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Negotiating Reclaimed Water Contracts: Agronomic Considerations

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Bottom line: With increasing pressures to use reclaimed water on golf courses, superintendents are faced with a new series of economic and agronomic challenges, the first of which is to deal with the overly optimistic picture of reclaimed water quality and value that suppliers have painted. Because reclaimed water frequently (though not always) is of lower quality than traditional water sources, turf quality can be seriously compromised unless aggressive leaching programs, improved irrigation systems, modified soil amendment and cultural programs, and the flexibility to replace salt sensitive turf varieties are taken into account. Even if all of these changes are incorporated, turf quality will still suffer unless the supplier can guarantee delivery of a prescribed quality and volume of reclaimed water. Golf courses that rely on reclaimed water have successfully dealt with the majority of these problems by instituting soil monitoring programs and cultural practices that optimize turf health under low quality water irrigation conditions. In the future, negotiation of strong contracts with suppliers may further reduce the potential hazards of using reclaimed water.

Figure 1. Salt-affected kikuyugrass fairway showing severe turf damage as a result of the use of reclaimed water. This fairway was later converted to a more salt tolerant paspalum variety, and is now thriving.

Water is a limited resource that is in increasing demand as populations, and particularly urban populations, continue to grow. The use of reclaimed (effluent) water on golf courses is a logical response to conserving water, but one that should be appreciated for the increased financial and agronomic demands that it can make on turf management operations. In this issue of *PACE Insights,* we will illustrate the types of problems that reclaimed can cause if adequate preparations are not made, and will provide pointers for successfully dealing with the use of reclaimed water on golf courses.

Dissolved salts: the source of the problem

All irrigation water contains dissolved salts (such as calcium, sodium, sulfates, chloride, magnesium, potassium, bicarbonates) whose presence can be beneficial to turf when they are present at low enough concentrations. However, if irrigation water contains high concentrations of dissolved salts, excessive levels can build up in the soil –enough to actually kill turf plants through salt toxicity or by robbing the plant of water.

In most cases, reclaimed water is of lower quality than the domestic water source from which it originates. This is because the reclamation process is not able to remove all of the salts and other materials that are added to the water in it first use by the community. For this reason, there is usually about a 10% increase in total dissolved salts (Pettygrove and Asano, 1984) in reclaimed water, vs. the original domestic water source. The impact of reclaimed water on a golf course, however, can only be evaluated by comparing the reclaimed water to the irrigation water that it will replace. For example, golf courses that use low quality well water may actually see an improvement in turf health if the reclaimed water is of slightly higher quality (see Table 4). In most cases, though, reclaimed water has lower quality than current domestic water sources. Tables 1 and 2 illustrate the dramatic differences that occur among different reclaimed water sources, and the types of problems that are most frequently encountered.

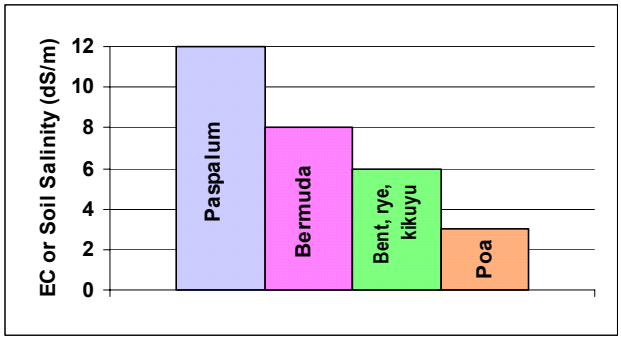
Table 1. Comparison of reclaimed water sources used for golf course irrigation in Southern California. Red shading indicates that the reclaimed water exceeds the recommended guidelines in Table 3. Yellow indicates the value is within 10% of guidelines and green shading indicates that the value falls within recommended guidelines.

Factor	Average Domestic	Big Canyon	Dove Canyon	Laguna Woods	Bear Creek	El Niguel	Oakmont
EC (dS/m)	**0.8**	**1.6**	**1.0**	**1.2**	**1.0**	**1.6**	**1.1**
SAR	**1.9**	**5.3**	**2.8**	**3.6**	**4.6**	**3.7**	**3.4**
SARadj	**3.4**	**11.2**	**5.3**	**6.1**	**7.5**	**6.6**	**6.12**
HCO3 (ppm)	**173.8**	**243**	**134**	**125**	**156**	**134**	**203**
B (ppm)	**0.17**	**0.52**	**0.26**	**0.41**	**0.62**	**0.42**	**0.64**
Cl (ppm)	**81.7**	**244**	**122**	**228**	**158**	**211**	**106**
Na (ppm)	**70.0**	**194**	**112**	**151**	**147**	**168**	**115**

Dealing with soil salts: the role of turf variety

Figure 2. Despite implementation of improved management practices, reclaimed water led to the severely damaged bentgrass fairway seen below. The bentgrass was eventually replaced with more salt tolerant bermudagrass as a means of dealing with this problem.

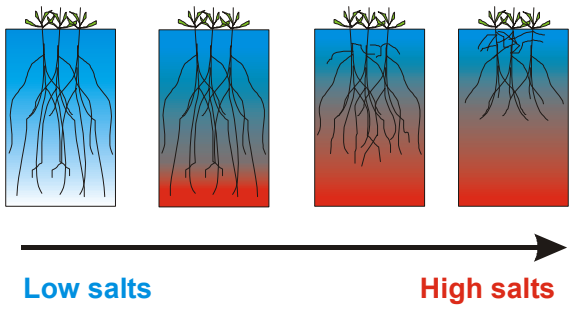
Figure 3. Different turf types differ markedly in their ability to tolerate soil salts, as illustrated in the graph below. Adapted from Harivandi et. al., 1992.



In some cases, the only way that golf courses can deal with the impact of reclaimed water is to switch to salt tolerant turf varieties such as bermudagrass or paspalum, as illustrated in Figures 1 and 2.

Hidden cost number 1: the need for leaching

The increasing accumulation of soil salts (illustrated by the increasing red areas below) that results over time from use of low quality reclaimed water, will result in shorter roots and unhealthy plants unless leaching programs are implemented.



A leaching fraction is the amount of water that must be applied during irrigation to maintain soil salts below levels that are damaging to the plant. To calculate the leaching fraction, you need to know the EC (electrical conductivity) of your irrigation water and the EC that is tolerated by the turf type that you are managing.

$$\text{Leaching fraction} = \frac{\text{EC of irrigation water}}{\text{EC tolerated by turf}}$$

For example, if your irrigation water has an EC of 1 dS/m (= 1mmho/cm or approximately 640 ppm total dissolved salts) and your turf type is poa (which, according to Figure 3, can't tolerate more than 3 dS/m), then your leaching fraction is 1/3 = 0.33. This means that you will need to apply 33% more water than is needed to saturate the root zone. Another way of saying this is that if you are irrigating for 10 minutes to replace the water lost by evapotranspiration and to saturate the root zone, you will need to add another 3.3 minutes of irrigation (for a total of 13.3 minutes) to prevent accumulation of salts to plant damaging levels.

To estimate the increase in water use that reclaimed water will produce for you, compare the leaching fraction for the water you are currently using vs. the leaching fraction that you will need with reclaimed water.

Hidden cost number 2: the need for improved monitoring and cultural practices

Leaching alone will not solve all salt-related problems if drainage, soil quality and irrigation distribution are not perfect. To increase the effectiveness of leaching programs, and to help you keep on top of salt related problems, the program outlined below is recommended. Implementation of this program will cost money and time, but the savings it will produce in terms of turf protection is well worth it.

Monitoring and Cultural Practices Guidelines

- Implement an annual aerial photography program to aid in identification and correction of salt accumulation in turf "hot spots" and declining trees.
- Initiate annual soil sampling and analysis program to identify soil chemistry problems before they become serious.
- Monitor soil salinity using a TDS-4 meter (or equivalent). Apply a leaching irrigation to prevent accumulation of salts to levels above the tolerance of your turf variety (see Figure 3).
- Based upon soil testing results, apply amendments to compensate for accumulation of sodium or for elemental deficits that may occur during leaching.
- Aerate fairways at least twice annually using a deep tine (to a 9-inch depth, if possible). Apply amendments in conjunction with aeration.
- Tree foliage may need to be trimmed to prevent contact with irrigation spray.

Table 2. Comparison of domestic and reclaimed water. The desired range is a compilation from values published in the scientific literature and experience at PACE Consulting. The average domestic and reclaimed values were compiled from the PACE soil and water database for golf courses. Note that the most common problems with reclaimed water are due to excesses in bicarbonates, chloride and sulfate. High sodium and boron are also common problems.

Parameter	Desired range	Average Domestic	Average Reclaimed
Electrical Conductivity EC (dS/m)	< 1.2	0.8	1.1
Sodium Absorption Ratio SAR	< 6.0	1.9	3.1
Adjusted SAR	<11	3.4	5.7
Bicarbonate HCO3 (ppm)	<90 (1.5 meq/l)	**173.8**	**194.4**
Boron B (ppm)	<0.50	0.17	0.44
Chloride Cl (ppm)	<100 (2.8 meq/l)	81.7	**129.6**
Sodium Na (ppm)	<160 (7 meq/l)	70.0	114.2
pH	6.5 - 8.4	7.7	7.1
Total Dissolved Salts TDS (ppm)	<768	616.7	729.2
Calcium Ca (ppm)	<100 (5.0 meq/l)	67.3	63.9
Magnesium Mg (ppm)	<40 (3.0 meq/l)	24.4	22.9
Potassium K (ppm)	<160 (4.1 meq/l)	3.9	25.5
Carbonate CO3 (ppm)	<50	2.7	0.0
Sulfate SO4 (ppm)	<200 (4.2 meq/l)	171.3	**196.0**
Iron Fe (ppm)	<0.30	0.16	0.20
Manganese Mn (ppm)	<0.15	0.01	0.03
Copper Cu (ppm)	<0.05	0.04	0.03
Zinc Zn (ppm)	<2.00	0.12	0.08

Hidden cost number 3: the need for improved irrigation distribution

While leaching programs can be very effective in reducing salt damage, they also highlight irrigation distribution problems and soil drainage problems. Frequently, more wet spots and/or bare areas occur as a result. To alleviate these problems, the following guidelines are suggested.

Water Management Guidelines:

- Avoid the use of reclaimed water on cool season turfgrass greens.
- Implement a periodic irrigation distribution monitoring program to insure that optimum distribution (greater than 75% distribution uniformity) is maintained.
- Install a water flow meter on one fairway to enable accurate calculation of leaching fractions. Consider installation of an in-line EC meter to monitor fluctations in water quality.
- Become even more picky about irrigation system maintenance, including replacement of worn or poorly selected sprinklers, dealing with pressure fluctuations, misaligned heads and sunken or broken sprinkler heads.
- Implement a leaching fraction for all areas where reclaimed water is used.
- Require that the water district provide access to daily, weekly and monthly summary values for water quality indicators. Of particular interest is electrical conductivity, sodium, chloride and boron levels. Independent water testing may be conducted by the golf course for more complete periodic evaluations.

Hidden cost number 4: reduced playability

Despite all of the efforts outlined above, some reduction in golf course playability due to salt related turf and tree damage may result. In addition, development of wet areas due to leaching programs may be difficult to avoid. Communicating with golfers so that their expectations for high quality turf are adjusted is critical.

Hidden cost number 5: possible turf variety changes

If, after several years of efforts, the above management programs do not provide effective salinity management for the soil-turfgrass system at your golf course, it may be necessary to switch turfgrasses to more salt tolerant types such as bermudagrass or paspalum.

Some pointers on contracts

- The price of reclaimed water should be keyed to current water prices and also water quality factors. Expect a 15-20% cost per unit reduction compared to domestic water.
- Define maximum acceptable quality limits. If water quality limits are exceeded, the contract may be voided by the golf course without penalty to the golf course. The values in Table 3 can be used as rough guidelines, but should be tailored to meet your unique conditions.
- Define delivery guarantees: including access to the pump area to allow restarts and guaranteed pump repair times.
- Include costs of fairway cultivation and amendment program that you will need to initiate to prevent soil damage from long term use of reclaimed water.
- Include costs of monitoring equipment (such as in-line EC and flow meters).
- Include the costs of soil testing and management consultations
- Estimate a 5 – 10% increase in water use to compensate for leaching fraction increases.

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Table 3. Recommended maximum limits for reclaimed water negotiation for use on sand based bermudagrass fairways. These limits do not insure that the water may be used in a sustainable fashion for turfgrass irrigation. They only prevent the reclaimed water quality from exceeding reasonable guidelines and reduce the hidden costs of using reclaimed water. Reclaimed water with quality factors falling within these guidelines may not provide a high quality golfing experience.

	Average Domestic	Average Reclaimed	Recommended Maximum
EC (dS/m)	0.8	1.1	**1.5**
SAR	1.9	3.1	**5.7**
SARadj	3.4	5.7	**11.6**
HCO3 (ppm)	173.8	194.4	**250.0**
B (ppm)	0.17	0.44	**0.50**
Cl (ppm)	81.7	129.6	**250.0**
Na (ppm)	70.0	114.2	**200.0**

Reclaimed water: is it all bad?

As mentioned above, the quality of reclaimed water is in the eye of the beholder, and may actually be a benefit in some situations, as illustrated in Table 4. The value of reclaimed water must be judged on a case-by-case basis.

Table 4. Comparison of well water sources used at several golf courses in Southern California. Note that in several cases (Fairbanks Ranch, Vista Valley, and San Diego) well water quality is inferior to reclaimed water quality values reported in Tables 1 and 2. These courses would benefit from use of higher quality reclaimed water.

Factor	Average Domestic	Fairbanks Ranch	Vista Valley	San Diego	Arrowhead	Friendly Hills	Oakmont
EC (dS/m)	0.8	2.8	2.8	4.0	0.5	0.7	0.9
SAR	1.9	3.2	2.8	5.2	0.8	1.2	1.6
SARadj	3.4	8.2	6.7	13.3	1.4	2.4	3.1
HCO3 (ppm)	173.8	366.1	389.5	363.9	189.5	244.1	185.4
B (ppm)	0.17	0.05	0.21	0.41	0.15	0.13	0.13
Cl (ppm)	81.7	322.7	609.3	1004.2	9.8	59.6	73.2
Na (ppm)	70.0	195.0	194.8	406.5	24.6	44.4	65.3