'.

Despite the generally low confidence in the accuracy of visual inspection and estimation from records, six of the twenty-one RWAs ($\approx$ 30%) who answered Q14 of the survey indicated that these two techniques were the only means used by their Authority of quantifying / identifying seepage, presumably due to the low cost and technical input required.

5.2.3 Piezometric Survey

Nine of the RWAs surveyed currently have piezometers installed with the intent of identifying / quantifying channel seepage. Of the major techniques used by Authorities, this was the technique which most RWAs were satisfied with (8 of the 9 Authorities were satisfied and 1 was very satisfied). Seven of the 9 RWAs believed the accuracy was acceptable and 2 perceived it to be highly accurate. It was generally seen as an expensive technique however, with more than half indicating it was a relatively high cost means of assessing channel seepage. The only comment made on this method was that 'groundwater levels point to problem areas' suggesting use of the method for identification rather than quantification.

5.2.4 Inflow-Outflow

Seven RWAs have used inflow-outflow studies to measure channel seepage. The statistics from the survey results indicate approximately half of the seven were moderately happy with this technique and believed it to be acceptably accurate and the other half were not satisfied and perceived the accuracy to be low. The majority saw this as a relatively inexpensive means of quantifying channel seepage. The comment was made that the technique requires very accurate measurement, which is often quite difficult.

5.2.5 Aerial Photographs

Seven RWAs use aerial photographs to identify channel seepage. It was generally perceived to be a technique of low to medium accuracy and relatively low to medium cost compared to other techniques. While slightly more than half were at least satisfied with the technique, about 40% were not satisfied. The comment was made by one respondent that the technique was useful when combined with other methods.

5.2.6 Pondage Tests

Six of the RWAs surveyed use pondage tests to quantify channel seepage. Five of the six RWAs perceived the method to be of moderate to high accuracy. Only one thought it was of low accuracy. Satisfaction with the outcome of pondage tests reflected the perception of accuracy. It was generally perceived to be a moderate to highly expensive means of channel seepage measurement. The one RWA who was not satisfied with the technique made the comment that using this technique ‘it is impossible to locate seepage hot spots’.

5.2.7 Groundwater Bores and Chemistry Analysis

All six of the RWAs surveyed who use groundwater bores and water chemistry analysis to identify / quantify channel seepage perceived it to be of medium to high accuracy, but also of medium to high cost. All six RWAs were satisfied with the results of this technique.

5.2.8 Soil Mapping

The four RWAs to use soil mapping for identifying / quantifying channel seepage were unanimous in their belief that it is a technique of low accuracy, low cost and ultimately not a satisfactory means of assessing channel seepage. Two comments on this technique suggested that the difficulty with the technique was due to the lack of a fine enough scale in soil maps, and the related problem of the variability of the soil types. The comments suggested that they did not actually attempt to map the soil types, but used existing soil maps.

5.2.9 EM31

The three RWAs who use EM31 for channel seepage assessment were each divided on their opinion of the accuracy, and in turn of their degree of satisfaction with this technique. One Authority believed it to be of low accuracy, one of moderate accuracy and one of high accuracy. Two Authorities saw it as a moderately expensive technique and one as a low cost tool. The Authority that was very satisfied with the technique and believed it to be highly accurate use it in conjunction with drilling and excavator sampling.

5.2.10 Idaho Seepage Meter

Five RWAs have used the Idaho seepage meter in the past, but none do so now. All of these Authorities were unsatisfied with the results of the Idaho meter, generally believing it to be of high cost and low accuracy. One of the comments cited the (unexplained) variability of the results as a reason for dissatisfaction with the Idaho meter.

5.2.11 EM34

Two RWAs have used EM34 for channel seepage assessment in the past, but only one continues to do so now. The Authority which has abandoned the technique and was unsatisfied with it, believed it to be of low accuracy. The other Authority, who used the technique in a quantitative manner when the survey were correlated against the results of the pondage tests, perceived the technique to be of moderate accuracy and were satisfied with the outcome.

5.2.12 Techniques only used by one RWA

The following section lists those techniques used only by one Authority, and a brief comment on their perception of the technique:

- Constant Head Permeameter: Perceived to be moderately accurate, of average expense and the RWA was satisfied with the results.
- Sentec Soil Moisture probe: Perceived to be moderately accurate, of average expense and the RWA was satisfied with the results.
- Measurement of Leakage Through Pipe (Defined as ‘Leak confined to drain or pipe and flow measured’): RWA is satisfied with this technique of measuring localised leaking which is believed to be of sufficient accuracy and low expense.
- EM38: This shallow geophysical technique was perceived by the RWA who used it to be of low accuracy and were therefore unsatisfied with the results.
- Channel Seepage Modelling / Application of Mathematical Equations: While satisfied with the outcome due to the reasonable accuracy of the results the RWA who used channel seepage modelling identified this a highly expensive means of channel seepage assessment.
- Slits in Channel Bed (‘used to confirm other techniques’): No further information was given as to the nature of this technique, which is viewed by the Authority as being highly accurate and of low cost.
- Indicator Plants (‘observe natural vegetation indicator plants’): This technique, described as one which should be used in conjunction with other techniques, was viewed by the Authority as being highly accurate and of low cost means of channel seepage assessment.
- Seismic Survey – No information given on accuracy, cost or satisfaction with outcome. The comment was made that the technique ‘has been used to locate aquifers with some success’.
- EKS – No information given on accuracy, cost or satisfaction with outcome. The comment was made that this technique ‘has been used to locate aquifers with some success’.

- Test hole measurement – No information given on the nature of this technique, or the accuracy, cost or satisfaction with the results. Presumably this refers to some form of point source infiltration test.

5.2.13 Techniques not used by any Authorities surveyed

The techniques which were included in the Table comprising Question 14 but are not used by any of the RWAs surveyed are listed below:

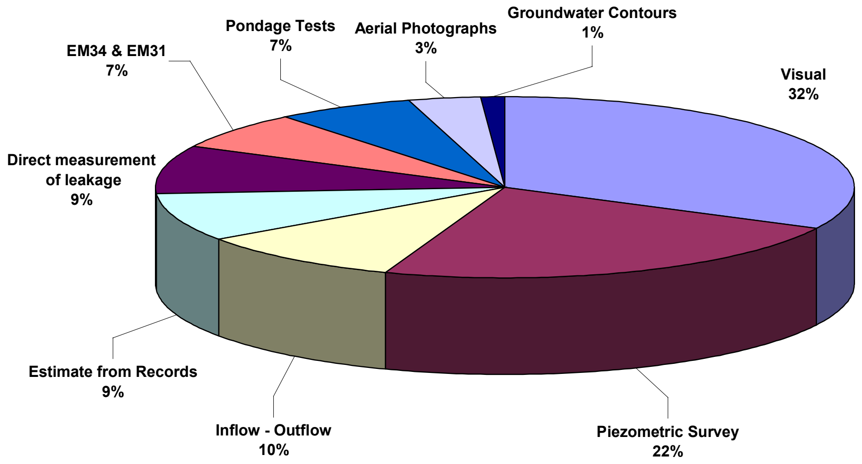
- Disc Permeameter;
- Electrical Resistivity; and
- Remote Sensing (other than aerial photographs)

5.3 Techniques Most Preferred By RWAs

Thirteen Authorities answered Question 15 which asked respondents for a list of three techniques most preferred by the Authority for seepage measurement and / or detection, in order of preference. To summarise the results into a meaningful statistical response, the no. 1 preferred technique was assigned a worth of 5 points, the no. 2 technique 3 points, and the no. 3 ranked technique 1 point. These were then added for each technique and the percentage results are presented in **Figure 5.2** below.

Seepage identification (visual, piezometers) rather than quantification techniques dominate channel seepage assessment methods.

Figure 5.2: Channel Seepage Assessment Techniques Most Preferred by Rural Water Authorities



Visual inspection of channels remains the most common method of channel seepage assessment, comprising almost one-third of the weighted responses. Use of shallow groundwater bores in the second most preferred means of assessing channel seepage. Behind these methods a range of other techniques are equally preferred by RWAs including inflow-outflow studies, estimation from records, direct measurement of leakage (ie when leakage occurs through banks as surface water, measuring flow with some device such as a V-notch weir), pondage tests and EM surveys, including both EM31 and EM34. Aerial photographs and groundwater contours are also used by one Authority.

5.4 Least Successful Techniques

The results to question 16 "List one or two techniques which you have found to be the least successful" was only responded to by 6 RWAs. There was no one technique which came through as being clearly worse than another. The six techniques and comments where provided are listed below (Note stream gauging and inflow-outflow are essentially referring to the same technique):

- Stream Gauging – Due to flat bed slope in system the accuracy is limited. For smaller to medium channels the inaccuracies in gauging can swamp estimates of losses.
- Inflow Outflow Studies – Seepage is likely to be within limits of accuracy of method.
- Piezometric Survey – Could not distinguish between natural groundwater and seepage.
- Idaho Seepage Meter – Only useful when seepage is greater than 5 mm/day. Problems with weeds and fast flowing channels. Can't use on batters. Very skewed distribution of measurements.
- Visual Inspection – Only gives an indication, does not quantify.
- EM34 – No comment provided

5.5 Extrapolation of Techniques

Question 18 of the survey asked if attempts had been made by the Authority to extrapolate the seepage results from one trial across a larger area. Only five Authorities had made such an attempt. The methods used are described below along with any comment provided:

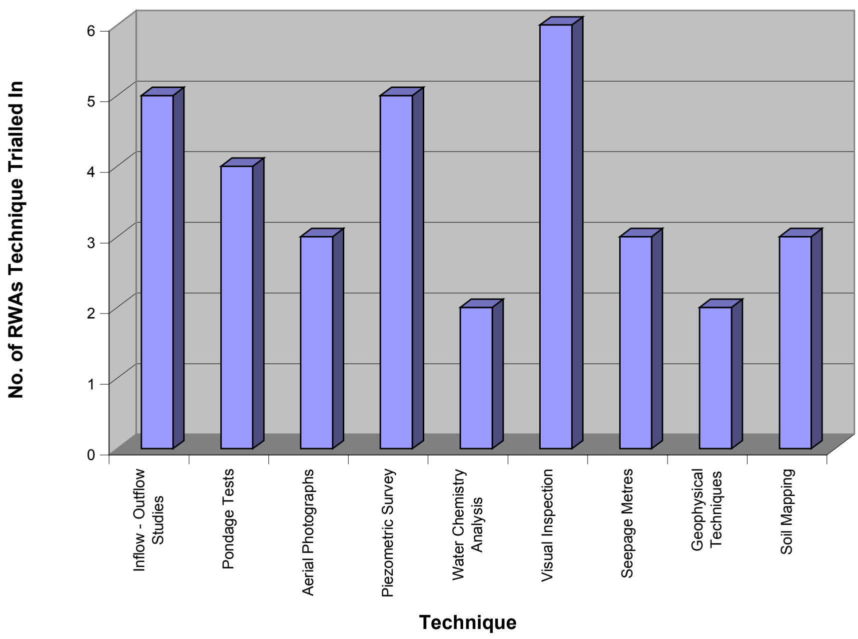
- EM 31 Survey (No comment provided);
- EM34 Survey – Correlating EM34 results against pondage test data and extrapolating to other sections using the established relationship where there was no pondage test data;
- Pondage tests and soil type – Indicative seepage rates based on pondages tests for various soils, extrapolated across the region on the basis of soil types to give total seepage figures; and,
- Seepage rates extrapolated against soil type.

5.6 Determination of Accuracy of Techniques

Question 19 of the survey asked if studies had been conducted by the RWA to determine the accuracy of various seepage measurement techniques. That is, had they conducted channel seepage studies for the sake of studying the technique, rather than primarily investigating the seepage losses in particular section of channel.

Eight of the twenty-four RWAs indicated they have conducted such investigations. **Figure 5.3** presents the range of techniques which were trialed in these investigations, and the number of Authorities which have used this technique. Again, visual inspection, inflow-outflow studies and piezometric surveys were identified as the most commonly used techniques for this purpose.

Figure 5.3: Techniques Used to Determine the Accuracy of Various Seepage Measurement Methods



6. Channel Seepage Remediation

Although the primary focus of the survey was not on channel seepage remediation, channel seepage measurement is often conducted with a view to determining which sections of channel should be remediated / lined. Two questions were included in the survey to determine the extent of channel seepage remediation being undertaken by Authorities (Q20 & Q21), and one to determine if and how post remediation seepage measurements are undertaken (Q22).

6.1 Extent of Channel Remediation / Lining

The majority of authorities do less than 5 km of remediation works per year.

Figure 6.1 presents the results of Q20, and depicts the typical length of channel which is annually remediated / lined by Authorities. The most common response was those RWAs undertaking remediation works between 0 – 5 km/yr. Only two other Authorities were undertaking remediation of lengths greater than this, with one lining between 5-10 km/yr and the other 15-20 km/yr. In both cases Authorities were delivering more than 400,000 ML/yr. Seven RWAs are not undertaking remediation works at all. The remaining five respondents did not know or could not approximate the length of channel lined each year, suggesting channel remediation is not a significant activity for these Authorities.

Figure 6.1: Typical Length of Channel Annually Lined / Remediated by Rural Water Authorities

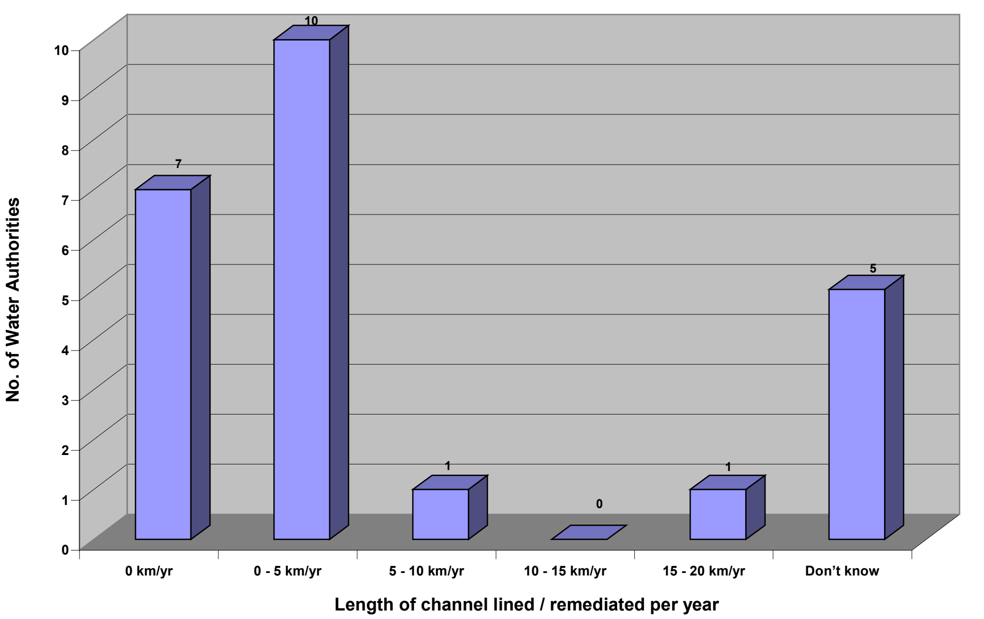
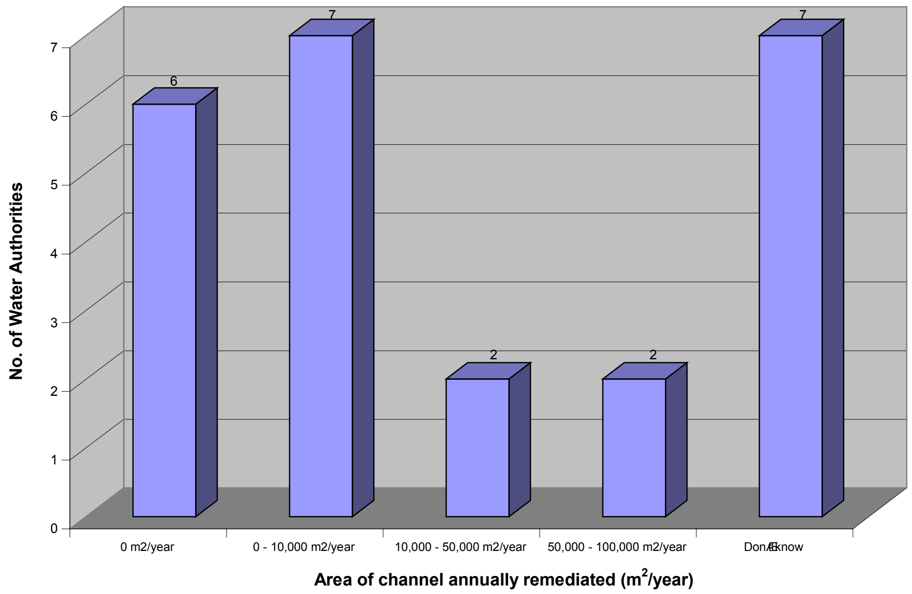


Figure 6.2 presents the results of Q21 which asked the same question as Q20, but requested an answer in units of area remediated rather than channel length. This was included to allow for variability in the size of channels. The results essentially reflect those of Figure 7.2, although a few RWAs which

were in the 0-5 km section have moved up into the higher categories in terms of area, apparently due to the greater size of their channels.

Figure 6.2: Typical Area of Channel Annually Lined / Remediated by Rural Water Authorities



6.2 Post-Remediation Channel Seepage Assessment

Question 22 of the survey asked if attempts are made by the RWAs to assess reductions in seepage / leakage after remediation works have been conducted, and if so, to identify the techniques which are used for this purpose. Nineteen of the twenty-four RWAs answered this question. An interesting note is that seven Authorities who indicated they didn't undertake remediation works (Q20), indicated that they did undertake post-remediation assessment. This suggests some confusion with the interpretation of the question. Only the data from those who previously indicated they were undertaking remediation was used in the analysis.

Of the Authorities undertaking remediation works, a high percentage (10 out 12) undertook some kind of assessment of the success of the works, as presented in **Figure 6.3**. However, while this may be seen as a positive trend in terms of the consideration given to the cost-benefit of channel seepage remediation, **Figure 6.4** indicates most of these post-remediation assessments are qualitative and not quantitative. **Figure 6.4** presents the results of the range of techniques which are used by RWAs for post-remediation channel seepage assessment, and the number of Authorities which have used the technique. Visual inspection and piezometric surveys were clearly identified as the most commonly used techniques for this purpose, with no other technique being used by more than two RWAs. These results indicate that either most Authorities assume that their channel remediation is effective and there is therefore no need for any quantitative assessment of channel remediation, ie a simple visual inspection is sufficient, or that an adequate means of post-remediation quantification is too difficult, too costly, or too technically challenging to be bothered with.

Figure 6.3: RWAs who attempt post-remediation channel seepage assessment

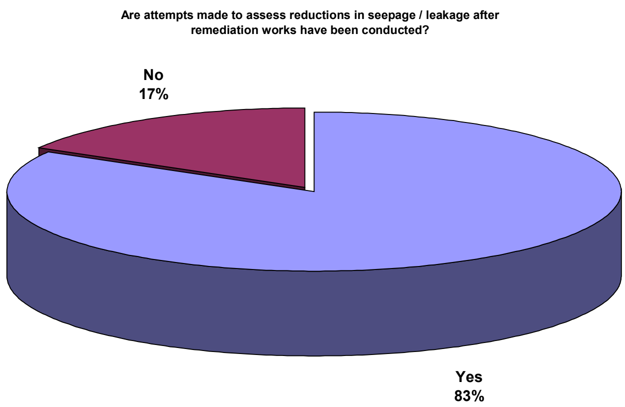
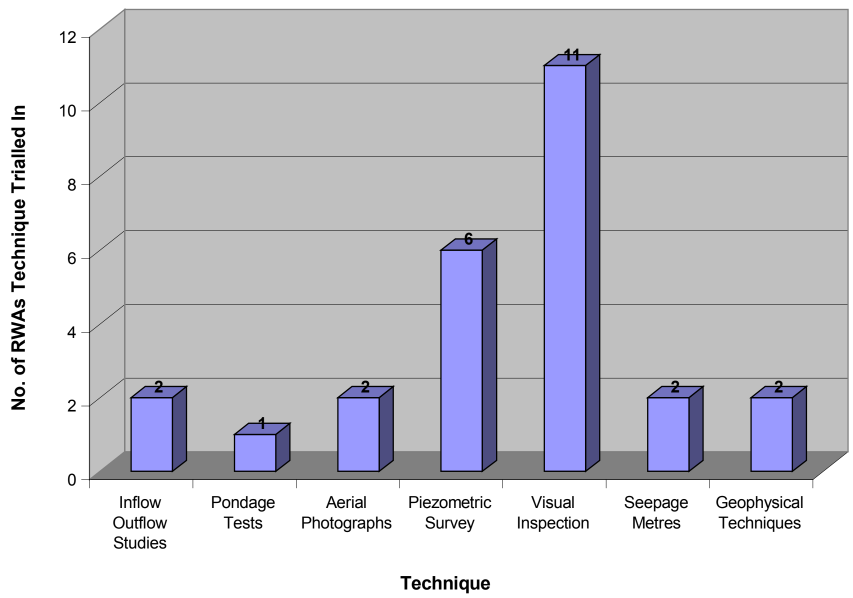


Figure 6.4: Techniques Used by Rural Water Authorities for Post-Remediation Channel Seepage Assessment



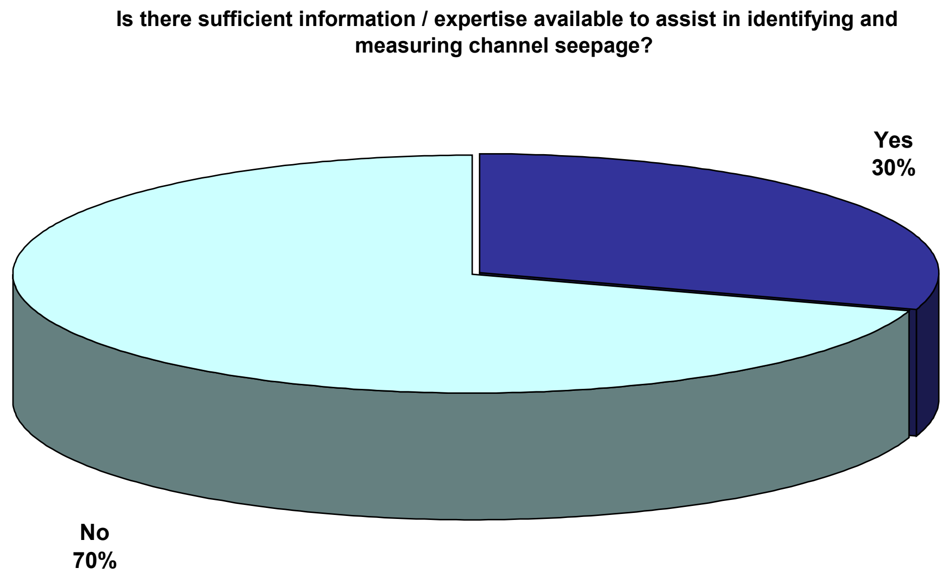
7. Demand For Guidelines

The final two questions of the survey sought to determine the general feeling amongst Authorities with regard to the need for assistance in assessing channel seepage. Both questions were well answered with 20 and 21 responses from the 24 surveys, for the two questions respectively.

Q23 asked if, in the opinion of the respondent, their is sufficient information / expertise available to assist in identifying and measuring channel seepage. **Figure 7.1** presents the results of this question. Quite clearly there is a feeling amongst RWAs that there is not sufficient information and/or expertise available to assist in identifying and measuring channel seepage, with 70% of respondents replying in the negative.

The majority of authorities believe that there is insufficient information and/or expertise on techniques for seepage identification and measurement.

Figure 7.1: RWAs Perception Of Adequacy Of Information / Expertise Available For Identifying And Measuring Channel Seepage



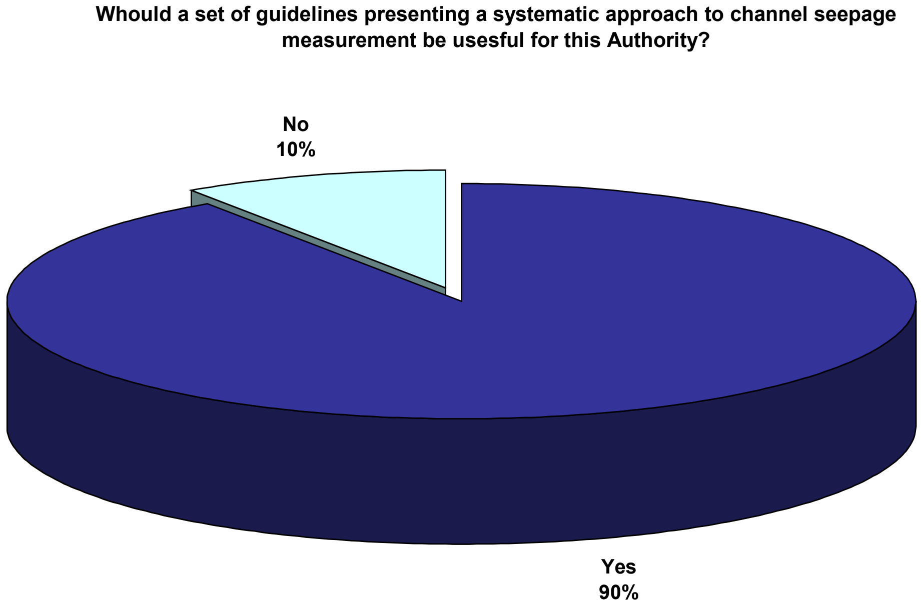
If answering in the negative respondents were asked to briefly describe the areas in which deficiencies exist. Some of the responses are listed below:

- No standard guidelines or specifications available;
- Need to develop a more systematic approach to quantifying problem and corrective action;
- Need further investigation into cheap, easy to use, accurate, flexible and reliable measurement systems;
- Don’t seem to be any accurate methods to determine losses effectively;
- More investigation required for less expensive broad coverage techniques such as EM34;
- Need to know more about who can fix problems; and,

- Information not available locally. Advice on a suitable process to identify and measure is required.

Q24 asked if a set of guidelines presenting a systematic approach to channel seepage measurement would be useful for their Authority. The results presented in **Figure 7.2** are overwhelmingly supportive of such an idea, with 90% of RWAs indicating their support of a document of this type.

Figure 7.2: Usefulness of Channel Seepage Guidelines to RWA



There is a strong demand for guidelines on channel seepage identification and measurement.

If answering in the positive to this question, respondents were asked to briefly describe the type of information that such guidelines should contain. Some of the responses are listed below:

- An accurate and cost effective method for measuring seepage and interpretation of results;
- Anything would help us;
- Decision support on most appropriate technique, specification for technique and guidance on interpreting results;
- Comparisons of seepage in different soils, a review of the process and extent of the problem, cost-benefit analysis of remediation vs effects, matrix of cost/ease of use vs accuracy/reliability;
- Relationship between types of soil and seepage and head of water and seepage;
- Low cost methods of assessing seepage other than visual inspection, remediation action plant – priorities;
- A systematic approach or guidelines would be of benefit and set an industry standard; and,
- A detailed description of available techniques, relative accuracy and cost.

8. Conclusions

The key outcomes from the survey are summarised below.

Water Supply, Size of Channel

- The majority of rural water authorities surveyed supply less than 100 GL/yr.

Network and Seepage Rates

- On average, 17.5% of released water is lost through unaccounted for processes.
- On average 4% of water is lost through seepage.
- An estimated 320 GL of water is lost each year from the authorities surveyed.
- The average length of earthen channel per GL of water supplied is 3.85 km. This result is skewed, however, by one RWA which has 54 km channel / GL supplied. When this result is removed the overall average drops to 1.45 km / GL water supplied.

Significance of Channel Seepage

- Two-thirds of all authorities surveyed have a reasonable or higher confidence in their estimate of seepage.
- Of the authorities surveyed, 42% rate channel seepage as a high or very high priority.

Channel Seepage Costs & Issues

- Measurement of channel seepage is most commonly considered the area where additional resources need to be applied.
- 25% of authorities have undertaken assessment of seepage at 3 or more sites.
- 50% have undertaken no on ground seepage measurement works at all.
- Extensive seepage investigations are generally only undertaken by water authorities delivering greater than 160 GL/Yr.
- There is a weak correlation between increased investigation and higher confidence in channel seepage estimates.
- The priority given to channel seepage appears dependent mostly on the perceived cost of the impacts of channel seepage
- Loss of water is considered the most significant cost consequence of channel seepage
- It is estimated that 46% of authorities do not know the extent of land degradation associated with channel seepage. A further 25% believe it to be less than 1 Ha.
- Of the authorities surveyed, 16% indicated that they are spending more on channel seepage identification, measurement and remediation than the estimated cost of water lost and other impacts of seepage from the channel.
- The average expenditure on channel seepage identification, measurement and remediation is approximately 60% of the estimated cost of water lost and other impacts of seepage from the channel
- Remediation works accounts for 61% of the monies spent on channel seepage, with monitoring and investigation contributing 35%.

Channel Seepage Measurement Techniques

- Cost and speed are considered the most important criteria in channel seepage assessment.
- Technical accuracy is considered of lesser importance.
- Seepage identification (visual, piezometers) rather than quantification techniques dominate channel seepage assessment methods.

Channel Seepage Remediation

- The majority of authorities do less than 5 km of remediation works per year.

Demand for Guidelines

- The majority of authorities believe that there is insufficient information and/or expertise on techniques for seepage identification and measurement.
- There is a strong demand for guidelines on channel seepage identification and measurement

Inconsistencies in Survey Responses

Another significant feature of the survey results was the apparent inconsistencies within and between surveys. This suggests that understanding of channel seepage issues and the approach to addressing them is ad-hoc for many authorities. Some of the main inconsistencies recognised include:

- A plot of confidence in seepage estimate against work undertaken to assess channel seepage shows that the amount of work undertaken on channel seepage assessment is only weakly correlated with the confidence of the Authority in their seepage estimate. Two important conclusions can be drawn from the plot:
    1. An increase in the amount of seepage assessment did not result in clear gains in an understanding of seepage rates, suggesting a lack of success, and a lack of direction in channel seepage measurement.
    2. Ten RWAs indicated they had not conducted any on-ground seepage assessment works in the past decade, and yet five of these indicated they had reasonable or better confidence in their estimate of seepage. To be reasonably confident in a seepage estimate which is based only on system records appears to indicate a certain degree of ignorance of channel seepage issues.
- Seepage identification techniques rather than quantification techniques dominate channel seepage assessment studies, which is an indication of the lack of real understanding of channel seepage losses.
- Channel seepage remediation projects are often undertaken without quantitative analysis of seepage. Qualitative techniques (particularly visual inspection and piezometric surveys) are the main means by which seepage sites are targeted for remediation. This is a less than ideal approach to selecting remediation sites which is unlikely to provide the

best return for dollars expended. The failure to clearly establish cost-benefit aspects of remediation contradicts the priority that the value of water lost is the major motivator for channel seepage investigations.

- The lack of correlation between the importance of channel seepage issues within an RWA and a number of key parameters such as seepage rate, ML lost to seepage and cost of seepage, is a further indication of the lack of a logical and systemic approach to addressing channel seepage.
- Pondage tests are universally regarded as the most accurate method of assessing channel seepage, however only one quarter of authorities (six) use pondage tests for seepage measurement.
- Inconsistencies between cost of channel seepage and channel seepage expenditure suggest an illogical approach to channel seepage expenditure.

Appendix A - Copy of Survey

Rural Water Authority Channel Seepage Measurement Survey

Please note that the purpose of this survey is to gain a nation wide picture of the significance of channel seepage and channel seepage measurement techniques. Information obtained from the surveys will be aggregated and reported on at a state and national level. Raw data from individual authorities will not be presented in the results.

If you do not know the answer to a question, please provide your best estimate.

1. Approximately what *quantity of water* does your Authority supply each year, on average?

_________________________ ML / yr

2. What is the total *length of earthen channels* within your Authority?

_________________________ km

3. What is the total *length of concrete channels* within your Authority?

_________________________ km

4. What *percentage of water* supplied by your Authority do you estimate is *lost* within your channel network? (ie unaccounted for water) (please circle):

Less than 2%	2% - 5%	5% - 10%	10% - 15%	15% - 20%	20% - 25%	More than 25%

5. Of the water lost within the channel network (Q4) what percentage do you estimate is lost to *seepage*? (please circle):

Less than 10%	10% - 20%	20% - 30%	30% - 50%	50% - 70%	70% - 90%	More than 90%

6. What *level of confidence* do you have in the above estimate (Q5)? (please circle):

Very Low	Low	Reasonable Confidence	High	Very High

7. How *importantly* are channel seepage issues *regarded* within your Authority? (please circle):

Not a Priority at all (Not an issue facing the organisation)	Low Priority (Within top 20 issues facing the organisation)	Average Priority (Within top 10 issues facing the organisation)	High Priority (Within top 3-5 issues facing the organisation)	Very High Priority (Top 1-2 issues facing the organisation)

8. What annual *cost estimate* would you assign to channel seepage within your Authority (land damage and loss of water)? (please circle):

Less than $10,000	$10,000 - $50,000	$50,000 - $100,000	$100,000 - $250,000	$250,000 - $500,000	More than $500,000	DON'T KNOW

Please indicate an approximate breakdown of these costs:

_____ % Loss of water

_____ % Land damage / degradation

_____ % Other (please specify)

9. Approximately *how much land* is directly degraded by channel seepage / leakage? (ie waterlogging and/ or salinisation) (please circle):

Less than 1 Ha	1 - 10 Ha	10 – 20 Ha	20 – 50 Ha	50 – 100 Ha	More than 100 Ha	DON'T KNOW

10. Approximately *how much money* does your Authority annually spend on channel seepage issues? (please circle):

Less than $10,000	$10,000 – $30,000	$30,000 – $50,000	$50,000 – $100,000	$100,000 – $150,000	$150,000 – $250,000	$250,000 – $500,000	More than $500,000

How is this money spent? (please indicate approximate percentage distribution)

_____ % Investigation / Assessment
_____ % Monitoring
_____ % Channel seepage remediation
_____ % Community education
_____ % Threat of litigation
_____ % Other (please describe)………………………………………………………….

11. Please rank in order of importance the *problems* associated with channel seepage within your Authority? (1 – greatest problem; 7 – least problem)

______ Financial loss to Authority
______ Economic loss of commodity to community/state/nation
______ Regional contribution to watertable rise
______ Local contribution to watertable rise and land salinisation / degradation
______ Community perception
______ Threat of litigation
______ Other (please describe)……………………………………………………….

12. How much *work* has been *undertaken* in the past 10 years to assess channel seepage issues (ie estimating losses, identifying priority areas etc). (please circle):

No Assessment	Minimal Assessment	Some Assessment	Significant Assessment	Extensive Assessment
No assessment made of channel seepage losses	Estimates of channel seepage system losses based on records	1 - 3 site specific seepage studies undertaken	3 – 5 site specific seepage studies undertaken	More than 5 site specific seepage studies undertaken

13. In your opinion, is your organisation devoting *sufficient time and resources* to the following channel seepage issues?

Channel Seepage Identification Y / N (Please circle) - If no, please explain

…………………………………………………………………………………

…………………………………………………………………………………

Channel Seepage Measurement / Quantification Y / N (Please circle) - If no, please explain

…………………………………………………………………………………

…………………………………………………………………………………

Channel Seepage Remediation Y / N (Please circle) - If no, please explain

…………………………………………………………………………………

…………………………………………………………………………………

Management of Channel Seepage Effects Y / N (Please circle) - If no, please explain

…………………………………………………………………………………

…………………………………………………………………………………

Community Education Y / N (Please circle) - If no, please explain

…………………………………………………………………………………

…………………………………………………………………………………

14. If seepage measurements have been made, please indicate the *techniques* which have been used to quantify / identify channel seepage within your Authority, by completing the following table.

Techniques	**Used in past** (please tick)	**Currently Used** (please tick)	**Perceived Accuracy** (please circle)	**Relative Cost**[1] (please circle)	**Satisfaction with Outcome**[2] (please circle)	**Comments** (eg ease of interpretation of results, where method most useful, if results were quantitative or qualitative, advan. / disadvan.)
			Note: Compared to other techniques			
Estimated from Records (ie unaccounted for water / district water balance)			Low Med High	Low Med High	Not S. Sat. Very S.	
Visual Inspection			Low Med High	Low Med High	Not S. Sat. Very S.	
Inflow – Outflow Studies			Low Med High	Low Med High	Not S. Sat. Very S.	
Aerial Photographs			Low Med High	Low Med High	Not S. Sat. Very S.	
Pondage Tests			Low Med High	Low Med High	Not S. Sat. Very S.	
Piezometric Survey (groundwater bores & use of Darcian principle)			Low Med High	Low Med High	Not S. Sat. Very S.	
Groundwater Bores & Water Chemistry Analysis (eg isotope analysis)			Low Med High	Low Med High	Not S. Sat. Very S.	
Seepage Meters						
Idaho Seepage Meter			Low Med High	Low Med High	Not S. Sat Very S.	
Constant Head Permeameter			Low Med High	Low Med High	Not S. Sat Very S.	
Disc Permeameter			Low Med High	Low Med High	Not S. Sat Very S.	
Other………………….. (please specify)			Low Med High	Low Med High	Not S. Sat Very S.	
Geophysical Surveys						
EM34			Low Med High	Low Med High	Not S. Sat Very S.	
EM31			Low Med High	Low Med High	Not S. Sat Very S.	
EM38			Low Med High	Low Med High	Not S. Sat Very S.	
Electrical Resistivity			Low Med High	Low Med High	Not S. Sat Very S.	
Other………………….. (please specify)			Low Med High	Low Med High	Not S. Sat Very S.	
Soil Mapping			Low Med High	Low Med High	Not S. Sat Very S.	
Remote Sensing (eg satellite imagery)			Low Med High	Low Med High	Not S. Sat Very S.	
Channel Seepage Modelling / Application of Mathematical Equations			Low Med High	Low Med High	Not S. Sat Very S.	
Other (Please specify)						
……………………….			Low Med High	Low Med High	Not S. Sat Very S.	
……………………….			Low Med High	Low Med High	Not S. Sat Very S.	

1. Note: Low costs: \$0 - \$200 / km channel; Med. costs: \$200 - \$500 / km channel; & High costs: > \$500 / km channel

2. Not S. = Not satisfied
S. = Satisfied
Very S. = Very satisfied

15. Please list the *techniques* which have been *preferred* by your Authority for seepage measurement and / or detection, (*in order of preference*), and use the space underneath to briefly describe why this technique has been favoured:

1.___________________________________

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2.___________________________________

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3.___________________________________

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16. List one or two *techniques* which you have found to be the *least* successful? Why?

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17. What are the main *criteria* used by your Authority for *selection of a technique*? Please rank in order of importance from 1 - 6 (1 - most important, 6 - least important):

Cost

Familiarity (ie Historical Reasons)

Speed / Broad Coverage

Technical Accuracy

Operational Constraints

Other (please specify)___________________________________

18. Has an attempt been made to *extrapolate* the results of one seepage trial across a larger area? If so, what was the technique and how was the extrapolation conducted?

………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

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19. Have studies been conducted by your Authority to *determine the accuracy* of various seepage measurement techniques? (ie have channel seepage studies been conducted for the sake of studying the technique rather than primarily investigating a particular channel?)

Y / N (Please circle) If yes, please tick the techniques which were trialed:

- ☐ Inflow-Outflow Studies
- ☐ Pondage Tests
- ☐ Aerial Photographs
- ☐ Piezometric Survey
- ☐ Water Chemistry Analysis
- ☐ Visual Inspection
- ☐ Seepage Meters (please specify type)……………………………………
- ☐ Geophysical Techniques (please specify type)……………………….
- ☐ Soil Mapping
- ☐ Remote Sensing (please specify type)……………………………………
- ☐ Modelling / Mathematical Equations
- Other (please specify)…………………………………………………

20. What is the approximate total *length* of channel that is annually remediated / lined within your Authority?

________________ km/yr Don't know ☐

21. What is the approximate total *area* of channel that is annually remediated / lined within your Authority?

________________ m^2/yr Don't know ☐

22. Are attempts generally made to *assess reductions* in seepage / leakage *after remediation* works have been conducted?

Y / N (Please circle) If yes, please tick the techniques which were trialed:

- ☐ Inflow-Outflow Studies
- ☐ Pondage Tests
- ☐ Aerial Photographs
- ☐ Piezometric Survey
- ☐ Water Chemistry Analysis
- ☐ Visual Inspection
- ☐ Seepage Meters (please specify type)……………………………………
- ☐ Geophysical Techniques (please specify type)……………………….
- ☐ Soil Mapping
- ☐ Remote Sensing (please specify type)……………………………………
- ☐ Modelling / Mathematical Equations
- Other (please specify)…………………………………………………

23. Do you think that there is *sufficient information / expertise* available to assist in identifying and measuring channel seepage?

Y/ N (please circle) If no please briefly describe the areas in which deficiencies exist:

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
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24. Would a *set of guidelines* presenting a systematic approach to channel seepage measurement be useful for this Authority?

Y / N (Please circle) If yes, what type of information should such guidelines contain?:

…………………………………………………………………………………
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(Please complete on back of sheet if insufficient space provided)

25. Please use this space to provide any additional comments you see as applicable to this survey.

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(Please complete on back of sheet if insufficient space provided)

26. Please list any reports that have been produced relating to channel seepage identification / measurement or remediation. (If possible a photocopy of the executive summary or conclusions / recommendations and reference list of the report would be greatly appreciated):

- ☐ ……………………………………………………………………………
  ……………………………………………………………………………
- ☐ ……………………………………………………………………………
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- ☐ ……………………………………………………………………………
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(Please complete list on back of sheet if insufficient space provided)

27. Would you like to receive a copy of the survey results? (Y/N):…………

For our records, and should the need arise to follow up a particular question in the survey, please indicate your name, position within the Authority, and contact details:

NAME: …………………………………………………………………………………
POSITION: ……………………………………………………………………………
CONTACT PHONE NO.: ……..………………………………………………………
E-MAIL ADDRESS.: …………..…………………………………………………

Thankyou for taking the time to complete this survey. Please post in the stamped and self-addressed envelope provided. If you have requested a copy of the results, they will be sent following collation and reporting.

IF YOU HAVE ANY QUESTIONS REGARDING ANY ASPECT OF THIS SURVEY, PLEASE DO NOT HESITATE TO CONTACT US (DETAILS BELOW):

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IF YOU HAVE ANY QUESTIONS REGARDING THE OVERALL CHANNEL SEEPAGE MEASUREMENT PROJECT PLEASE CONTACT THE PROJECT TEAM MANAGER, PETER JACKSON.

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Manager, Technical Services
Wimmera Mallee Water
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Horsham VIC 3402

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Fax: (03) 5362 6192
E-mail: peterjac@wmwater.org.au

Appendix B - Graphs of Channel Seepage Importance to RWAs

Figure B.1: Importance of Channel Seepage Issues Vs Seepage Rate

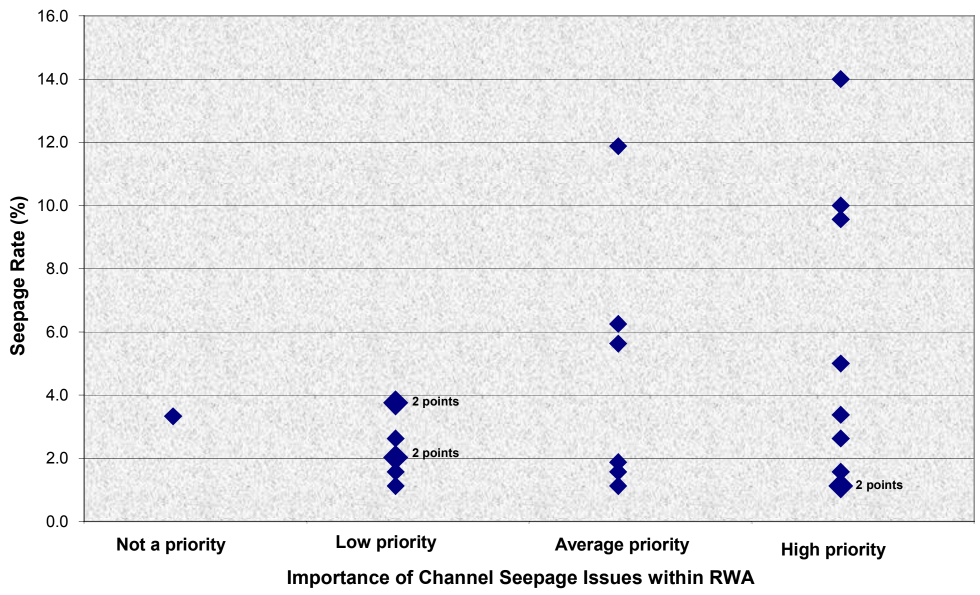


Figure B.2: Importance of Channel Seepage Issues Vs GL Delivered/Yr

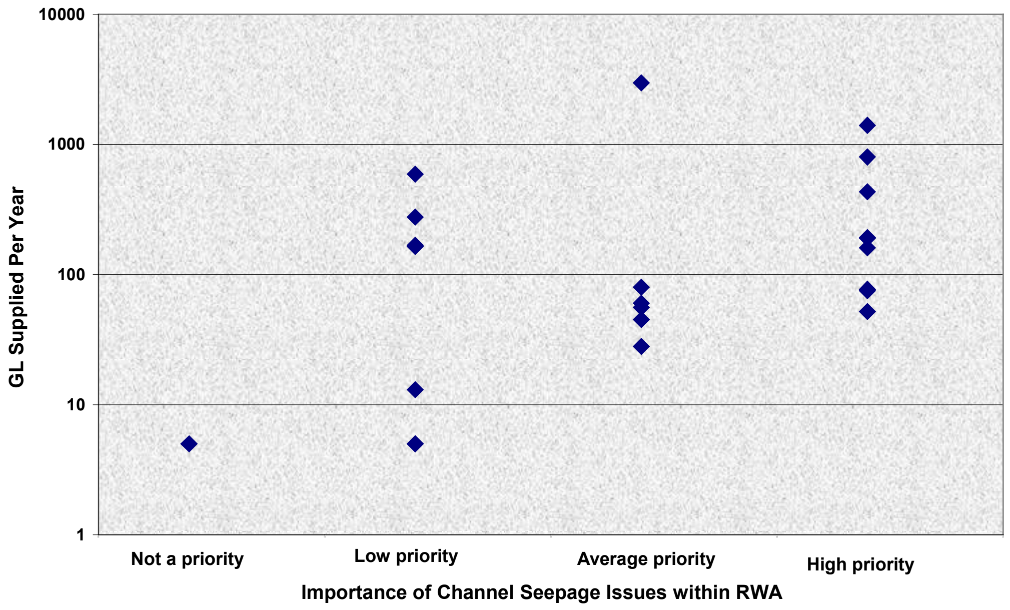


Figure B.3: Importance of Channel Seepage Issues Vs ML Lost to Seepage per Year

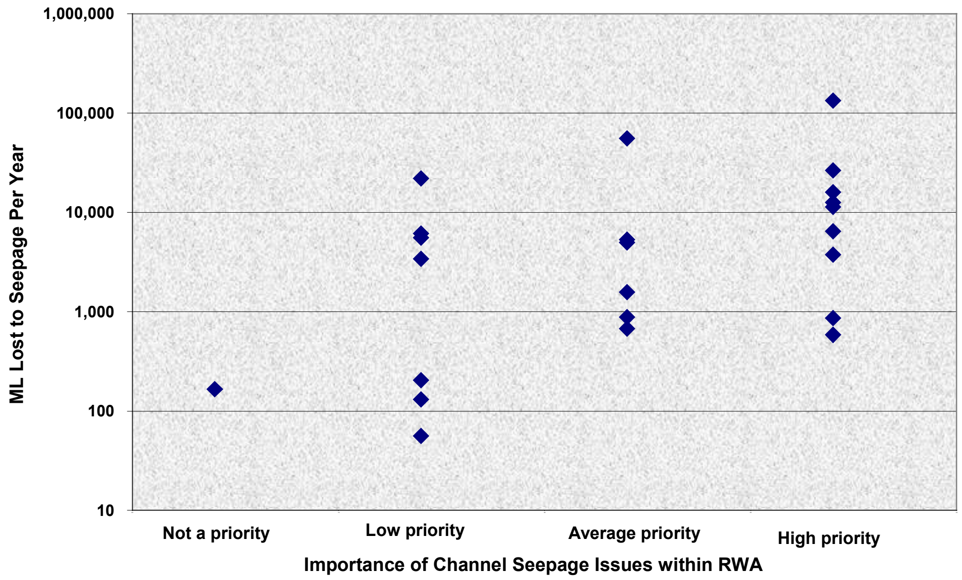
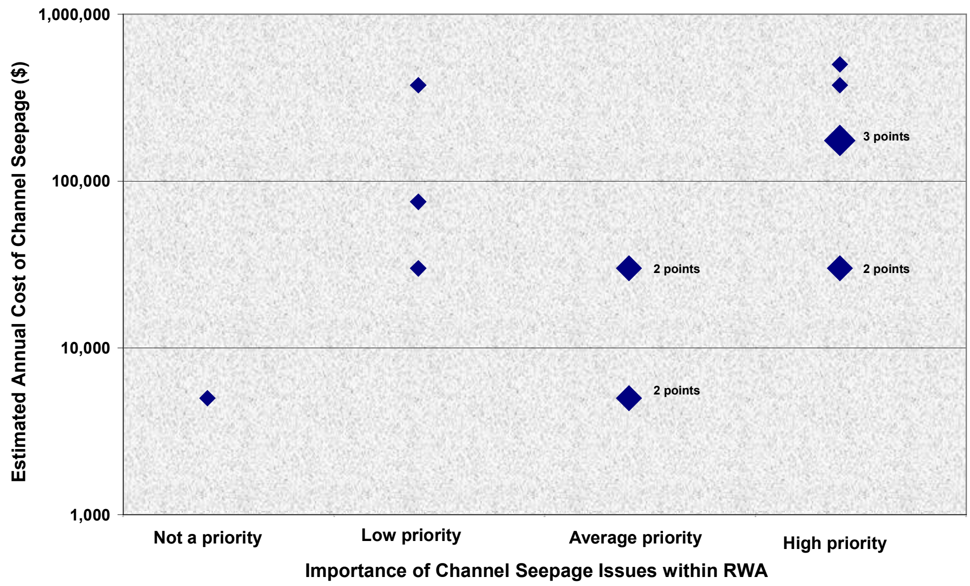


Figure B.4: Importance of Channel Seepage Issues Vs Estimated Cost of Channel Seepage



“Current Knowledge of Channel Seepage Issues and Measurement in the Australian Rural Water Industry”

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