SURVEY OF AUSTRALIAN GOLF COURSES USING RECLAIMED WASTEWATER

SUPPLEMENTARY REPORT FOR HORTICULTURE AUSTRALIA LIMITED PROJECT TU 1003

Australian Golf Course Superintendents Association

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We wish to thank all the golf clubs and golf course superintendents that took the time to fill in the survey.

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1. INTRODUCTION

As the pressure on the available water supplies increases, the use of potable water for irrigating turf is becoming increasingly unacceptable and alternative water sources are being developed. Groundwater in particular has traditionally been exploited, however, the availability of this water source is also under pressure due to diminishing reserves, over exploitation and deteriorating quality.

Reclaimed wastewater has been used for at least 25 years on Australian golf courses and it can provide an acceptable quality water supply for turf and an appropriate method of reuse for the sewerage authority. As the pressure increases on the available water supplies through urban development, more golf courses are turning to reclaimed wastewater for irrigating turf. In particular, with many new golf course developments taking place in Australia, reclaimed water is the only water source being made available for irrigating turf.

Reclaimed water is increasingly being used for the following reasons;

a. The lack of potable water for irrigating because of;

    i. Water restrictions due to drought.
    ii. Cost.
    iii. Unacceptable from a social, community and environmental point of view.

b. The lack of groundwater due to;

    i. Reduced yields due to falling watertable and the lack of recharge.
    ii. Deteriorating water quality (e.g. increasing salinity and sodicity)

c. The lack of stormwater runoff due to;

    i. Insufficient on-site catchment
    ii. Lack of space for sufficient storage
    iii. Drought
    iv. Increasing environmental restrictions in catchments to hold runoff water that would otherwise go into creeks etc.

d. The only water supply available.

e. The most accessible water supply.

f. Statutory requirements for “land disposal”.

g. Requirements of development applications.

The Problem
While there is a general acceptance of using reclaimed wastewater, there are a number of problems that are of concern to golf courses already using or contemplating the use of this water resource. These concerns have been an impediment to its adoption and include;

a. A lack of awareness by Clubs of water quality issues.

b. A lack of awareness by Sewerage/Water Authorities and Regulatory Authorities of the industry specific water quality issues that affect turf management and turf quality (e.g. nitrogen and phosphorus concentrations).

c. A lack of detailed water quality data provided by Waste Water Treatment Plants (WWTP) for decisions to be made on how the water is best managed and what remedial requirements need to be put in place (e.g. acid injection for pH modification and bicarbonate control).

d. A lack of understanding of both the short and long term soil/water/turf interactions.

e. Increasing concerns by Clubs on the implications of using reclaimed wastewater from a human health perspective.

f. It is very difficult to identify or find out from the Regulatory Authorities who are the users of reclaimed wastewater. Permits at present in Australia exist with Water/Sewerage Authorities, Local Government and the Environment Protection Authorities. None of which can easily identify all the users.

g. The various State guidelines and the proposed National guidelines relating to reuse are generic and do not (and would not be expected to) relate to specific industries.

The result of this lack of knowledge is that Golf Clubs have often committed to the use of reclaimed wastewater and then subsequently found that they need to upgrade the irrigation infrastructure to comply with regulations or to modify the effects of the dissolved constituents in the water. Soil/turf/water problems due to; high salinity, high sodicity, suspended solids, algae and excessive nutrients often require changes in the irrigation infrastructure such as;

- Water treatment (e.g. acid injection, gypsum injection).

- Modification of irrigation systems including;

    - Preventing spray drift into neighbouring properties.
    - Wind shut down devices.
    - More sophisticated irrigation control systems.
    - Weather stations.

2. OBJECTIVES

The aims of the project were to;

1. Compile a data base of Australian golf courses using reclaimed wastewater including;

a. Water quality.
b. Turf species.
c. Soil types.
d. Years of use.

2. To identify the benefits, problems and remedial measures associated with the use of reclaimed wastewater.

3. To provide an information resource for golf clubs and the turf industry on reclaimed wastewater reuse.

Issues addressed in the survey
The key issues that were addressed include the following;

1. Quality of reclaimed wastewater.

2. Water/ Soil / Turf problems associated with the use of reclaimed wastewater and how they are (or are not) being resolved.

3. To determine the requirements and standard of the Reclaimed wastewater management plan. These are referred to as Environment Improvement Plans, Irrigation Management Plans and Environment Management Plans and vary from state to state and often from site to site within the area of responsibility for the same regulatory authority.

4. To determine the extent of the on-going soil / water/ turf monitoring program and how the data is utilised and reported (both within the user organization and to the regulatory authority).

Benefits to the industry
The following benefits are expected to be derived from this project;

A database accessible through the AGCSA's web site on;

1. Current users of reclaimed wastewater.

2. Quality of the reclaimed wastewater currently being used.

3. Water / Soil / Turf issues and how they are being addressed.

4. Reclaimed water management strategies to minimise turf, soil and environmental impacts.

5. Infrastructure requirements associated with the use of reclaimed wastewater.

3. METHOD

The first and essentially most important part of the survey was to identify as many of the golf courses using reclaimed wastewater as possible. This was done by several means including;

- Notification in the AGCSA's email newsletter 'The Cut'.
- Notification on the AGCSA's web site.

- Direct contact by email or mail with courses already known to AGCSA staff using reclaimed wastewater.
- Contact with various state statutory and regulatory authorities.
- Contact through State Golf Course Superintendents Associations.

It is believed that at least 80 percent of reclaimed wastewater users have been identified.

All the identified users of reclaimed wastewater were contacted by either mail, email or telephone.

A survey was formulated (Appendix 1) and includes the following key parameters;

1. Volume of reclaimed wastewater being used.
2. Quality of reclaimed wastewater being used.
3. No. of years reclaimed wastewater has been used.
4. What monitoring programs are in place;
    i. Soil
    ii. Reclaimed wastewater
    iii. Turf quality and composition

5. Is there an Environmental Management Plan
6. Key environmental issues related to reuse.
7. Alterations to;
    i. Golf course layout
    ii. Irrigation layout
    iii. Irrigation control system
    iv. Storages and storage management
    v. Water treatment
    vi. Turf profiles e.g. greens construction

8. Soil and water analysis results (copies) of all data available.

9. Issues associated with reclaimed wastewater;
    i. Bicarbonates
    ii. Salinity
    iii. Sodium
    iv. Disease
    v. Algae
    vi. Nutrients
    vii. Problems

The survey was placed on the AGCSA's web site at www.agcsa.com.au and for those that did not have access to the web they were sent a copy of the survey. Of the survey returns 89% were filled in on the website. Following the sending out of the surveys Clubs were followed up three times.

The data was compiled and is presented in charts and tables.

4. RESULTS

The results are detailed in the attached charts and tables and are summarised as follows;

4.1 National results

The National statistics are summarised as follows;

- **Survey returns:** In excess of 40 percent of surveys were returned for New South Wales, Victoria, Queensland and South Australia (fig. 1). No returns were received for Tasmania and Western Australia.

- **Area irrigated and volume of reclaimed wastewater used:** Key statistics for reclaimed wastewater used and area irrigated are detailed in table 1 and figure 3:

Table 1: Area irrigated and volume of reclaimed wastewater used

State	% of Clubs that replied to survey	Area irrigated (Ha)	Volume of RW used/annum (ML)	Potential area irrigated (Ha)*	Potential volume of RW used/annum (ML)**
VIC	43	238	1005	595	2513
NSW	50	203	953	406	1906
QLD	47	954	3452	2030	7345
SA	83	132	580	159	699
Total	**-**	**1527**	**5990**	**3190**	**12463**

*Potential area calculated based on the total area irrigated of the respondents x number of golf courses identified as using reclaimed wastewater

**Potential volume of reclaimed wastewater calculated based on the volume of RW used by the respondents x number of golf courses identified as using reclaimed wastewater

- **Class of reclaimed wastewater:** The class of reclaimed wastewater used varies between the states (fig. 4) with;
  - Majority of clubs in Queensland using class A or B.
  - All clubs in NSW are class A or B.
  - Majority of clubs in Victoria using class C.
  - 80% of clubs in SA using class B.

- **Number of years reclaimed wastewater used:** Most of the clubs surveyed have been using reclaimed wastewater for 15 years or more (fig. 5).

4.2 Victoria

The results of the survey for Victoria are detailed in charts 12 - 30 and the key points are summarised as follows;

- The majority (73%) of golf courses use C-class reclaimed wastewater (fig. 12), however, this is expected to change with increasing reuse in public open space.
- 37% of clubs have been using reclaimed wastewater for 15 years or more (fig. 15).
- 82% of clubs have reclaimed wastewater management plan (Fig. 17).
- 64% of clubs have been audited (fig. 17).
- Water quality:
  - 64% of clubs have a salinity of 500 – 1000 and 18% have a salinity of 1000 – 1500 mg/L (fig. 18).
  - 27% of clubs have chloride levels greater than 300 mg/L (fig. 19).
  - 27% of clubs have sodium levels of 200 – 300 (fig. 23).
  - 55% of clubs have nitrogen levels of 10 – 20 mg/L (fig. 20).
  - 64% of clubs have phosphorus levels of 5 -10 mg/L (fig. 21).

- 64% of golf courses have modified their irrigation systems with most having modified their sprinklers and controllers (fig. 29).
- 46% of golf courses undertake soil sampling every 0 – 12 months (fig. 30).
- Over 40% of golf courses undertake water sampling every 6 months with over 30% only sampling every 2 years or more.

4.3 Queensland

Queensland has the largest number of golf courses using reclaimed wastewater (33) and the results of the survey are detailed in charts 31 – 46 and the key points are summarised as follows;

- 64% of clubs utilise B-class reclaimed wastewater (fig. 31).
- 51% of clubs have been using reclaimed wastewater for 15 years or more (fig. 34).
- 93% of clubs have a reclaimed wastewater management plan.
- 43% of clubs have been audited (fig. 36).
- Water quality:
    - 36% of clubs have a salinity of 500 – 1000 mg/L and 14% a salinity of 1000 – 1500 mg/L (fig. 37).
    - 14% of clubs have chloride levels of 200 – 300 mg/L (fig. 38).
    - 43% of clubs have nitrogen levels of 0 – 10 mg/L and 43% have no data for nitrogen (fig. 39).
    - 43% of clubs have sodium levels of 100 - 200 and 14% sodium level of 200 – 300 mg/L (fig. 41).
    - 29% of clubs have phosphorus levels of 0 – 5 mg/L, 21% at 5 – 10 mg/L and 50% of clubs have no data for phosphorus (fig. 40).
- The majority of golf courses using reclaimed wastewater (79%) have fine textured soils on fairways that are loams through to clays (fig. 42).
- 29% of golf courses have modified their irrigation systems with 21% having installed acid injection systems and 14% have modified their irrigation controller (fig. 45).
- 100% of golf courses undertake soil sampling every 0 – 12 months (fig. 46).
- Over 60% of golf courses undertake water sampling every 6 months.

4.4 South Australia

The results of the survey for South Australia are detailed in charts 47 - 60 and the key points are summarised as follows;

- 80% of golf courses use B-class reclaimed wastewater (fig 47).
- 60% of clubs have been using reclaimed wastewater for 15 years or more (fig. 50).
- 100% of clubs have a reclaimed wastewater management plan (fig 51).
- 60% of clubs have been audited (fig. 52).
- Water quality:
    - 40% of clubs have a salinity of 1000 – 1500 (fig. 53).
    - 60% of clubs have chloride levels greater than 300 mg/L (fig. 54).
    - 60% of clubs have nitrogen levels of 20 – 30 mg/L and 20% have no data for nitrogen (fig. 55).
    - 40% of clubs have sodium levels of 200 – 300 (fig. 57).
    - 20% of clubs have phosphorus levels greater than 10 mg/L and 20% of clubs have no data for phosphorus (fig. 56).
- All golf courses have modified their irrigation systems. Acid injection systems, gypsum injection systems and sprinkler and controller systems are the parts of the system that have been modified.

4.5 New South Wales

The results of the survey for New South Wales are detailed in charts 61 - 78 and the key points are summarised as follows;

- 63% of golf courses use A-class reclaimed wastewater (fig. 61).
- 63% of clubs have been using reclaimed wastewater for 15 years or more (fig. 64).
- 37% of clubs have a reclaimed wastewater management plan (fig. 65).
- 63% of clubs have been audited (fig. 66).
- Water quality:
    - 75% of clubs have a salinity of 0 – 500 (fig. 67).
    - 50% of clubs have chloride levels greater than 100 - 200 mg/L (fig. 68).
    - 37% of clubs have nitrogen levels of 10 – 20 mg/L and 37% have no data for nitrogen (fig. 69).
    - 50% of clubs have sodium levels of 200 – 300 (fig. 71).
    - 37% of clubs have phosphorus levels of 5 -10 mg/L and 37% of clubs have no data for phosphorus (fig. 70).
- 62% of golf courses have modified their irrigation systems with 25% having installed acid injection systems and 50% have modified their sprinklers (fig. 77).
- 87% of golf courses undertake soil sampling every 0 – 12 months (fig. 78).
- 63% of golf courses undertake water sampling every 6 months.

4.6. Comments on reclaimed wastewater use

As part of the survey, respondents were requested to comment on particular aspects related to the use reclaimed wastewater. The following is a summary of the comments provided on questions 27, 29, 35 and 37 from the survey and are particularly presented where there was more than one respondent making the comment.

Q 27: Are there any particular issues that relate to the quality of the reclaimed water (e.g. high salinity, high nutrients etc.)?

Q 29: Has there been any changes in the quality of the treated effluent?

Q 35: Have there been any deleterious effects of the reclaimed water on soils (e.g. increasing salts or sodium) and turf?

Q 37: Are there any management strategies that you have implemented as a result of the quality of the reclaimed water?

Problems identified

- Increasing water sodium, chloride, pH, bicarbonates and SAR concentrations with adverse effects on soils.

- Summer months result in increases in reclaimed wastewater salinity levels.

- Effluent is mixed with storm water in the lake system and can get more concentrated if there has been no rain.

- Sodium and salinity levels increase in turf areas over summer.

- Reclaimed wastewater has an adverse impact due to;

    - Low lying areas that are difficult to drain.
    - Poor irrigation design preventing even water distribution.
    - High cart traffic areas compounding compaction and resulting in a loss of soil structure in fairways, tees and greens.

- Minimal rainfall to leach accumulated salts and soil degradation due to sodium and salt accumulation.

- 9 holes were rebuilt on landfill with a thin sand profile on a clay base so salt and turf burn is a factor following long periods without rain.

- A-class water is now available but is three times more expensive.

- Phosphorus levels remain high.

- High nutrients result in increased growth, thatch accumulation and soft, “puffy”growth.

- High sodium resulting in poor soil structure and increased “black layer”.

- High bicarbonates reducing levels of soil calcium.

- The water quality changes throughout the irrigation season. Salinity, sodium, phosphorus and SAR can increase as the irrigation period progresses.

- Hot dry summers without any rain to flush the greens occasionally can lead to turf damage at the end of the season. Increased moss and algae.

- Algae and suspended solids block solenoids.

- High nutrient concentrations cause algae outbreaks in the storage lakes.

- Increasing salinity and sodium accumulation results in greater disease pressure.

- pH is currently 8.8 - caused by high sodium content.

- Salinity levels continue to increase - Currently Class 3

- Sodicity levels continue to increase - Currently Class 2

- Chloride levels commonly create leaf burn and continue to increase salt levels.

- Shallow and weakened root system on 328 greens. Continuous Ectotrophic Root-Infecting Fungi testing indicates fine white root hairs being damaged at a very early stage of development.

- The turf throughout periods of little or no rainfall with high clay content soils becomes yellow/ blotchy. Fertilisers do little to combat. Soils become hydrophobic. Very unsightly.

Management techniques employed to minimise effects of reclaimed wastewater

- The use of granulated gypsum on all turf areas during renovations to control sodium levels.
- Gypsum applications on greens on a monthly basis and at least 4 times a year over entire course.
- Use of sulphur burning technology starting to reverse sodium and salinity accumulation in heavier soils (fairways). Cost effective method for water quality improvement.
- Acid injection introduced and utilised on tees and greens only. Effective but costly.
- Water and soil testing to ensure calcium levels increase and to minimise sodium.
- Calcium applications made as per soil test recommendations.
- Foliar fertilising to ensure nutrients are not locked up in the soil.
- Deep water applications to increase leaching of salts.
- Accumulation of sodium and chloride during the irrigation season but majority leached out with good winter rainfall.
- Increase renovations and in particular verti-draining.
- The quality of the effluent water has improved with the upgrade of the treatment plant 3 years ago.
- Addition of microbes to the pumping pond to reduce the phosphorus and nitrogen.
- The ability to change the mix ratio of effluent/run-off water dilutes salts and sodium.
- Fertiliser program adjusted according to nutrient load in the reclaimed wastewater.
- Change certain turf areas (fairway) to more salt tolerant couch grasses.
- Fertiliser and renovation programme is designed to keep the soil healthy. Calcium products are applied monthly and phosphorous fertiliser rarely used.
- Specific operating procedures that relate to the safe use of reclaimed water have been initiated. These are part of the overall course management system and cover occupational health and safety as well as environmental issues.
- There is always the potential for the water to have detrimental affects, but monitoring suggests that costly management is making the impact on soils and turf manageable.
- Regular Verti-draining of greens, tees and fairways.

- New aeration system to oxygenate water, bacteria program along with barley hay filtration at recycled water entry points.

- Regular water and soil monitoring is essential.

5. CONCLUSIONS

There are several comments that can be made in relation to the survey;

1. There was a high survey return (greater than 50%).

2. About 80% of golf courses in Australia using reclaimed wastewater have been identified.

3. Increasing/high salinity, sodicity and bicarbonates are the key reclaimed wastewater quality concerns.

4. High awareness of the need for regular soil and water testing.

5. Increasing problems on fine-textured soils with the accumulation of salts and sodium.

6. Need for increased soil and water management including;

    a. Soil aeration and decompaction.
    b. Leaching of salts.
    c. Regular applications of gypsum.
    d. Water modification through water acidification and gypsum injection.

7. Most golf courses have undertaken some form of modification of the irrigation system to comply with the legal requirements of using reclaimed wastewater or to modify water quality.

8. The rising cost of reclaimed wastewater is increasingly an issue.

NATIONAL STATISTICS

Figures 1 – 11

Fig. 1: % Surveys returned of Australian golf courses identified as using reclaimed water for irrigation

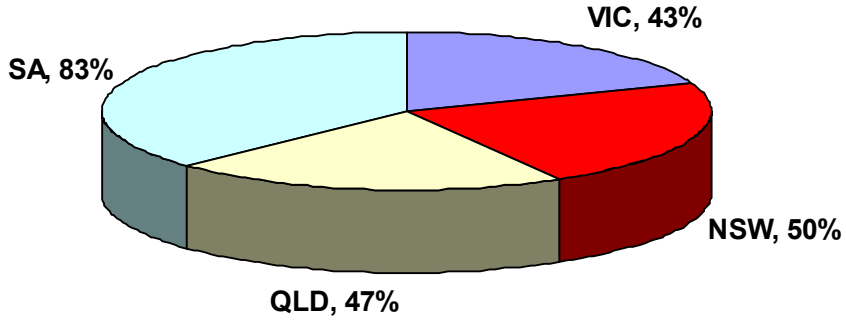


Fig. 2: Area Irrigated per annum with Reclaimed Water on Australian Golf Courses (Hectares)

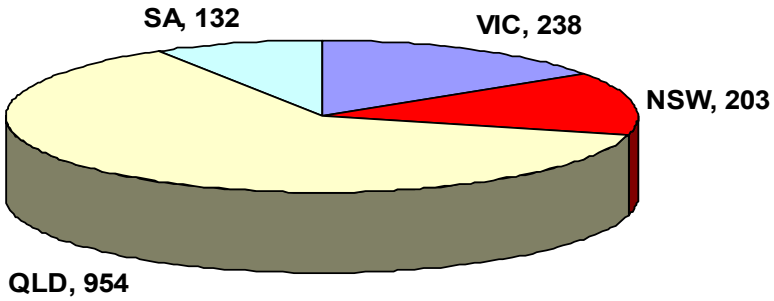
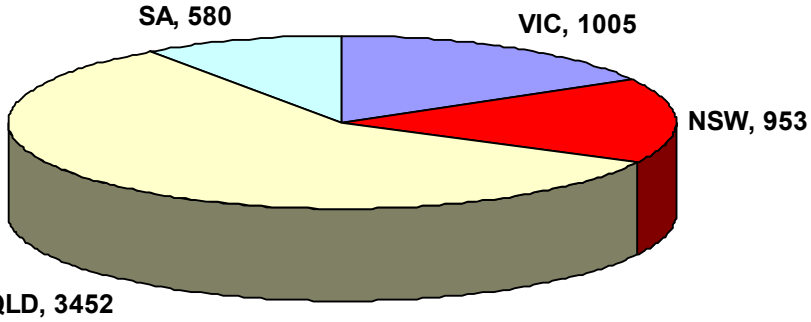


Fig. 3: Volume of Reclaimed Water used per annum on Australian Golf Courses (Megalitres)



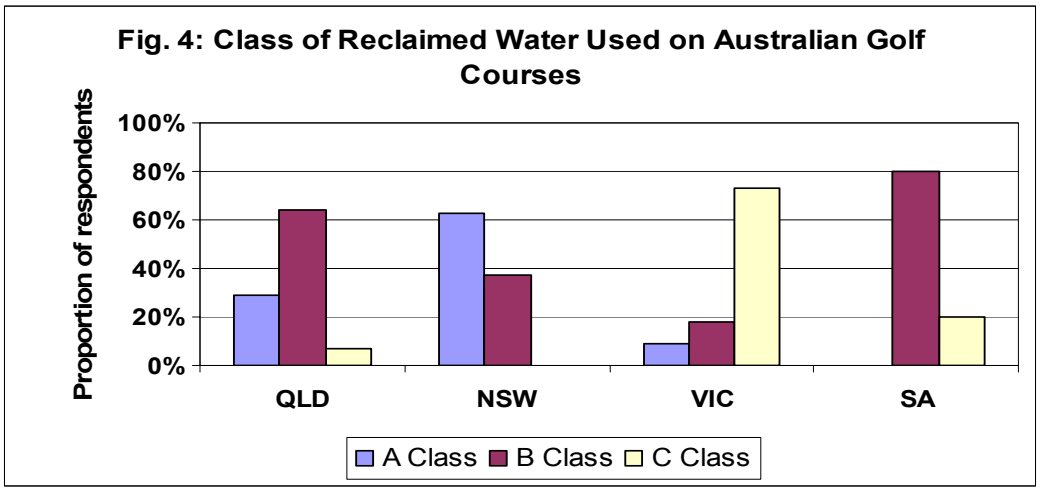


Fig. 4: Class of Reclaimed Water Used on Australian Golf Courses
Proportion of respondents
100%
80%
60%
40%
20%
0%
QLD
NSW
VIC
SA
A Class
B Class
C Class

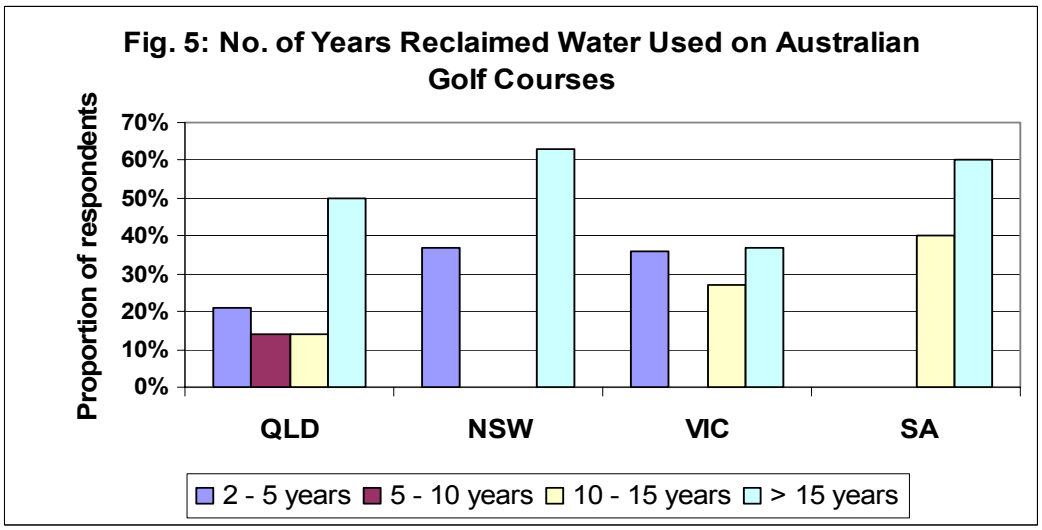


Fig. 5: No. of Years Reclaimed Water Used on Australian Golf Courses
Proportion of respondents
70%
60%
50%
40%
30%
20%
10%
0%
QLD
NSW
VIC
SA
2 - 5 years
5 - 10 years
10 - 15 years
> 15 years

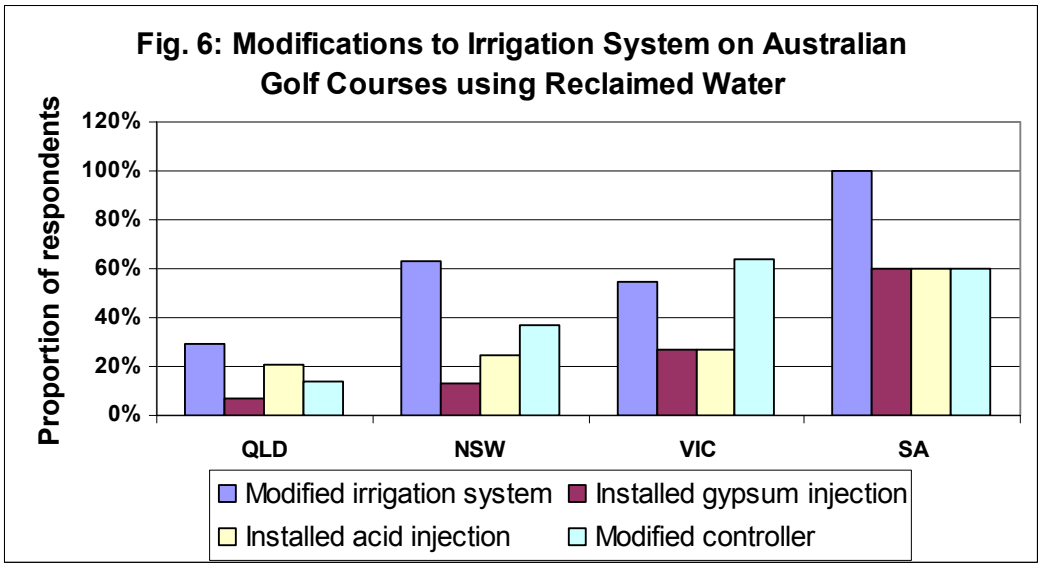


Fig. 6: Modifications to Irrigation System on Australian Golf Courses using Reclaimed Water
Proportion of respondents
120%
100%
80%
60%
40%
20%
0%
QLD
NSW
VIC
SA
Modified irrigation system
Installed gypsum injection
Installed acid injection
Modified controller

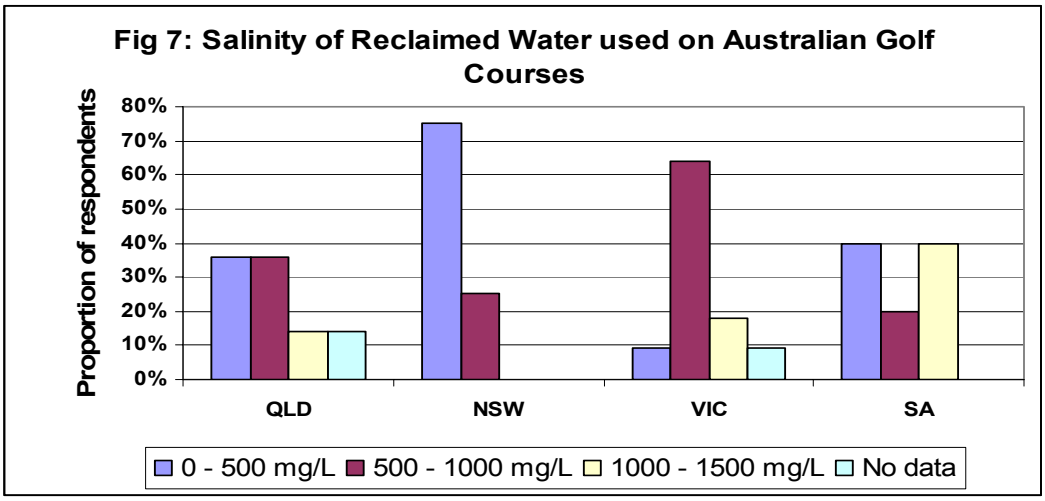


Fig 7: Salinity of Reclaimed Water used on Australian Golf Courses
Proportion of respondents
80%
70%
60%
50%
40%
30%
20%
10%
0%
QLD
NSW
VIC
SA
0 - 500 mg/L
500 - 1000 mg/L
1000 - 1500 mg/L
No data

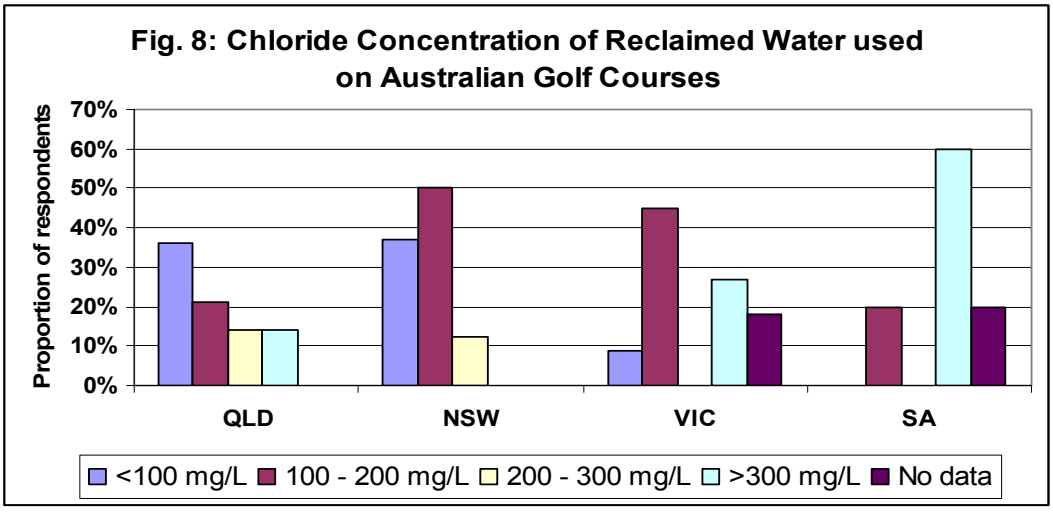


Fig. 8: Chloride Concentration of Reclaimed Water used on Australian Golf Courses
Proportion of respondents
70%
60%
50%
40%
30%
20%
10%
0%
QLD
NSW
VIC
SA
<100 mg/L
100 - 200 mg/L
200 - 300 mg/L
>300 mg/L
No data

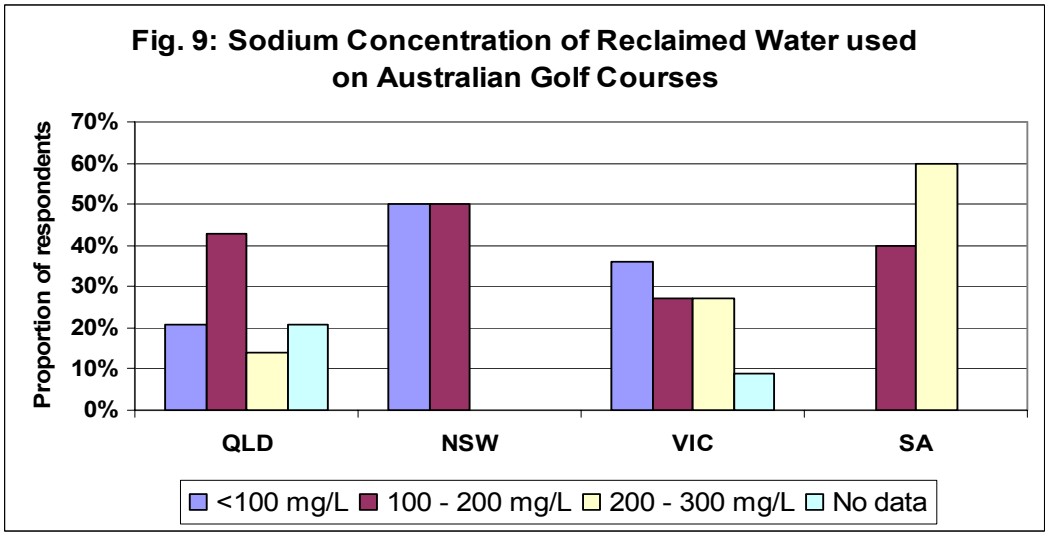


Fig. 9: Sodium Concentration of Reclaimed Water used on Australian Golf Courses
Proportion of respondents
70%
60%
50%
40%
30%
20%
10%
0%
QLD
NSW
VIC
SA
<100 mg/L
100 - 200 mg/L
200 - 300 mg/L
No data

Fig. 10: Australian Golf Courses Reporting some Problem associated with the use of Reclaimed Water

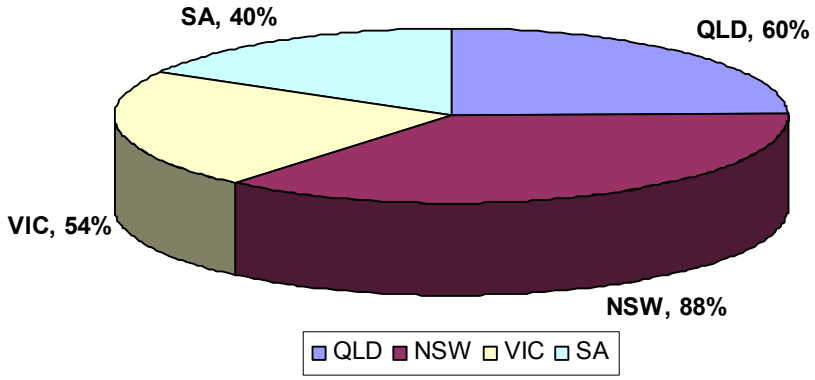
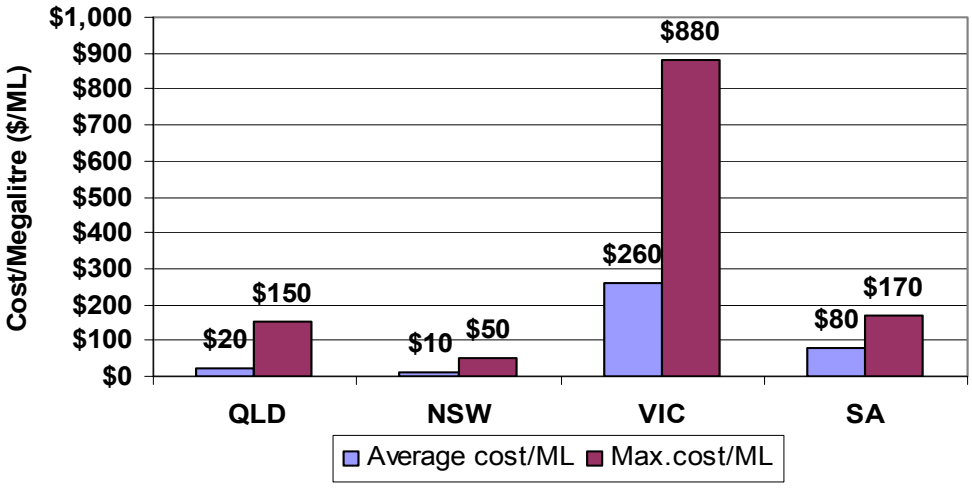


Fig. 11: Average and Maximum Cost of Reclaimed Water used on Australian Golf Courses



VICTORIAN STATISTICS

Figures 12 – 30

Fig. 12: Class of Reclaimed water used to Irrigate Victorian Golf Courses

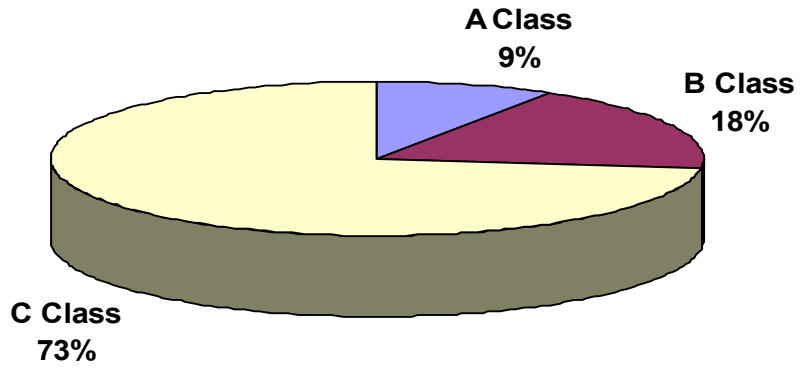


Fig. 13: Water sources other than Reclaimed Water used for Irrigating Victorian Golf Courses

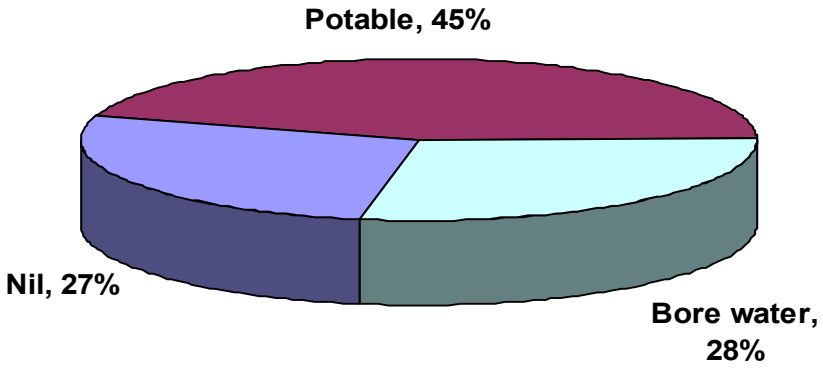


Fig. 14: Proportion of Irrigation Water provided by Reclaimed Water on Victorian Golf Courses

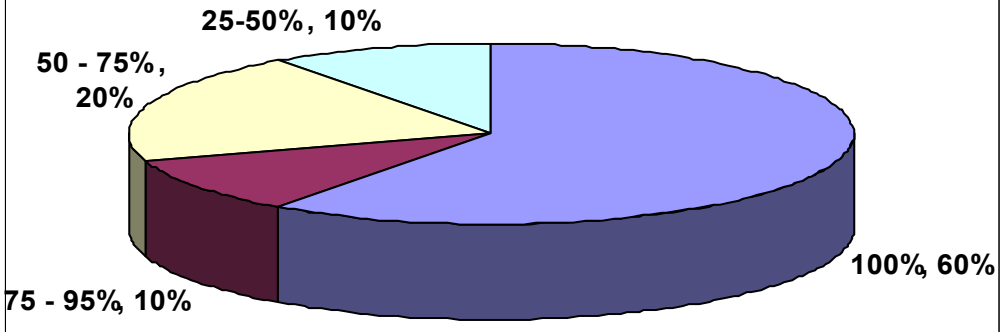


Fig. 15: No. of Years Reclaimed Water used on Victorian Golf Courses

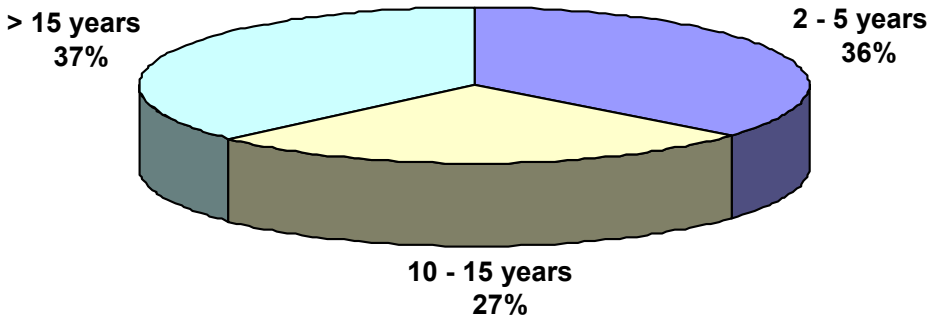


Fig. 16: Authorities Responsible for Regulating the Use of Reclaimed Water on Victorian Golf Courses

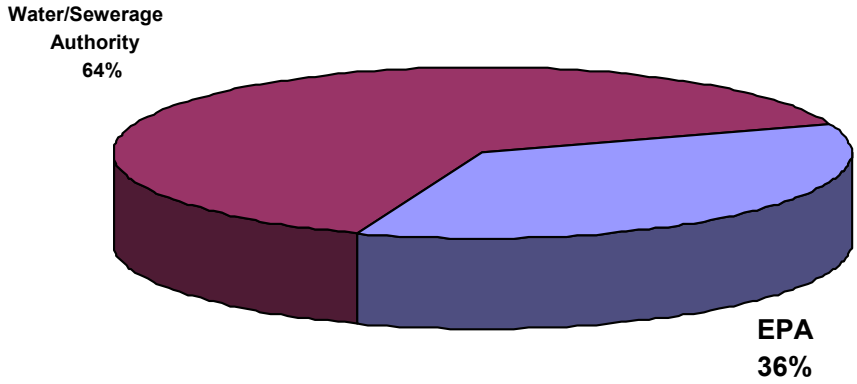


Fig. 17: Audits of Victorian Golf Golf using Reclaimed Water

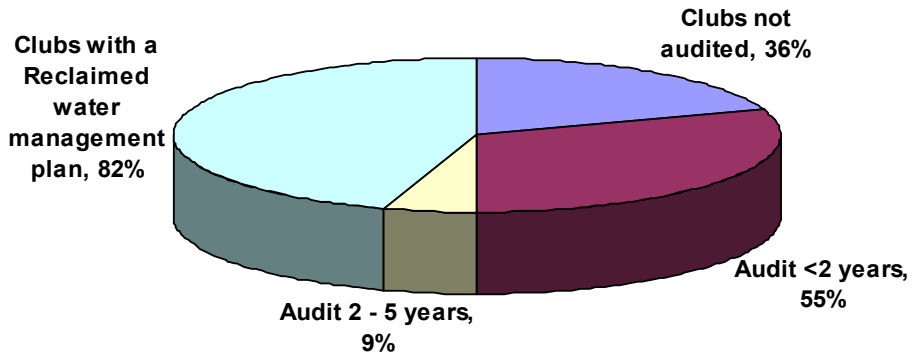


Fig. 18: Salinity (Total Soluble Salts) of Reclaimed Water used on Victorian Golf Courses

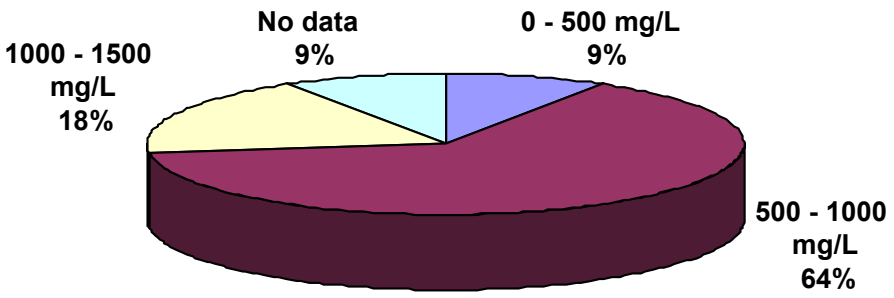


Fig. 20: Total Nitrogen Concentration of Reclaimed Water used on Victorian Golf Courses

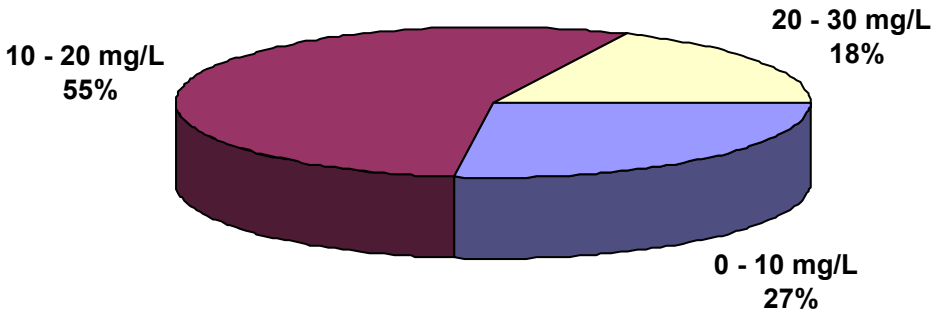


Fig. 21: Total Phosphorus Concentration of Reclaimed Water used on Victorian Golf Courses

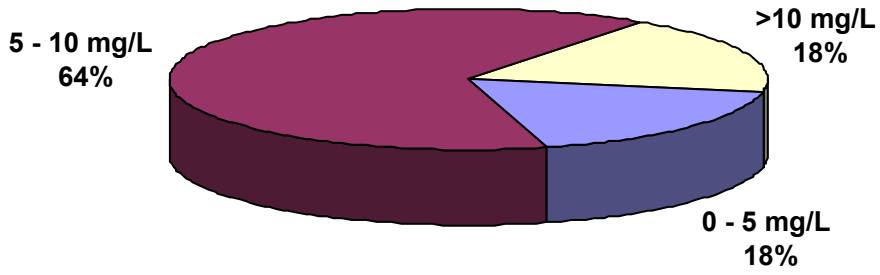


Fig. 22: Sodium Adsorption Ratio of Reclaimed Water used on Victorian Golf Courses

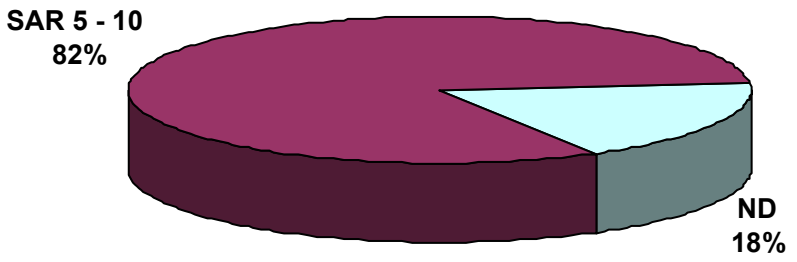


Fig 23: Sodium Concentration of Reclaimed Water used on Victorian Golf Courses

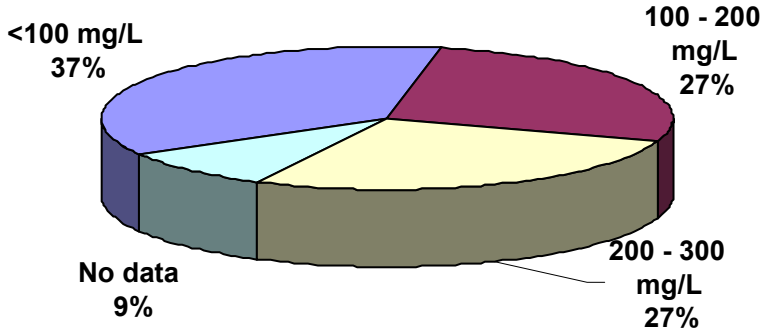


Fig. 24: Areas where Reclaimed Water is used on Victorian Golf Courses

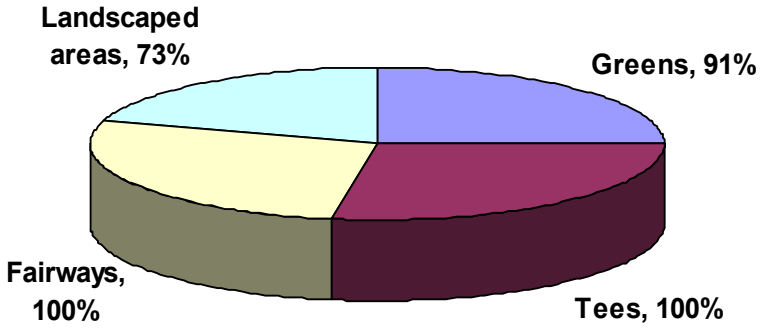


Fig. 25: Areas where Reclaimed Water is used on Victorian Golf Courses

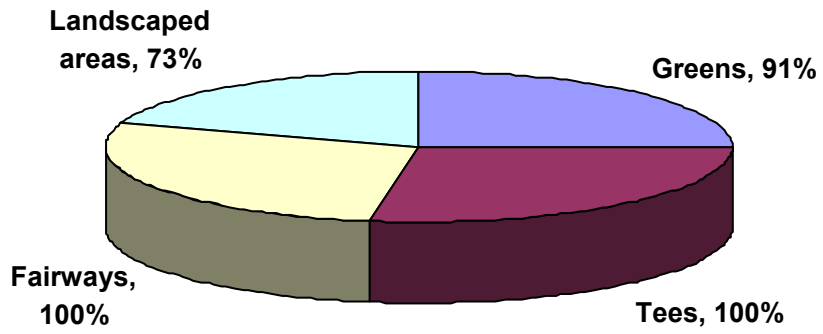


Fig. 26: Grass types used on Greens on Victorian Golf Courses using Reclaimed Water

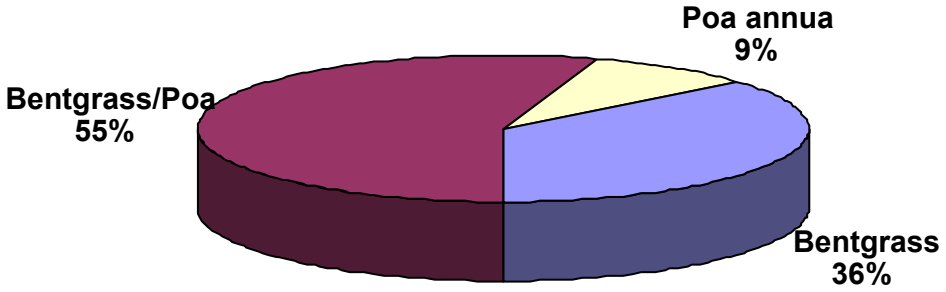


Fig. 27: Grass types used on Tees on Victorian Golf Courses using Reclaimed Water

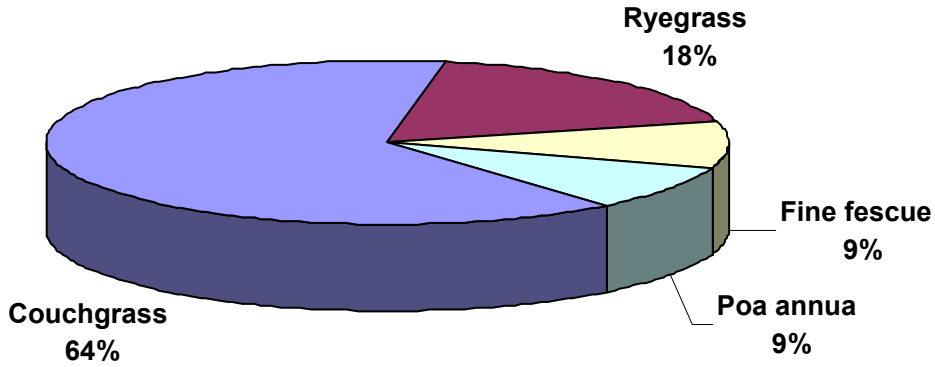


Fig. 28: Grass types used on Fairways on Victorian Golf Courses using Reclaimed Water

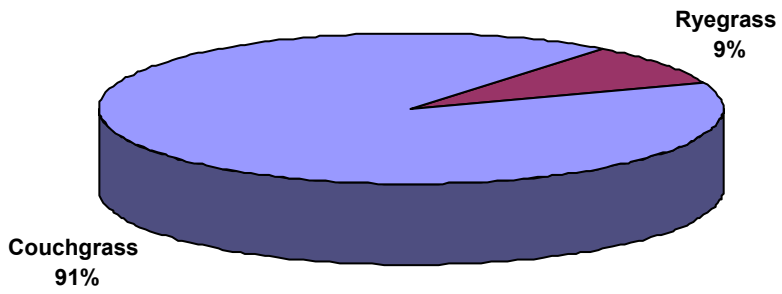


Fig. 29: Modifications made to Irrigation Systems on Victorian Golf Courses using Reclaimed Water

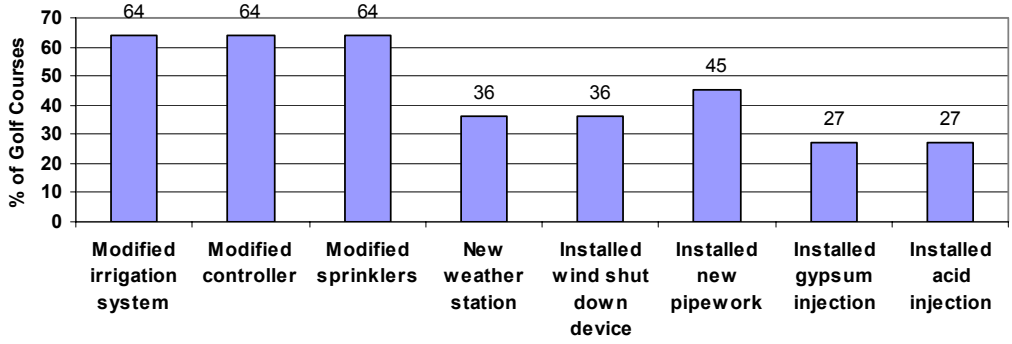
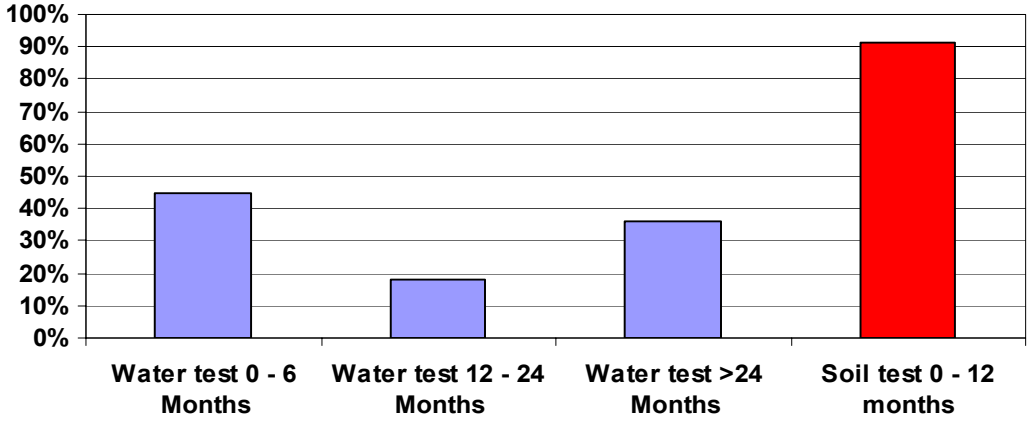


Fig. 30: Frequency of Water and Soil Testing on Victorian Golf Courses using Reclaimed Water



QUEENSLAND STATISTICS

Figures 31 – 46

Fig. 31: Class of Reclaimed water used to Irrigate Queensland Golf Courses

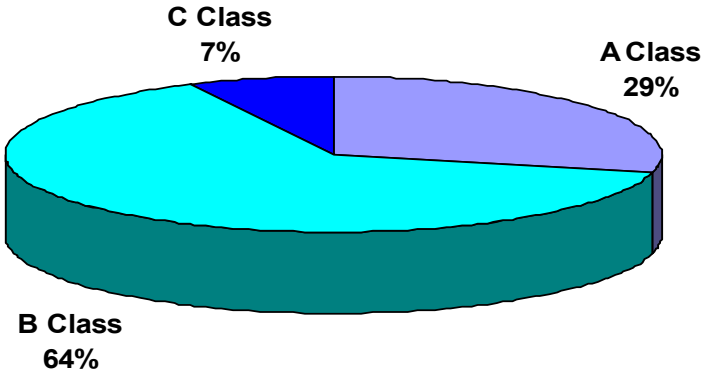


Fig. 32: Water Sources other than Reclaimed Water used for Irrigating Golf Courses in Queensland

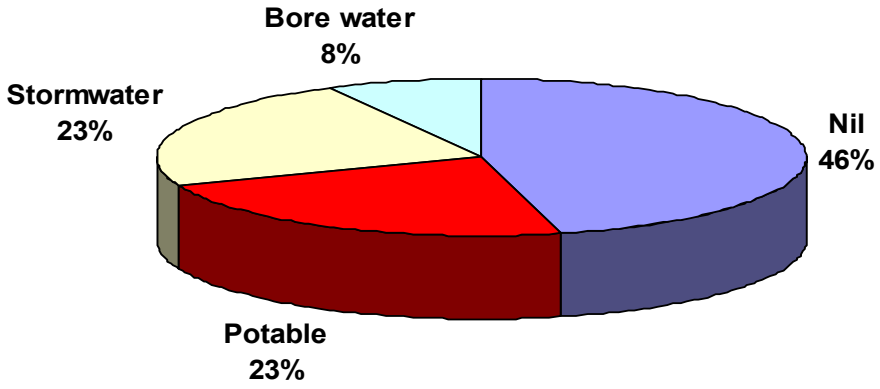


Fig. 33: Proportion of Irrigation Water provided by Reclaimed Water on Queensland Golf Courses

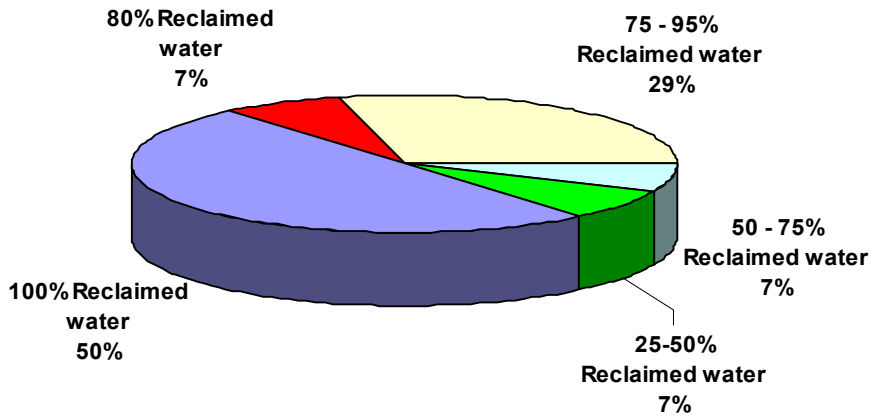


Fig. 34:No. of Years Reclaimed Water used on Queensland Golf Courses

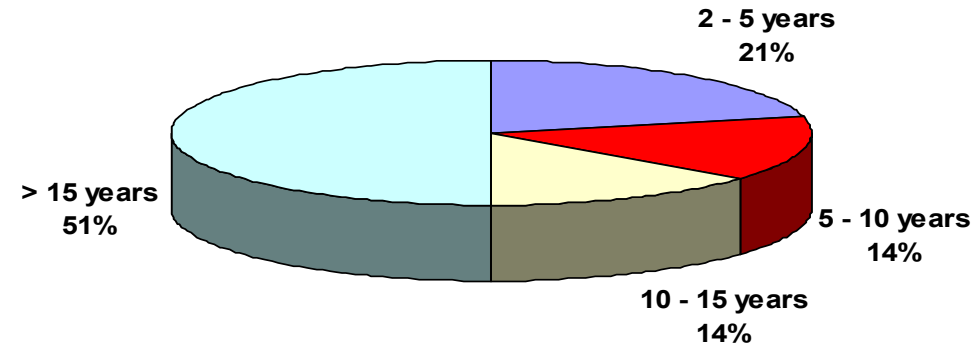


Fig. 35: Authorities Responsible for Regulating the Use of Reclaimed Water on Queensland Golf Courses

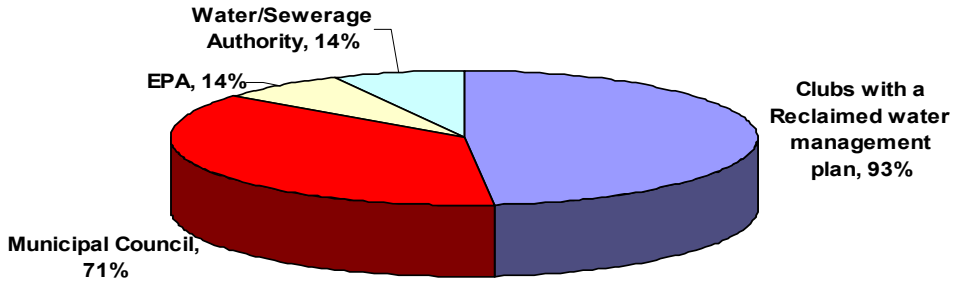


Fig. 36: Audits of Queensland Golf Courses using Reclaimed Water

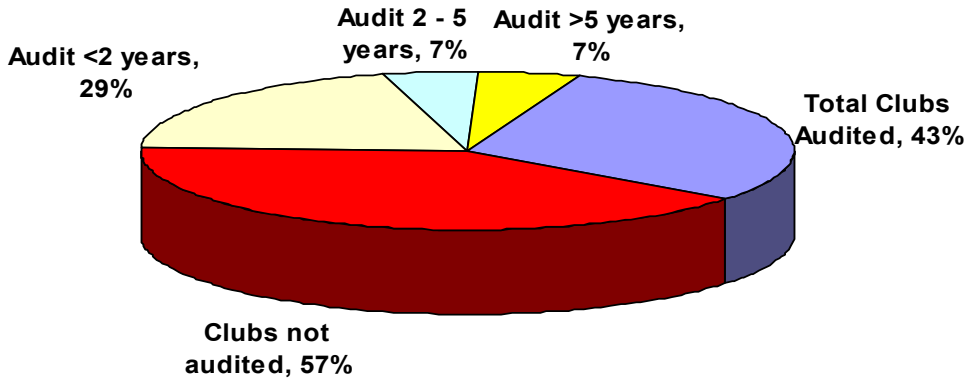


Fig. 37: Salinity of Reclaimed Water used on Queensland Golf Courses

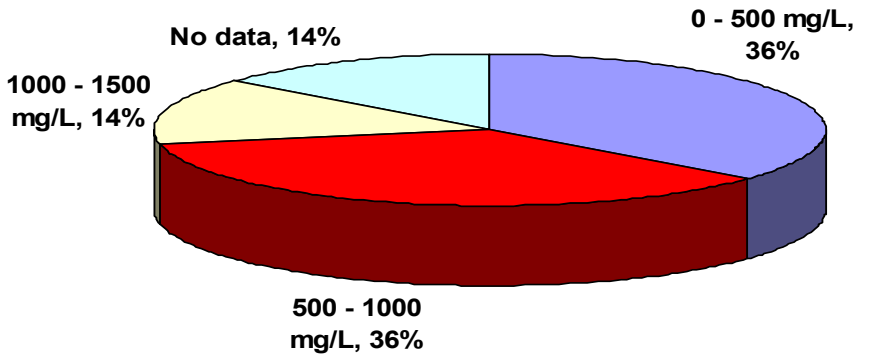


Fig. 38: Chloride Concentrations of Reclaimed Water used on Queensland Golf Courses

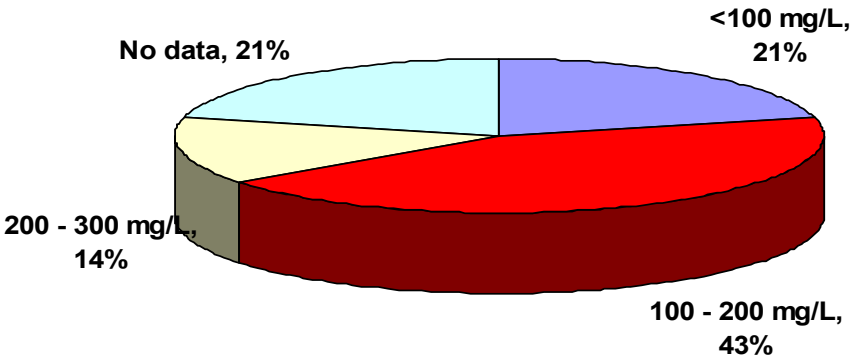


Fig. 39: Total Nitrogen Concentration of Reclaimed Water used on Queensland Golf Courses

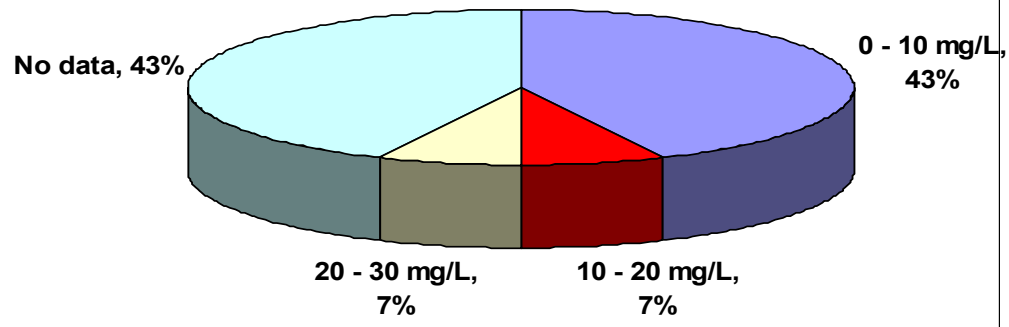


Fig. 40: Total Phosphorus Concentration of Reclaimed Water used on Queensland Golf Courses

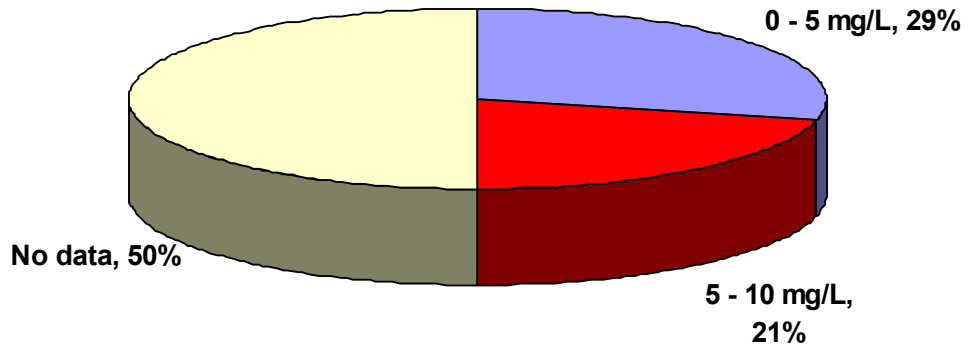


Fig. 41: Sodium Concentration of Reclaimed Water used on Queensland Golf Course

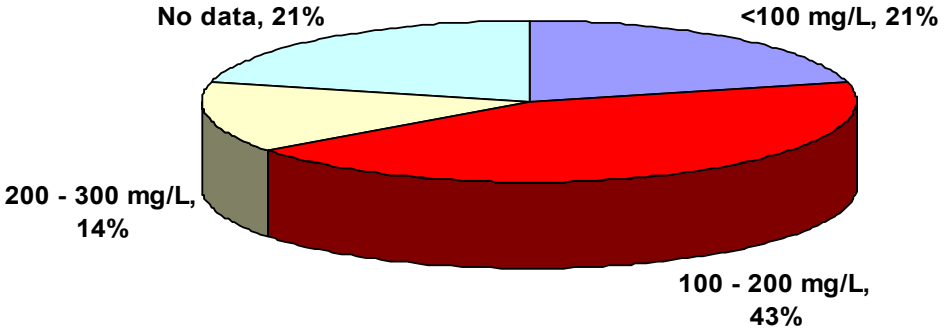


Fig. 42: Soil Types on Queensland Golf Courses using Reclaimed Water

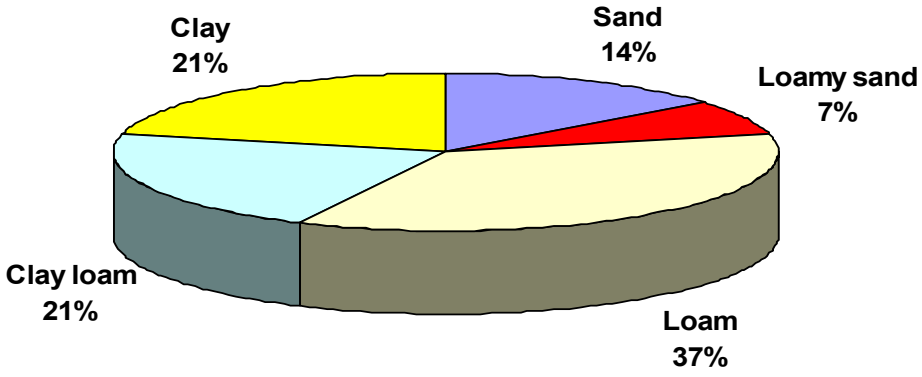


Fig. 43: Areas where Reclaimed Water is used on Queensland Golf Courses

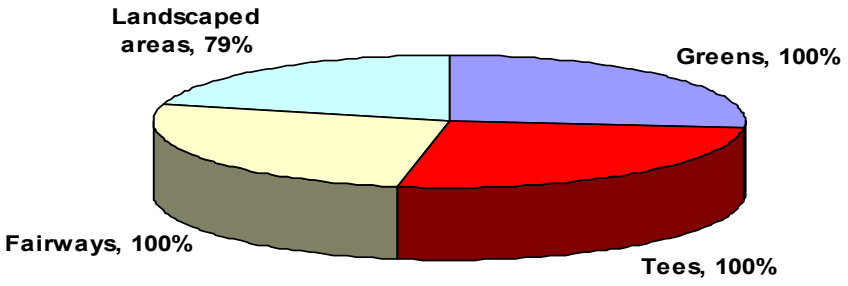


Fig. 44: Grass types used on Greens, Tees and Fairways on Queensland Golf Courses using Reclaimed Water

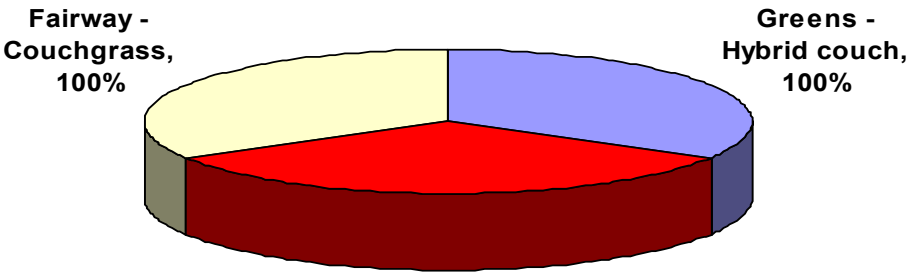
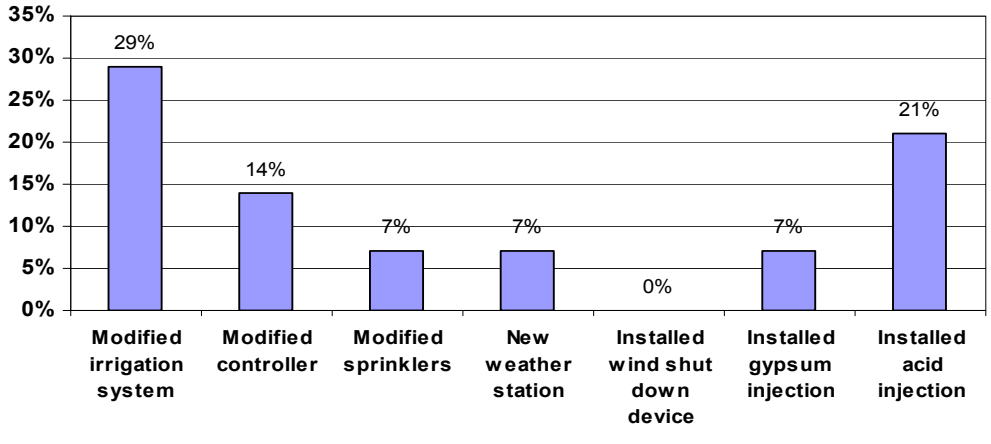


Fig. 45: Modifications made to Irrigation Systems on Queensland Golf Courses using Reclaimed Water



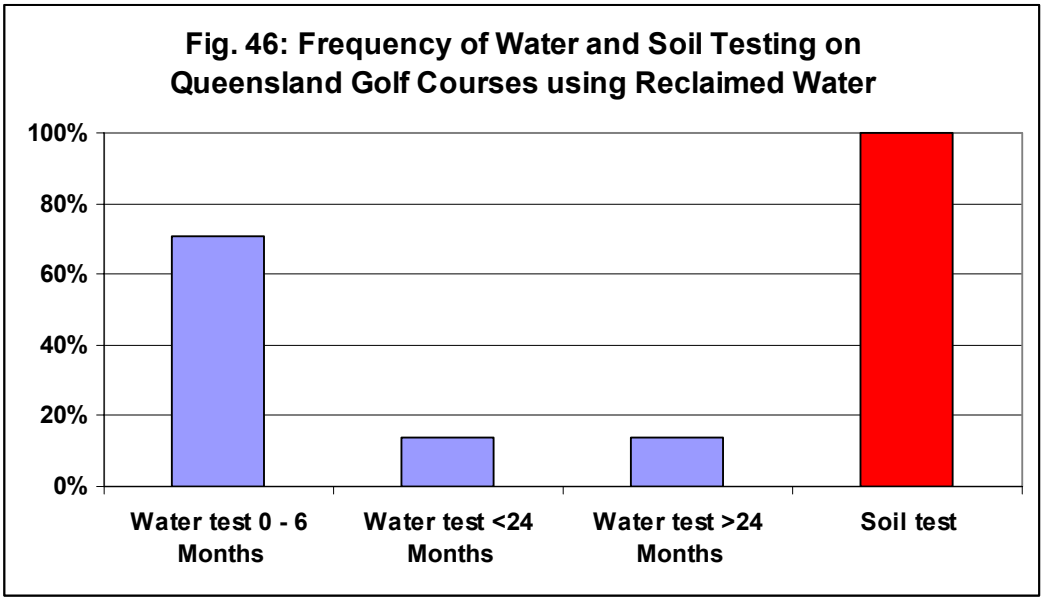


Fig. 46: Frequency of Water and Soil Testing on Queensland Golf Courses using Reclaimed Water
100%
80%
60%
40%
20%
0%
Water test 0 - 6 Months
Water test <24 Months
Water test >24 Months
Soil test

SOUTH AUSTRALIAN STATISTICS

Figures 47 – 60

Fig. 47: Class of Reclaimed Water used to Irrigate South Australian Golf Courses

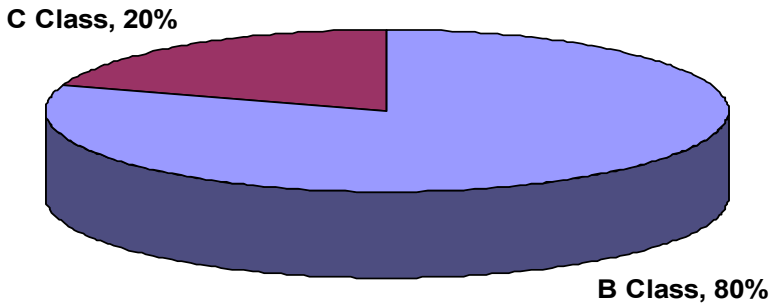


Fig. 48: Water Sources other than Reclaimed water used on South Australian Golf Courses

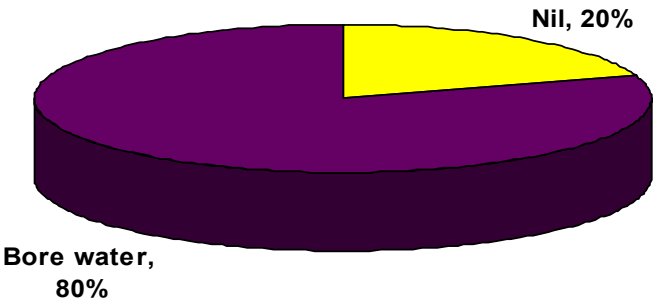


Fig. 49: Proportion of Irrigation Water Provided by Reclaimed Water on South Australian Golf Courses

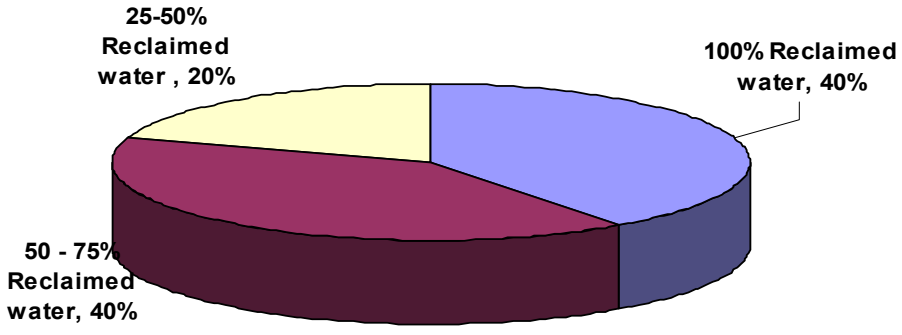


Fig. 50: No. of Years reclaimed Water used on South Australian Golf Courses

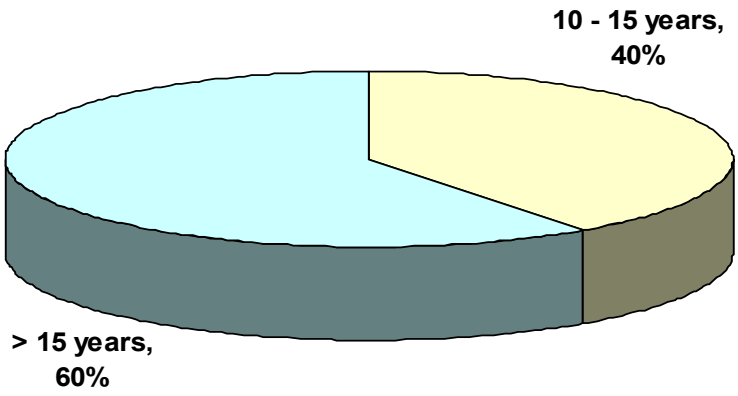


Fig. 51: Authorities Responsible for the Use of Reclaimed Water on South Australian Golf Courses

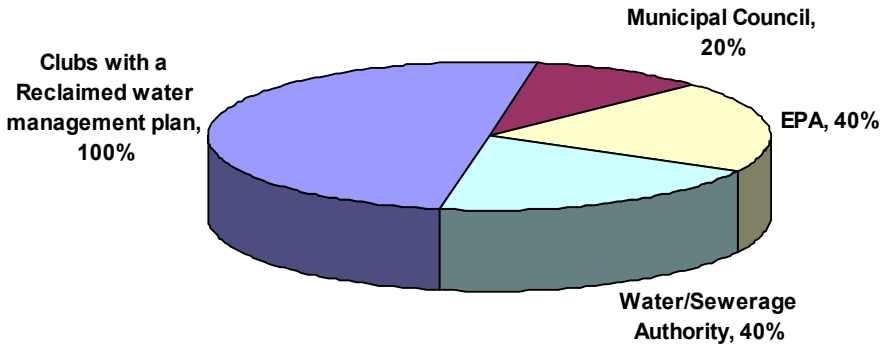


Fig. 52: Audits of South Australian Golf Courses using Reclaimed Water

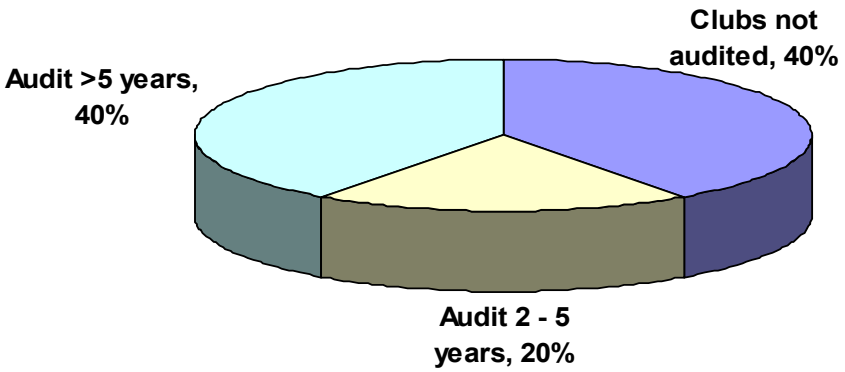


Fig. 53: Salinity (Total Soluble Salts) of Reclaimed Water used on South Australian Golf Courses

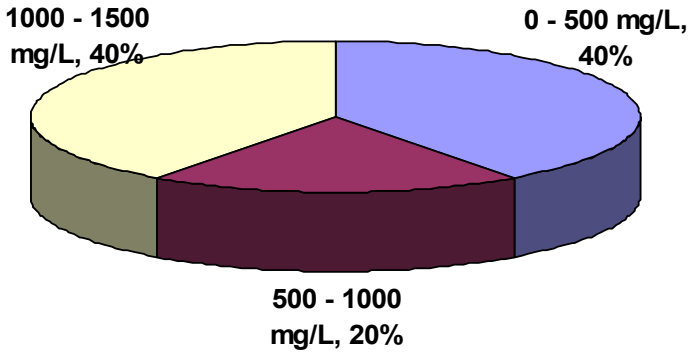


Fig. 54: Chloride Concentrations of Reclaimed Water used on South Australian Golf Courses

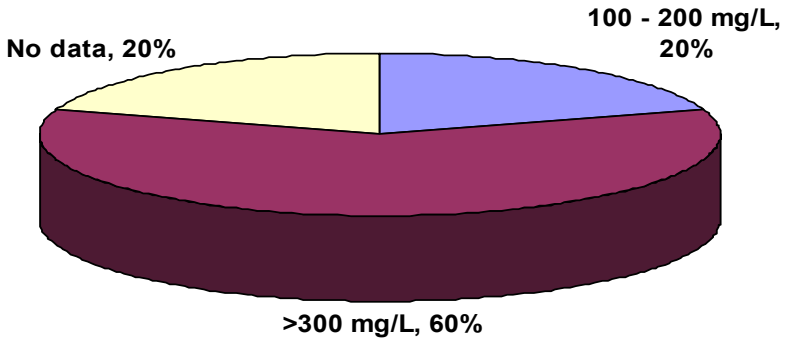


Fig. 55: Total Nitrogen Concentration of Reclaimed Water used on South Australian Golf Courses

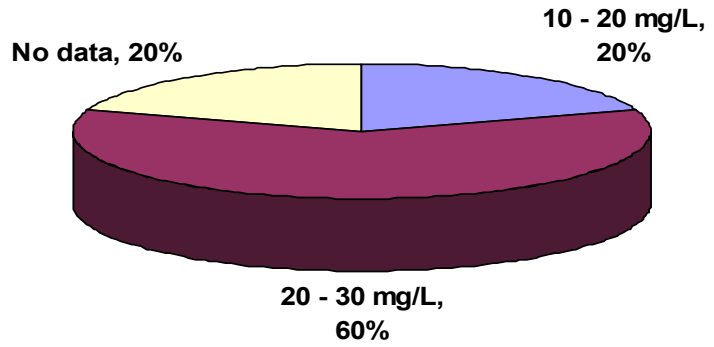


Fig. 56: Total Phosphorus Concentration in Reclaimed Water used on South Australian Golf Courses

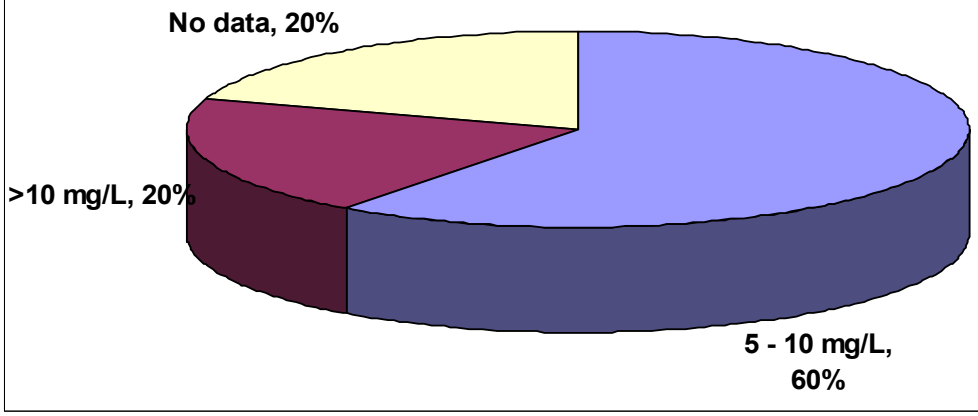


Fig. 57: Sodium Concentration of Reclaimed Water used on South Australian Golf Courses

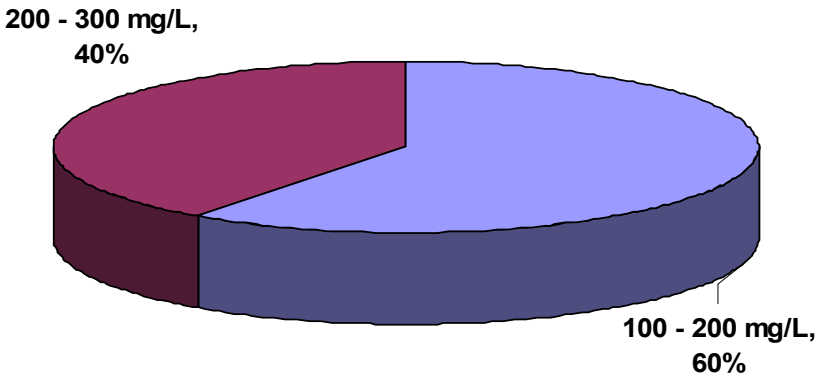


Fig. 58: Sodium Adsorption Ratio of Reclaimed Water used on South Australian Golf Courses

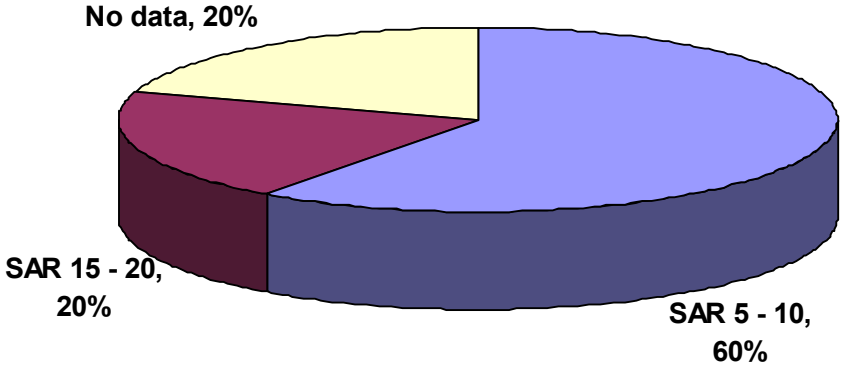


Fig. 59: Predominant Grass Type on Greens, Tees and Fairways on South Australian Golf Courses using Reclaimed Water

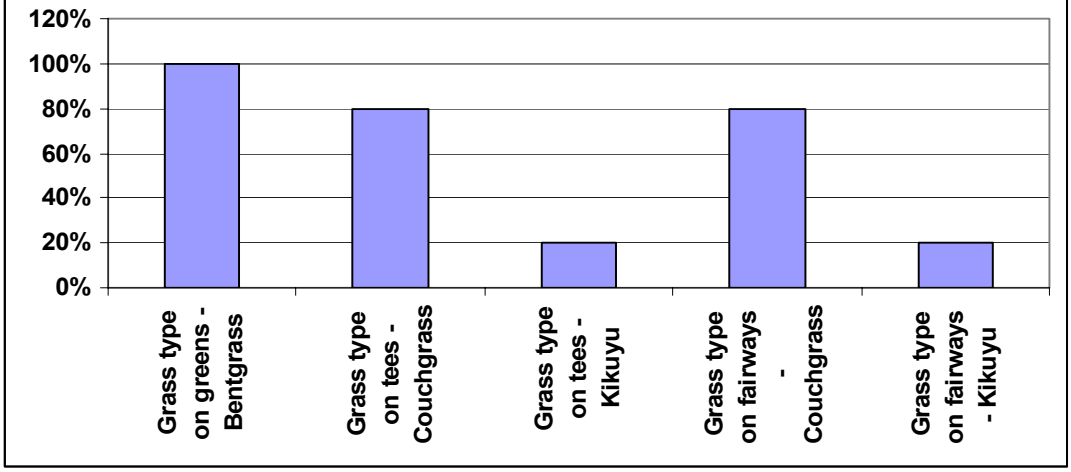
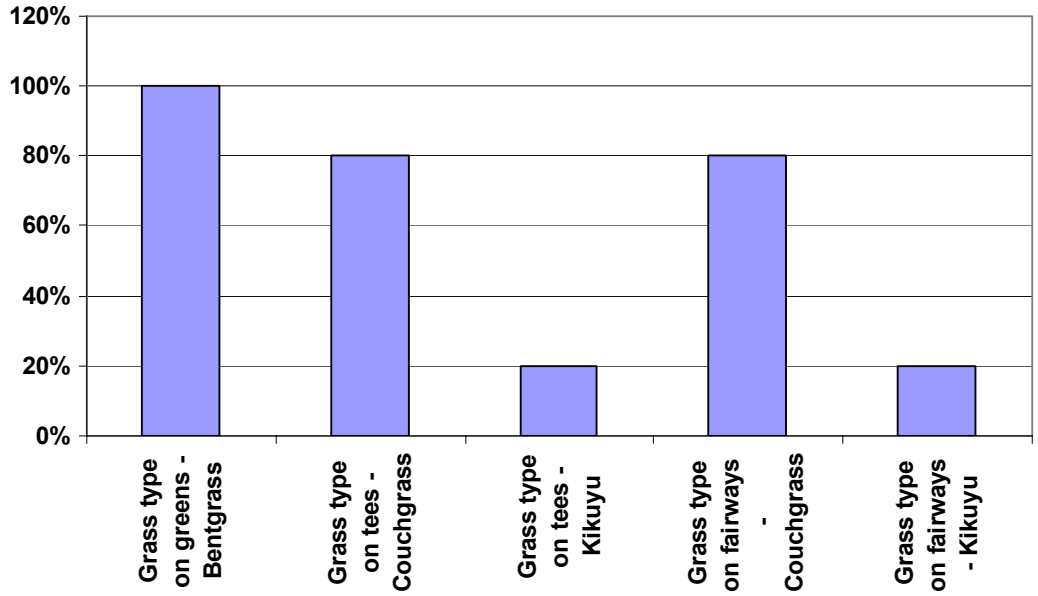


Fig. 60: Predominant Grass Type on Greens, Tees and Fairways on Golf Courses using Reclaimed Water



NEW SOUTH WALES STATISTICS

Figures 61 – 78

Fig. 61: Class of Reclaimed Water Used to Irrigate New South Wales Golf Courses

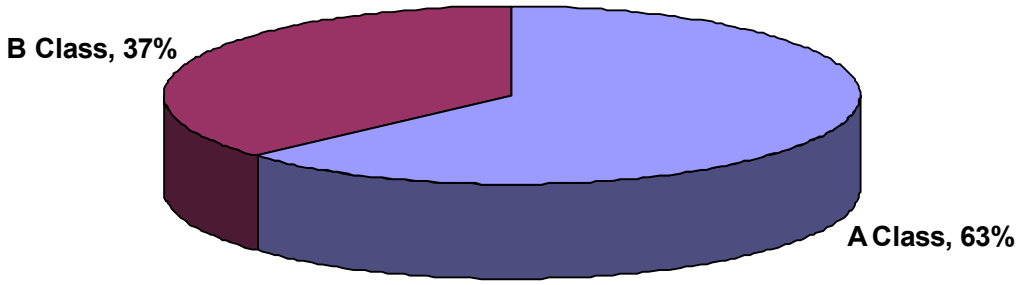


Fig. 62: Water Sources other than Reclaimed Water used for Irrigating New South Wales Golf Courses

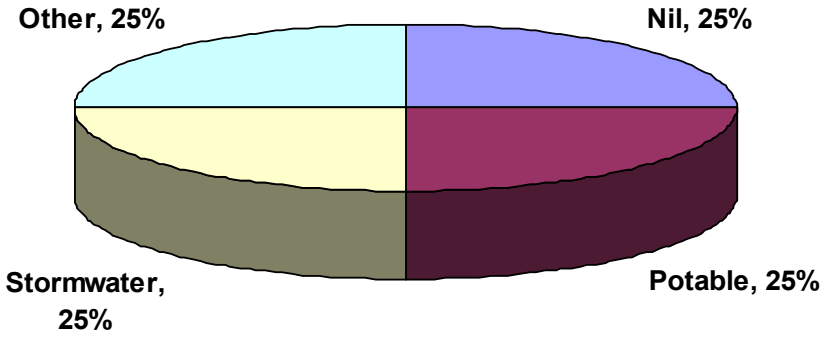


Fig. 63: Proportion of Irrigation Water provided by Reclaimed Water on New South Wales Golf Courses

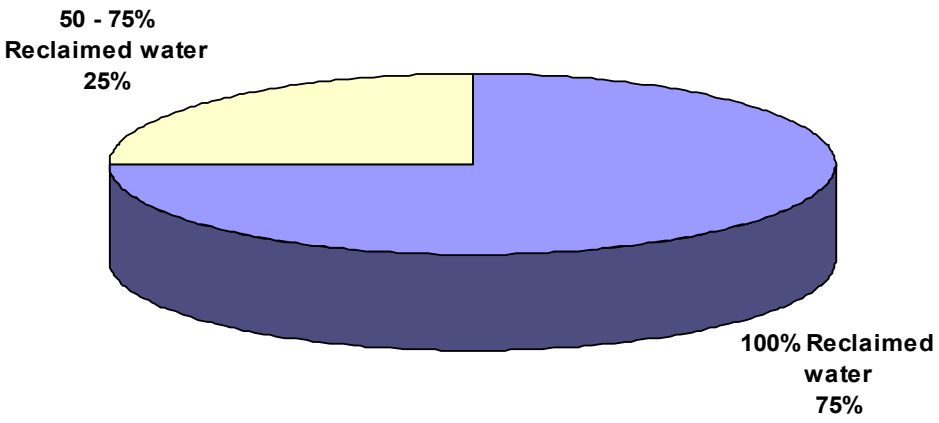


Fig. 64: No. of Years Reclaimed Water used on New South wales Golf Courses

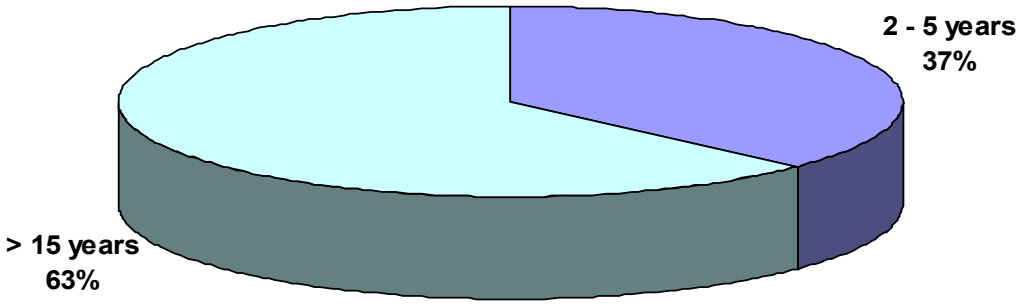


Fig. 65: Authorities Responsible for Regulating the Use of Reclaimed Water on New South Wales Golf Courses

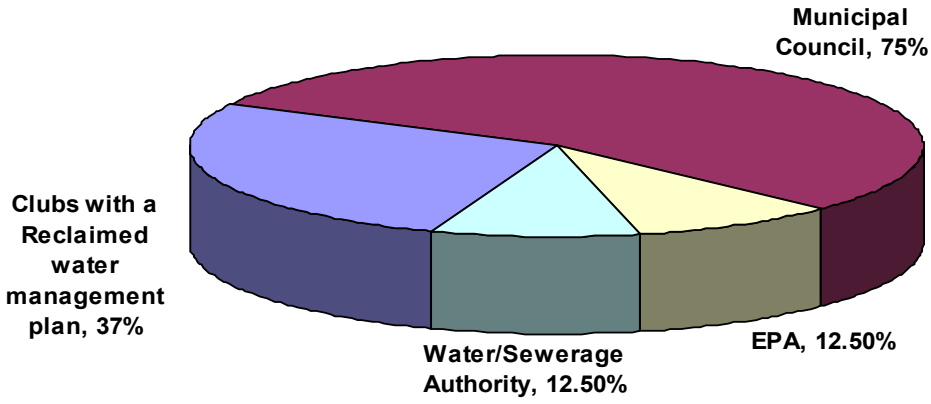


Fig. 66: Audits of New South Wales Golf Courses using Reclaimed Water

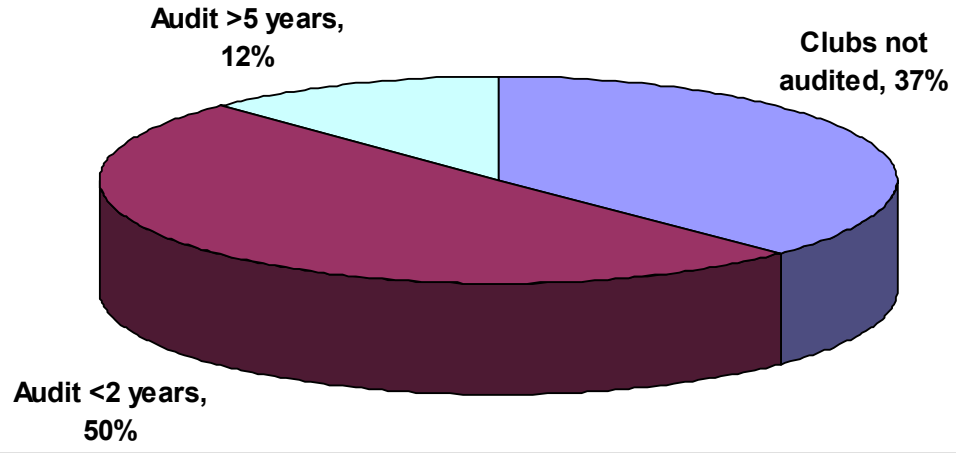


Fig. 67: Salinity (Total Soluble Salts) of Reclaimed Water used on New South Wales Golf Courses

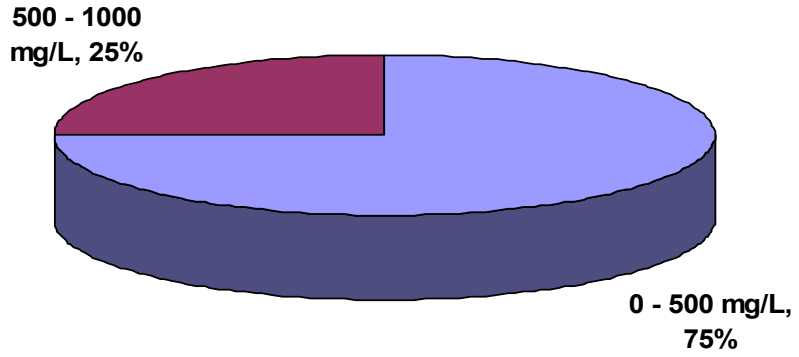


Fig. 68: Chloride Concentration of Reclaimed Water used on New South Wales Golf Courses

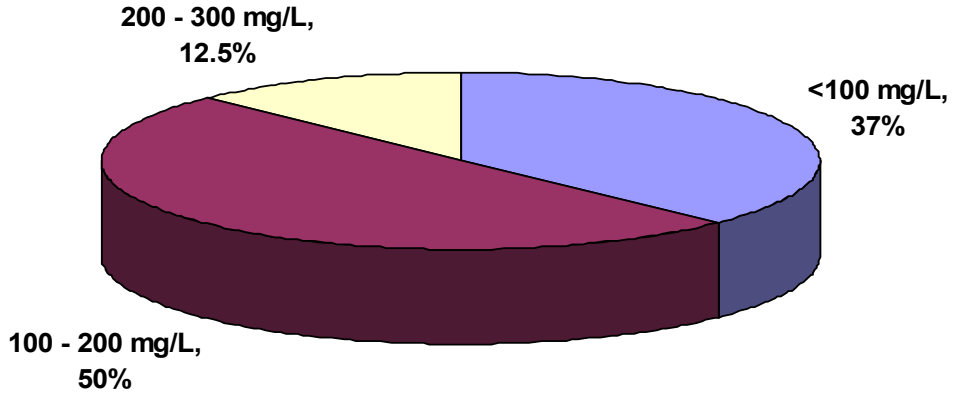


Fig. 69: Total Nitrogen Concentration of Reclaimed Water used on New South Wales Golf Courses

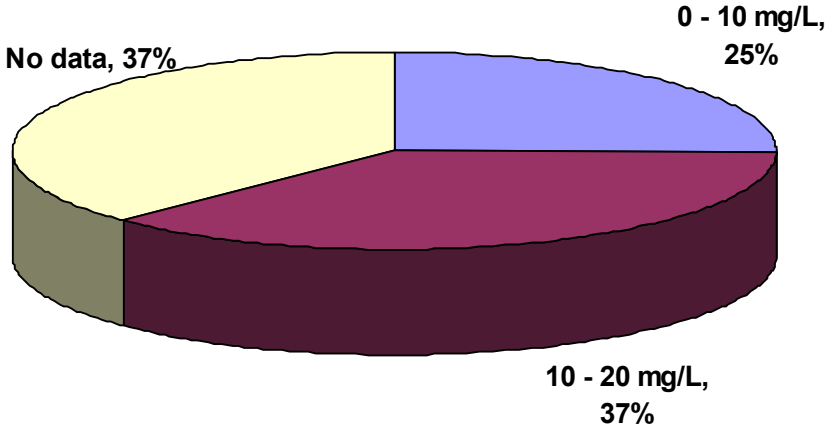


Fig. 70: Total Phosphorus Concentration of Reclaimed Water used on New South Wales Golf Courses

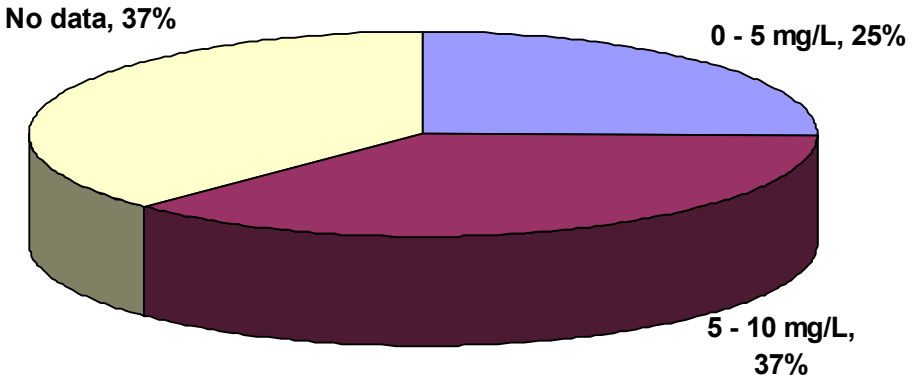


Fig. 71: Sodium Concentration of Reclaimed Water used on New South Wales Golf Courses

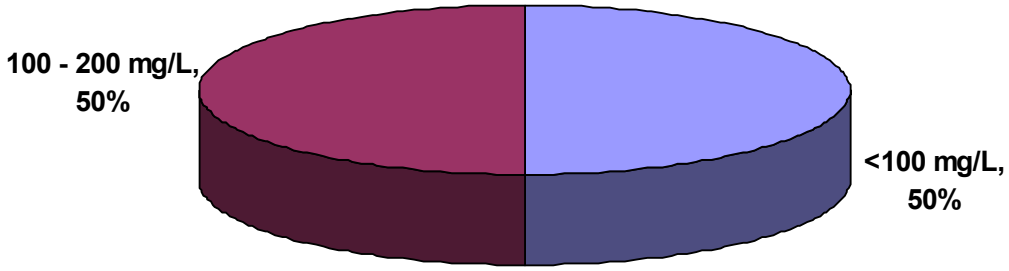


Fig. 72: Sodium Adsorption Ratio of Reclaimed Water used on New South Wales Golf Courses

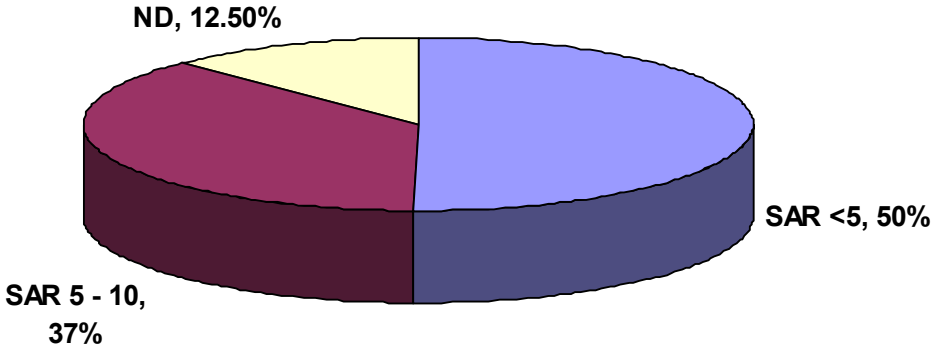


Fig. 73: Areas where Reclaimed Water is used on New South Wales Golf Courses

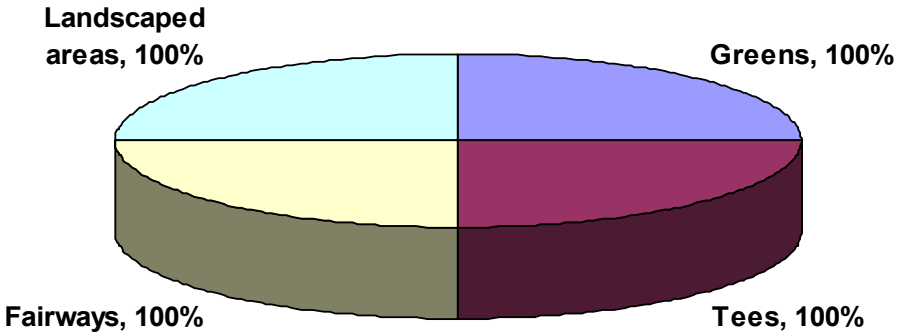


Fig. 74: Grass Types used on Greens on New South Wales Golf Courses using Reclaimed Water

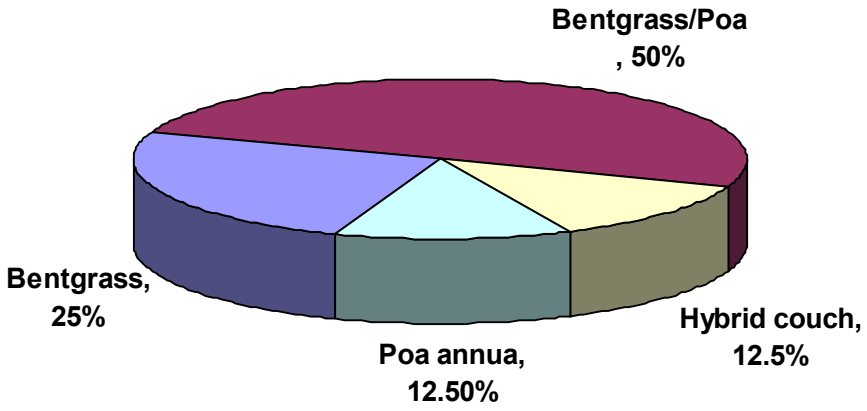


Fig. 75: Grass types used on Tees on New South Wales Golf Courses using Reclaimed Water

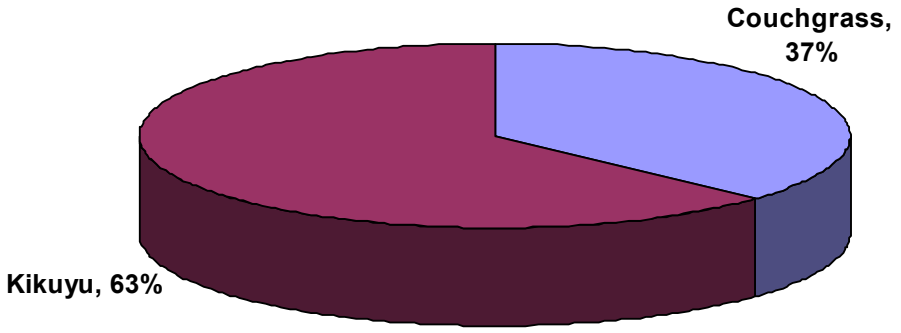


Fig. 76: Grass Types used on Fairways on New South Wales Golf Courses using Reclaimed Water

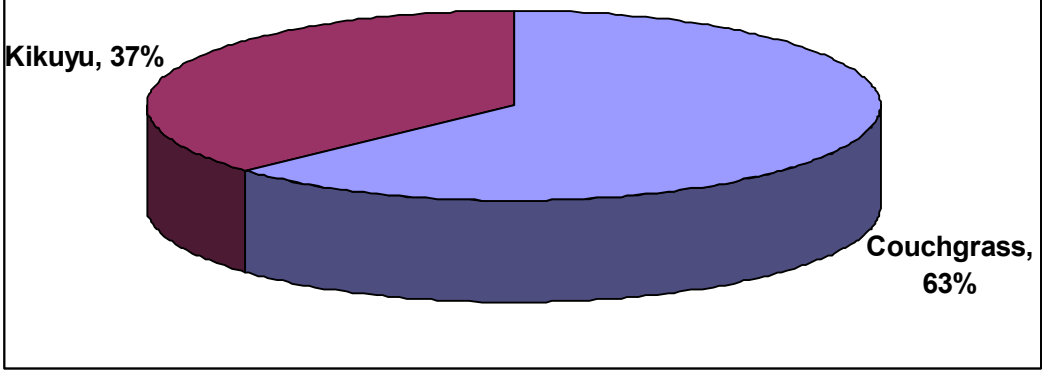


Fig. 77: Modifications made to Irrigation Systems on New South Wales Golf Course using Reclaimed Water

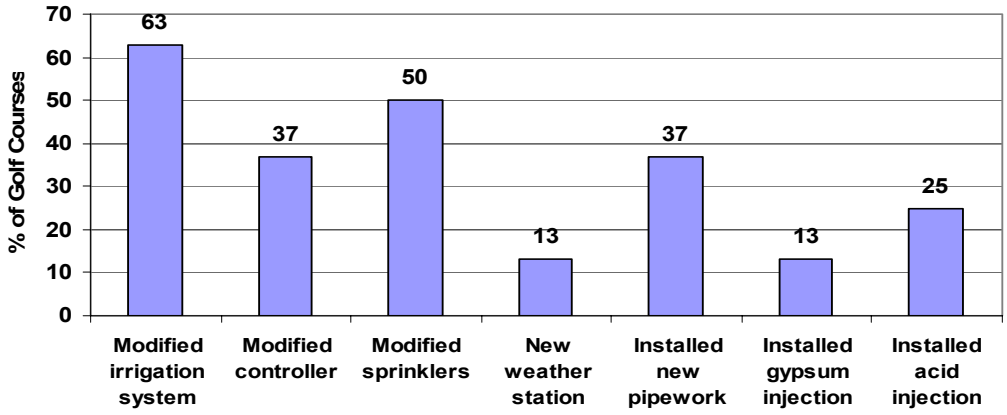
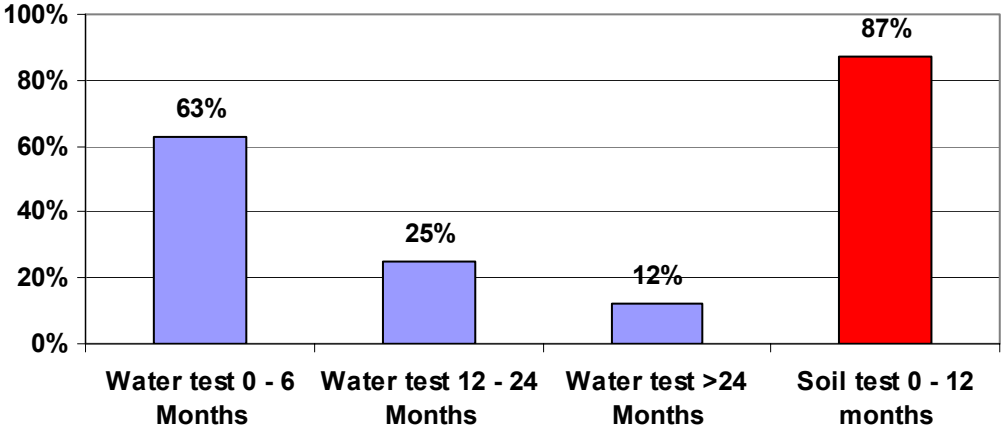


Fig. 78: Frequency of Water and Soil Testing on New South Wales Golf Courses using Reclaimed Water



APPENDIX 1: RECLAIMED WASTEWATER SURVEY FORMAT

RECLAIMED WATER REUSE SURVEY

Over the past three years, the AGCSA, in conjunction with Barwon Heads Golf Club and Horticulture Australia, has undertaken an effluent monitoring project at the Barwon Heads Golf Club on Victoria's Bellarine Peninsula. The project has involved the extensive sampling and analysis of soils and water to assess the impact of effluent on the course, and has raised considerable interest from other golf courses using treated effluent for irrigation.

We have been fortunate to obtain additional funding to extend the project for another sampling period. Part of the additional funding been allocated to undertake a survey of all golf courses using treated effluent to determine water quality, impact on soils and turf condition and any issues associated with the use and monitoring of treated effluent.

The results of the survey will be compiled in a database that can be accessed through the AGCSA web site. There will be a list of golf courses contributing to the project and a compilation and analysis of the data published, however, the **details for individual clubs will be kept confidential**.

The success of this project is dependent on having as many contributors as possible and we would appreciate it if you could take the time to fill in the survey form. If you have any queries please contact John Neylan on 03 9548 8600 or by email on john@agcsa.com.au. The survey can be submitted via the AGCSA web site or faxed to 03 95488600.

The survey can also be filled out via the AGCSA web page at
http://turfshop.com.au/watersurvey.htm

The AGCSA thanks, in advance, those superintendents for their help with this survey.

1. CLUB NAME:_____
2. STATE:_____
3. NAME_____
   _____
   _____
   _____
4. TELEPHONE_____
   _____

5. FAX_____
   _____

6. EMAIL_____

7. CLASS OF RECLAIMED WATER USED:

   A ☐

   B ☐

   C ☐

8. VOLUME OF RECLAIMED WATER USED (ANNUAL USE)_____

9. WHAT IS THE MAIN SOURCE OF THE RECLAIMED WATER?

   MUNICIPAL SEWAGE ☐

   INDUSTRIAL ☐

   ABBORTOIRS ☐

10. WHAT IS THE COST OF THE RECLAIMED WATER?_____

11. DO YOU USE ANY OTHER WATER SOURCES? YES/NO_____

12. IF YES WHAT

    Bore ☐

    Potable (mains) ☐

    Stormwater ☐

13. IF RECLAIMED WATER IS MIXED WITH OTHER WATER SOURCES WHAT PROPORTION OF RECLAIMED WATER IS USED?

    <20% ☐

    25 – 50% ☐

    50 – 75% ☐

    75 – 95% ☐

14. HOW LONG HAS THE RECLAIMED WATER BEEN USED ON THE GOLF COURSE?

    Less than 2 YEARS ☐

    2 –5 YEARS ☐

5 – 10 YEARS ☐

10 – 15 YEARS ☐

Greater than 15 YEARS ☐

15. WHERE IS THE RECLAIMED WATER USED?
GREENS (Y/N)_____

TEES (Y/N)_____

FAIRWAYS (Y/N)_____

LANDSCAPE AREAS (Y/N)_____

16. WHAT IS THE TOTAL AREA IRRIGATED WITH RECLAIMED WATER?_____

17. WHAT GRASS TYPES ARE USED ON THE GOLF COURSE?

GREENS

HYBRID COUCHGRASS ☐

SEASHORE PASPALUM ☐

BENTGRASS ☐

POA ANNUA (WINTERGRASS) ☐

MIX OF BENTGRASS AND POA ANNUA ☐

TEES

COUCHGRASS ☐

KIKUYU ☐

SEASHORE PASPALUM ☐

RYEGRASS ☐

POA ANNUA ☐

BENTGRASS ☐

FINE FESCUE ☐

FAIRWAYS

KIKUYU ☐

SEASHORE PASPALUM ☐

COUCHGRASS ☐

BENTGRASS ☐

RYEGRASS ☐

FINE FESCUE ☐

18. WHAT IS THE PREDOMIINANT SOIL TYPE ON THE GOLF COURSE?

SAND ☐

LOAMY SAND ☐

LOAM ☐

CLAY LOAM ☐

CLAY ☐

19. DO YOU HAVE A RECLAIMED WATER MANAGEMENT PLAN? (Y/N)_____

20. WHO IS THE REGULATORY AUTHORITY THAT CONTROLS THE USE OF RECLAIMED WATER?

ENVIRONMENTAL PROTECTION AUTHORITY ☐

LOCAL MUNICIPAL COUNCIL ☐

WATER/SEWERAGE AUTHORITY ☐

21. HAVE YOU HAD AN AUDIT BY THE REGULATORY AUTHORITY (Y/N)_____

22. IF YES WHEN WAS THE LAST AUDIT;

Less than 2 years ☐

2 – 5 years ☐

Greater than 5 years ☐

23. DID YOU HAVE TO MODIFY OR UPGRADE THE IRRIGATION SYSTEM TO COMPLY WITH THE REUSE OF RECLAIMED WATER REGULATIONS (Y/N)_____

24. IF YES DID YOU;
Install a new controller (Y/N)_____
Change sprinkler types (Y/N)_____
Install a weather station (Y/N)_____
Install wind shut down devices (Y/N)_____
Install new pipe work (Y/N)_____
Gypsum injection (Y/N) _____
Acid injection (Y/N)_____
Other_____

25. HOW OFTEN IS THE RECLAIMED WATER TESTED?

0 – 6 MONTHS ☐

6 – 12 MONTHS ☐

12 – 24 MONTHS ☐

greater than 24 months ☐

26. RECLAIMED WATER QUALITY DATA

Salinity (TDS)

0 – 500 mg/L (ppm) ☐

500 – 1000 mg/L ☐

1000 – 1500 mg/L ☐

greater than1500 mg/L ☐

no data ☐

Sodium

Less than 100 mg/L ☐

100 – 200 mg/L ☐

200 – 300 mg/L ☐

greater than 300 mg/L ☐

no data ☐

Chloride

Less than 100 mg/L ☐

100 – 200 mg/L ☐

200 – 300 mg/L ☐

greater than 300 mg/L ☐

no data ☐

Total phosphorus

0 – 5 mg/L ☐

5 – 10 mg/L ☐

greater than 10 mg/L ☐

no data ☐

Total nitrogen

0 – 10 mg/L ☐

10 – 20 mg/L ☐

20 - 30 mg/L ☐

greater than 30 mg/L ☐

no data ☐

Sodium Adsorption Ratio (SAR)

Less than 5 ☐

5 – 10 ☐

10 – 15 ☐

15 – 20 ☐

greater than 20 ☐

no data ☐

27. ARE THERE ANY PARTICULAR ISSUES THAT RELATE TO THE QUALITY OF THE RECLAIMED WATER (e.g. high salinity, high nutrients etc.). PLEASE DETAIL._____

28. HAS THERE BEEN ANY CHANGES IN THE QUALITY OF THE TREATED EFFLUENT (Y/N)_____

29. IF YES PLEASE DETAIL (e.g. increasing salinity)._____

_____
_____

30. DO YOU UNDERTAKE REGULAR SOIL SAMPLING?
    (Y/N)_____

31. WHAT AREAS DO YOU SAMPLE?
    GREENS (Y/N)_____
    TEES (Y/N)_____
    FAIRWAYS (Y/N)_____

32. HOW OFTEN?

    0 – 6 MONTHS ☐

    6 – 12 MONTHS ☐

    12 – 24 MONTHS ☐

    greater than 24 months ☐

33. WHAT PARAMETERS DO YOU ANALYSE FOR?
    pH (Y/N)_____
    Salinity (Y/N)_____
    Calcium (Y/N) _____
    Sodium (Y/N) _____
    Magnesium (Y/N)_____
    Potassium (Y/N)_____
    Phosphorus (Y/N)_____
    Nitrogen (Y/N)_____
    Trace elements (Y/N)_____

34. HAVE THERE BEEN ANY DELETERIOUS EFFECTS OF THE
    RECLAIMED WATER ON;
    SOILS (e.g. increasing salts or sodium) (Y/N)_____
    TURF (e.g. salt burn) (Y/N)_____

35. IF YES PLEASE DETAIL.

_____
_____
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36. ARE THERE ANY MANAGEMENT STRATEGIES THAT YOU HAVE IMPLEMENTED AS A RESULT OF THE QUALITY OF THE RECLAIMED WATER? (Y/N)_____

37. PLEASE DETAIL_____
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38. CAN YOU PROVIDE A TYPICAL WATER ANALYSIS (Y/N). IF SO PLEASE FAX TO 03 95488622_____

39. CAN YOU PROVIDE A TYPICAL SOIL ANALYSIS (Y/N). IF SO PLEASE FAX TO 03 95488622_____

MANY THANKS FOR YOUR PARTICIPATION.

APPENDIX 2: GOLF CLUBS IDENTIFIED AS USING RECLAIMED WASTEWATER*

Victoria	**New South Wales**	**Queensland**	**Queensland**
13th Beach	Castle Hill CC	Arundel Hills Country Club	Southport GC
Barwon Heads GC	Condobolin GC	Brookwater Golf Club	Surfers Paradise GC
Cape Schank Resort	Coolangatta-Tweed Heads GC	Byron Bay GC	The Glades Golf & Spa
Centenary Park GC	Dunheved GC	Caloundra GC	The Links Port douglas
Chalambar GC	Easts Liesure & GC	Coffs Harbour GC	Townsville GC
Croydon GC	Kiama GC	Coolangatta -Tweed GC	
Edenhope GC	Kooindah Waters	Gailes GC	
Eynesbury	Magenta Shores	Gold Coast Burleigh GC	**Tasmania**
Gisborne	New Brighton GC	Horton Park Golf Club	Pittwater GC
Goonawarra GC	Pambula-Merimbula GC	Hyatt Regency Coolum	Bicheno GC
Growling Frog GC	Richmond GC	Indooroopilly Golf Club	Exetar GC
Horsham GC	South West Rocks CC	Lakelands Golf Club	North West Bay GC
Long Island CC	St. Georges Basin CC	Mt Coolum Golf Club	
Melton Valley	Yamba GC	Mt. Isa	**Western Australia**
Patterson River CC		North Lakes GC	Busselton GC
Peninsula CGC	**South Australia**	Novotel Twin Waters Resort	Manjimup GC
Rosebud CC	Adelaide Shores GC	Ocean Shores CC	Broome GC
Sandhurst GC	Clare GC	Pacific Golf Club	Port Hedland GC
St. Andrews Beach	Glenelg GC	Pacific Golf Operations	
Stawell GC	Kooyonga GC	Pacific Harbour Golf and Country Club	
The Sands Torquay	Victor Harbour GC	Parkwood International Golf Course	
Warracknabeal GC	Willunga GC	Redland Bay Golf Club	
Warrnambool GC		Royal Pines Resort	
Werribee Park Golf Club		Royal Queensland Golf Club	
Woodend		Sanctuary Cove Resort	

**** The clubs listed have been compiled from various sources and while every effort has been made to confirm that they use reclaimed wastewater no warranty is provided on the accuracy of the information.***