EARTH'S LARGEST POWER SWEEPING RESOURCE™

Transcript of Presentation Data From the Webinar Held With Street Sweeper Manufacturers on December 18, 2024

Summary:
Presentations from five experts highlighted the need for a unified, reliable testing method for street sweepers to demonstrate their effectiveness in removing pollutants, including microplastics. The webinar emphasized the cost-effectiveness of street sweeping compared to other methods of pavement-based pollutant removal.

The value of sweeper test results would be that, when combined with making the results available to the U.S. stormwater community — along with current study results that show street sweeping to be up to 700% more cost-effective for pavement-based pollutant removal — an increase in the market for street-class sweepers would occur. Part of that increase would come via widespread crediting of street sweeping in MS4 stormwater management programs.

The Stormwater Testing and Evaluation for Products and Practices (STEPP) program was presented as a potential organization for standardizing testing and verifying sweeper performance, thereby facilitating market expansion for sweepers and resulting in a reduction in water runoff pollution. Finally, technological advancements like a real-time notification apps for parking restrictions during sweeping were also discussed.

Instigator and Moderator: **Ranger Kidwell-Ross, MA, *Founder and owner of the World Sweeping Companies***
Those companies include WorldSweeper.com, the contractor-centric World Sweeping Association*; and, the nonprofit World Sweeping Foundation*

***Note:** As you read through this information, all underlined words are links to URLs of the information being referenced.*

Ranger Kidwell-Ross:
Thank you for attending. This is my 37th year of providing the sweeping industry with information. I've written and/or published and posted over 1,000 articles about power sweeping. In the early ’90s I started *American Sweeper*, the first magazine for power sweeping. The reason I founded the magazine was because I thought it would be a way to remind public works professionals that they weren’t sweeping up horse poop anymore. Rather, they were now cleaning up pollution from clutch plates, brake linings and other material, including phosphorus and nitrogen, that needed to be removed from the pavement so they wouldn't run off into US waterways.

Having already been writing for the parking lot sweeping industry for several years I had come to realize that, when it came to pavement-based pollutants, street sweeping was the ‘first line of defense’ for water quality. However, public works directors around the country were largely still sweeping for cosmetic results, not to attain environmental and water quality improvement.

More recently, it has become obvious that an understanding of street sweeping — including data that show exactly how good various sweepers are at removing pollutants — should be made readily available to the stormwater sector. That would not not only be a good way to expand the marketplace for sweeping but it would also do something for water runoff quality in the US and around the world. That's the central idea of what we’ll be talking about today,

If you've been following the WorldSweeper newsletter, and my editorials in them, you'll know that in October of 2024 I conducted a very insightful webinar, entitled “The Future of Street Sweeping in Stormwater Management” with Seth Brown, one of the presenters today. Seth is the Executive Director of the National Municipal Stormwater Alliance (NMSA) as well as the Stormwater Testing and Evaluation for Products and Practices (STEPP) sub organization.

Also in the upcoming, December 2024, issue of the newsletter I am publishing my recent webinar called “Pollutant Removal Credits in Minnesota: The Sweeping Details,” with Mike Trojan, hydrologist emeritus. He's been one of the foremost people involved with storm water pollution abatement, which he did through the state of Minnesota.

Well known and credentialed tester of sweepers, Roger Sutherland, is here to provide information on his experience in the sweeper testing process. Finally, the remaining presenter in today's webinar, Dr. James Houle, is very well known in the stormwater community in the Northeast. He is here to talk to us about what is going on in regard to crediting for street sweeping in the Northeast.

Here is some needed background: Because we don't have a unified testing for street sweeping, we're stuck with the test that was performed by the South Coast Air Quality Management District (AQMD) about 20 years ago. Every sweeper that took that test, to my knowledge, passed. That makes it essentially meaningless.

That test is also basically impossible, to say nothing of very expensive, to redo. It also doesn't mean much to stormwater professionals. That is the segment that I think will end up becoming the primary marketplace for street sweeping due to the microplastic initiatives cropping up all over, in addition to current pollution and trash removal initiatives.

I am part of the Sea Grant/NOAA grant effort through the City of Santa Barbara and USC that has delegated Roger Sutherland and myself to develop a sweeper test that makes sense. We have finances to test probably four to six sweepers. We'd like to include many more. The intent is to find out what different street sweepers can do in terms of removing microplastics and other small micron material, as well as general removal of trash. Roger and I, hopefully with input from the different companies in the sweeper manufacturing community, will design and conduct that test.

Right now the mechanical broom segment of the industry has also become hamstrung by a test that was recently done for the City of LA by Larry Walker and Associates (LWA). As an air sweeper to test LWA used a brand new Elgin RegenX. When it came time to test a broom sweeper, though, an Elgin Broom Bear was pulled out of the City's fleet. As far as I know, nobody took a look to see how long any of the broom bristles were on it or whether it was otherwise in top condition.

The Broom Bear came in at just 35% pickup; the RegenX came in at 75%. Roger has done lots of sweeper testing. When he did, as he'll tell you, he came up with much better numbers for both the air sweepers and the

broom sweepers. We believe that if we can develop a testing process that can be believed by the national stormwater community, then that will expand the marketplace for sweepers.

Right now we have exhaustive studies out of Minnesota and Florida that show street sweeping is five-to-seven times more cost effective in picking up a pound of phosphorus or nitrogen than any other method. In other words the next best method, catch basins and catch basin cleaning and filtration, is 500% to 700% times more expensive. We'll now hear from Roger Sutherland.

Roger Sutherland, PE; Principal Cascade Water Resources.

*Note: You may click on Roger's name, above, to view his current vita. It is also strongly suggested that readers open and follow along with Roger's presentation, entitled "***Real World Street Sweeper Pick-up Performance Testing***." Note the link is provided as a pdf file. Slide numbers to match content of each presentation are shown throughout as you read.*

Slides 1-2: My presentation spans about 40 years. As you can see, I've completed a lot of street testing over my 52-year career. It started with some work in 1982 in Reno, NV, when I asked Bob Pitt to join me on a non-point source pollution project, and he taught me how he tests street sweeper pickup performance. It was a Section 208 project from the original Clean Water Act in 1972.

I will only discuss the last two street sweeper testing projects I completed. One was done for the Elgin Sweeper Company in 2008. The other one was for the cities of Glendale and Burbank, California, which was part of a TMDL project for the LA River basin focused on reducing heavy metals.

Slide 3-4: Street sweeper pick-up performance is a function of many things, but clearly, the type of sweeper has shown itself to be the most important. The industry typically classifies sweepers as mechanical brooms, vacuums, or regenerative air. Testing results for sweepers need to be segmented by type.

Forward speed is important, but we've learned through our testing over the years that it's not as important as I thought it was initially: the difference between sweeping at 10 vs. five miles per hour is only about a 15% reduction in pickup performance. And if one can go twice as fast, one can sweep a lot more curbs in a shift, which results in more pollutants being removed by the sweeper for the day compared to sweeping slower. But I wouldn't recommend exceeding ten mph. Plus, good operators know how to slow down when they encounter a heavier loading.

When it comes to the Sea Grant study that Ranger mentioned, the question was: "How do we design a pickup performance test that represents real-world sweeping conditions?" This is a question I've been asking myself for well over a decade. Several variables could be varied in the test; however, depending on how many test runs you want to conduct on a single sweeper model, it gets more expensive if pavement type, forward speed or anything else is varied.

Our plan for the Santa Barbara testing this summer is to select values of these other parameters that are reasonable and replicable, and then run single passes so we can test more machines with the lowest costs. We must have safe testing conditions, which means no traffic. Many past pickup performance tests are not very realistic.

Slide 6: Here you can see a typical unscientific test with too much material on the ground arranged by a city. We need a realistic performance test measuring the street sweeper's ability to pick up street dirt as it exists in the real world. Plus, the test needs to measure each machine's ability to pick up all of the different particle sizes of the street dirt that is found.

The tests I designed for Elgin and the 2012 California TMDL project evolved through many previous efforts. This is the same test procedure recently used by Larry Walker and Associates (LWA) for the LA street sweeping project Ranger mentioned earlier. It's the test that I'm going to discuss here.

Slide 7-8: We need dry pavement conditions for any test, at least initially. We can use water for dust suppression when testing street sweepers, but then we have to wait longer for the pavement to dry before we can vacuum up what material remains behind. Since it rains in Illinois in the summer, we didn't want to take any chances, so we erected a tent, as slide 8 shows. I'll now run through the basics of the test.

Slides 9-10: These slides document the realistic, real-world test I first conducted in Illinois and later in California. Slide 9 shows the test track. At this location in Illinois, an extruded curb was put down in the parking lot. In California, the test track was an existing concrete curb and gutter with asphalt pavement in the street located at the old Burbank Wastewater Treatment Plant.

Both test tracks were 50 feet long by two feet wide. The one in Illinois was all asphalt pavement, which is predominant throughout the country. Notice that it's not in great condition — it's considered 'fair' pavement condition. There are cracks, but we sealed them. The message to all the cities, counties, DOTs, and other highway people is: if you have a deteriorating pavement with a bunch of cracks, seal those cracks with tar. Otherwise, they're only going to create opportunities for street dirt to accumulate. The runoff will get it but the street sweeper might not.

Slides 11-13: First, I created a batch of street dirt simulant (link is to word's definition). Street dirt is the debris and contaminants being swept by a sweeper. We make this simulant out of a series of inert silica products in a recipe that mimics what we always observe in real-world street dirt. We then spread a known weight of this particulate material on the test track using a fertilizer (we sieve a sample of the simulant so we know its initial particle size distribution (PSD).)

Of course, before running the test, we allow the sweeper operator a few practice runs since we will want him or her try to maintain a specified forward speed best while doing a good job of sweeping the test track. For the actual test, after the track is loaded with the simulant, we execute a single pass of a street sweeper, trying to maintain a specified forward speed. Of course, we record the time it takes for the sweeper to sweep the test track so we can calculate exactly the forward speed.

If dust suppression water is used, we have to wait until the pavement completely dries. If no water is used we can quickly move on to the next step, which is to use a Shop-Vac-like vacuum with a stainless-steel canister to vacuum up any remaining material. This material is then transferred to a zip-lock bag that we take to the lab and have sieved along with a sample of the simulant using a standard set of sieve sizes.

For the Elgin tests, we attempted to match the mean particle size distribution (PSD) found in Bellevue, Washington, during the Nationwide Urban Runoff Project (NURP) conducted in the early 1980s. This is the most extensive number of samples of street dirt ever collected anywhere in the country before 2008. Notice we had some problems matching the 600–1000-micron range and the 125-250-micron range found in the NURP. So, the PSD used was somewhat finer than the mean observed in NURP.

Slides14-18: Here are some pictures that show the process I described previously, like spreading the stimulant using a calibrated fertilizer spreader. We're spreading a known quantity of simulant, seven-and-a-half pounds, over 50 feet. That equals 792 pounds per mile. That's a little bit on the high side of what we see daily in urban America but within the range of the data collected throughout the country over the years.

As I mentioned previously, we give the operator a couple of practice runs before we spread the test material. We also show pictures of a test being conducted and yours truly carefully vacuuming up all the remaining material. I then carefully transfer that material from the vacuum canister to a zip-lock bag, making sure I get all of it.

Slides 19-21 The next slides show the results of the Elgin testing. Ranger mentioned the pickup efficiencies that I documented for the Elgin sweepers were much greater than those recently obtained in LA. However, the results I will show later for the Cities of Burbank and Glendale, CA were also not as good as the Elgin tests. For Elgin, we tested three different types of sweepers. We tested a single Whirlwind vacuum, two regenerative air models, and the mechanical Eagle. The Eagle was tested with and without water. Notice that when water was used for dust suppression, the pickup performance was reduced by approximately 20%.

The Elgin pickup performances were very impressive. The Whirlwind did a slightly better job than the Crosswind regenerative. And the mechanical

broom sweeper didn't do that bad at all. In fact, it was surprisingly better than what I expected, even in the fine particle range. So, for those manufacturing mechanical sweepers who are afraid this test will not bode well for your product, one might be surprised.

That's especially so when water is used for dust suppression, which will likely be our recommendation for the upcoming Santa Barbara tests. I've never tested these air machines with water, so we really don't know the impact water has on their pickup performance until we try that. Dust suppression is a huge issue, and until dustless sweeper designs are improved and refined it will remain the real world we currently live in.

Slide 22: The last slide was the results of the testing that was done for the Cities of Glendale and Burbank, California in 2012. All of the results shown were tests that didn't use water for dust suppression, and air quality was not monitored during the tests. Nor was it for the Elgin tests.

The slide was part of a presentation I made to StormCon in 2013. As you can see we tested five different sweepers. These were all machines being operated by Burbank and Glendale at the time. For these tests we varied the weight of the material being swept and the forward speed. I averaged the results of each sweeper and showed that in the last column of the table. The regenerative air sweepers did very well, and so did the Allianz air machine (Allianz is no longer in business).

The Schwarze M6000 mechanical sweeper came in at only 55.5% removal. However, if you look down at the mechanical Broom Bear, it came in with 68.7% as the average pickup performance for all four of its different test runs. Yet the work that Los Angeles recently did came up with only a 35% pickup rate for an Elgin Broom Bear. So, I suspect there were some problems with that Broom Bear, which needs to be considered when reviewing those results.

When you want to test a sweeper, you must ensure it's in top operating condition. It can be old, but let's ensure it has the proper broom bristle lengths and configuration and operates mechanically as designed.

James “Jamie” Houle, Ph.D., Director of the UNH Stormwater Center
His Ph.D. in Natural Resources and Environmental Science and over twenty years of experience with water quality related issues in New England; and, he is a certified professional in stormwater quality (CPSWQ) and a certified professional in erosion and sediment control (CPESC).

*Open and follow along with Jame’s presentation, entitled “**Clean Sweep Ground Truthing Organic Matter Collection for New Hampshire Communities**” The link, which is provided as a pdf file, is located here. Slide numbers to match content of the presentation are shown throughout as you read.*

Everything I'm going to talk about is available online. Check out this PDF link to gain access to all of our materials. (Link from UNH added to WorldSweeper website to facilitate widespread access.)

Being in the Northeast, I think I'm not going to say anything too different from what Mike Trojan will say. Being forthright, we basically took Minnesota's great, measured sweeping credit program, and we're trying to adopt it here in the Northeast. However, we did do some follow up research.

If you look throughout the literature on sweeping studies it is dominated by particle and particle size characteristics. Those are indicative of only a part of our seasonal street debris. In the northeast we have a street sweeping season that's bifurcated into two distinct seasons that have very, very different debris characteristics.

We have a non-fall season that's dominated by street dirt with typical particle-associated characteristics. In the fall, the debris is dominated by organic leaf litter. We stand on the shoulders of a lot of Bill Selbig’s work

out of the USGS in Wisconsin, who started to detail this as it pertains to nutrient loading.

PDF page 3: In most areas of New England people are worried about phosphorus, and we're worried about nitrogen as well in our coastal areas. Like in MN we found that up to about 60 to 70% of the annual load is deposited during the fall season for phosphorus, and the same thing occurs for nitrogen as well.

So we think that there's a huge upside to our sweeping operations particularly in the fall, which I would call a kind of source control for nutrients. (Via sweeping) we can prevent a lot of the phosphorus and nitrogen from actually making it into our closed drainage networks. That's what the research is focused on, we also focus on crediting programs because in our area we have a lot of water quality impairments. We also have something called 'residual destination authority' that's just launching throughout the Northeast now that really requires phosphorus and nitrogen control plans along with tracking and accounting for nutrient load reductions. This dominates a lot of our research on structural controls.

PDF page 6: However, I really feel like there's a missed opportunity on the non-structural side. This is something that our MS4 permits require communities to do already, and we feel that the current credits that are out there for these operations severely underestimate the load that can that be eliminated through sweeping operations.

So the more we can enhance the operational side of street sweeping, the better. We thought early on there were different operational efficiencies with respect to different types of sweeper technologies. Our permits largely focus on vacuum and vacuum-assisted sweeping technologies with the idea that they are more efficient at picking up the debris. But from a practical perspective, when we get to the boots on the ground, we find that there are a lot of problems in the northeast, particularly around the fall season, with vacuum and vacuum-assisted type sweepers. The most functional operations teams really use some type of tandem sweeping, or a mix of operational approaches.

So if you send an air sweeper out in the fall to collect leaves, which are never going to be totally dry unless we don't have rain or precipitation which we get about once every three days, it's going to be very, very

difficult to pick stuff up with a straight air/vacuum sweeper technology. So we often see mechanical sweepers go out first followed by a vacuum sweeper for polishing and to pick up the remaining debris.

PDF pages 7 - 10: Some municipalities use mixes of other technologies, some emphasize more personnel. I don't think there's a one size fits all approach. This is an operational approach that we're only starting to begin to play with or adapt to better meet these types of non-structural control measures.

We adopted, forthright, the Minnesota data, and particularly the pollutant load data associated with the fall and non-fall seasons. When we did follow up with data collection the results were very close to what the University of Minnesota studies documented, which gave us a lot of confidence in the methods.

There's also a ‘conservativeness’ that the Minnesota approaches this with, meaning they don't just take the average values. They only take the first quartile range for phosphorus loading, which is the same approach we adopted for phosphorus and nitrogen so we're already reducing the estimated load that we're picking up from the pavement.

The one thing that we've done on top of Minnesota's work is we've started to develop regressions so we can estimate volume and get credits associated with volume. The MN credit is based on mass of collected material so we have developed conversions from volume to mass. And of course, this takes into account the fall and non-fall season; the bulk density associated with fall operations is completely different than the bulk density associated with non-fall operations. If you think about a cubic yard of leaves and debris that's dominated by organic material, that's very, very different than a cubic yard of street dirt associated with sanding and salting operations.

So we've started to do those regressions, because in order to take advantage of the Minnesota credit you need a weight. Unfortunately, we find that a lot of communities here don't have scales, and that’s a problem. (As a result) we find that estimating volume of material collected is a lot more manageable, at least on the ground by the practitioners that are doing this on a day-to-day basis. So that's one of the additions that we've added.

We also looked at the existing modeled credits associated with our 2017 permits and have updated them. Those are being adopted in the new permits that are just coming out right now. But there's almost an order of magnitude difference between even the new model credits and the measured approach. And so from a credit perspective, if I'm a community and I'm trying to convince my community to spend money on sweeping operations and purchase new sweepers and hire new operators, what justifies that is the nutrient load reduction credits that helps with permit compliance.

(In my slide) What I'm showing is the old measured credit, which is almost laughable how small it is. So if we apply the old modeled credit, it basically takes a pollutant load export rate and assigns it to the land use; in this case, we're talking about medium density residential land uses in general. We then look at collection over a certain area of associated impervious cover that you estimate from your sweeping efforts either in lane miles or area (acreage). Lane miles times a standard lane width, typically, we use about eight feet, we can find the area of impervious swept and access the credits.

Comparing that to the measured approach, meaning if you collect it you get credit for it, I think that’s something we have to be open to. Because, if you think about typical operations, you don’t need to be up to date with all the math associated with developing a credit using the model, we now explain to them that if you pick it up, you get credit for it. I mean, that one is very easy to understand, and it actually incentivizes the behavior, the type of behavior that we want, which is more and more operational removal of this load. That’s an embraceable concept, and one that there is very little downside to.

Mike Trojan might be seeing this approach is gaining steam, where you have communities that are trying to outpace each other. So there's a lot of really exciting and kind of inspirational outcomes that could be associated with this measured approach. Currently we're looking at the drafts of our new permits, and the measured approach is not in there, and I'm not exactly sure why.

I think we've been told by our permit writers that it's a lot easier to write in the model credit than it is to write in the variables associated with a

measured approach. But we're really working to change that here in the Northeast, and we're standing on the shoulders of giants like Minnesota that have started this. The last thing to consider is the average bulk density.

We're collecting samples, and then applying these multipliers to fall and non-fall seasonal volumes. By using the Minnesota approach, then applying this bulk density, we can now translate from volume estimates to mass.

One more thing: And as far as costs, (these credits for sweeping) are pretty much a game changer. It’s the collection of organic material in the fall that's really where we see removal of the bulk of the nutrient load. Our goal is clean streets, but it's also nutrient load reductions because that's what dominates our permit requirements.

What street sweeping can do is very encouraging from a dollar per pound for removal perspective compared to any structural controls. The caveat here is that, conceivably, if you build a structural control, you get this credit in perpetuity. So people have argued, well, this cost is a yearly cost, so every year I have to go pick that up. And certainly that's true. It's an operational cost and an activity that needs to be repeated annually.

I don't think you have to pay for the equipment every year. You certainly have to pay for the man hours. But one of the things that's masked in these costs associated with the structural controls is the long term operation and maintenance burden.

We see many communities, especially in the northeast, are very behind on the inspection and maintenance of existing structural stormwater control measures. While they get credit in perpetuity on paper now it is conceivable that somewhere down the road there will be inspection and maintenance requirements associated with these load reductions.

The lack of operation and maintenance of these facilities diminishes their function to almost nothing, perhaps after as little as five years. That caveat needs to be discussed. An ancillary benefit to investing is sweeping and even catch basin cleaning is that you are investing in operation and maintenance staff.

When we talk about the functional efficiency of this type of load reduction, I think sweeping operations are well within the operational grasp of municipalities compared to designing subsurface gravel wetland systems and constructing them throughout the built environment. And certainly there's a learning curve with respect to operation and maintenance of those facilities. So sweeping has become kind of the lowest of the low hanging fruit.

My advice to municipalities that are struggling with these new and ever-increasing load reduction requirements is before you get into wide scale implementation of structural controls, make sure that you're hitting the easy things out of the park. All the non-structural stuff, like street sweeping and catch basin cleaning are more routine and likely already required at some frequency.

But without these improved credits and without more information and more research around the operational efficiencies of these activities like sweeping this is still kind of a hard sell to communities because they have too much to do with too little staff. Without the data and the economic estimates it’s difficult to really convince them that they should weigh in heavily on the sweeping operations. That’s why developing data via testing is so critical.

James was asked to clarify for anyone who doesn’t already know what structural versus non-structural solutions means. He responded: Structural is building something, implementing something, as opposed to something that is more some type of activity.

Non-structural controls for storm water are largely sweeping, catch basin cleaning, which was mentioned earlier, and educational campaigns. Even though we also stand on the shoulders of folks in the Chesapeake Bay area that have been working on these credits for decades, they have yet to develop a load reduction associated with outreach and education.

Mike Trojan, **Hydrologist Emeritus, Stormwater Pollution Abatement**
*It is strongly suggested that readers open and follow along with Mike's presentation, entitled "***Creating MS4 Credits for Sweeping***" The link is provided as a pdf file. Slide numbers to match content of the presentation are shown throughout as you read.*

Slide 1: We have to hear things a number of times for them to sink in. Jamie talked about credit. So what is the credit? And he explained, it's based upon the amount of pollutant reduction that you get from a certain practice. So, in this example (shown on his slide), if you only filter the captured runoff and send it back to the storm sewer system, you get a 60% credit for sediment. If you infiltrate the runoff, you 100% credit. So that's the credit.

Slide 2-4: Credits, as Jamie mentioned, are used to meet permit requirements or to meet local water quality goals that people have to meet. For those you need to quantify the pollution. Historically, structural practices have been credited, like rain gardens, ponds and swales. Non-structural practices like street sweeping have not been credited or have been under-credited.

In fact, when we did a literature review back about four years ago, we found out that about 75% of the MS4s don't even give a credit for street sweeping. Also, the credits that did exist at the time, like this one (see Slide 5) from the Chesapeake Bay were pretty low. Although we've known about Roger Sutherland's sweeper testing work over the years, it's Bill Selbig's work that really brought this to light for us in Minnesota. That's because Bill's work was done in Wisconsin, right next door to us in Minnesota.

Slide 5: We didn't currently have any illusions that we're going to get 84% of the annual phosphorus load removed with street sweeping. But then Bill showed, next door in Wisconsin, that that was a high end number that you *could* get.

Slide 6: The bottom line is that if you do sweeping at the right place, at the right time and with the right equipment, you can get some pretty effective results. So I've identified four crediting approaches. The first one mentioned are the Chesapeake Bay numbers that I showed earlier. They're based on removal efficiency value. You get 10% per lane mile swept or something like that. They're an empirical approach.

There's also a modeling approach, as Jamie mentioned. We have no doubt that if the right model existed, it could do a good job. Then, there's monitoring, and this is some of the work that's being done in Southern California. Elizabeth Fassman-Beck, is leading this group.

If you go out and monitor the water quality (from runoff) before and after sweeping, that's probably the best indicator of what you're picking up. But the problem with that is you can't control all the factors that come into play, like speed, pavement condition, and type of sweeper.

Then there's this mass-based approach that we used here in Minnesota. Our motivation behind it was just to get people to start sweeping. We'll give you credit for sweeping. Just start going out and start picking up what's on the roads.

Slide 7: How does it work? Well, you collect a certain amount of mass, and you multiply that by the pollutant concentration in the material. You need to know the dry weight mass, or the water content, and you need to know the amount of material, the mass of material that you're collecting.

Those two are really not that difficult to get with the right equipment. This last one, that we need to know the pollutant concentration in the material, is more challenging. It's highly variable with location and season; we see spikes of phosphorus and nitrogen concentrations in the sweeping material in the autumn.

Slide 8: We worked with University of Minnesota to do some research to derive relationships between pollutant concentration and the material. At the end of the study, we developed a street sweeping calculator where you can calculate phosphorus removed. The model option on the right is which is miles swept. You can see that generates a low removal amount. If you go out and you collect the material, you can get a pretty good credit, again depending on how you do it. It's a very easy tool to use.

Slide 9: You put in the dry mass that you collected and you determine whether it was done in the fall or not during the fall. There are two options, fall leaf collection and non-fall leaf collection. You also have an option to look at percent of organic matter. Then, at the bottom, it will tell you the pounds of phosphorus removed.

As the slide shows in this particular example, we are removing 0.13 pounds. We have a wet mass option also if you know the water content. The volume approach that Jamie mentioned works, but we did not have that option. We heard from the MS4s, the cities, that the volume option would be the most favorable option, but we were not able to establish those relationships. Jamie talked about ‘stealing’ stuff from Minnesota. I think maybe we'll be trying to steal some of that stuff from Jamie now.

Slide 10: The main advantage of the mass based approach is the results are not affected by variables such as driver, speed, parked cars, season, etc. You just go out, you collect material, you measure it, and you get a credit. So it's really not that difficult to implement.

However, there are some problems with it. Removing a pound of pollutant from the street does not equal removing a pound of pollutant that's going to be received by your lake or river, especially if you leave on the pavement a lot of the fine materials where the pollutants tend to accumulate more.

Those relationships are very difficult to establish, and I believe there might be some work trying to get at that particular question. The work that Roger showed earlier was encouraging in that the sweepers appear to be doing a pretty good job with some of the finer materials.

The relationships between pollutant concentration and mass of material are also difficult to establish. As was mentioned, we take a conservative approach by taking the lower quartile of what we found in our research rather than the average or the median of that. With that, it's very quick overview.

One other thing before I move on. Jamie mentioned at the end about getting education. The University of Minnesota has picked up on this and now offers a sweeping class every year, which is being done through the

University of Minnesota Extension Office. It's one thing to do the work, but then it’s important to spread the message, too.

Ranger Kidwell-Ross:

Street Sweeping Far More Effective — and Cost-Effective — Than All Other BMPs for Stormwater Runoff Pollutant Removal

$Cost/Pound: TN, TP, PM for Separation or Recovery

All $Costs/Pound Updated to Reflect 2020 CPI

TN = Total Nitrogen • TP = Total Phosphorus • PM = Particulate Matter

Separation or Recovery Method	Cost ($/lb) (excluding SW landfill costs) TN	TP	PM
BMP Treatment Train[a]	$1,068	$37,243	$29.70
FL Database for BMPs[b]	$2,171	$11,995	$46.84
Screened Hydrodynamic Separator[c] (Range of costs shown in parentheses.)	$4,261 ($1,462 - 16,976)	$10,521 ($3,621 - $41,903)	$4.60 ($1 - $15)
Baffled Hydrodynamic Separator[c] (Range of costs shown in parentheses.)	$3,450 ($1,462 - $16,976)	$8,511 ($3,621 - $41,904)	$3.43 (1 - 15)
Catch Basin Cleaning[d] (2nd lowest)	$1,016	$1,656	$0.70
Street Cleaning (*lowest cost*)	$189	$294	$0.11

The graphic above is derived from an exhaustive series of studies done by the University of Florida, with support from the Florida Stormwater Association and the Florida Department of Environmental Protection. These studies were done with the involvement of 14 MS4s. The three studies were completed in 2007, 2011 and 2019.

These organizations have very strong data on what they found out. However, they unfortunately did not separate out the data between mechanical broom and air sweepers. Dr. Sansalone, the principal investigator, agreed that was unfortunate in retrospect but said it would probably cost $100,000 to go back now and do that. Had that been done, the data would likely show air sweepers to be even more cost-effective per pound of pollutant removed.

The graphic above shows the cost of having a mixed fleet of air and broom sweepers remove a pound of nitrogen, a pound of phosphorus, and general particulate matter (PM). PM is the stuff that has to be removed to achieve good cosmetics so that a street looks good. Shown in the graphic are the different treatments that can handle that sort of thing.

Look at the much higher cost in all of these instances for everything besides sweeping: Street sweeping came up with a cost of $189 per pound of nitrogen, $294 for a pound of phosphorus. The other methods were as high as over $37,000 to remove a pound of phosphorus.

Southern California now has a commitment to remove trash as well as microplastics. So we need to put those two items into our street sweeper testing process in the summer of 2025. But if you think about the overall comparative value of sweeping, which includes getting rid of the pollutant-laden small micron material as well as the particulate matter, it costs 11 cents a pound to do that via a sweeper. With catch basins, PM removal runs up to 70 cents per pound.

That's just a thumbnail of what is happening out in the ‘real world,’ whether the stormwater community realizes it or not. We learned earlier that a very low credit system is being offered in the Chesapeake area, because of whatever process they went through. However, given data from these other areas that amount of credit is actually way too low for the process of sweeping.

The reason for getting the street sweeper manufacturers together to understand all this is to help them realize that the industry needs a unified testing process done for the sweepers in the US marketplace — one that is not just pass/fail. Stormwater professionals and others need to know how well the different sweeper types and models can perform.

The published data should include the different sizes of micron material that were there to pick up and the amount/percentage that each sweeper was able to remove. Finally, the information then needs to get somehow unified and presented in a venue and fashion so the stormwater sector can understand it.

My suggestion has long been that the industry needs a Sweeper Manufacturers Association, something I believe the manufacturers would benefit by doing. However it occurs, though, it is vitally important that testing data are developed and then made widely available to, and recognized by, the stormwater community.

Those are the people now under pressure to hit their prescribed removal of Total Maximum Daily Loads (TMDLs) so as to satisfy their EPA and state permit requirements. Many MS4s are no doubt currently out of compliance with their TMDLs due to regulatory complexities and the nature of their discharges. The situation varies by region as well as by the specific water bodies involved.

If street sweeping is to become the leading BMP for pavement-based pollution removal — data from current overall testing clearly show it deserves that status — the stormwater community will require a testing process that is respected and understood. When that happens, the industry won't be limited to trying to convince prospects about the extraordinary value of street sweeping by providing variations of data from Chesapeake to Florida to Wisconsin to New Hampshire and so forth.

The sweeping industry needs a process, one that will be generally accepted by the stormwater pros around the country. The amount of street sweeping and the amount of tandem sweeping and so forth can and should be significantly increased through that process. And with that, let me introduce Dr. Seth Brown.

Dr. Seth Brown, Executive Director of the National Municipal Stormwater Alliance and STEPP
Open and follow along with Seth's presentation, entitled ***"Overview of the STEPP Program and the Applicability in the Street Sweeping Industry****." Note the link is provided as a pdf file. Slide numbers to match content of the presentation are shown throughout as you read.*

Thanks for everybody's time and thanks to Ranger for putting this all together. The perspective that I'm going to bring here is not the research. There's good research going on; great research going on. But I want to provide some insight to what you're talking about in terms of gaining a national perspective. A way to unify how we credit, how we research, and especially how we credit practices such as street sweeping for stormwater pollutant removal.

Slide 1: The National Municipal Stormwater Alliance (NMSA) is the group that that I lead as Executive Director. I'll give some context on NMSA, as well as the stormwater sector at large that NMSA represents. To start, we're calling it an 'Alliance' because we don't represent professionals as individuals.

We represent organizations, whether that's companies or whether that's nonprofits and others that have some kind of tie to what's called an MS4, which is a "municipal, separate storm sewer system." That's the moniker that's used in the regulatory context. Our stated goal is to "develop a national testing/evaluation and verification program for stormwater products and practices."

MS4s are municipalities and other entities such as universities or hospitals or airports and more that are required by federal law to get a permit to discharge urban runoff. There are about 7,250 of these entities across the

country. Allow me to give you a sense of scale about our organization: NMSA was founded in 2016 its 501c3 approval in 2018. We started with five state organizations.

The environmental regulations in the country are under the construct of federalism, which is to say that there's a federal rule. However, states are given the power to enforce those rules at the state level. All but four states in the country have their own stormwater programs that they regulate on their own. Jamie, who you heard from earlier, is associated with two of those, New Hampshire and Massachusetts. The other two are Idaho and New Mexico. I think we're going to see big movement to get those remaining four to start regulating themselves during the next administration.

The point is that the states have a lot of power in this area. Organically, there have been a number of state organizations that represent stormwater programs that have been established. The biggest I believe is the California Stormwater Quality Association, which represents the entire state of California. There's a Florida Stormwater Association, the Ohio Stormwater Association, and Minnesota's is the Minnesota Cities Stormwater Coalition.

But for at least 35-40 states, there's a formal organization that represents the stormwater discharges in their state. NMSA represents 26 of those state organizations, or over half the country. And if you add up all the communities, that includes 4,400 of them, so that's over half the MS4s that are out there.

My point is that NMSA represents a pretty good swath of the country and the interests of those who implement these stormwater programs. And just to give you a sense of scale on the sector, every two years there's an organization called the Water Environment Federation (WEF) that does a survey of the MS4s. We help them out as well; I do a lot of the analysis for them and we have found that the total money spent annually in the budgets of the stormwater programs across the country ranges between $20 and $30 billion; there's a funding gap of between $7.5 and $8.5 billion dollars as well. So there's a lot of unmet needs. It's been 10 years since the EPA did their last survey of needs in the sector.

It's been 10 years since the EPA did their last survey of needs in the sector. Specifically, EPA does their own type of survey on drinking water, and the “Clean Water” sector (wastewater and stormwater). They found a 385% increase in the needs of the stormwater sector from the 2022 survey compared to the 2012 survey. The point being, stormwater is a significant sector and it's growing. Issues related to resilience and flooding are growing.

All that is driving more interest in these programs and in managing stormwater on the quantity side as well as how much we have to manage on the quality side. There is more and more research going on that identifies the issues that have been talked about here, emerging concerns like microplastics and PFAS. More recently, 6PPD-quinone, which is an aspect of, or a chemical within, tires that wears off. That's becoming a big deal especially in the Pacific Northwest where it has been shown to be highly toxic to salmon species.

There's a lot of interest across the country identifying street sweeping as one of the ways to manage these problems in a nonstructural way; probably one of the most effective ways. That’s some context on the stormwater sector where I'm coming from, who I represent, and the scale of the sector. I will also say that the performance of stormwater infrastructure is not well understood.

We're very young sector compared to wastewater and drinking water, other types of environmental issues. It's difficult. It's a chaotic system, right? Wastewater systems are highly regulated, but they're also highly engineered: they’re in plants, there's pumps, there's faucets. By contrast, in the stormwater world we're at the whim of the weather, which in the last number of years has been becoming even more chaotic than it has been traditionally. So it’s a difficult infrastructure to try to measure performance in and getting more so.

Slide 2-5: That all said, there's a greater and greater realization that we need to have a better recognition about, or appreciation and understanding of the performance of different ways to improve in the sector. Essentially, that’s why NMSA was started. The STEPP program was started by the Water Environment Federation over a decade ago, as a concept. We took it over about 2021 and have grown it since we launched it. Basically, you can think about our STEPP program (the acronym that

stands for Stormwater Testing and Evaluation for Products and Practices), as the Consumer Reports™ for stormwater infrastructure.

We did this because, as Ranger talked about, there has been no national effort prior to this to understand, in a consistent way, how all available stormwater pollution abatement systems perform. What is needed is a better understanding of how to make decisions on addressing stormwater management pollution.

Slide 6-11: Currently, there are two programs at the state level that are well known. New Jersey has a lab-based testing program. Washington state has a field-based program. We are leveraging both of these state level groups, helping to unify them to cover both lab and field testing. A national coverage is needed because those programs are now being used across the country, but they weren't designed that way. So we're trying to make the programs national; we're trying to improve water quality, and we're really trying to improve the value proposition for stormwater investments.

We are gaining a better understanding of performance, as I mentioned, so what do we do now? For one, we are developing ASTM testing standards. Here's where we are with that right now: specifically, we recently launched, in April of 2024, lab testing verification services for trash capture technologies. That's not being done anywhere by any other entity at all in the world that I know of, certainly not in the US. Two applications are going through our process right now. Our first verification is going to be done in probably March of this year, with a second one to follow a couple months later. That's what we are doing now.

In the future we are going to continue to develop ASTM standards. That's the basis that underpins our program, and we're going to continue to expand those. There's a street sweeping testing standard being developed currently. More should be developed, frankly, so we can take this great research that's going on and we can formalize it into standards that are internationally accepted and used. That's what will provide more credibility and consistency. That's really what we're talking about.

NMSA oversees the process of lab testing; we don't lead the testing ourselves. We oversee those who do the testing, and we make sure that they use the ASTM testing standards appropriately. We are going to expand upon the number of, and types of, similar technologies.

This could include, and I think should include, street sweeping technologies of all kinds. We're going to provide technical support to users, so that means to the city or county or whoever holds an MS4 permit, who needs to meet permit requirements, if they have some.

We've already seen today how cost-effective street sweeping appears to be. If we can provide verification of that performance and the verification of that cost-effectiveness, that's very powerful. That would help somebody who's running one of these programs allocate their very limited resources. All of them are trying to find the most cost-effective solutions.

I believe there's a great opportunity for the street sweeping industry in this context. NMSA could assist not only in generating the verified performance data, but we also could help provide the context for what this data means and how to you use it.

However, here is what we do not do: We do not perform testing ourselves and we do not certify products or practices. We do provide verified information. Again, certification means you can use a particular product in a given state or jurisdiction. However, doing so is up to the jurisdictions, not to us.

ASTM is what we use, and we're using ASTM as the standards testing organization as this organization is familiar to and used by a lot of engineers across the country, across the world, so it's a shorthand when we term something an ASTM standard. That makes it a lot easier, a lot more accepted for use, and people will tend to appreciate and understand and trust the data that comes out of an ASTM standard.

Standardized testing is really what we rely on to provide robust, consistent. We need test methods that provide data that people can trust, and verification just means someone comes in with a performance claim that we can verify. We use third party reviewers; some of the best researchers in the world can and do review this information, which provides even more credibility of the data that's produced.

A simplified version of how the verification process works is this: a product or practice representative submits an application to our program, the STEPP program. We review the application and make sure we have all the information we need. We review the plan, the plan for testing or the quality

assurance, and we also have that reviewed externally. Once the testing is done, we review the reports. We have our external group review the report, and there's also a public review process. We're trying to be as transparent as we can with this process.

We store and handle that data, and then we provide a proof of verification; basically, saying testing was done. We verified the performance, and using these we can verify that the standards were followed that were supposed to be followed. As a result this becomes trusted data.

We provide that back to the representative. They then go and request certification for use by jurisdictions or states and are either accepted or not. If not, it starts over again if necessary. We verify performance certification, since we can now provide the information to them quickly and easily.

The NMSA/STEPP organizations provide technical support to our members, which are states, jurisdictions and others. They are the ones who are going to employ and purchase stormwater infrastructure along with practices and products. They want to know “how do I use this data?” and “How does this work in my program or in my climate?” These are things that don't exist right now but these are the types of questions that need to be answered at the local level for jurisdictions to be able to meet their permits.

We feel that the value of STEPP is that it helps to write informed decisions. We help those who are making decisions to understand what is the most cost-effective way of doing what needs to be done. We're trying to foster this national marketplace. Right now, if you have a product or service you have to go jurisdiction by jurisdiction, state by state. It's not an open and unified market, it's a highly inefficient, fragmented market.

Our job as an organization is to help stormwater programs get the best, most effective and technically effective solutions possible to meet their needs. The more we can do, the more water quality improvement we're going to see.

As for who's paying for the program — we want this to be broadly used and we're getting we're adding public members all the time. We currently have the capital region in Minnesota, which is the Watershed District there

in Saint Paul that represents, I think five communities. Northern Kentucky's Sanitation District 1 is also on board: They represent 30 plus communities. We also have the Department Ecology in Washington State and others.

Slide 12: We also have a lot in the industry paying for this, because they see the opportunity and the benefit to them. As I mentioned we've launched a lot as an organization and as a program this year, things that have been a long time coming. At stormwatertesting.org you can find out more information.

Slide 13: We have a number of applications currently going through and being processed and we expect many more in 2025. An ever increasing number of communities want to have more information they can rely on about street sweeping, because I think they believe that there is more credit to be gained from street sweeping. And we believe so too. We're talking to Colorado, we're talking to Indianapolis, and many others that are we hope will join shortly and we are confident we're going to get many more members in the next one or two years.

We're also part of the Centers of Excellence for Stormwater Infrastructure and Technology. STEPP is part of these centers of excellence, organizations that are really focusing on research and increasingly getting into field testing as well.

Ranger Kidwell-Ross:
We have to come up with a testing process that is fair for everybody. It also has to be replicable. The current South Coast Air Quality Management Districts (SCAQMD) so-called 'PM10 Compliance' test is not viable. I was at that test. They had 10% paint pigment as their PM10s.

I was told by testing officials, as I recall, that they lowered the curve to 70% as the pickup level needed for a sweeper to pass. That means a sweeper could have left *all* of the paint pigment and 19% of the rest and still passed. SCAQMD was mostly interested in air quality anyway, not stormwater runoff pollutant removal.

The industry also needs a testing process that separates out broom vs. air sweeper results. Another current challenge is that, as an industry, an estimated 3 million gallons of water becomes polluted every day via the dust suppression systems of street sweepers. As Roger related, at least

one study has shown that a sweeper picks up 20% less small micron material when using water.

In the Sea Grant testing process Roger and I will conduct in the summer of 2025, it appears that our budget will only allow testing of four to six sweepers. If so, it will be difficult picking the make/models that should be tested.

However, with some financial input from the combined group of sweeper manufacturers we would have the ability to test more in California. It would increase the validity and acceptance if we have a larger number of makes and models in that test.

As a component of the Sea Grant California study we're also developing an Internet app that will allow citizens to receive real time notification of when their cars need to be out of the way, instead of the current typical four-hour timeframe. Wherever you want street sweeping to be most effective the cars have to not be there. At least three car lengths are lost for every one car parked on a street during sweeping.

With the app that will be developed, instead of having to move their car for a four-hour window citizens will be able to log on and get notices to see when the sweeper is coming. People can be notified the day before, as an example, as well as when the sweeper is a mile away. They will then have the opportunity to move their car out of the way and re-park as soon as the sweeper passes.

Instead of having ‘meter maids’ come around behind a sweeper — who knows how far behind — we intend to put ‘ticketing cameras’ onto the sweepers. Those can transmit the vehicle information to wherever it needs to go in order to send tickets to the owners of vehicles that were in the way. Even when people can re-park after a sweeper goes by, tickets will still pay for a significant portion of the of the process of street sweeping.

These are the kinds of things that we can bring into the world of street sweeping that are not there now. However, overriding all of these technological innovations, the only way street sweeping will become more widely embraced as the most cost-effective BMP for stormwater pollution removal requires testing that shows what various sweeper models can do.

Unified testing results, given what the results have been to date in Florida, Minnesota and elsewhere, will serve to expand significantly the amount of sweeping done in the US. Street sweeping will also become the catalyst for having MS4s receive needed credits for TMDL removal as a result of the amount and type of street sweeping performed.

Note to Readers:
For more information about sweeping and stormwater, we suggest you access the following informational PDF files located at the WorldSweeper website:

- The main benefits of connecting sweepers and stormwater professionals
- How policy changes can impact the collaboration between the sweeping community and stormwater professionals
- The many positive sweeping industry changes due to MS4 creation

In an earlier email we provided an opportunity to view the 15-minute, AI-generated, podcast based upon the presentation you've just read. To listen to that, which does a great job of synthesizing the value of street sweeper testing and then making the results available to the stormwater community, click here.

To start receiving the free, now bi-monthly, e-newsletter from WorldSweeper, go here to sign up. To contact Ranger Kidwell-Ross, the person who instigated and moderated the webinar detailed via this document, call 360.739.7323 (Pacific Time Zone) or send email to ranger@worldsweeper.com.