Modern Putting Greens—

(Continued from Page 9)

(ca. 4.4 in. hr.$^{-1}$) or low (ca. 1.9 in. hr.$^{-1}$) rainfall rate. Rainfall was applied for 3 hours to ensure a constant drainage rate. At the end of the rainfall period, the rain device was turned off.

Drainage outflow was measured every 5 minutes for both the 3-hour rainfall period and for a 48-hour drainage period. Soil water contents were measured every 20 minutes for the first 24 hours of the drainage period. Soil moisture levels were measured hourly for the ramining 24 hours. This resulted in about 44,000 total drainage outflow measurements and 113,000 total soil moisture measurements for the full 18 runs of the study. Data collection began on 6 August 1997 and ended on 30 October 1997.

Results

Due to space limitations, only a portion of the data collected in the study will be presented in this article. Specifically, we will present only the high rainfall rate data since, after the first two hours of the drainage period, rainfall rate had little effect on the experimental results.

During rainfall, drainage rates from the research greens exhibited a significant interaction between profile design (either with or without a gravel blanket) and root zone permeability. The USGA profile greens, containing the gravel blanket, had higher drainage rates than the California profile greens. Additionally, drainage rates from the USGA greens were essentially the same regardless of root zone permeability. This result differed from that of the California greens, where the drainage rate during rainfall was substantially reduced for the low-permeability root zone compared to the high-permeability root zone. Finally, drainage rates in the USGA greens consistently increased with increasing green slope, while this was not the case for the California greens.

Although drainage rates were much lower after 27 hours without rainfall, outflow was still observed from all research greens. The California-style greens had higher overall drainage rates than the USGA greens, due principally to differences between the high-permeability root zone treatments. Also reversed from that observed during rainfall was the effect of green slope, where drainage rates of the California greens exhibited a larger increase with increasing slope than the USGA greens.

Just as drainage rates showed an interaction between profile design and root zone permeability, the pattern of soil moistures through a cross-section of the root zone yielded a similar interaction. This pattern is illustrated by Figures 1 and 2, where isobands of soil moisture are shown as a function of distance upslope and root zone depth for each of the profile design:root zone permeability combinations. Also, the individual figures correspond to green slopes of 0%, 2% and 4%.

After 48 hours drainage at 0% slope, both California profiles showed an effect due to drain spacing. Lower soil moistures were observed over the drain lines at 2 ft. and 17 ft., and higher moistures were observed between the drains. This contrasts with the USGA profiles where soil water contents were more uniform laterally across the soil profile. As expected, root zone permeability yielded the low-permeability root zone for both profiles. It was interesting, however, that the levels of near-surface soil moistures were similar in the California high-permeability and the USGA low-permeability greens.

All research greens exhibited increased water contents with root zone depth. In both permeability rates in the California profiles, water contents increased by about 15% to 2% from the 2 in. to the 10 in. depths. The USGA low-permeability greens yielded about a 10% increase and, while not readily apparent from the figures, the USGA high-permeability greens had a 4% increase in water content with depth.

The patterns of soil moisture for greens sloped at 2% were somewhat similar to those observed at 0% slope. This small slope applied to the greens, however, generated some downslope accumulation of soil moisture for all systems. Consequently, the soil moisture pattern due to drain spacing in the California profile greens was skewed in the downslope direction, and downslope water accumulation, particularly at depth, was observed in the USGA greens. This downslope soil water accumulation was accentuated in all greens after 48 hours at 4% slope. Drain spacing effects disappeared for the California greens and evidence of water

(Continued on Page 12)

Scholarship Scramble—

(Continued from Front Cover)

bringing the MGCSA participants to the course. Izaty's golf pro Rich Oberfeld did a great job on the scoreboard and the Izaty's staff treated us to a wonderful day and a successful scholarship scramble.

Next month's meeting, the MGCSA Golf Championship, will be at Heritage Links Golf Club in Lakeville on August 16. Host superintendent will be Paul Eckholm, CGCS. Defending champion Chris Manor, MTI Distributing Co., is expected to be on hand to defend his title.

Top 20 Scramble Results

Elm Creek Golf Links of Plymouth	59
Albany Golf Club	60
Benson Golf Club	60
Purple Hawk Country Club	60
Midland Hills Country Club	61
Pine Meadows Golf Course	61
New Richmond & MTI Distributing Co.	61
E-Z-GO Golf Cars	61
Country Club Turf	61
Mesaba Country Club	62
The Minikahda Club	62
National Mower & Plaisted Companies	62
Minnesota Golf Cars	62
Valley View Golf Course	62
Rich Spring Golf Course	62
P & H Warehouse	62
The Wilds	63
Fox Hollow Golf Club	63
Precision Turf & Chemical	64
Twin City Hydro Seeding	64
Paskvan & MTI Distributing Co.	64
North Star Turf Supply & Par Aide Products & National Mower	64

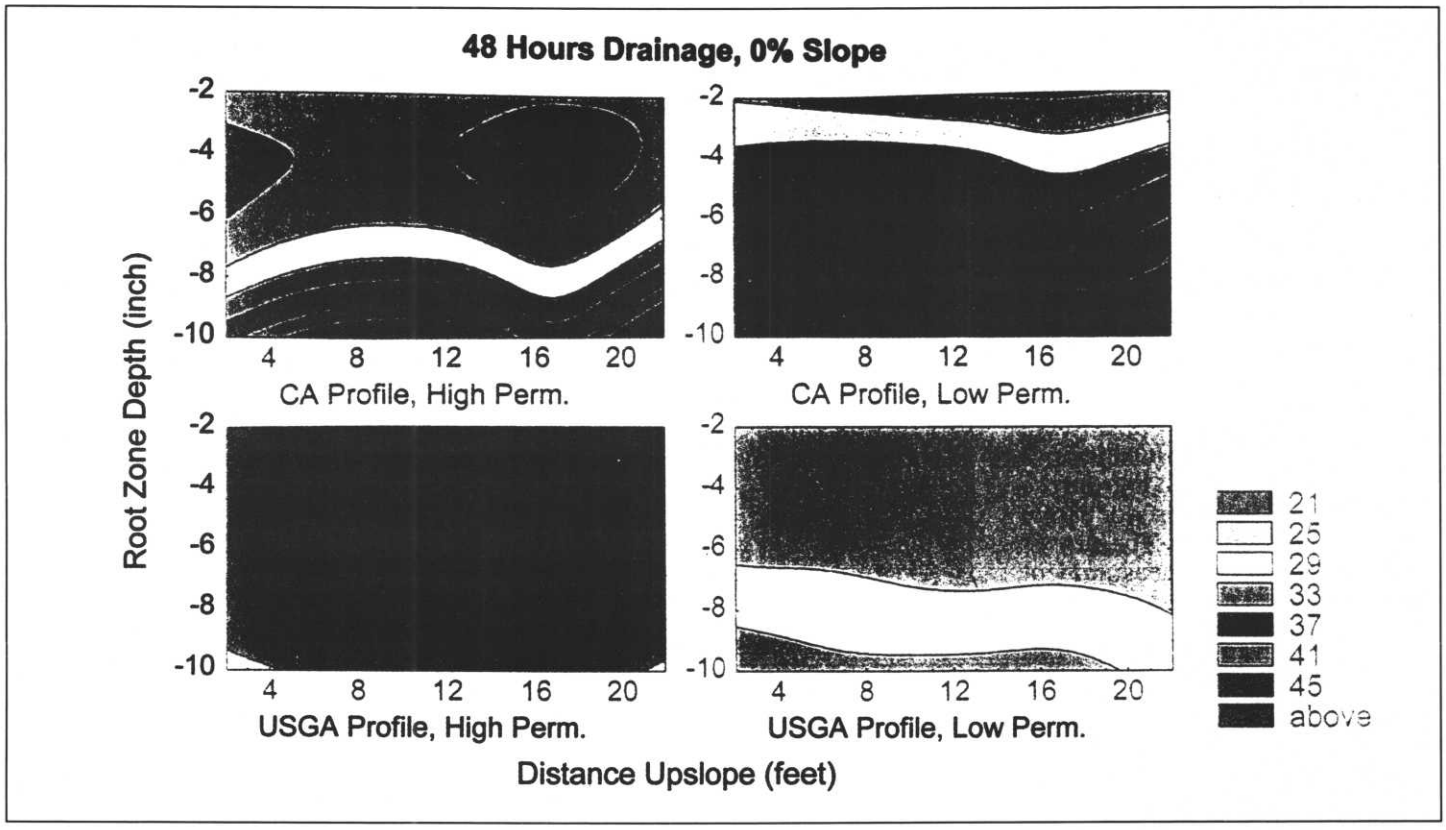

Figure 1. These contour plots demonstrate the soil moisture (% by volume) after 48 hours of drainage for research greens sloped at 0%. Individual plots show results for the California profile with a high permeability root zone, the California profile with a low permeability root zone, the USGA profile with a high permeability root zone and the USGA profile with a low permeability root zone. Each plot shows moistures in a cross-section of the root zone with the horizontal axis given as distance upslope (feet) and the vertical axis given as root zone depth (inch). The plots are shown with the vertical axis expanded 16.7 times true scale.

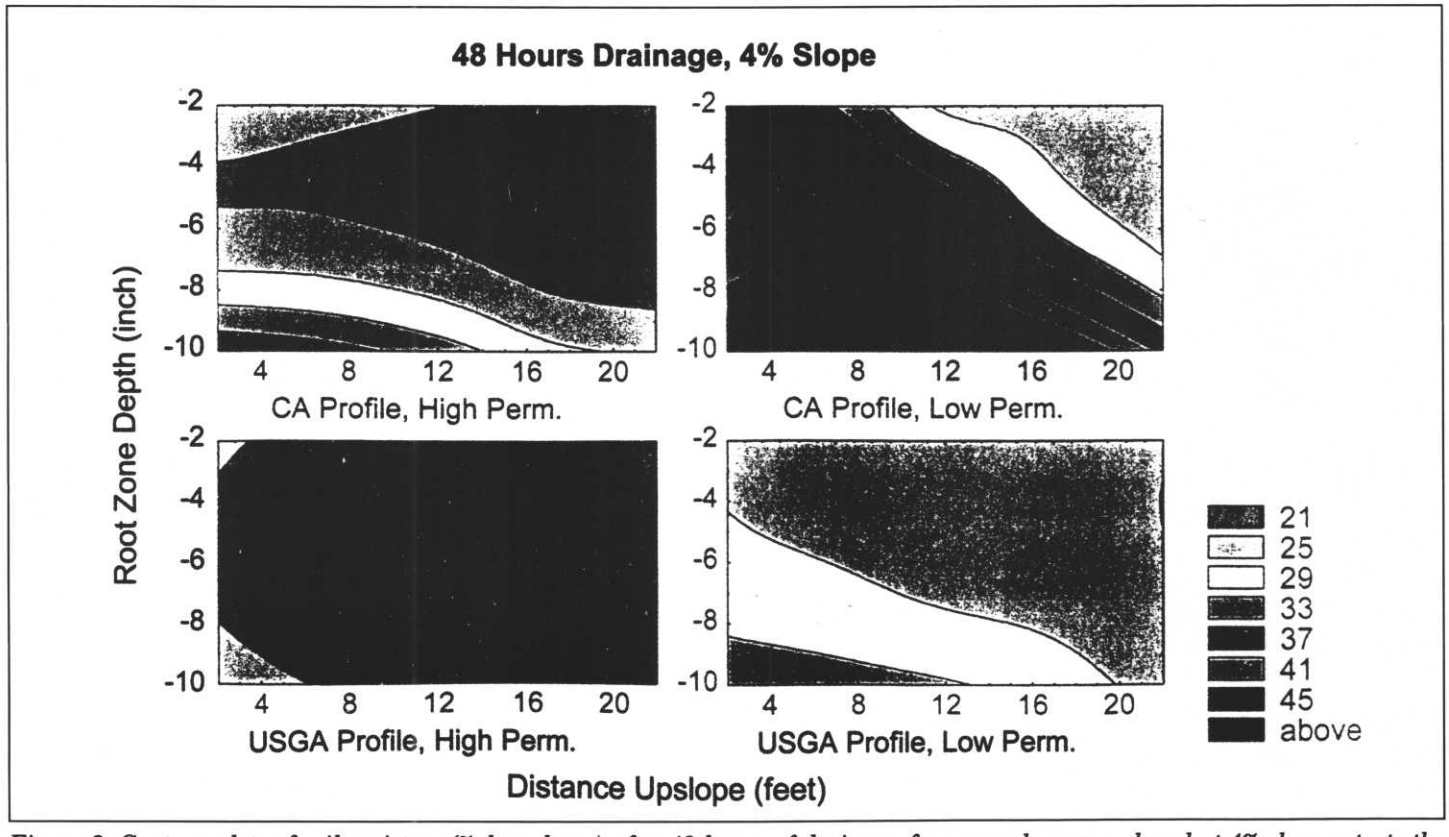

Figure 2. Contour plots of soil moisture (% by volume) after 48 hours of drainage for research greens sloped at 4% demonstrate the differences in drainage characteristics between California and USGA profile greens.

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Modern Greens—

(Continued from Page 12)

perching in the USGA greens was absent near the upslope end. Finally, the 4% slope had the greatest influence on near-surface soil moistures in the California low-permeability greens, where water contents ranged from 37% to 25% within a distance of about 18 ft.

It is important to point out that whereas results of Figures 1 and 2 are for 48 hours of drainage, similar soil moisture patterns were observed at earlier sampling times. The exception was that overall water contents were higher at earlier sampling times and slope effects did not become apparent until about 12 hours after rainfall stopped.

Table 1
Mean drainage rates during rainfall application and after 27-hour drainage for the experimental putting greens.

Green Profile	Root Zone Permeability	Green Slope	Drainage Rate During Rainfall	Drainage Rate 27 Hours
		%	gal. hr.$^{-1}$	gal. hr.$^{-1}$
California	High	0	59	0.22
		2	67	0.51
		4	52	0.52
	Low	0	10	0.08
		2	6	0.22
		4	3	0.46
USGA	High	0	82	0.13
		2	130	0.21
		4	140	0.24
	Low	0	81	0.17
		2	98	0.29
		4	146	0.30
LSD (0.05)			11	0.14

Implications

This research illustrates that when it comes to greens drainage, we need to go beyond considering just the root zone permeability or the profile design and consider the interaction of these two factors. Given equal root zone permeability, the USGA profile yielded more rapid drainage. Indeed, even rainfall rates of about 4.4 in. hr.$^{-1}$ failed to overwhelm drainage of the USGA profiles as evidenced by equivalent drainage rates for both the low- and high-permeability root zones. Consequently, it appears that California profiles need a root zone permeability about 20 in. hr.$^{-1}$ greater than USGA profiles to yield similar drainage rates. Of course, greens built to California specifications may be reasonably expected to have these higher permeabilities since the root zones frequently contain pure sand.

Drainage rate represents an intensity attribute. The capacity attribute of subsurface drainage, in the context of the present study, is the completeness of excess water removal from the respective root zones. Here, it is commonly thought that formation of a perched water table in a USGA green would result in a less completely drained root zone than a California green. Our results show that for equal root zone permeabilities the experimental USGA greens are drier after 48 hours (interpreted as having an increased drainage capacity) than the experimental USGA greens are drier after 48 hours (interpreted as having an increased drainage capacity) than the experimental California greens. Also, the California greens exhibited higher soil moistures midway between the drain lines. Both of these soil moisture features result from the need for water to move laterally through the root zone in a California green before reaching a drain line. This rather slow route for water to exit the root zone, as compared with flow into and through the gravel of a USGA green, resulted in wetter soil conditions even after 48 hours of drainage. Again, for more complete drainage, a California green appears to need a higher root zone permeability than a USGA green.

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Modern Putting Greens—

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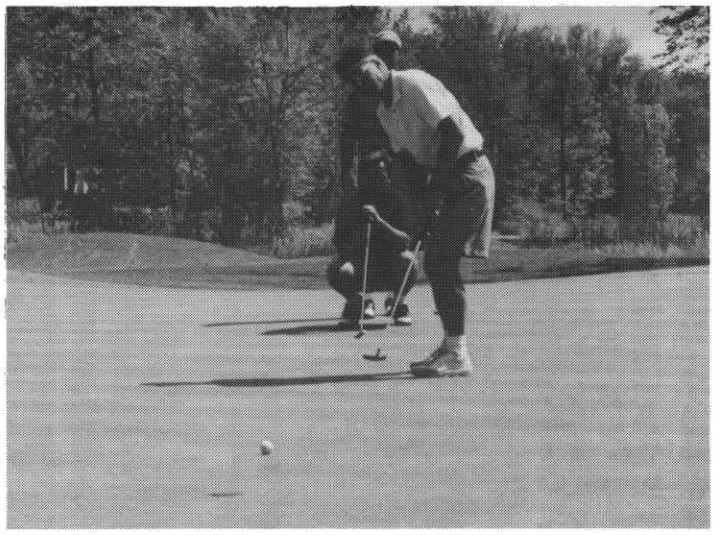
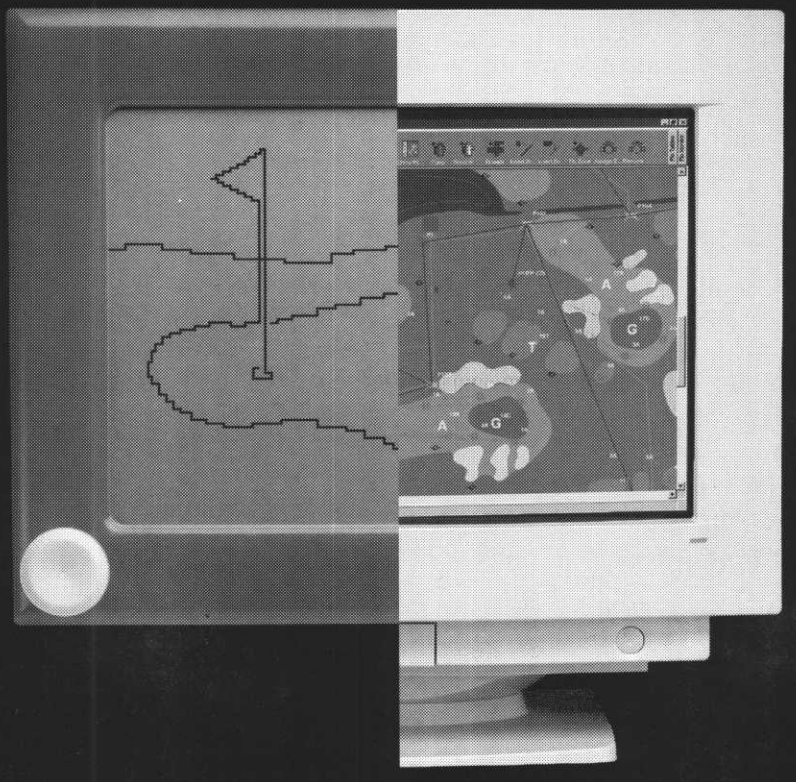
This research also illustrates that we need to consider how a putting green, either a California or USGA construction method, fits into the landscape; that is, the green slope and direction. Green slope clearly had an effect on water redistribution following rainfall, and did so for both putting green construction methods. Within each profile design, however, the lower permeability root zone yielded enhanced downslope accumulation simply because there was more moisture retained and accessible for migration in this root zone. Interestingly, increasing slope in the California profiles resulted in higher drainage rates at 27 hours and slightly drier root zones after 48 hours. Thus, green slope may be beneficial for continued drainage of a California green.

On the other hand, the slope-induced, lateral differences in soil moisture observed for both the California and USGA greens appear to be analogous to spatially non-uniform soil moistures observed within greens on golf courses. This spatial non-uniformity may result in the formation of localized drying or "hot spots" at upslope locations and excessive soil wetness in downslope locations. Both green construction methods apparently face this dilemma.



TOM JOHNSON, New Richmond GC, drills a 12-footer for birdie in this year's Scholarship Scramble at Izatys Golf & YC.

(Editor's Note: This article was reprinted with permission from the USGA Green Section Record. Guy Prettyman is a graduate student pursuing his master's degree in soil science. Dr. Ed McCoy is an associate professor of soil science at Ohio State University. The authors with to acknowledge the USGA and the GCSAA for their support of this research project.)



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GCSAA ONLINE REPORT

http://www.gcsaa.org

New Password — Protection System Installed

If you've visited the site in the last couple of weeks, you probably noticed that a new password-protection system was installed on July 1. Although the initial transition went extremely well, the cruch of registrations caused a glitch on the second day that prevented most users from posting on the discussion forums for several days. There were also a few other smaller glitches along the way, but for the most part, the entire system is functioning properly now. If you experience any difficulty registering or re-entering the members-only area, please notify the web staff (mail to: infoserv@gcsaa.org) and send along your user name and password.

Here's a look at our current registration numbers: Within 24 hours (right before a busy holiday weekend), more than 600 of you reregistered for the members-only area. At this writing, more than 1,800 of you have already returned.

If you haven't visited the members-only area since July 1, we want you back! As you know, greater participation in the site makes the forums more spirited, interesting and diverse. If you haven't registered, here's a link to the new registration form — you'll only have to fill it out once, and it shouldn't take more than about two minutes to complete.

Getting To The Big Easy Gets Easier

If you're going to the next GCSAA conference and show in New Orleans, get your clickin' fingers ready. On August 2, the third conference and show site will open its doors for registration and program information. If you've ever registered too late to get into the seminar of your choice, be sure to be one of the first visitors — for the first-time ever, GCSAA's registration service will be providing REAL-TIME online conference and show registration. You'll have a confirmation of your plans before you log off your computer.

Other features of the conference site include online hotel arrangements, full event information and a personal planner, while upcoming additions include an online exhibit hall, attendee directory and online silent auction.

The registration form:
http://www.gcsaa.org/security/memreg.html

No More Scrolling: ERS Database Simplifies Job Postings

Viewing the job listings on the web site is now more convenient than ever. If you're a web subscriber to GCSAA's Employment Referral Service, you can now browse through a searchable database to find the positions that most closely match your interests. You can search by region, job category or ad date. Then, once you get the results, you can click on the box next to the positions that interest you, and view the entire descriptions of only those jobs. Or, if you're only interested in one, click on the title, and then print out all the details of that particular position.

ERS web subscribers may search the database at:
http://www.gcsaa.org/members/ers/search/erssearch.html

To subscribe to ERS:
https://www.ksinet.com/gcsaa/ersform.html

Technology Update: *Not Just a "Flash" In the Pan*

If you'd like to check out a technology that is changing the way some web sites are designed, check out Macromedia's Flash web player. Flash allows web sites to display vector-based graphics (rather than the standard pixel images), and supports streaming MP3 audio and animation. If you have a 4.0 browser and want to view sites that feature this cutting-edge web design, download the Flash plug-in and browse through Macromedia's online gallery.

Download the Flash Web Player:
http://www.macromedia.com/software/flash/gallery/collection/

Great Links *Ask Jeeves — The Butler Always Knows*

If you need to find relatively simple information on the web quickly, try "Ask Jeeves" (http://www.askjeeves.com),

(Continued on Page 20)

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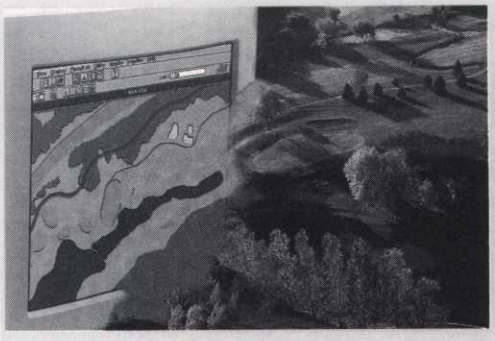

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GCSAA Online—

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which uses natural language to process your request. The search engine features an entertaining interface and is powered by a proprietary knowledge base. However, just in case Jeeves doesn't know the answer to your question, it also searches for matches from several of the web's most popular search engines. Ask Jeeves is a great resource, particularly if your keyword could be interpreted in a variety of ways by simple text searches.

About the GCSAA Online Report

The GCSAA Online Report is designed to help you make the most of your time on the association's web site. In each issue, you'll find out what's happening on the site, what's coming next and how to make the most of your overall browsing experience. In addition, you'll get the answers to your most frequently asked questions, as well as a brief rundown of GCSAA's upcoming activities.

Questions? Suggestions?

If you have any questions or comments about any part of the web site, or have a suggestion for a future issue of this newsletter, feel free to contact the web staff or any member of the Information Services Committee. The web staff is also particularly interested in hearing how the web may be used to help you fulfill your day-to-day responsibilities.

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All GCSAA staff members can also be contacted by calling headquarters at 1-800-472-7878.

* * * *

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