4 **Water with high bicarbonate makes for a sodic soil.**

Water report	*Soil salinity report*	*Texture report*
Total Salts	416 mg/L, Good	TSS	1530 mg/L, Normal	22% Sand
SAR	3.2, Fair	SAR	**13**, Sodic	40% Silt
HCO_3	305 mg/L; Adj SAR **4.2**, Poor	Boron	0.15 mg/L, No Concern	**38%** Clay
Boron	0.06 mg/L, No Concern			

This irrigation water is classified as **Poor** because of the high Adj SAR of **4.2**; this Adj SAR poses a potential, long-term soil problem where calcium is removed from the soil.
This soil is classified as **Sodic** with an SAR of 13 because of the high Adj SAR in the water.
This soil is classified as a **Clay Loam** with low permeability.

Plant symptoms. Brown areas, similar to drought stress; soil water fails to drain.
Management strategy. Aerify soil and sand topdress; apply 10 pounds pelletized gypsum/1,000 sq. ft. and repeat in 30 days. Leach regularly with best available water. Investigate the possibility of acidifying this water because of the bicarbonates, but consult with a water quality specialist.

5 **Water with high boron makes for a soil with high boron.**

Water report	*Soil salinity report*	*Texture report*
Total Salts	756 mg/L, Good	TSS	1,260 mg/L, Normal	40% Sand
SAR	0.7, Excellent	SAR	0.9, Normal	40% Silt
HCO_3	0.0 mg/L; No Adj SAR	Boron	**3.50 mg/L**, Concern for Sensitive Plant	20% Clay
Boron	**1.93 mg/L**, Concern			

This irrigation water is classified as **Good** because of the low total salts, but the high boron makes it potentially harmful to sensitive plants such as Kentucky bluegrass and ornamentals.
This soil is classified as **Normal** because of the TSS and SAR, but boron in this soil can be a problem; most turf can tolerate relatively high concentrations of boron, but ornamentals such as trees cannot.
This soil is classified as a **Loam** with moderate permeability.

Plant symptoms. Burnt leaf tips; however, frequent mowing removes the problem.
Management strategy. Do not use this water on ornamental trees and cool season grasses; consult a water quality specialist if necessary.

6 **Water from very heavy rainfall makes for unexpected results.**

Water report	*Soil salinity report*	*Texture report*
Total Salts	0 mg/L, Excellent	TSS	95 mg/L, Normal	93% Sand
SAR	0.0, Excellent	SAR	0.1, Normal	4% Silt
HCO_3	0.0 mg/L; No Adj SAR	Boron	0.00 mg/L, No Concern	3% Clay
Boron	0.00 mg/L, No Concern			

This rainfall water is classified as **Excellent** because of the very low total salts and the very low SAR, but the very low salts may be too much of a good thing in sandy soils.
This soil is classified as **Normal**, but very heavy rainfall leaches minerals and nutrients.
This soil is classified as a **Sand** with very high permeability.

Plant symptoms. Yellowing from nutrient deficiencies.
Management strategy. Test soil for nutrient deficiencies; apply 1 lb N/1,000 sq. ft. per month during the growing season; monitor turf.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 20 cents per copy. 0216 GH

Turf Irrigation Water Quality: A Concise Guide

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Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

This Fact Sheet helps turf managers assess their irrigation water by using four key water properties that are listed on water reports and four key soil properties listed on soil salinity and texture reports. The second half of this Fact Sheet provides six illustrative case-studies for bermudagrass lawns to model site-specific irrigation strategies.

Four Key Irrigation Water Properties

Total salts is typically reported in units of milligrams per liter (mg/L) as TDS (total dissolved solids) or TSS (total soluble salts); for all practical purposes, TDS and TSS are interchangeable terms. However, TDS and TSS are often indirectly measured as EC (electrical conductivity) multiplied by 0.64. While EC is the historical method of classifying irrigation water, total salts makes more intuitive sense; either can be used (Table 1).

The **SAR** (sodium adsorption ratio) is used for determining the ratio of sodium to calcium and magnesium in soils. This relationship is important because sodium strips calcium from soil particles and prevents soil aggregates from forming and creating flow paths in the soil. Although SAR is typically a soil parameter, it can also be used to classify irrigation water (Table 2) because that water will eventually determine the salt chemistry of the soil. The SAR is unitless because it is a ratio.

The **Adj SAR** (adjusted sodium adsorption ratio) is another parameter typically used for soils. It adjusts for lost calcium in the form of calcium carbonate deposits. This calcium loss essentially increases the SAR of irrigation water and decreases the soil's ability to form soil aggregates. Use Adj SAR when it exceeds the unadjusted ratio. The regular classification system for SAR (Table 2) is still used after the adjustment.

The SAR and total salts together help predict water infiltration rates. Infiltration rates are improved by high total salts, but high salts may damage turfgrass. Therefore, water with high salts can be helpful (Figure 1, page 2) and harmful (Table 1) simultaneously.

Boron is a nutrient, but in high concentrations is toxic to plants. In addition, boron is difficult to leach from the soil. It requires about three times the water to leach boron from the soil as it does salts. Water containing less than 1.0 mg/L boron should be of no concern for most plant materials, while water with more than 2.0 mg/L boron is unsuitable for irrigation use.

Table 2. Classification of irrigation water based on SAR.

SAR	*Classification*	*Management*
< 1	Excellent	None
1–2	Good	Little concern; add pelletized gypsum periodically
2–4	Fair	Aerify soil, sand topdress, apply pelletized gypsum, monitor soils
4–8	Poor	Aerify soil, sand topdress, apply pelletized gypsum, monitor soils closely, leach regularly
8–15	Very Poor	Requires special attention; consult water specialist
> 15	Unacceptable	Do not use

Table 1. Classification of irrigation water based on total salts (mg/L or ppm) and EC (µS/cm or µmhos).

Total Salts	*EC*	*Classification*	*Management*
< 320	< 500	Excellent	None
320–960	500–1,500	Good	Little concern, especially with periodic rainfall
960–1,920	1,500–3,000	Fair	Leach salts from soil as needed
1,920–3,200	3,000–5,000	Poor	Routinely leach; monitor soils
3,200–3,840	5,000–6,000	Very Poor	Requires special attention; consult water specialist
> 3,840	> 6,000	Unacceptable	Do not use

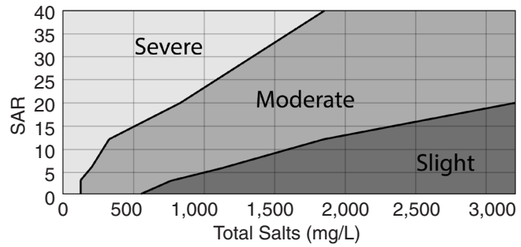

Figure 1. Total salts and SAR are used together to predict the effect of irrigation water on infiltration hazard. (Adapted from Harivandi, 1999).

Table 3. Classification of soil extracts based on TSS (mg/L or ppm) and EC (µS/cm or µmhos).

TSS	*EC*	*Classification*	*Management*
< 2,560	< 4,000	Normal	None
2,560–5,120	4,000–8,000	Above Normal	Little concern, especially with periodic leaching
> 5,120	> 8,000	Saline	Leach regularly with best available water

Four Key Soil Properties

The **TSS** (total soluble salts) in soil is similar to that in water; the difference is that the classification limits are higher (Table 3).

ESP (exchangeable sodium percent) is the percent of soil exchange sites occupied by sodium. Few laboratories actually measure this relationship; instead, they calculate ESP from SAR. Since the relationship between calculated ESP and SAR are proportional, either parameter can be used to classify sodium in soil (Table 4).

Boron in soil can be toxic to plants, depending on boron concentrations and plant sensitivity. Ornamental trees and shrubs are sensitive at levels above 0.5 mg/L boron. At boron levels above 2.0 mg/L, Kentucky bluegrass is sensitive. Most other turfgrass are not sensitive until the levels are above 6.0 mg/L.

Soil texture is the percent sand, silt, and clay in the soil. Soils with high clay content have very low permeability rates. The permeability rates for sandy soils are very high. Texture analysis can be performed by turf professionals using texture-by-feel or by soil laboratories.

Table 4. Classification of irrigation water based on ESP and SAR.

SAR	*ESP*	*Classification*	*Management*
< 12	< 15	Normal	None
≥ 12	≥ 15	Sodic	Aerify soil, sand topdress, apply pelletized gypsum, leach regularly with best available water

Further Reading

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Six Illustrative Case Studies for Bermudagrass Lawns

1 Water with high total salts makes for a saline soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts	**2,700 mg/L**, Poor	TSS	**6,000 mg/L**, Saline	35% Sand
SAR	1.5, Good	SAR	2.2, Normal	30% Silt
HCO_3	0.0 mg/L; No Adj SAR	Boron	0.03 mg/L, No Concern	**35%** Clay
Boron	0.05 mg/L, No Concern		

This irrigation water is classified as **Poor** because of the high total salts.
This soil is classified as **Saline** because of the high TSS.
This soil is classified as a **Clay Loam** with low permeability.

Plant symptoms. Brown areas, similar to drought stress.
Management strategy. Regularly use excess irrigation water to leach salts from the soil. Use best available water.

2 Water with high sodium makes for a sodic soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts	1,320 mg/L, Fair	TSS	2,000 mg/L, Normal	35% Sand
SAR	**7.0**, Poor	SAR	**16**, Sodic	20% Silt
HCO_3	0.0 mg/L; No Adj SAR	Boron	0.45 mg/L, No Concern	**45%** Clay
Boron	0.12 mg/L, No Concern		

This irrigation water is classified as **Poor** because of the high SAR.
This soil is classified as **Sodic** because of the high SAR.
This soil is classified as a **Clay** with very low permeability.

Plant symptoms. Brown areas, similar to drought stress; soil water fails to drain.
Management strategy. Aerify soil and sand topdress; apply 10 pounds pelletized gypsum/1,000 sq. ft. and repeat in 30 days. Utilize a maintenance program of 5 pounds pelletized gypsum/1,000 sq. ft. per month during growing season. Leach regularly with best available water.

3 Water with both high total salts and high sodium makes for a saline-sodic soil.

Water report	*Soil salinity report*	*Texture report*
Total Salts	**2,120 mg/L**, Poor	TSS	**5,400 mg/L**, Saline	40% Sand
SAR	**6.6**, Poor	SAR	**14**, Sodic	40% Silt
HCO_3	0.0 mg/L; No Adj SAR	Boron	**0.95 mg/L**, Concern for Sensitive Ornamentals	20% Clay
Boron	0.55 mg/L, No Concern		

This irrigation water is classified as **Poor** because of high total salts and high SAR.
This soil is classified as **Saline-Sodic** because of the high TSS and the high SAR.
This soil is classified as a **Loam** with moderate permeability.

Plant symptoms. Brown areas, similar but not identical to drought stress.
Management strategy. Aerify soil and sand topdress; apply 10 pounds pelletized gypsum/1,000 sq. ft. and repeat in 30 days; utilize a maintenance program of 5 pounds pelletized gypsum/1,000 sq. ft. per month during growing season. Leach regularly with best available water. Use different water supply for ornamental trees.