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Table 2. Mean (standard deviation) percent reduction in total load resulting from discharge water passing through the filter, summarized by hydrograph peak flow rate and pollutant (n represents number of replicates).

Peak Flow (L/s)	NO_3-N (nitrate nitrogen)	DRP (dissolved phosphorus)	Chlorothalonil	Metalaxyl
0.63 (n=3)	5.2 (0.43) a	53.5 (1.75) a	59.3 (1.89) a	31.0 (1.31) a
1.26 (n=3)	4.9 (0.56) a	53.9 (4.71) a	64.4 (7.45) a	30.1 (5.52) a
1.89 (n=3)	3.9 (0.11) b	47.3 (10.87) a	50.8 (12.05) a	25.5 (4.05) a
mean across all flows (n=9)	4.7 (0.68)	51.6 (7.17)	58.2 (9.91)	28.8 (4.58)

* mean (standard deviation) values within columns followed by different letters indicates statistically significant differences ($p<0.05$).

the filter and after flowing through the filter. The filters were created with a blend of activated carbon, activated alumina, and zeolite (Table 1, page 40). The blend was created by using equal parts by weight of each material.

Significant reductions in concentrations and loading across all three hydrographs were measured for dissolved phosphorus (51.6 percent), chlorothalonil (58.2 percent), and metalaxyl (28.8 percent). Nitrate nitrogen was reduced by 4.7 percent. Peak flow rate had a measurable effect on the amount of pollutant removed from solution (Table 2). In general, filter removal efficiency for all four contaminants tended to decrease as peak flow rate increased across all peak flow hydrographs. Removal efficiency also depended on the pollutant type. For example, approximately 50 percent reduction in the total loads of dissolved phosphorus and chlorothalonil was observed as a function of flow rates across all peak flow hydrographs (Table 2). Similarly, metalaxyl removal was nearly 30 percent of its total load. In contrast, filter removal efficiencies for NO_3 were significantly less (4 to 5 percent).

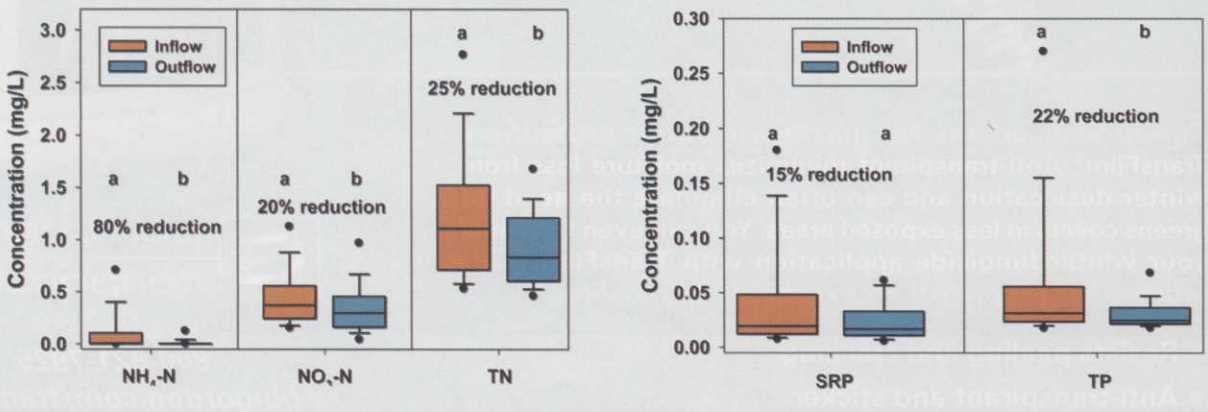
The reduction of dissolved phosphorus measured here is comparable to results achieved by incorporating aluminum oxide materials into the soil. However, the extent of dissolved phosphorus removal observed in this study was not as great as that observed in previously cited batch and column type studies. The reduced efficiency was attributed to shorter contact times with the filter media, a direct consequence of greater flow rates.

With respect to nitrate removal, the results were somewhat surprising; we expected a greater removal efficiency than was observed. Admittedly, clinoptilolite has been identified as an ideal agent for sorbing nitrogen as ammonium and not nitrate. However, activated carbon has been shown to be an effective nitrate sorbent. Nitrate removal may be most efficiently and economically achieved through microbial denitrification prior to or after water discharge through an end-of-tile filter. Cellulosic byproduct materials such as wood mulch, sawdust and leaf compost are well-suited, abundant and sources of carbon necessary for microbial denitrification.

Regarding chlorothalonil and metalaxyl, we assume adsorption to activated carbon to be the primary removal mechanism due to their chemical structure and hydrophobic nature. Variation in chemical structure may account for the differential removal efficiencies observed for each of these pollutants.

For example, chlorothalonil is significantly less water soluble (0.6 ppm) than metalaxyl (7100 ppm). Thus metalaxyl may be more hydrophobically attracted to the activated carbon in the filter cartridge than chlorothalonil. As with dissolved phosphorus, total removal of metalaxyl and chlorothalonil remained relatively constant

Figure 1. Box and whiskers plots of various nitrogen and phosphorus species entering (inflow) and exiting (outflow) filter cartridge system at Northland Country Club, Duluth, Minn., (n = 51) during 2009 sampling period. Boxes are bound by 25th and 75th percentiles, line in the box is median. Whiskers represent 10th and 90th percentiles while filled circles represent 5th and 95th percentiles. For each nutrient specie, different letters indicate statistically significant differences in median values ($P < 0.05$).



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over the three studied hydrograph shapes. We attribute this trend to the high surface area of activated carbon. Again, using different types of activated carbons could increase their removal efficiency.

As previously described, the removal efficiency for all contaminants was consistently highest at the extremes of the rising and receding limbs of the hydrograph when the flow rates were least (and residence time high).

Thus, not surprisingly, this filter design may be most effective under baseflow conditions rather than storm flow events. These filters can be used under baseflow and storm flow conditions. However, the large volume of storm flow may rapidly expend the filter. Overall, further field-scale, long-term studies of these filters are required to determine the longevity of these filter materials; once adsorption sites are exhausted the filter will require replacement.

FIELD STUDY

The field phase of the research is taking place on two golf courses (Ridgewood Country Club, Waco, Texas, and Northland Country Club, Duluth, Minn.). The experiment in Waco is set up on a practice chipping green. The 8,000 square-foot green is 100 percent sand.

Water drains through a subsurface network of 4-inch perforated tile to an outlet containing a filter network. The filter has

IMPACT ON THE BUSINESS

Protecting water quality

A closed-loop bioremediation system was the answer to high contaminants found in a water way at The Rock Golf Club in Ontario. BY JASON WINTER

Planning for The Rock Golf Club and the resort began in 1998. It was marketed as Canada's first JW Marriott property and as one of the country's newest and exciting resort communities. Local residents, numerous environmental groups, and the Township of Muskoka Lakes raised many environmental concerns about the proposed use of land in a pristine region of Ontario.

The boom of new golf course construction in the Muskoka region during the 1990s, in conjunction with concerned citizens' questions about the new development, resulted in requests for several studies to be conducted to determine the health of the region's lands and lakes prior to this proposed development. In the end, the construction of The Rock was approved and a new standard was developed that would be the new environmental guideline that all new courses planned for construction in Canada would have to follow. Once the site plan agreement was in place and construction was underway, The Rock faced many challenges and continues to be under the watchful eye of adjacent landowners and the Township of Muskoka Lakes.

Water quality management continues to play a major role and is a major expense to the club as very aggressive monitoring of existing tributaries and management of stormwater ponds continues. During the first two years of operation, elevated levels of phosphorous were detected at Tributary B (one of five) that met "trigger" values and required investigation as to the source.

The site plan agreement had a condition in place stating that extensive water quality monitoring would have to continue for three years where no two consecutive "trigger" values were met or the monitoring cycle of three years would start over. With the high cost of monitoring water quality, the new golf course superintendent set out an action plan to identify and eliminate the source of contaminants. The primary goal of identifying these sources was to further show the commitment of the club to be a steward of the environment, gain support and acceptance of the club from adjacent property owners and ultimately reduce the cost of testing and the start of a new three-year monitoring cycle. Investigations into the source of the contaminants were found upstream of Tributary B in an area where equipment washing had been taking place since the opening of the golf course. Situated close to a natural water course and riparian area, this practice of washing grass clippings from machinery proved to have an adverse effect on water quality.

With the source identified, the next step was to research ways to manage water used to wash equipment and find an appropriate and cost effective way to eliminate this contamination. Some of the systems researched included flocculation systems, a collection sump/solid separator system and the latest bioremediation closed-loop systems. With management company Marriott Golf committed to the environment and owner approval for funding, the choice was made to purchase the Mi-T-M closed-loop bioremediation system that would continually treat and recycle water throughout the season. Implementation of the closed-loop Mi-T-M system would ultimately reduce water consumption from an estimated 700 gallons per day to approximately 1,500 gallons per year.

The system was designed with both a solid separator and grass-clipping separator ahead of the five compartment filtration chambers. The chambers are designed to allow the introduced microbes to react and neutralize any contaminants in the water. This water is then pressurized through a pressure tank where the filtered water is again used to wash equipment.

The operation also needed a chemical storage area for pesticides and a safe mix/load area for the spray technician.

Funding was again approved for this state-of-the-art building to be constructed and further reduce the impact that a spill may have on the environment and water quality. The building serves for both storage and mixing/loading purposes. It was constructed with a 6-inch perimeter sill, an impermeable sump with a capacity of 325 gallons and a 1 percent slope that would direct any spillage to the sump area and not out of the building. Other features implemented in the design of this building are a premixer and stainless-steel sink, which allow for safer product handling. These features further reduced the potential for chemical to splash onto the applicator as the sprayer is being filled directly with water from the irrigation system. Water from the irrigation system was plumbed into the building and regulated down to 50 psi so that many different applications and procedures could happen simultaneously, ultimately speeding up the mixing process. Building a structure with these features has allowed the applicator to get on the golf course much quicker than before and be more precise with the mixing. Chemical applications are completed quicker, thus reducing the visibility of the sprayer to the guests.

The results of both of these efforts have resulted in vastly improved water quality and have proven the club's commitment to preserving the environment.

The Rock is looking forward to continuing to improve its water quality in the future. Much of the work done is cost prohibitive for a lot of properties, but there are several less expensive alternatives that can result in successes similar to ours. Our continued efforts will focus on educating people in the community, neighboring property owners and government groups at all levels to help them understand that The Rock is fully committed to continuing its environmental efforts. **GCI**

Jason Winter is the golf course superintendent at The Rock Golf Club in Minett, Ontario.

Source: The Environmental Institute for Golf's online environmental resource, EDGE (www.eifg.org/edge/).

recently been fitted with cartridges containing activated carbon, cement kiln dust and sand. Laboratory tests suggest that these materials should significantly reduce the amount of pollutants routed through the subsurface drainage.

At Northland Country Club preliminary data indicate that upwards of 20 percent to 60 percent of the pollutants measured at the stream outlet on the course are cycled through the tile drainage network. A filter identical to that tested in the large-scale laboratory study was installed in late 2008 on a tile drainage outlet that conveys water from a significant portion of the course.

The drainage water is a combination of subsurface drainage and surface flows that are collected in micro-depressions and routed to the tile.

Data are collected simultaneously using Isco 6712 automated samplers at the inflow and outflow of the filter following every 4,000 gallons of water that pass through the filter. This is a "real world" application of the filter and is representative of both baseflow and storm flow concentrations.

Preliminary findings from 2009 data at the field study in Minnesota indicate that the filter provides significant reductions in ammonium, nitrate, total nitrogen and total phosphorus (Figure 1, page 42).

No results are yet available for the pesticides. The removal of dissolved phosphorus from the tile flow was not as great as expected. This discrepancy in results for dissolved phosphorus is surprising, considering that in the laboratory the filters were able to substantially reduce dissolved phosphorus.

FUTURE RESEARCH

Future research will investigate different activated carbons and different byproduct mixes, inclusion of a denitrification barrier prior to/after the filter, long-term sorption capability, efficiency dependence on influent concentrations, optimizing contact time and scaling for larger applications. Identification and demonstration of a filter technology will offer superintendents a scientifically based option to better manage drainage waters in problem or environmentally sensitive areas. At this time it appears that drain tile filters have significant promise to reduce pollutant loads.

This information is important for golf course superintendents who need to protect their surface waters and comply with regulatory and/or permitting laws. **GCI**

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NATURAL **BALANCE**

An Audubon-certified golf course in Minnesota, "the land of a thousand lakes," finds the right mix of techniques to cut back on labor spent on algae and duckweed control. BY MEGAN LEONHARDT

Working as a superintendent at a golf facility in "the land of a thousand lakes" is not an easy task, but Scott Thayer, superintendent of Legends Club in Prior Lake, Minn., has found that with a little ingenuity and the right combination of products, the facility's 21 water features sparkle.

Legends Club is an 18-hole, daily-fee facility with a 30-acre lake anchoring it. With a maintenance budget of $725,000 a year, Thayer makes sure his wetlands, streams, marshes, ponds and lakes are well cared for.

The course has a man-made irrigation lake that's connected to several of the ponds and lakes through underground piping. Keeping this pond clean is crucial. Some of the biggest problems Thayer faces each season are the filamentous algae and duckweed, as well as other vegetation. To combat these pond pests, Thayer uses a combination of pond products and manual labor. He uses the biodegradable AquaSpherePRO and supplements it with Blast, a beneficial bacterial product that breaks down organic compost.

"It really cleaned up the water, and it's taken away 95 percent of the algae," Thayer says of his program. "We used to be spending 50 to 60 hours per season cleaning in past years, but I have not had to clean it yet this year," Thayer says of the old method, which included stringing rope between metal landscape rakes to pull the algae to the side of the pond and hauling in out by hand. Now he spends about $100 per month on treatment products, and the labor costs are minuscule. He uses two biodegradable spheres for every acre of lake each month.

Of course, managing Legends' water features not only requires cleaning, but also upkeep. Though the 30-acre lake, which is 5- to 6-feet deep in some areas, is controlled by the State Department of Natural Resources, Legends has installed a bubbler to help with water and air quality during the harsh winter months.

His advice to other superintendents is to be patient. The right mix of products will make pond water cleaner in the long run, he says.

"Keeping movement in the lake will also help the products work even better," Thayer says. "If the product is not doing what you need, then circulating the water or algae will help eradicate it as well." GCI

Leonhardt is a freelance writer based in Medina, Ohio.

Tim Moraghan is principal of Aspire Golf Consulting in Long Valley, N.J. He can be reached at tmoraghan@aspire-golf.com or 908-635-7978.

WATER, WATER... ANYWHERE?

Golf course superintendents in the Northeast or Southeast may not be overly concerned about a water shortage following the recent golf season. Ask Bethpage Black's Craig Currier or Merion's Matt Shaffer, who both dealt with excessive rains as they prepared for major events this season.

Water will soon, if it's not already, become as valuable as oil to our industry. Where do golf course superintendents turn when one of the most precious asset of a golf course becomes so regulated? We make it our job to use the growing number of technologies available to help us water responsibly.

Mike Huck, principal of Irrigation & Turfgrass Services of Dana Point, Calif., explains, "It all centers on a properly functioning irrigation system first, and controlling the amount of water used second."

While this is a great starting point, economic pressures don't allow all golf courses to invest in state-of-the-art irrigation systems. Mike suggests superintendents conduct a uniformity audit and data interpretation. This test evaluates the general performance of the irrigation system and pinpoints shortcomings. Once the system functions well, the next step is to reduce and monitor water use.

Tom Brodeur of the TPC of Boston implemented a moisture-monitoring sequence of measuring points within each putting surface to determine water volumes and irrigation needs. The system evaluates putting surface performance and consistency.

A 30-inch probe – a Field Scout soil-moisture meter – is inserted 3 inches into the soil to gather moisture data. Each green profile is reviewed and nine measuring points across the surface are determined for water content measuring. Next, the points are numbered and entered into a data file.

During advance and tournament week Brodeur's team checks the points throughout each day to establish a benchmark point of volumetric water content.

The goal is to avoid over-watering and inconsistencies on the playing surfaces. Once a baseline is formed and a "number" reached, water management begins. Checking the points daily, a water team can apply water only where needed to meet the prescribed moisture level. Water may be added only to several positions on the green or to none at all if water volume meets the determined number.

Staff can be easily trained to determine points and take measurements. This increases uniform water management and avoids oversaturation.

Brodeur uses this method as part of his regular maintenance practices to save money, water and labor expenses, and to assist in cultural practices, disease monitoring and to provide improved playing conditions.

Russ Myers, CGCS, of Southern Hills Country Club in Tulsa, Okla., hosted the U.S. Amateur Championship during hot, dry August.

Watering effectively to avoid subsurface saturation was vital to delivering top-level playing conditions. Russ' solution was to use a similar monitoring system but with individual handheld units, HydroSense and Spectrum Technologies, which are distributed by Precision Turf.

He gave watering personnel the units and provided them with the "number" for soil water volume, establishing a breakpoint as to whether to water or not.

His goal was to identify potential wilting, avoid watering during the hottest part of the day and leave no question as to what's wet and dry within the soil. Russ believes everyone has a different take on what's moist or dry when they're feeling the soil. The hand-held units take the guesswork away from his irrigation staff.

The measurement within the soil is at 4 inches deep – the length of the probe. Each morning his preevent watering team checked the greens' stress points for the number. If the reading was below the established point they watered only enough to bring moisture content up to previously established points. This method eliminated the wilting potential during the day and allowed playing conditions and agronomics to remain uniform.

Myers says he has eliminated wet turf, reduced disease concerns and provided firm and consistent playing conditions while keeping irrigation use to a minimum.

Matt Shaffer at Merion Golf Club in Ardmore, Pa., has never been afraid of not watering. He's the industry's leader in not irrigating turf. Matt has installed UgMO wireless senors within the soil profiles of Merion's greens. These devices send internal information to a central computer for regular monitoring. Shaffer says his water usage is down, the sensors provide an accurate soil water content and they eliminate guesswork when watering daily.

Proper water management provided firm playing conditions for the Walker Cup matches, despite the rains. By understanding proper soil water volumes, Matt was able to restore playing consistency quickly and provided the needed challenge for play.

As water quality diminishes and reclaimed water use increases, establishing effective management of salinity, sodium and bicarbonates becomes vital for turf health.

Shaffer is now evaluating use of these devices for fairways and teeing grounds. **GCI**

Terry Buchen, CGCS, MG, is president of Golf Agronomy International. He's a 41-year, life member of the GCSAA. He can be reached at 757-561-7777 or terrybuchen@earthlink.net.

Travels With Terry

Globetrotting consulting agronomist Terry Buchen visits many golf courses annually with his digital camera in hand. He shares helpful ideas relating to maintenance equipment from the golf course superintendents he visits – as well as a few ideas of his own – with timely photos and captions that explore the changing world of golf course management.

SIDE AND BACK BOARDS

At the Bald Peak Colony Club in Melvin Village, N.H., Ian Ladd, mechanic, and Todd Pollini, superintendent, built wooden side and back boards for a Toro Workman using scrap wood. The back board measures 55 inches by 13 inches by ½ inch and was painted with two coats of leftover green paint. The side boards measure 63 inches by 10 inches by ½ inch and they were left natural with no paint, stain or waterproofing. The wooden stakes are two-by-fours that were cut in half lengthwise. Each measures 2-feet long; they're attached to the side boards and back board with sheetrock screws and there's a horizontal 2-inch by 2-inch board attached between both stakes, also with sheetrock screws, for added support. With the added bed height, lightweight materials such as grass clippings, leaves and mulch can be transported in greater volumes. The total labor time was about one hour. There were no material costs because they used scrap wood and on-hand supplies.

EXHAUSTING ALL OPTIONS

Jim Swartzel, equipment manager, Justin Bowman, assistant mechanic, and Craig De Jong, superintendent, at The Hasentree Club in Wake Forest, N.C., modified their Toro Multi Pro 5700 Sprayer so the engine exhaust would not burn the grass when it sits in one location for 10 to 15 minutes while spraying. (They first tried putting a board on the grass with limited results). The exhaust was extended and moved upward using a 1 7/8-inch diameter flexible exhaust pipe approximately 18 inches long. The pipe was attached to the existing exhaust pipe with a muffler clamp and the end was raised to another muffler clamp that was welded to the bottom of the sprayer operator's foot step. The ends of the flexible pipe were filed down to remove any sharp edges. The project took about one hour; materials cost about $10. **GCI**

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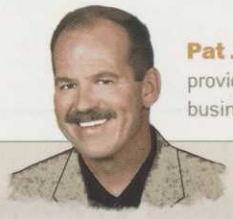

Pat Jones is president of Flagstick LLC, a consulting firm that provides sales and marketing intelligence to green industry businesses. He can be reached at psjhawk@cox.net or 440-478-4763.

IT'S JUST BUSINESS

Just the other day, as I was desperately pondering what I'd write about this month, it occurred to me that our old friends at GCSAA hadn't done anything interesting or controversial in a while. It seemed like they were hunkered down, riding out the recession and trying to avoid any big nasty issues like PDI or relocating the headquarters or giving the Old Tom Morris award to a dead guy for purely political reasons.

Then, like manna from heaven, my e-mail inbox dinged. It was a note from a well-connected GCSAA member who was forwarding a message from the Club Managers Association of America. It was a very interesting narrative about why CMAA was planning to drop out the Golf Industry Show after 2011.

Voila! My what-to-write-about problem was solved.

By now, I suspect you've heard that GCSAA is bailing out of dirty, nasty old New Orleans for the wholesome environs of Las Vegas in 2012. Hurrah! The moral compass has been straightened!

Let's look at this from a few perspectives. First, to quote "The Godfather," let's consider the "It's not personal, it's just business" point of view.

There's no question that some people simply don't take to New Orleans' down-and-dirty atmosphere and the whole Bourbon Street drink-till-you-puke-then-drink-more mentality. There were certainly a number of folks who had plentiful budgets but stayed away from The Big Easy because of the perception that they were fiddling while Rome was burning back at their clubs. And, unfortunately, the specter of Hurricane Katrina and a ruined and violent city still looms large in the minds of some.

So, I suspect that there were a few very vocal critics within the membership (and perhaps on the board) who simply can't stand New Orleans. The city is like Cajun food…an acquired taste. It holds little attraction for those who don't enjoy the spectacle, the weirdness and the Bacchanalian atmosphere.

So, I think that from a strictly business standpoint, the GCSAA was worried that New Orleans would no longer be the draw that it had been in the past. Attendance of 12,000 to 14,000 (I – and others – dispute the 17,000 number GCSAA released after the 2009 event) simply isn't acceptable when the event drives half the revenue of the association and its partners every year. A few thousand more attendees are worth a big pile of cash to everyone involved.

One final business thought: Las Vegas is hurting right now. There's no question that the city is headhunting any major convention it can get. I think Vegas – once again in Godfather parlance – made the GIS an offer it couldn't refuse.

Second, consider the exhibitors' perspective. According to the GCSAA news release about the change in locations, the GIS contacted exhibitors in advance of the decision. There's no indication of what the exhibitors – who pay all the bills – thought about this in the text of the release, but I can tell you what I've heard from my friends in industry. The short, less-profanity-laced version is, "Oh my, I mildly dislike shows in Las Vegas." Why? Two reasons.

First, the Las Vegas Convention Center is a strict union shop. As an exhibitor, you can't fart without permission from a Teamsters steward. Want to plug in an electrical cord? That'll require two union members and cost $150. Want to have coffee and donuts in your booth? We'll send six people over – one to push the cart, one to count the donuts, one to check the temperature of the coffee and three to back them up.

So, despite the allure and glamour of Vegas, it's one of the most expensive places to do business in the country. But, perhaps worse, it also represents the ultimate bait-and-switch from a conference point of view. The city does everything it can to attract shows like the GIS. Then, once attendees arrive, it does everything possible to keep them from actually going to the seminars and trade show. Quite simply, people who are in classes or looking at products on the show floor are not losing money at the tables. Once they get you there, they want you in the casinos. Period.

Years ago, those same issues – cost and distraction – led GCSAA to drop Sin City from the show rotation. Have those challenges gone away? Doubt it. But, I'd be shocked if Vegas didn't offer a tremendous deal to get the show back. And, money talks. In this case, it talked loudly enough that it seems – and the CMAA's announcement alleges – that GCSAA acted "unilaterally" to change the venue. And the club guys were chapped about it.

When you treat a great association like CMAA like a second-class citizen, you shouldn't be surprised that they'd react like this. What's more, it was pretty clear that CMAA's members and exhibitors felt like they were lost in a sea of superintendents at the combined show. The culture of the organization and its premiere event was rapidly being degraded by being literally and figuratively stuck down at the end of the hall.

When it was formed, the justification for the new, combined GIS was that it was a reflection of the concept of "team management" within the club/facility structure. That notion assumes the fact that the GIS partners would also act like a team. Correct me if I'm wrong, but teams work together. When one member of the team decides that its interests are more important than the other members', no one wins. **GCI**