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research report

Assessment of Soil and Wash Water Quality Beneath Salt-Spreader Racks

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16. Abstract

The Virginia Department of Transportation's (VDOT) winter maintenance program hinges primarily on the use of granular NaCl for deicing. On average, VDOT applies more than 300,000 tons of NaCl each winter season. The majority of this salt is spread by way of salt-spreaders attached to dump trucks. The spreaders require cleaning and lubricating after each use. The purpose of this research was to determine if VDOT should provide an impermeable surface beneath the spreaders to prevent potential contamination resulting from lubrication and, if so, to determine if washing could occur on the same impermeable surface, thus reducing the number of times the spreaders are handled by providing a single location for washing and lubricating.

The results showed that potentially significant volumes of excess lubricants can be generated by way of the spreader lubrication process and that this excess should, therefore, be captured. In the majority of cases, this could be done by means of a drip pan or similar device. Because of dilution, if washing and lubrication were to occur at the same location and the wash water and lubricant mixture were contained and conveyed to the nearby salt ponds, lubricant concentrations found in the pond water would be relatively low. Although laboratory results indicate that these concentrations could be reduced even further by way of an in-line organoclay filter, this method of lubricant capture would be more expensive and labor intensive than the simple use of drip pans.

Although paving beneath existing spreader racks was not advised unless other provisions for washing at the spreader racks are also made available, proposed best management practices were developed for three different site conditions that are likely to be found at VDOT's maintenance facilities. The benefits of following these practices include decreased potential for soil contamination beneath spreader racks and decreased potential for wash water runoff contamination and associated salt pond contamination.

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ABSTRACT

The Virginia Department of Transportation's (VDOT) winter maintenance program hinges primarily on the use of granular NaCl for deicing. On average, VDOT applies more than 300,000 tons of NaCl each winter season. The majority of this salt is spread by way of salt-spreaders attached to dump trucks. The spreaders require cleaning and lubricating after each use. The purpose of this research was to determine if VDOT should provide an impermeable surface beneath the spreaders to prevent potential contamination resulting from lubrication and, if so, to determine if washing could occur on the same impermeable surface, thus reducing the number of times the spreaders are handled by providing a single location for washing and lubricating.

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Although paving beneath existing spreader racks was not advised unless other provisions for washing at the spreader racks are also made available, proposed best management practices were developed for three different site conditions that are likely to be found at VDOT's maintenance facilities. The benefits of following these practices include decreased potential for soil contamination beneath spreader racks and decreased potential for wash water runoff contamination and associated salt pond contamination.

FINAL REPORT

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INTRODUCTION

Oil-water mixtures are a common waste stream in many industrial applications, oil production operations, and accidental spills (Cheryan and Rajagopalan, 1998; Gammoun et al., 2007; Vlasopoulos et al., 2006). The Virginia Department of Transportation (VDOT) is evaluating the advantages and disadvantages of providing an impermeable surface beneath the spreader racks with a drain conveyance to the salt pond. This design would permit washing and lubricating the spreader racks at one location, thus eliminating the need to handle the spreaders multiple times. One key part of this evaluation is the effective management of the resulting oil-water waste stream produced during the salt-spreader maintenance.

VDOT is responsible for maintaining more than 57,000 miles of interstate, primary, and secondary roadways. VDOT's winter maintenance program is correspondingly large and hinges primarily on the use of granular NaCl for deicing. Between 2000 and 2005, VDOT applied approximately 330,000 tons of NaCl per year. This salt, along with various other anti-icing chemicals, is stored at area headquarters and dedicated chemical storage facilities, at least one of which is located in every county. In total, salt is stored at more than 300 locations throughout the state. Most of the storage facilities are composed of a building used to stockpile the chemicals, an adjacent impermeable pad that serves as a loading area for trucks, a stormwater storage pond or collection basin, and spreader racks (see Figure 1). The pad is designed to contain any chemicals that may be spilled during the loading process; the runoff from this area is directed to and stored in the nearby stormwater pond. The pond itself is designed to be impermeable to prevent infiltration of the water containing varying concentrations of anti-icing chemicals. The spreader racks are used for lubrication and storage of the spreaders used to apply salt from dump trucks.

Figure 1. Salt-Spreader Racks Typical of Those Found at VDOT Area Headquarters Maintenance Facilities

After each use, salt-spreaders must be washed to remove excess salt and lubricated as part of the typical maintenance practice to ensure efficient performance. To ensure both the trucks and spreaders are thoroughly cleaned, it is assumed that at most facilities spreaders are removed from the trucks on the salt loading pads where they are washed. The resulting wash water is then collected and conveyed to the storage ponds. After the spreaders are washed, they are remounted onto the trucks, transported to the salt-spreader rack, removed again from the trucks, hung on the rack, and later lubricated. This multistep procedure is related to the fact that not all salt-spreader racks at VDOT facilities are designed to collect excess lubricants or wash water. Accordingly, as noted in the aforementioned procedure, washing usually occurs at the loading pad, whereby wash water is conveyed to the salt pond, and lubrication occurs at the salt-spreader rack, where lubricants can come into contact with the ground beneath the racks, potentially impairing the quality of soil and groundwater. These two variables, the amount of salt water generated during the washing process and the volume of lubricants potentially coming into contact with the ground during lubrication, were unknown at the outset of this study.

Over the past 3 years, the Virginia Transportation Research Council (VTRC) and the University of Virginia (UVA) have collected data on the quantity, quality, and possible treatment of runoff from VDOT road-salt storage facilities (Fitch et al., 2004, 2005, 2006). Water samples from 45 salt pond facilities throughout the state (5 facilities in each of VDOT's nine transportation districts) were collected and analyzed to quantify chloride-ion concentration, total suspended solids (TSS), and oil and grease. It was found that chloride concentrations were significantly greater than those specified in state and federal regulatory guidelines, with concentrations routinely exceeding 1,600 mg/L (2,636 mg/L NaCl). Average concentrations of TSS and oil and grease were 20 and 9.5 mg/L, respectively (Fitch et al., 2004, 2005).

Because of the very large volumes of water it captures and must dispose of annually, the limited options for disposal, and the high cost of these disposal options, VDOT is in the process of evaluating the use of this waste water to generate brine for the purposes of pre-wetting of granular NaCl and direct brine application (Fitch et al., 2008). In addition, in an effort to make the spreader washing and lubrication process more streamlined, VDOT is considering paving the areas beneath the spreader racks and directing any runoff generated at the racks to the salt ponds. Theoretically, this would eliminate the need to remove and reload the spreaders prior to hanging them in the spreader racks by allowing them to be washed, lubricated, and stored in a single location. This would also prevent excess lubricants from coming in direct contact with the ground and thereby reduce the potential for subsurface and groundwater contamination. However, if the runoff water collected beneath the spreader racks and directed to the ponds has significant oil and grease concentrations (resulting from the excess lubricants), this may render the pond water unsuitable for brine production by way of recycling and/or unsuitable for disposal at publicly owned treatment works.

PURPOSE AND SCOPE

The purpose of this research was to evaluate the potential advantages and disadvantages of paving beneath the racks used for storing salt-spreaders and determine if the runoff associated with lubricating and washing the spreaders would impair VDOT's prospects to dispose of or recycle the salt water captured at its salt storage facilities. The specific objectives of the study were (1) to identify and characterize the lubricants used for spreader maintenance; (2) to analyze for the presence of soil contamination attributable to the current lubrication practices; (3) to quantify the volume of wash water and lubricants that could potentially be collected when spreaders are maintained at the rack; (4) to evaluate the effectiveness of a selected sorbent (a commercially available organically modified bentonite) to remove lubricant hydrocarbons from the runoff from the spreader racks; and (5) to develop best management practices (BMPs) for washing, lubricating, and storing salt-spreaders. Because VDOT currently stores its salt-spreaders on hanging racks that allow for lubrication, but not washing and rinsing, if washing, rinsing, lubrication, and storage could occur at a single location, spreader maintenance would require fewer steps and less time.

The scope was limited to VDOT maintenance facilities.

METHODS

Identification and Characterization of Lubricants and Soil Contamination

More than 320 VDOT maintenance managers were surveyed regarding the type of lubricants they currently and previously used to maintain VDOT's salt-spreaders. The survey (see Appendix A) was developed and administered electronically with the help of VDOT's Knowledge Management Division. Based in part on the results of the survey, two lubricants, i.e., Lubrikote (Select Specialty Products, Inc.) and Zep Dry Moly (Zep, Inc.), were analyzed. Lubrikote was characterized and used in laboratory scale experiments. Zep Dry Moly, which is not petroleum based, was characterized to allow a comparison of the constituents in a petroleum-based and a non–petroleum-based molybdenum disulfide lubricant.

Samples of lubricants found at each facility were collected from seven selected VDOT maintenance locations. Soil samples beneath five randomly selected spreader rack bays were collected at each of these same seven locations and sent to the U.S. Coast Guard's Marine Safety Laboratory for gas chromatography–mass spectrometry analysis. The soil samples were extracted with cyclohexane, dried, and injected in accordance with ASTM D 5739-00. The oils were diluted in cyclohexane and analyzed in accordance with the same standard procedure. The major compounds were identified using mass spectrometry. The compounds identified in the lubricant samples were compared to those extracted from soil samples to determine the presence or absence of petroleum based lubricants. The Marine Safety Laboratory has a standard suite of 37 compounds that they scan for using mass spectroscopy to identify an oil-contaminated water or soil. These compounds are a subset of the complex organic material that comprises a petroleum product. The lubricant and soil samples were scanned for these 37 compounds; although these are the only compounds specifically identified, they are not the sole constituents of the products.

Wash Water and Lubricant Volume Quantification

To estimate the volume of rinse water that would potentially be collected if VDOT were to capture this water at the spreader racks, researchers observed a total of 15 trucks at three locations as the trucks were being washed after the application of deicing chemicals. Each washing was timed and then multiplied by the site-specific water flow rate, resulting in an approximate volume of waste water generated per truck and spreader unit combination cleaned.

Lubricant runoff volumes were quantified by measuring the volume of excess lubricants coming off a total of nine spreaders at five VDOT maintenance facilities. Sorbent pads were weighed and placed under each spreader prior to lubrication. Spreaders were lubricated by maintenance personnel using the procedure most commonly used at the particular facility. All lubricants coming off the spreaders during and up to 30 minutes after the lubrication process were captured by the sorbent pads. The pads were reweighed, and the total lubricant weight was calculated. Lubricant weights were converted to volumes based on the product's density as provided on the label and/or the material safety data sheet.

Oil Sorption Study

Column sorption experiments were conducted to assess the effectiveness of two commercially available organically modified bentonite clays (organoclays), EC-199 manufactured by Biomin, Inc., and PM-199 manufactured by CETCO (a subsidiary of AMCOL International Corporation), to remove two lubricant products used by VDOT. The lubricants used in this portion of the study, Lubrikote and a chain lube from Seymour of Sycamore, were chosen because they represent a high-petroleum-based and a low-petroleum-based lubricant, respectively. Lubricants that did not contain petroleum products, such as Zep Dry Moly, were not studied because VDOT's current concerns are hydrocarbon deposition onto the ground or impervious pad under the salt-spreader racks and any wash water runoff coming from this area.

The glass column used was 13 in long with an inner diameter of 1.5 in and an internal volume of 150 mL. The column was filled with quartz gravel with particle diameters ranging between 4 and 10 mm and organoclay. Three mixtures of organoclay and gravel were used to evaluate the efficiency of removal. The mixtures were 90% gravel/10% organoclay, 80% gravel/20% organoclay, and 70% gravel/ 30% organoclay. It was found that mixtures with greater than 30% organoclay either were less efficient or caused an unacceptable decrease in flow-through velocities, so mixtures with more than 30% organoclay were not studied. The influent oil concentration was 1.5 g/L. Water was passed through the column at a rate of 15 mL/min using a peristaltic pump, and oil was introduced to the water flow at a rate of 1.7 mL/hr using a syringe pump. A diagram of the experimental setup is shown in Figure 2.

The experiment was run until oil breakthrough occurred in the column effluent, at which time the test was stopped and the mass of oil sorbed per mass of organoclay was calculated. Control columns were run simultaneously to quantify the amount of oil retention achieved by the quartz gravel without organoclay.

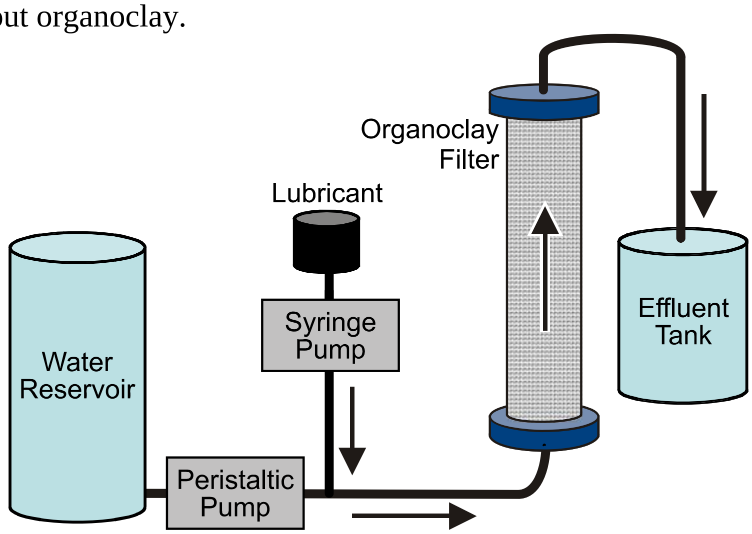

Figure 2. Schematic of Column Experiment Setup

Development of Best Management Practices for Washing, Lubricating, and Storing Salt-Spreaders

To develop the BMPs for washing, lubricating, and storing salt-spreaders, the researchers observed the current washing and lubricating practices at selected VDOT area headquarters and collected and measured excess lubricants. This was followed by discussions with VDOT area headquarters maintenance personnel and personnel from VDOT's Environmental Division regarding their experiences and concerns with such procedures. All BMPs were developed with the goal of minimizing waste and reducing the potential for site contamination.

RESULTS AND DISCUSSION

Characterization of Lubricants and Soil Extracts

A total of 99 lubricant-use survey responses were received. Based on information received in the responses, 21 products are currently being used for spreader lubrication at VDOT facilities. Most (approximately 62%) of VDOT's maintenance managers who responded used Lubrikote and/or Lubra-Seal (see Table 1). It is worth noting that of the 21 lubricants being used by survey respondents, none was a bio-based lubricant (as defined in ASTM D 5864-05). Although a number of bio-based lubricants are available (some even manufactured by the same companies represented in Table 1), this designation does not ensure that use of the product will not result in contamination similar to that possible with non-biobased products. In general, however, biodegradable oils are less toxic and will degrade faster as compared to petroleum-based oils (Honary, 2001).

The chromatogram for Lubrikote is shown in Figure 3. Of the 37 compounds specifically identified, the prominent compounds found in the lubricant were n-C17, n-C18, dibenzothiophenes, naphthalenes, phenanthrenes, triterpanes, pyrenes, and other hydrocarbons. Figure 4 shows the chromatogram of Zep Dry Moly; it looks markedly different than the chromatogram of Lubrikote. The only organic compounds present in the Zep Dry Moly chromatogram were lightweight volatile compounds resulting from its aerosol nature.

Figure 5 shows the cyclohexane extract from a soil sample collected from under the spreader racks at a VDOT location. This chromatogram for the soil extract shows the presence of dibenzothiophene, triterpanes, and pyrene, among other heavy hydrocarbons. The

Table 1. Summary of Survey Responses Showing Spreader Lubricants Used at VDOT Maintenance Facilities

Product Name	Number of Users
Lubrikote	33
Lubra-Seal	29
Zep Dry Moly	9
Lifeline	7
Eliminator	5
Gunk chain and cable lube	5
NAPA open gear lube	3
Lubest	3
NAPA chain and cable lube	3
Seymour	2
Fortress	2
Domade-corrosion inhibitor	2
Neutro-Wash	1
Chemtek	1
Release	1
Lube Master ccx 97	1
Pro/Chem gear lubricant	1
Momar Black gaulet	1
Tube grease	1
Lawson Products LP2A	1
PB Blaster	1

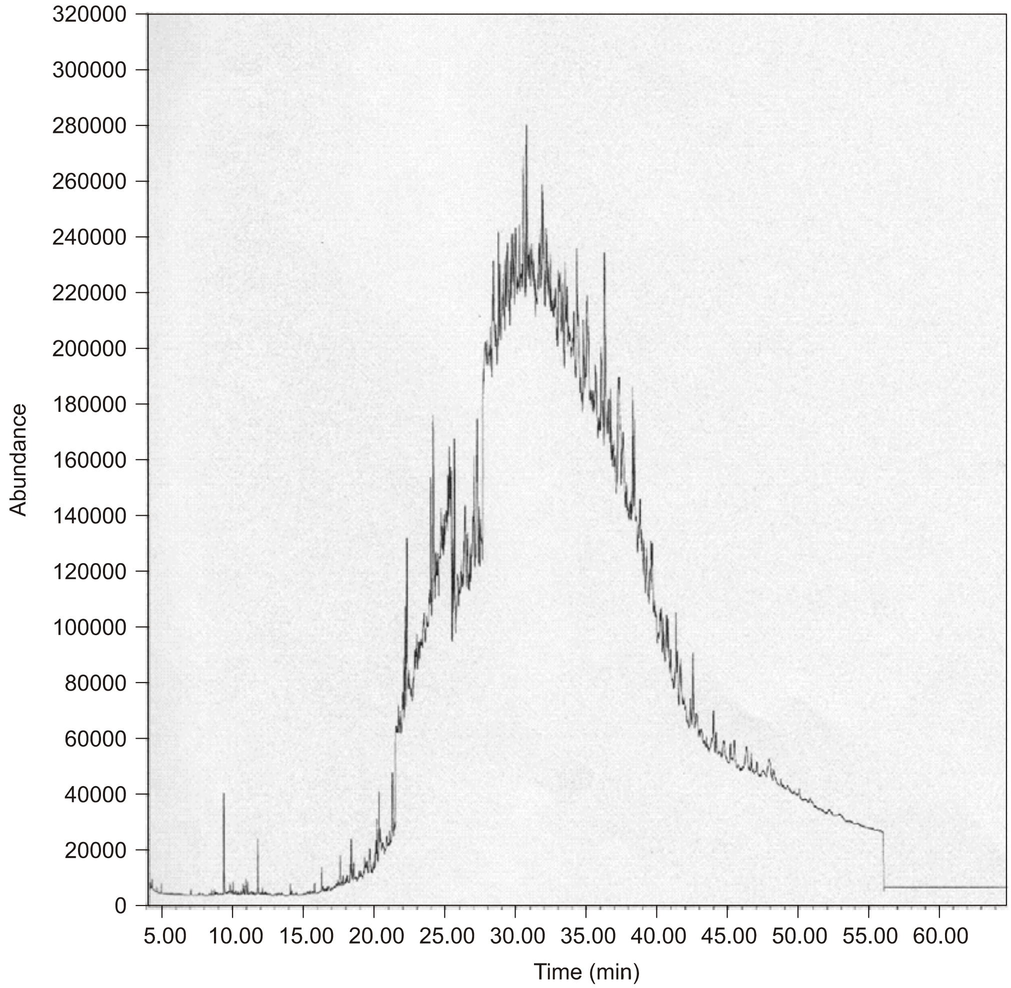

Figure 3. Gas Chromatogram for Lubrikote

chromatogram of the pure lubricant and that of the soil extract are not expected to be perfect matches, as weathering and degradation cause changes in the organic constituents in the lubricant present in the soil (Wang and Fingas, 1995).

The additional soil samples from the seven VDOT locations were analyzed, and lubricants were present in all samples. Table 2 shows the locations studied and the corresponding organic compounds detected in the soil samples. Based on these data, it is clear that products used for spreader lubrication are present in the soil directly under the spreader racks. Although from visual inspection it appears that the contamination resulting from the lubricants is localized, the soil sampling results do highlight the need to contain and capture excess lubricants to limit soil and potential wash water runoff contamination in the future, just as VDOT has proposed.

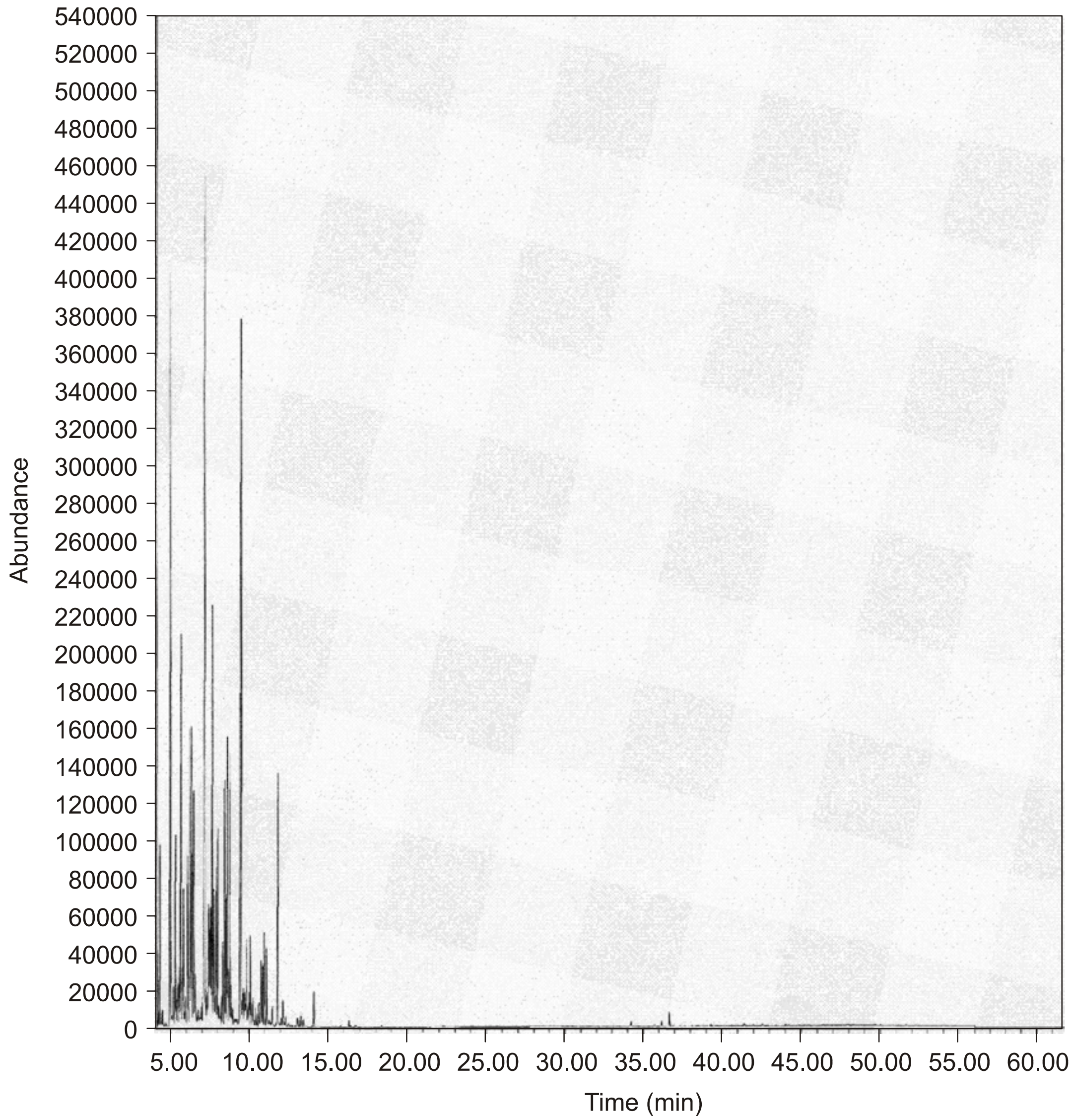

Figure 4. Gas Chromatogram for Zep Dry Moly

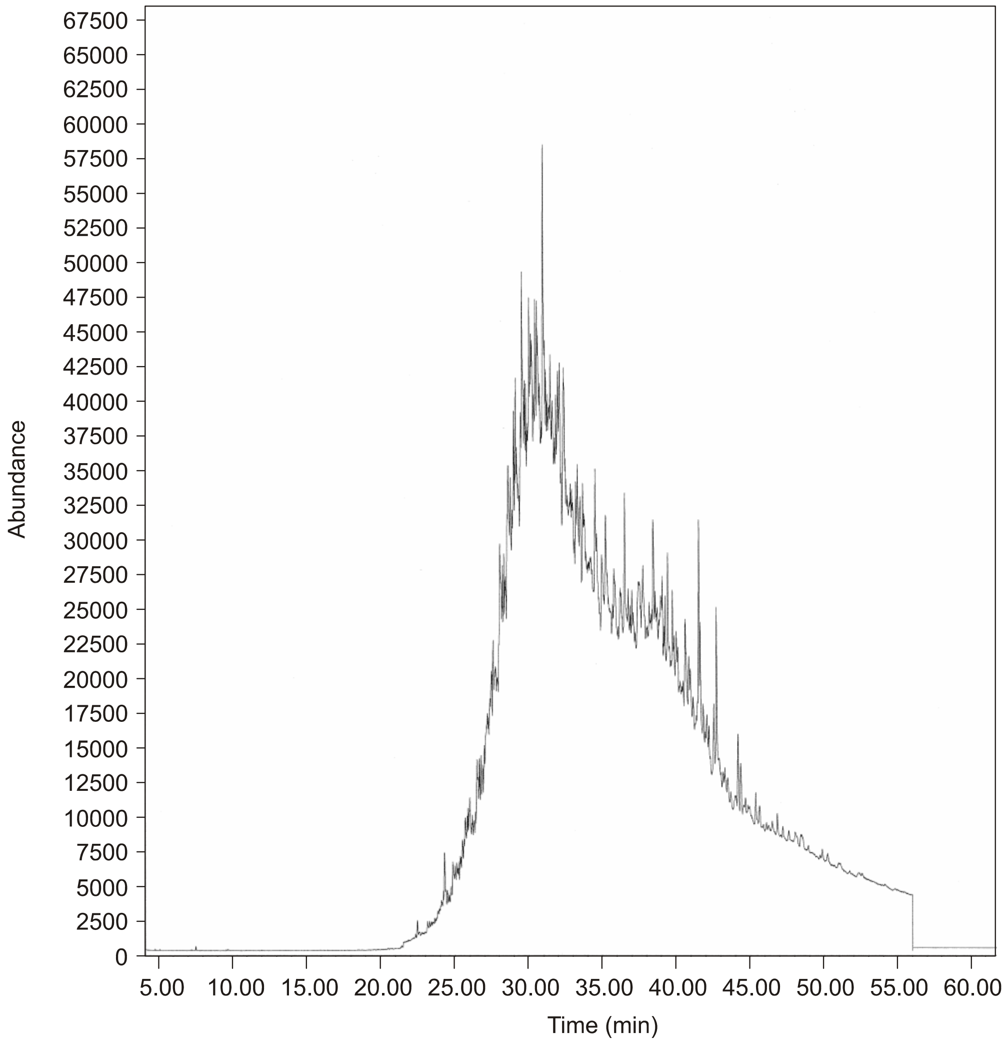

Figure 5. Gas Chromatogram of Cyclohexane Extract of Soil Sample Taken Under Spreader Rack

Table 2. Summary of VDOT Locations Sampled and Corresponding Organic Compounds Detected at Each Site

Organic Compound	Keene	Boyd Tavern	Yancey Mills	Zion Crossroads	Salem	Staunton	Free Union
Saturated hydrocarbons				x			x
Pristane	x						
Phytane	x						x
Acyclic isoprenoids	x			x	x	x	x
Naphthalenes	x			x		x	x
Phenanthrene/anthracene		x	x	x		x	
Benzo-naphthiophene		x					
Dibenzo- thiophenes	x	x	x	x	x	x	x
Triterpanes		x	x	x		x	x
Hopanes	x	x	x	x		x	x
Steranes	x	x		x	x	x	x
Pyrene/fluoranthene	x	x	x	x	x	x	
Methyl pyrene	x	x		x			
Chrysene		x				x	
Sesquiterpanes							

Wash Water and Lubricant Volume Quantification

In all washing operations observed, the spreader and the truck were washed together as a single unit (i.e., the spreader was not decoupled from the truck prior to washing as was assumed was commonly done prior to the initiation of the study). On average, approximately 400 L of water is used to wash each VDOT salt-spreader and truck following the completion of NaCl application. This value is significantly higher than the 130 L found in a similar study done for the New Jersey Department of Transportation (Meegoda et al., 2004). Because this value is inclusive of the water required to wash the truck, it is assumed that it would drop substantially if only the spreader was washed at the rack (i.e., the truck would be washed at the loading pad and, therefore, would not contribute to the volume of water collected at the rack). Assuming an average maintenance facility has seven spreaders, the total volume of water generated for washing is estimated to be 2,800 L.

Three methods of lubricant application were observed during site visits: (1) spraying with a garden sprayer, (2) spraying from an aerosol can, and (3) pouring and brushing directly from a bucket. The average lubricant waste (excess) volume estimate was 1,188 mL for each spreader lubricated. This average reflects both the different types of lubricants applied (as shown in Table 1) and the different methods of application. Again, based on an average of seven spreaders per site, the total waste lubricant volume for a typical maintenance facility was determined to be approximately 8.3 L.

Most of the spreaders observed as part of the study were lubricated while still on the truck. This allowed for rotation of the discharge/feed conveyer that runs the length of the spreader, thereby allowing for complete lubrication. Once a spreader is disconnected from the truck (i.e., hung on the spreader rack), the conveyer is no longer operable and cannot be completely lubricated in a safe manner.

If it were assumed that all of the waste lubricant and the wash water volumes were collected as runoff, this water would have a lubricant concentration of approximately 2.56 g/L. Again, this concentration is based on the volumes generated when the truck and spreader were washed simultaneously. If the spreaders were washed separately, it is assumed that the volume of wash water generated would be approximately one-half of the 2,800 L measured and would result in a lubricant concentration in the wash water runoff of approximately 5.2 g/L. If this runoff was not filtered and flowed directly to the associated salt-water storage pond, additional dilution would occur. With an average storage volume of nearly 300,000 L (Fitch et al., 2004, 2005), the lubricant concentration would be further reduced to approximately 24 mg/L.

It should be emphasized that each of these concentration calculations was based heavily on a number of assumptions. For example, the 24 mg/L concentration in the salt-water storage pond water was based on a single lubrication and would, therefore, increase by roughly this amount with each subsequent lubrication. This concentration also reflected the assumption that the pond volume was near capacity; if the water volume in the pond was lower, the concentration would be higher. Another assumption was that all of the 8.3 L of excess lubricant would enter the pond as runoff. This is highly unlikely since, in most cases, the spreader lubrication process occurs days prior to the next washing event. During this period (time of lubrication to time of washing), the excess lubricant on the pad would dry and/or volatilize to some degree depending on environmental conditions and, in so doing, reduce the lubricant concentration in the runoff generated during the washing process.

It should also be noted that although the estimated concentrations of lubricants were low (24 mg/L) and were based on the worst case scenario, it would be relatively easy to prevent the majority of the excess lubricants from coming into contact with the spreader rack bottom (impervious or otherwise) and/or any wash water runoff simply by capturing this excess in a drip pan placed beneath the spreader at the time of lubrication.

Oil Sorption Study

Organoclays are largely studied for their ability to sequester, either through adsorption or partitioning, dissolved nonionic organic compounds such as benzene and chlorinated aliphatic and aromatic compounds (Bartelt-Hunt et al., 2003; Smith et al., 1990). However, the organophilic nature of these bentonite materials has prompted their use in oil removal applications. There is limited experimental data quantifying the removal efficiencies of commercially available organoclays. Of the few studies published, Moazed and Viraraghavan (2005) determined the sorption capacity of an organoclay/anthracite mixture for two cutting oils, a refinery effluent and a water collected from an oil production well (Moazed and Viraraghavan, 2005). The organoclay mixture manufactured by Biomin, Inc., showed removal efficiencies in excess of 70% for concentrations tested. An earlier study by Muller et al. (1995) found that organoclays manufactured by Biomin, Inc., and Rheox, Inc., were successful at reducing oil and grease present in waste mixtures obtained from the metal industry. The study also showed that granular activated carbon (GAC) outperforms the organoclays (Muller et al., 1995). However, other studies have shown that emulsified oils can blind the pores of GACs, which results in reduced efficiency (Alther, 2002). Vlaspolous (2006) conducted a life cycle assessment of filter technologies, and GAC production and use had higher environmental impacts than organoclays in the categories investigated, including use phase energy consumption, global warming, and eutrophication.

The current study found that both organoclays tested showed strong uptake and removal of lubricants from a lubricant-water mixture. As previously indicated, Lubrikote is a molybdenum-bearing petroleum-based lubricant with a high concentration of hydrocarbon compounds and Tool Crib Chain and Cable Lube from Seymour of Sycamore are molybdenum-bearing petroleum-based lubricants with a low concentration of hydrocarbon compounds. It was also found that the characteristics of the hydrocarbons present in the lubricant products affect the interaction with the organoclay sorbents.

Table 3 shows the results of the column breakthrough experiments for mixtures of EC-199 and quartz gravel with Lubrikote. Different proportions of organoclay and gravel were used, ranging from 0% organoclay and 100% gravel to 30% organoclay and 70% gravel. For mixtures containing greater than 30% organoclay, excessive swelling of the organoclay caused unacceptable reductions in flow rate. The column experiments showed that 10% by volume of organoclay with 90% quartz gravel was the most efficient mixture for sorbing Lubrikote to EC-

Table 3. Column Results for EC-199 Organoclay with Lubrikote

% Organoclay	Mass Clay (g)	Total Mass Oil Retained (g)	Mass Oil Sorbed/g Clay
0	0	2.9	
0	0	1.1	
20 (bentonite)[a]	14.5	2.7	0.19
10	6.0	21.4	3.55
10	6.0	20.7	3.45
20	13.7	22.9	1.67
20	13.7	27.8	2.03
30[b]	24.5	26.3	1.07

[a]Twenty percent unmodified bentonite powder was used to assess the contribution of oil uptake because of the bentonite structure. Uptake was negligible.
[b]Thirty percent EC-199 clogged before oil had passed in the effluent.

199 organoclay. The column experiments with 10% organoclay by volume showed the maximum oil sorbed per gram of clay used, with 3.5 +/- 0.05 g of oil sorbed per gram of clay.

Table 4 shows the results of oil breakthrough experiments for PM-199 organoclay with Lubrikote. The same mixtures of organoclay and quartz gravel were used with EC-199 and PM-199. PM-199 did not show a reduction in flow rate with 30% organoclay; however, efficiency did not increase, and thus mixtures with greater than 30% organoclay were not tested. The mixture with 10% by volume organoclay and 90% by volume quartz gravel was the most efficient mixture tested, with 2.0 +/- 0.2 g of oil sorbed per gram of clay.

Table 5 shows the results of EC-199 with the Tool Crib Chain and Cable Lube from Seymour of Sycamore. Both EC-199 and PM-199 showed decreased uptake and removal of the Seymour product compared to Lubrikote (see Table 6 for PM-199 results). It is likely that the complex hydrocarbon compounds present in Lubrikote have a stronger affinity to the organically modified clay than the Seymour product.

Table 4. Column Results for PM-199 Organoclay with Lubrikote

% Organoclay	Mass Clay (g)	Total Mass Oil Retained (g)	Mass Oil Sorbed/g Clay
10	6.4	13.8	2.15
10	5.9	11.0	1.86
20	14.4	13.8	0.95
20	14.4	16.9	1.17
30	24.9	36.5	1.46

Table 5. Column Results for EC-199 Organoclay with Seymour of Sycamore

% Organoclay	Mass Clay (g)	Total Mass Oil Retained (g)	Mass Oil Sorbed/g Clay
10	5.9	7.9	1.34
10	5.9	8.0	1.36
20	14.3	7.3	0.51
20	14.3	8.9	0.62
30	24.7	11.7	0.47
30	24.7	8.6	0.35

Table 6. Column Results for PM-199 Organoclay with Seymour of Sycamore

% Organoclay	Mass Clay (g)	Total Mass Oil Retained (g)	Mass Oil Sorbed/g Clay
10	5.8	10.3	1.78
10	5.8	11.4	1.97
20	14.3	11.0	0.77
20	14.3	11.1	0.78
30	24.6	11.7	0.48
30	24.6	11.0	0.45

Based on the removal rates obtained in the laboratory study and the wash water volumes measured in the field, it is estimated that approximately 5.3 L of EC-199 and 9.3 L of PM-199 would be needed to remove the maximum excess hydrocarbon-based lubricant volumes expected in the runoff flow generated during a single washing event. The approximate cost for the clay material needed for filter construction is between $12 and $15. This cost, however, does not include the cost of the filter housing material or the gravel used as part of the filter matrix. A consideration of equal importance is filter maintenance. Based on the removal rates obtained and the design of the filters tested, it is likely that cleaning and disposing of the spent clay material and repacking of the filter would be required following each washing event. If left unchecked, the filter could clog or simply fail to remove the lubricants in the wash water.

Best Management Practices for Washing, Lubricating, and Storing Salt-Spreaders

BMPs for washing, lubricating, and storing salt-spreaders are provided in Appendix B.

CONCLUSIONS

- *In contrast with the original assumption of this investigation, maintenance staff at most of the VDOT facilities visited washed salt-spreaders and trucks as a single unit on the loading pad and most of the spreaders were lubricated while still on the truck.* Unless it is changed in the future, this practice diminishes the advantages of and the need for paving beneath the spreader racks at these facilities.

- *Based on the volumes of water used for washing and excess lubricants measured at a limited number of sites, wash water runoff from the spreader rack potentially could have lubricant concentrations up to 5.2 g/L.* If this water was conveyed to the salt-water retention ponds, the concentration of hydrocarbons in the ponds would remain relatively low because of the large volume of water typically stored in these structures.

- *Lubrikote and Lubra-Seal are the primary lubrication products used at VDOT facilities; however, numerous products are being used across Virginia.* Both products are molybdenum-bearing petroleum-based lubricants with high concentrations of hydrocarbon compounds. This, coupled with the various manners of lubricant application, determines the magnitude and chemical composition of lubricant being deposited on the ground surface during salt-spreader maintenance.

- *A high percentage of the excess lubricants coming from the spreaders could be captured by means of a drip pan or similar device during and immediately following lubrication*. The use of this type of simple device would be an inexpensive and uncomplicated method of preventing potential soil and wash water contamination.

- *The two commercially available organoclay products tested (EC-199 and PM-199) were effective at removing the high concentration hydrocarbon lubricants from water*. These same organoclays were much less effective at removing lubricants that were not petroleum based. Although effective, use of an organoclay filter would require frequent maintenance in the field.

- *There is a need to capture excess product from the lubrication process to prevent soil contamination*. If the bottoms of new or existing spreader racks were made impervious, there would be a greater potential for containing the excess lubricants, but these lubricants would also potentially contaminate any wash water runoff generated at the rack.

RECOMMENDATIONS

1. *VDOT's Administrative Services Division should not pave beneath existing spreader racks unless a water source and a method of conveying wash water runoff to the salt pond are also available at the site*. In addition, alternative methods of lubricating the spreader need to be identified since, in most cases, the conveyer will not be functional when the spreader is on the storage rack.

2. *VDOT's Administrative Services Division and district maintenance engineers should use the BMPs provided in Appendix B as a guide for washing, lubricating, and storing salt-spreaders*.

3. *VDOT's Environmental Division should revise its current guidance on spreader lubrication to include recommending lubricating on the loading pad provided a drip tray or other form of containment is placed beneath the spreader at the time of lubrication*.

COST AND BENEFITS ASSESSMENT

Implementing the proposed recommendations should provide VDOT with several modest benefits with minimal costs. More specifically, the costs of implementing the new BMPs will include the costs associated with staff instruction, the purchase of drip pans, and possibly the proper disposal of excess lubricants that are collected (in cases where these lubricants are not reused). The benefits of following these BMPs include decreased potential for soil contamination beneath spreader racks and decreased potential for wash water runoff contamination and associated salt-pond contamination.

The cost of paving beneath a spreader rack would include costs associated with grading, base material, the asphalt base layer, the asphalt surface layer, water source installation, drainage and conveyance system to salt pond, and filter system installation and maintenance. The costs associated with this alternative would be significantly higher and the benefits of providing this impervious surface would be similar to those associated with the BMPs but would allow the spreader to be washed independently of the truck.

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APPENDIX A

SURVEY REGARDING SALT SPREADER LUBRICANTS

1. What product(s) do you currently use to lubricate and/or prevent corrosion of your spreaders? Please select all that apply.

   - Lubri Kote
   - Zep dry moly
   - Seymour (Sycamore chain and cable lube)
   - Eliminator
   - Other

2. If you selected “Other” in the previous question, please identify the product.

3. What other spreader lubrication or corrosion inhibitor product(s) have you used in the past 12 months?

   - Lubri Kote
   - Zep dry moly
   - Seymour (Sycamore chain and cable lube)
   - Eliminator
   - Other

4. If you selected “Other” in the last question, please identify the product.

5. Do you have plans to switch to a different product in the next 6 months? If yes, please name the product(s) in the next question.

   - Yes
   - No

6. If you answered yes in the previous question, that you do plan to switch to a different product in the next 6 months, please list the name of that product below.

APPENDIX B

PROPOSED BEST MANAGEMENT PRACTICES FOR VDOT MAINTENANCE FACILITIES FOR WASHING. LUBRICATING, AND STORING SALT-SPREADERS

The BMPs proposed here are dependent on the existing conditions at the spreader rack. Spreaders are lubricated using a variety of products and methods, and although there is potential for changes and improvement with respect to these two aspects of spreader maintenance, the BMPs listed here do not address these variables but instead are limited to the location and timing of washing and lubrication.

Spreader Rack with Pervious Bottom

- Both the spreader and the truck should be washed on the loading pad so as to contain the salt-laden wash water.
- The spreader should be moved to the rack for drying and lubrication *or* the spreader should be allowed to dry and should be lubricated on the loading pad.
- A drip pan should be placed beneath the components of the spreader to be lubricated for a minimum of 15 minutes in order to collect excess lubricants.

Spreader Rack with Impervious Bottom without Water and/or Drainage to Collection Pond or Tank

- Both the spreader and the truck should be washed on the loading pad so as to contain the salt-laden wash water.
- The spreader should be moved to the rack for drying and lubrication.
- A drip pan should be placed beneath the components of the spreader to be lubricated for a minimum of 15 minutes in order to collect excess lubricants.

Spreader Rack with Impervious Surface with Water and Drainage to Collection Pond or Tank

- The spreader should be washed at the rack after it is unloaded from the truck.
- The spreader should be allowed to dry and should be lubricated at the rack.
- A drip pan should be placed beneath the components of the spreader to be lubricated for a minimum of 15 minutes in order to collect excess lubricants.