Historical and Current Overview on Characteristics and Capabilities of Street-Class Power Sweepers

Information developed and provided by:
Ranger Kidwell-Ross, Editor, WorldSweeper.com
Toll free: 866.635.2205 • Direct: 360.724.7355 • editor@worldsweeper.com
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Designers of sweeping programs who are located in areas with pollution runoff issues must stop thinking of sweeping as strictly a cosmetic practice. Instead, they need to learn about the relatively inexpensive role sweeping offers for removal of pollutants from the runoff stream.

In the early 1980s, a test of the effectiveness of street sweepers was conducted as part of the Nationwide Urban Runoff Program (NURP) studies. The statistically inconclusive results it reached about the value of street sweeping as a Best Management Practice for storm water runoff pollution have dogged the sweeping industry ever since. However, in recent years, the mandates of NPDES Phase I and II — especially with the advancement of TMDL requirements — have spurred a number of studies that make it clear sweeping deserves a more central role.

Street cleaning has the broadest potential for reducing storm water pollution in the urban environment. That's because half of all of the rain that falls on impervious surfaces connected to urban storm water collection systems are falling on pavement. In the past five years, updated sweeper designs that are much more efficient at picking up accumulated contaminants have entered the market. These are much more efficient than the older mechanical broom sweepers owned by a majority of communities today.

Yet, many jurisdictions that are now imposing storm water runoff taxes and spending high dollars in an attempt to reduce their runoff pollution have, at the same time, cut back on their sweeping efforts. The only rational reason can be that they lack knowledge about the positive, relatively cost-effective impact a well-planned environmental sweeping program now can attain.

Wherever Clean Water Act compliance is required, sweeping program designers in areas with pollution runoff issues must stop thinking of sweeping as strictly a cosmetic practice. Instead, they need to learn about the role newer sweepers can have in removing pollutants from the runoff stream.

Even a contemporary analysis of the ’80s NURP street sweeping studies, which were held in six locations around the U.S., shows the combined results were skewed significantly by an unexplainable, negative outcome in a just one of the test areas, North Carolina. When the results of that single test location are removed, the result shows sweeping has a statistically positive overall outcome.

More good news is that even today’s mechanical broom sweepers, the technology tested during the NURP trials, have a much-improved pickup efficiency. That said, even the new broom machines still have little facility for picking up particles smaller than about 63 microns. (For comparison, human hair is about 72 microns in width.)

When it came to small-micron materials the NURP-era broom sweepers, in some instances, left behind *more* small-micron particles than were removed. Even today, although to the untrained eye the path behind a mechanical broom sweeper may look clean, the broom’s rotation against the pavement and lack of a vacuum system combine to leave a significant level of small particles in place.

Until recent years, that fact hasn’t mattered. However, today we understand the importance of small-micron pickup: *Even though particles of under 250 microns compose less than 30% of the total material on most city streets, over 50% of the total runoff pollutants targeted by the USEPA Clean Water Act are typically attached to that smaller material.*

The strength of mechanical broom technology is its effectiveness at removing larger, coarse materials and gross pollutants. However, current studies indicate that, when pollutant-laden fine material needs to be removed, a mechanical broom sweeper is not a sensible choice.

Studies confirm the real-world pickup efficiency of the old broom sweepers is probably only between 20%–35%. Despite this fact, mechanical broom sweepers continue to be the leading type used by municipalities in the U.S. Mechanical broom sweepers remain popular for several reasons, perhaps the primary one being that sweeping managers are more familiar with the technology. There is also no question that broom machines have a better reputation for handling wet vegetation and large debris. Since the larger, more visible material is typically what spurs “we need a sweeper” phone calls to city hall, that is also a factor.

The good news: Recent testing shows that the overall pickup ability of the latest mechanical broom sweepers may have increased to as much as double that. However, the caveat is that the material left by broom sweepers most likely skews toward leaving the smaller micron material, which is what contains the majority of pollutants.

When it comes to removal of non-point source pollutants and meeting of the BMP requirements of Phase I and II, recent studies confirm that the newer technologies of regenerative air and vacuum sweeper models appear to clearly offer a better choice. In the past five years, designs that are much more efficient at picking up particles smaller than 250 microns have entered the market. [http://www.worldsweeper.com/Street/Studies/BurbankGlendaleTesting8.11.html] The latest testing indicates that the pickup efficiencies of regenerative air and vacuum sweepers, especially in light-to-medium debris, are 80% to 90%. This is much higher than the 30% widely cited in the NURP study mechanical broom results.

A study of structural BMPs by Caltrans indicates the cost per pound of pollutant removed as Total Suspended Solids (TSS), runs $14 to $84 (updated to 2015 dollars), *not including* land costs. Other studies by Sutherland indicate that today's mechanical broom sweepers reduce TSS for $7 to $13 per pound. Regenerative air and vacuum sweepers do so for $3 to $7 per pound of pollutant that would typically be transported in runoff. Air sweeper effectiveness is enhanced over mechanical broom sweepers since they rely on air technology to entrain the smaller debris and can be outfitted with a better system to entrain fugitive dust. However, keep in mind that both sweeper types remove vastly more large debris in conjunction with the small-micron pollutants.

Specifying sweepers with gutter broom pitch, tilt and speed adjustment are also important in order to maximize small micron pickup and minimize dust. In addition, dust suppression water nozzles can be included at the gutter broom.

A caution: Total pickup of smaller materials is dependent upon a variety of factors. Maximization of TSS pickup depends on proper utilization of the gutter brooms, speed of operation, correct usage, roadway condition and the ability of dust suppression systems. However, when it comes to runoff pollutant reduction, maximizing small-micron pickup and minimizing output of fugitive dust are the most important factors.

Like all infrastructure maintenance and repair items, sweeping frequency and machine purchase are dependent upon budget. However, the ever-tightening BMP mandates of Phase I and II are casting the cost of sweeping into a new light. The *relative* cost of sweeping, as compared to infrastructure-based pollution reduction efforts, should become the baseline. *As indicated above, sweeping is highly cost-effective when compared to structural best management practices such as detention ponds and settling or filtering devices.*

In 2015, data provided by Seattle Public Utilities, the City of Seattle, Washington's stormwater lead agency, indicated that, when it comes to removal of pollutants from the runoff stream, regenerative air sweepers were four-to-ten times as cost-effective as any of the City's end-of-the-pipe solutions. Seattle's data show that in 2011, its first year of enacting an air sweeping program as an adjunct to existing end-of-the-pipe solutions, the reduction in Seattle's stormwater pollutants entering Puget Sound was a whopping 300%.
(www.WorldSweeper.com/Street/BestPractices/SeattleSweepingProgram6.15.html)

For any agency that wants to institute a relatively low cost modeling of what sweeping might do in terms of pollution reduction, Sutherland's company has developed modeling software that uses historic rainfall data, which in most locales spans over 50 years, to accurately predict sweeping efficiencies for watersheds. This has aided a number of municipalities in determining relative pickup volume at given sweeping frequency intervals without having to conduct costly studies of their own.

For example, Sutherland's Livonia, Michigan, study found the optimal frequency (during the nine months when sweeping can occur in snow belt areas, since sweeping rarely occurs during the months of December through February) for residential areas was about once every 3 weeks. Every two weeks is typically reasonable for higher-density residential and general commercial. In major traffic areas, like arterials, optimal sweeping was determined to be once per week. Optimal frequency depends, however,

upon accumulation of the contaminated material typically called “street dirt.” Monitoring accumulation can be of great value, as well as determining the chemical component of what is collecting on given roadways.

There’s a tendency to sweep the downtown core on a daily basis for aesthetic reasons. In many instances, it would actually be cheaper to use the newer crop of relatively inexpensive pathway sweepers, or to do hand sweeping with youths at risk, etc. With a full-size sweeper, overall costs can be in the range of $150/mile, which is a high price to pay for this type of cosmetic sweeping.

Not only can a correctly designed sweeping program remove a significant amount of targeted chemicals; ‘correct’ sweeping also has a positive impact on the gross pollutants that contribute sediment, silt and organic debris to streams and other waterways. Another efficiency sweeping offers is that it prolongs the operational efficiency of structural-based devices, as well as reduces the ongoing maintenance they require. Although by no means a ‘silver bullet,’ widespread agreement is developing that sweeping should begin taking a more central role in storm water runoff plans.

Well-informed NPDES managers have become aware of how cost-effective sweeping is when compared to infrastructure-based solutions. As a result, they are now requiring an increase in air sweeper usage, combined with increased sweeping frequency, a foundation of their storm water runoff plans. The problem they’re faced with is that, even in the face of the EPA mandates, their budgets are still largely based on the frequency of sweeping needed to provide a pleasing aesthetic value and, to a lesser extent, keep storm drains flowing.

Because of power sweeping’s demonstrated lower cost per pound of pollutant removal, jurisdictions under Phase I or II mandates clearly should develop an optimal sweeping frequency designed to minimize the *overall* cost of meeting their non-point pollutant reduction goals. Only by comparing sweeping to end-of-the-pipe solutions, like sedimentation tanks and filters, grassy swales, detention ponds and all the other infrastructure-based solutions now emerging, can the most cost-effective mix of sweeping and other technologies be attained.

Once an optimal, least overall cost for achieving TMDL limits (or attainment of other goals) has been established for a given watershed, the next question is figuring out how to pay for that mixture of solutions. To assist in this regard, some cities are now including the sweeping department within the overall budget for storm water runoff reduction. That way, if a storm water utility fee is being collected through NPDES mandates, the cost of sweepers and sweeping can be funded as a component.

Following are the main points infrastructure managers should consider when trying to assess how sweeping should fit into their overall NPDES pollution reduction plan.

Foremost is to answer the question “Why are we sweeping?” Is it just for cosmetic/aesthetic reasons, or are there water quality aspects to consider? If the answer includes water quality, then collaborate with your storm water people to examine your current program. As you re-define your budget allocations, you’ll also want to put a larger value on the small-micron pickup effectiveness of the sweeper you choose. In addition, evaluate both the sweeping frequency and the conditions under which sweepers will be used.

If your target is water quality goals, forget about sweeping areas without curb-and-gutter, since there will be no appreciable accumulation. Talk to other managers in your regional area — especially those who own types of sweepers different from the ones you use currently — and find out what their experience has been.

Review the many sweeping studies available, most of which are available at the WorldSweeper.com website. (WorldSweeper.com/Street/Studies/ and WorldSweeper.com/Street/BestPractices/) Use the information compiled by other agencies, especially results from geographical areas similar to the one you're in, to make future sweeper purchase decisions that maximize the potential for addressing the water and/or air pollution problems in your particular area.

If you truly want a sweeper that will make a difference, do not simply rely on the well-known certification process for sweepers that was designed and conducted by a California agency, the South Coast Air Quality Management District (SCAQMD), when it was mandated in the 1990s to reduce airborne pollution in its jurisdictional area.

SCAQMD's "PM_{10} Certification" is now widely used by manufacturers to tout that the machines in their product line are effective environmental sweepers. The fact is that, over time, sweeper manufacturers have been able to find a way to certify virtually all makes and models of street sweepers. Over 50 models — including almost every type and configuration of street sweeper on the market — have gained certification via compliance with the brief SCAQMD test, rendering any given machine's compliance essentially meaningless.

Sweeper types aside, probably the single biggest factor driving street sweeping effectiveness is removal of vehicles on sweeping days. This is vital because a single car represents three spaces that can't be swept, since the sweeper operator must swing out around a car and then can't get back to the curb line until well past each parked vehicle.

Although often a political hot potato, with the rise of recognition about our deteriorating environmental landscape the negatives can be minimized via citizen education. It is vitally important to get 'buy-in' about why car removal during sweeping is so important. Develop and print brochures on the topic, and find innovative ways to distribute the information. For example, send the information out in city billing envelopes, put them onto your website as pdf files and provide them to environmental groups for distribution.

Many cities are now using the Internet creatively in this regard. For example, consider developing an email signup website location that automatically reminds citizens to move their cars prior to sweeping days. Keep in mind that, once in place, money collected from vehicle citations will create an income stream that may even pay for a major portion of the sweeping program.

You might also consider the contracting out of sweeping services to the private sector, which can often provide significant cost and service advantages. In England, statute requires that cities bid in-house sweeping against contractors every few years. This tends to keep municipal operations more efficient. Some larger U.K. municipalities even bid on providing sweeping to smaller cities nearby.

Some innovative U.S. sweeper dealers are now offering 'cradle-to-grave' sweeper purchases, another standard practice in Europe. With these arrangements, the cost is actually a monthly payment that includes all standard repair items and upkeep for the pre-agreed life of the sweeper and chassis, usually five years. This type of arrangement provides municipalities with the advantage of a predictable, steady budget item.

Another way to potentially save money when using a contractor is to issue computerized fuel cards for your municipal contract. When the city pays the tab for fuel, federal fuel excise taxes (currently $.28/gallon) and, if mandated, state fuel excise taxes, are refundable.

Also recommended is to remove disposal costs from your sweeping bids. Because future cost increases in this area are an unknown, experienced sweeping contractors realize they must overbid to account for unforeseen tipping fee increases that may not ever occur. Plus, when the contractor pays for disposal there is actually a disincentive to doing a great job; the more material that is removed from the roadway, the less money the contractor makes.

Is a portion of your pollution problem derived from runoff from commercial parking lots? Many cities have instituted an impervious surface area taxation schedule on their business communities. Monies collected are typically earmarked for use in pollution abatement efforts. Consider providing a refund to businesses that prove they sweep their entire surface area with an air sweeper at a given frequency.

To provide a positive monetary incentive in this regard, collect data from local sweeping contractors to determine an average cost per sweep per acre, for example, in your area. Then, be sure the impervious area tax refund you offer is more than enough to cover their cost of sweeping. After all, the goal is to remove pollutants from the runoff stream, not to penalize your business sector.

When you are in the market for a sweeper, be sure to test current models according to your particular requirements. If leaves are your biggest problem, then finalize your sweeper purchase in the fall when you can compare the current sweeper models on their ability to pick them up. If snow (i.e., sand and cinders cleanup) is the central issue, then test under those conditions.

I've seen cities in all parts of the country test sweepers by putting an impossible amount of material down in some municipal parking area and then eyeballing which sweeper appears to leave behind the smallest pile. This methodology is especially senseless when choosing a sweeper for environmental reasons.

If you're in the snow belt, investigate the new crop of waterless sweepers designed to let you sweep all year long. If the machine offers a transport system to move the particles the broom raises away from the pavement's surface, these offer dry pickup of much finer particles than is possible when no air assist is present. Even though a newer mechanical broom sweeper moves the fine particles, without air assist or the presence of water for dust suppression, the particles simply fall back to the ground.

Today, a number of sweeper models can be operated on CNG or other diesel alternatives. However, since by 2010 the emissions of diesel engines will be cleaner than the current CNG engines, most CNG conversion companies have already exited

the marketplace. Further, CNG appears to only be widely accepted in Southern California where it's mandated. Paradoxically, the mandate has actually eliminated the ability to sell some high efficiency sweeper models since they are unable to use the limited number of CNG options available.

Is most of the material within 3-feet of the curb line? One of the current models of vacuum sweepers offers a side-shift sweeping head that allows it to employ suction right up next to the curb.

Need to find ways to get more bang for your buck? You may be able to work creatively with sweeping contractors in other ways than hiring them to sweep. These may include sweeper repair and assistance with sweeper selection.

Establishing a debris-screening and/or composting program can save over 50% on disposal costs. If one of your local sweeping contractors operates a debris-screening program, the company may have enough capacity to add city debris to its existing operation.

If your city is small, investigate sharing a sweeper and its usage with one or more neighboring districts. Some smaller California cities have found value in combining budgets to fund a storm water runoff compliance official in charge of keeping up with the information needed to assure each of the cities stays compliant.

Some cities have found other ways for their sweepers to pull double duty. The City of Palmdale, California, has found another creative way for their sweepers to pull double duty. The city has employed a video camera system that's mounted on the dash of its sweepers. Drivers are trained to look for problem areas and the system makes it easy to create a 'report flag' on the video. Since the sweeper is traversing most areas of a city, it can be an inexpensive way to spot graffiti, signs down, lights out, curbs needing repair, overhanging trees, pothole problems, etc. The system also documents exactly when sweeping occurred at any particular location.

People do what they do now because of learned behavior. This includes both your sweeping personnel and your citizens. Both need to be educated about the latest in industry findings. You may find that your sweeping department passionately defends its current use of outmoded or inappropriate sweepers, as well as the fact they are deployed inefficiently or are on routes that are too infrequent to do much good.

Educate your sweeping managers, as well as rank-and-file sweeper operators, about why a different sweeping frequency, type of sweeper or switching to air-based technology now makes more sense. You'll find doing so can even have positive implications for how well any new sweepers will be operated and maintained.

Another way to reduce overall sweeping costs is to switch to one of the variety of high-dumping sweepers that are now available. These are designed to dump into dump trucks or roll-off containers, instead of using the sweeper for transport to a disposal facility.

Use of high-dumping sweepers keeps the relatively more expensive sweeper on the job, as well as keeps small-micron material from escaping due to double handling.

In the long-term, in order to make your sweeping program more efficient you may find it cost-effective to upgrade part of your road system, especially in runoff non-attainment areas. For example, steep curb cuts and potholes degrade performance of all types of sweepers, but more so regenerative air and, to some extent, vacuum sweepers. Take a critical look at your roadway infrastructure to gain clues for improvement. Good pavement conditions result in a significant reduction of pollutants found in the runoff stream.

EPA Phase I permits now need to prove they are achieving BMP results, and Phase II permits will soon need to do the same. Before you spend significant dollars on retro-fitting and other relatively expensive infrastructure-based projects, you'd be well advised to learn how sweeping your streets with today's new technology is able to address runoff pollution on the order of 100% to 1000% more cost-effectively.

Ranger Kidwell-Ross was the founder and, for over a decade, editor of American Sweeper *magazine. Today he heads up the world's largest information resource dedicated to power sweeping, the WorldSweeper.com website. He is also the Executive Director of the World Sweeping Association (www.WorldSweepingPros.org) and the world's most published author on the topic of power sweeping.*

You may reach him via email sent to editor@worldsweeper.com. You may also reach him by calling, toll free, 866.635.2205.