Dust Suppression Pilot Study Report 2018/2019

February 2020

Dominion Diamond Mines

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21 February 2020

To: Distribution List (enclosed):

RE: Submission of Ekati Diamond Mine Dust Suppression Pilot Study Report, 2018/2019

Dominion Diamond Mines ULC (Dominion) is pleased to circulate the Dust Suppressant Pilot Study Report 2018/2019. This report covers the dust suppressant activities undertaken in both 2018 and 2019, as well as a best management practices section that incorporates the findings of the pilot study since it's initiation in 2015.

The Dust Suppressant Pilot Study addresses comments and concerns received from community members, regulators, and the Independent Environmental Monitoring Agency (IEMA) about whether the current dust suppression practices could be improved and satisfies Measure 6-2 (a) of the Report of Environmental Assessment (EA) for the Jay Project.

Dominion trusts that you will find the report to be clear and informative. Please contact the undersigned at Harry.O'Keefe@ddcorp.ca or 867-880-4400 ext 2232 or Claudine Lee – Head of Environment at Claudine.Lee@ddcorp.ca or 867-880-4400 ext 2289 should you have any questions or concerns.

Sincerely,

Harry O'Keefe
Superintendent Environment Operations

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1 Introduction

1.1 The Ekati Diamond Mine

Dominion Diamond Mines ULC (Dominion) is a Canadian diamond mining company with ownership interests in two major producing diamond mines in Canada's Northwest Territories (NWT). The company operates the Ekati Diamond Mine (in which it owns a controlling interest), and also owns 40% of the Diavik Diamond Mine. It supplies premium rough diamond assortments to the global market through its sorting and selling operations in Canada, Belgium, and India.

The Ekati mine is located in the NWT, located approximately 200 kilometres (km) south of the Arctic Circle and 300 km northeast of Yellowknife (Figure 1). The mine is situated within the Lac de Gras watershed at the headwaters of the Coppermine River drainage basin, which flows north to the Arctic Ocean (Figure 1). The Ekati mine is located 100 km north of the tree line on the Arctic tundra in a semi-arid environment.

The local terrain is characterized by boulder fields, tundra, wetlands, eskers, and numerous lakes with interconnecting streams. There are more than 8,000 lakes within the 266,300-hectare claim block. It is an area of continuous permafrost with a shallow active layer (less than 2 metres [m] thick) which thaws during the brief summer. While extreme winter temperatures dominate the majority of the year, there are generally five months of spring, summer and fall weather, but only four of those months (June through September) see daytime temperatures above freezing.

The Ekati mine began construction in 1997 and officially opened in October 1998 as the first diamond mine in Canada. In 2018, the company commemorated 20 years of production at the Ekati mine. From January 1, 2018 to December 31, 2018, the Ekati mine had four open pits (at the Misery, Pigeon, Lynx, and Sable kimberlites) in active mine development and production for all or part of the year, and one underground mine in production (Koala Underground), which ceased in November 2018. From January 1, 2019 to December 31, 2019, there were three open pits (at the Pigeon, Lynx, and Sable kimberlites) in active mine development and production for all or part of the year, and one underground pit in development (Misery Underground) until November 2019, when production began. Mining of the Lynx kimberlite was completed in September 2019.

Six open pits have completed development and production but are still considered in an operational phase, as mining of the pipe is either transitioning to underground mining (such as the Misery and possibly the Fox pit), or the open pit is being utilized for Processed Kimberlite (PK) deposition and minewater management (such as Beartooth, Panda, Koala North, and Koala pits).

In a semi-arid environment, the summer months are often hot and dry, with the majority of over land run-off occurs during spring freshet and minimal precipitation in the spring and through the summer months. At this time of year, light vehicle and haul traffic on the gravel roads can cause dusty conditions at site, resulting in the dispersal of dust aggregates onto the surrounding tundra. Dust management practices at the Ekati mine have primarily relied on the use of DL-10 (a chemical dust suppressant) and road watering, which both have limitations in their use and ability to suppress dust over the entire summer season. As a result, Dominion recognized that there was a potential opportunity for the improvement of dust management.

Dominion initiated a pilot study in 2015 to address comments and concerns received from community members, regulators, and the Independent Environmental Monitoring Agency (IEMA) about whether the current dust suppression practices could be improved and to satisfy Measure 6-2 (a) of the Report of Environmental Assessment (EA) for the Jay Project, which stated that:

> *ii. Dominion will implement the Caribou Offset and Mitigation Plan as described in DAR-MVEIRB-UT2-06 and incorporate the following into the Plan:*

- *An enhanced dust mitigation study including:*
    - *A pilot test on application of dust suppressant*
    - *A dustfall sampling program*
    - *Report on results and propose improvements to be incorporated into the Air Quality Emission Monitoring and Management Plan*
    - *If dust mitigation improvements are identified, Dominion will apply them on all roads at Ekati*

The dust suppression pilot study continued in 2018 and 2019. Results and learnings from the 2018 and 2019 dust suppressant pilot study are presented in this report. The year, 2019 marks the fifth and final year of the pilot program. A section on best practices for applying the alternative dust suppressant product, EnviroKleen®, (hereafter "EnviroKleen") has also been included in this report. This report is considered the final report for the dust suppression pilot studyThe dust suppression pilot study continued in 2018 and 2019. Results and learnings from the 2018 and 2019 dust suppressant pilot study are presented in this report. 2019 marks the fifth and final year of the pilot program. A section on best practices for applying the alternative dust suppressant product, EnviroKleen®, (hereafter "EnviroKleen") has also been included in this report. This report is considered the final report for the dust suppression pilot study.

1.2 Engagement

Fugitive dust and its potential effects on vegetation, wildlife, and water quality have long been a community and regulatory concern at the Ekati Diamond Mine. Dust suppression as a mechanism to mitigate the effects of fugitive dust at the Ekati Diamond Mine has been employed since the commencement of mining in 1998.

Throughout the Jay Project permitting process, communities and regulators continued to share concerns about the dispersion of dust generated by vehicles and its potential impacts on the environment. In response to those concerns, commencing in 2015, Dominion undertook a pilot study to investigate if the current dust suppression practices and products could be improved.

Following the distribution of the 2015 EnviroKleen Pilot Study Report, Dominion received comments from the Łutsel K'e Dene First Nation requesting that testing of both the terrestrial and aquatic receiving environment occur for impacts of EnviroKleen as no studies had previously been completed in a tundra environment. In response to these comments soil sampling, water quality monitoring and toxicity testing were added to the pilot study in 2017 (Dominion 2018).

1.3 Study Objectives

Dominion is committed to continual improvement in its environmental practices and aims to mitigate dustfall generated by mobile equipment. In alignment with this, and with Measure 6-2 (a) of the Jay EA, the objectives of the 2018/2019 dust suppression study were to:

- Compare the relative effectiveness of EnviroKleen and DL-10 on a larger scale, building on the positive initial results of the 2015 study and inform a decision to expand the use of EnviroKleen;
- Determine the degree to which EnviroKleen travels into the surrounding environment to inform the decision on whether an application buffer is needed near waterbodies; and
- Conduct additional testing to investigate EnviroKleen's potential for toxicity.

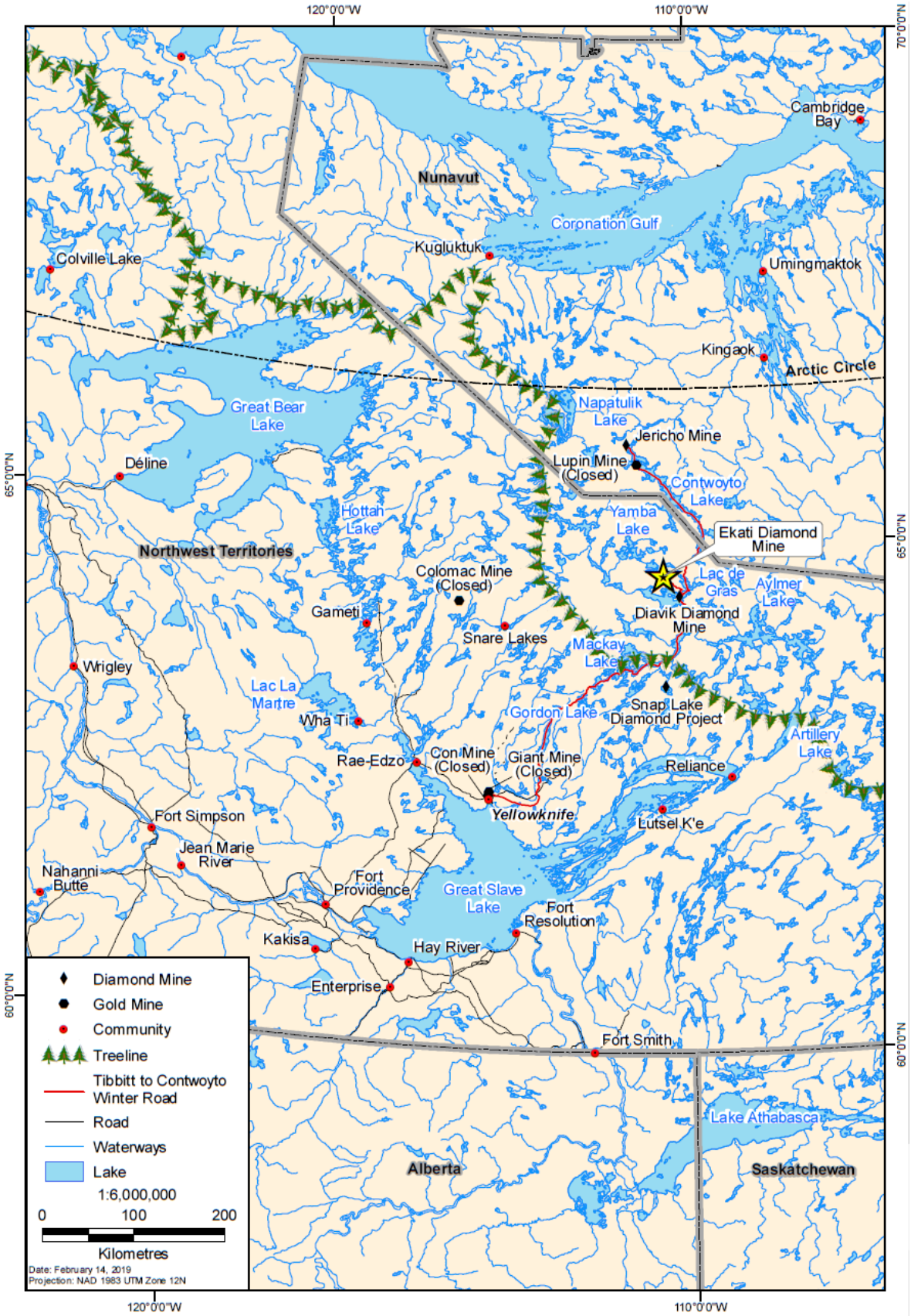

FIGURE 1. LOCATION OF THE EKATI DIAMOND MINE, NORTHWEST TERRITORIES

1.4 Summary of Dust Suppression used at the Ekati Mine

Various methods of dust suppression have been used on-site including road watering, the application of DL-10, the use of EK-35 on the airstrip, and the application of EnviroKleen. Application details are outlined below.

1.4.1 Water

Road watering is currently used to suppress dust under the following conditions:

- In the spring, prior to weather being suitable for the application of chemical dust suppressants (daily average temperature must be at least 10 degrees Celsius),
- On the sections of road near a water body, where dust suppressants cannot be applied, and;
- On pit roads and ramps.

While water application is effective at mitigating dust dispersal, it must be applied frequently (multiple times a day) to remain effective. This requires dedicated personnel, equipment, diesel fuel, uses water, and also generates emissions for the increased truck use. The frequent use of water also results in a greater loss of fine material from the road surface, consequently increasing the formation of potholes and washboard on the road which increased the requirement for road maintenance activities and resurfacing. Road fines are integral in the development of a compacted road surface that can better withstand usage and minimize dust generation.

1.4.2 DL-10

DL-10 is an asphalt-based emulsified oil dust control product developed for use on unpaved roadways and approved for use as a chemical dust suppressant in the Northwest Territories (NWT), by the Government of the Northwest Territories (GNWT). Unlike water, DL-10 remains on the road after application and forms a hard crust which limits release of dust for as long as the crust is maintained. However, with heavy road use (such as on the haul roads) and arid climates, the crust becomes cracked and breaks apart, reducing the product's ability to suppress dust generation.

Prior to the dust suppressant pilot study, DL-10 was the primary chemical suppressant used on-site. DL-10 was applied during summer months on Misery Road to within 30 m of waterbodies, and in select areas around Main Camp. Use of DL-10 was progressively reduced on Misery Road as application of EnviroKleen increased annually (Section 1.4.4). DL-10 application continued around Main Camp.

1.4.3 EK-35

EK-35 is a synthetic organic hydrocarbon-based fluid formulated with a naturally-occurring pitch/resin blend binder system that works by binding the fine silt or clay particles together, making them larger so that they are less likely to become airborne and settle out more quickly. This product has been approved by the airline industry, is certified non-corrosive by Boeing and is the standard product used on unpaved runways.

EK-35 is the dust suppressant that used on the Ekati airport runway. The product has typically been applied annually on the airport runway and surrounding areas (helicopter pad, taxi way and apron), except for 2019, a year when all areas around the airport were treated, except the runway.

1.4.4 EnviroKleen

EnviroKleen is a colourless, odorless, synthetically formulated hydrocarbon-based fluid which is enhanced with polymeric binders instead of a pitch/rosin binder, as is the case in EK-35. EnviroKleen controls and stabilizes dust by weighing and agglomerating particles using a re-workable and cohesive action (Midwest 2013). As fines are generated, they are captured, preventing them from escaping as dust. The use of EnviroKleen in the pilot study was intended to offer potential performance improvements for dust suppression over the use of DL-10.

EnviroKleen is insoluble in water and has been demonstrated to be neither acutely nor chronically toxic in tests with various aquatic species (DDM 2018). EnviroKleen is naturally biodegradable and readily breaks down over time to form carbon monoxide, carbon dioxide and water. In response to community and reviewer concerns and in order to confirm the toxicity results provided by Midwest, Dominion forwarded samples of EnvironKleen for acute and chronic toxicity testing in 2017 (DDM 2018). Results indicated that there were no adverse effects on the acute survival of *Oncorhynchus mykiss* (Rainbow Trout), and aquatic invertebrates, *Daphnia magna*, or *Ceriodaphnia dubia* with all tests producing LC50 values >10,000 mg/L (the highest concentration evaluated), no observed effects concentration (NOEC) and lowest observed effects concentration (LOEC) values of 10,000 and >10,000 mg/L, respectively (DDM 2018).

Dominion selected EnviroKleen to trial for the following site-specific reasons:

- used previously in underground operations on site, as approved by the GNWT Inspector;
- Midwest (the manufacturer of EnviroKleen) technicians would work with and train the operators who will be responsible for the application, ensuring that the product is applied correctly and efficiently to maximize the products impacts on dust suppression;
- has been used locally in Fort Good Hope, NWT and Wekweètì, NWT; and
- non-toxic and is not water-soluble.

Use of EnviroKleen generally increased at the Ekati mine since the pilot dust suppressant study was initiated in 2015. Since 2015, EnviroKleen was applied along sections, or the entirety of Misery Road, within varying distances (15 m or 30 m) from waterbodies. Beginning in 2019, EnviroKleen was applied to Sable Road (Section 2.1). Between the construction of Sable Road in 2016 and 2019, watering was used to managed and mitigate dust on the road.

2 Methodology

2.1 Study Location

The Misery Road was the most heavily used haul road at the Ekati mine in 2018 with the movement of ore from Misery and Lynx pits to the Processing Plant at Main Camp. In 2019, vehicle traffic on Sable Road increased with the movement of ore from Sable Pit to the Processing Plant at Main Camp, whereas vehicle traffic decreased on Misery Road, following the completion of mining at Lynx Pit in September 2019 and with the transition from open pit to underground operations at Misery Pit beginning in the summer of 2018. Heavy vehicles were used more frequently on Misery Road in 2018 and were transitioned to Sable Road in 2019. Weight of equipment, speed, size of tires and number of axels are key factors contributing to dust generation potential and thus the potential for fugitive dust generation.

Throughout the course of the dust suppression pilot study, Dominion expanded the EnviroKleen application study area. In 2015, the initial study area included treatment of a small, 1 km segment on Misery Road that was selected for two main reasons; 1) position from the prevailing wind direction (segment was perpendicular to the prevailing wind) and 2) distance from water bodies (segment was greater than 30 m from all waterbodies).The study area was expanded in 2016 to approximately 10 km of treated road surface. In 2017 and 2018, the full extent of the Misery Road was treated, with the exception of buffer area surrounding waterbodies (Figure 2). EnviroKleen was applied to the full extent of the Sable Road (Figure 3) and the Ekati Haul Road (Figure 3) in 2019, with the exception of buffers around waterbodies.

The buffer distance around waterbodies also changed throughout the duration of the study. In accordance with GNWT Inspector approval, EnviroKleen was permitted to be applied to within 30 m of waterbodies in 2015 and 2016 and to within 15 m of a waterbodies in 2017, 2018, and 2019. In years with partial EnviroKleen application (2015 and 2016), DL-10 was applied on all areas of the Misery Road that were not treated EnviroKleen, to within 30 m of waterbodies, as per standard procedure. In areas where chemical dust suppressants are not applied, water was used for dust suppression.

2.2 Preparation and Pre-Treatment of Road

In order to maximize its effectiveness, the EnviroKleen application requires very specific weather and road conditions. Ideal conditions include ambient temperatures above 10° C, and sunny skies during the day the product is applied. The road must be dry, with a small amount of moisture to break the surface tension and ensure proper absorption of product. The road should also be freshly surfaced with fresh aggregate and recently graded.

In each year of EnviroKleen application, the road surface was prepared with fresh -3/4” aggregate and graded within one to two days of product application. Depending on the road conditions, a light watering was applied prior to the first application to help break the surface tension and aid absorption of the EnviroKleen into the road.

To designate that application area, stakes were placed along the road to indicate areas within the buffer zone for waterbodies (Figure 4).

2.3 EnviroKleen Application

Midwest staff trained Dominion personnel on the equipment and proper application protocols prior to the initial application. EnviroKleen was applied to the road surface, without the addition of water dilution. Applications were performed using a computerized bulk fluid spray truck mounted with a 25 ft sprayer bar (Figure 5) that was purchased and used since 2017 to reduce application time due to less frequent refilling and an increase in the applicator spray width. Prior to 2017, applications were made using an EnviroKleen-Sprayer (E-sprayer) designed specifically for the application of EnviroKleen (Figure 6). The E-Sprayer was mounted on a flatbed truck and fitted with ten 2 usg/min V jet spray nozzles over the 10 ft long spray bar. Six 100 L totes were set up on the truck at one time. The setup and application protocol were optimized in 2015 and repeated for the 2016 application but continued to result in lengthy application time due to the narrow width of the sprayer bar and the time required to manually load and change out the EnviroKleen totes.

Application details for 2018 and 2019 are provided in Table 1. Cumulative annual application rate (the amount of EnviroKleen applied per unit area of road treated) was approximately similar between years, ranging from 0.8 L/m^2 in 2018 and 1.22 L/m^2 in 2019 (Table 1). Comparatively, the application rate was 1.33 L/m^2 in 2017 (Dominion 2018).

The 2018 initial application took place in early June, followed by maintenance applications in June, July, and August. The application was not completed over a series of consecutive days due to the following challenges:

- Large amount of precipitation and poor weather conditions over prolonged periods in June; and
- Road degradation as a result of the precipitation events often meant prepping the road surface multiple times before the EnviroKleen application could take place.

The 2019 initial application occurred in early July with maintenance applications in July, August, and September. The first maintenance application in 2019 was delayed until July and was not completed over a series of consecutive days due to the following challenges:

- Unseasonably cold weather, followed by heavy rain events throughout the month of June; and
- Equipment-related issues resulted in an incomplete first application and a delayed second application.

TABLE 1. ENVIROKLEEN APPLICATION DETAILS, 2018 TO 2019

	Volume of EnviroKleen Applied (L)	
	Misery Road	**Sable Road**
Week	**2018**	**2019**
0		
1	230,000	
2	45,000	
3		
4		140,000
5		
6	45,000	
7		
8	45,000	170,000
9		
10	45,000	
11		
12		
13		120,000
Total (L)	410,000	430,000
Length of Road Treated* (km)	27.7	23.2
Width of Road Treated (m)	18.5	15.2
Application Area (m^2)	512,450	352,640
Application Rate (L/m^2)	0.80	1.22

** does not account for buffer areas*
Note: Week 0 was the first week in June.

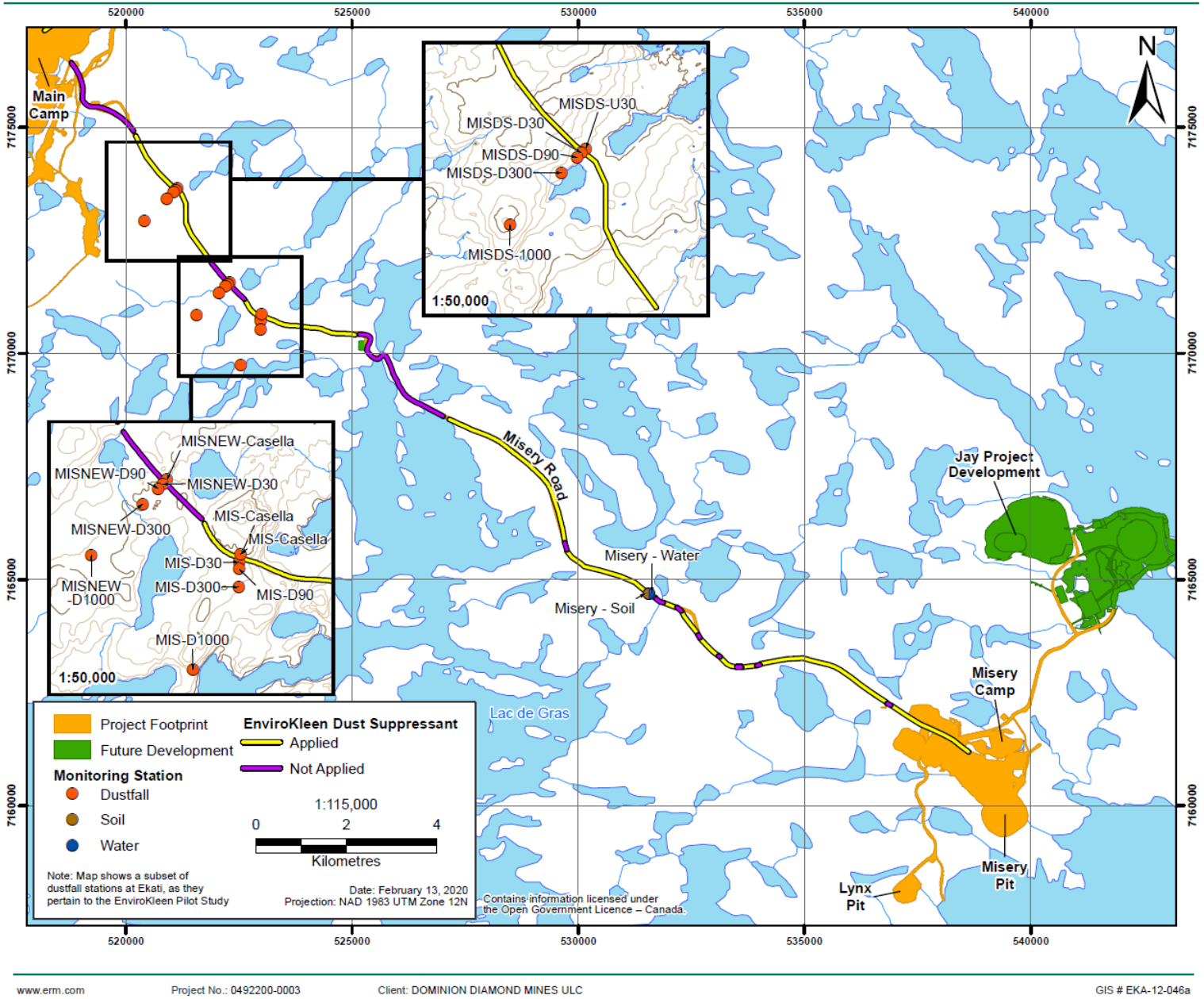

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FIGURE 2. MISERY ROAD WITH ENVIROKLEEN APPLICATION LOCATIONS AND MONITORING STATIONS, 2018

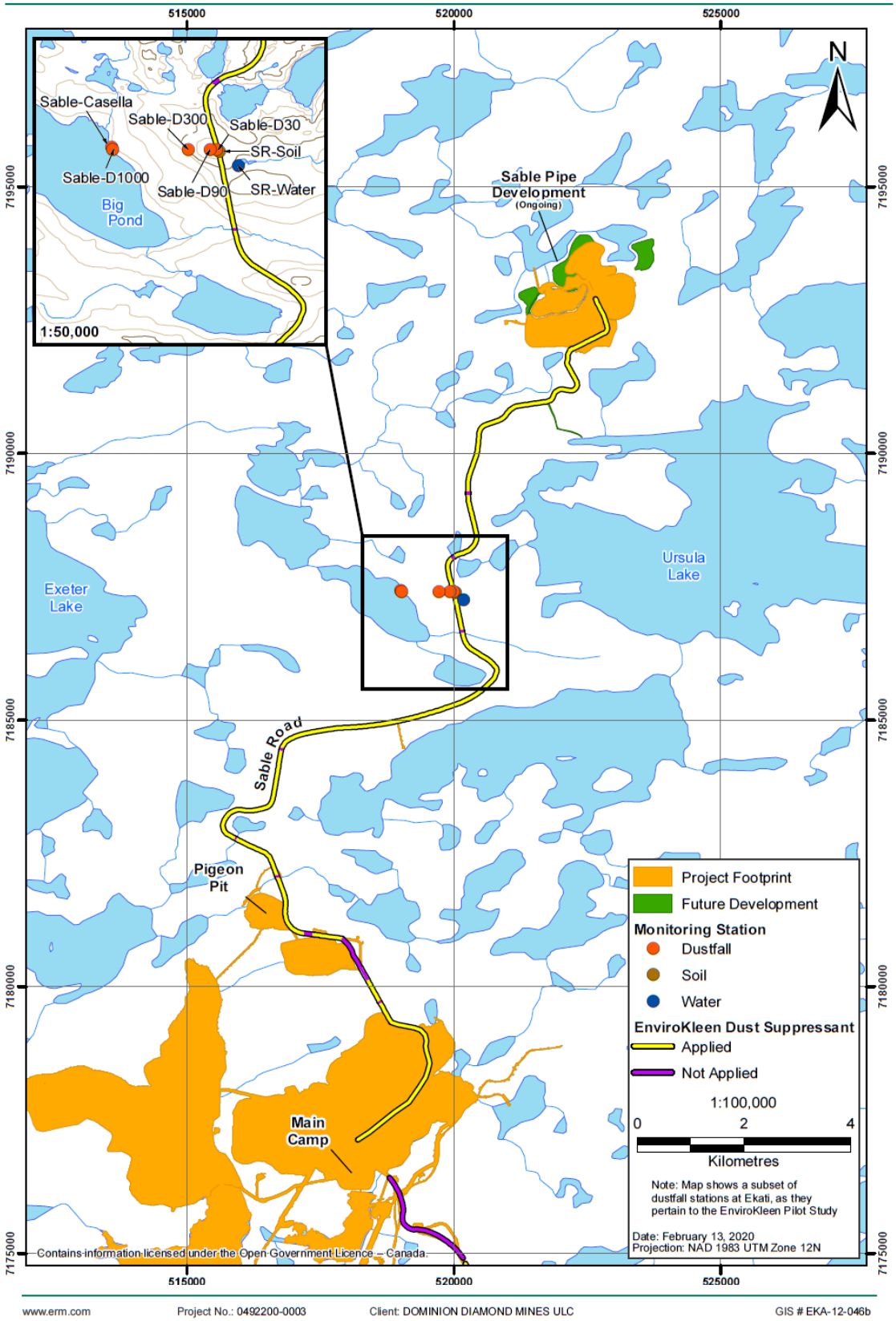


FIGURE 3. SABLE ROAD WITH ENVIROKLEEN APPLICATION LOCATIONS AND MONITORING STATIONS, 2019

2.4 Dustfall Collection and Analysis

The dustfall monitoring program is designed to monitor dustfall at various locations around the Ekati mine as well as background dustfall. Dustfall transects are operated along Misery Road and Sable Road as part of the routine Air Quality Monitoring Program (AQMP).

To monitor dustfall in the summer months (June to September), dustfall transects were located on Misery Road, at Km 6 “Mis’ and ‘MisNew’ respectively) and on Sable Road at approximately Km 11. For the purposes of this study, an additional transect of dustfall stations was introduced in 2015 at km 3.5, corresponding with the 2015 EnviroKleen treatment area. This monitoring location labelled ‘MisDS’ for ‘Misery Dust Suppression’, was monitored from 2015 to 2017. Dustfall monitoring locations relevant to the dust suppression study are depicted in Figure 2 and Figure 3, and further dust station details are summarized in Table 2.

Each dustfall station consisted of paired dustfall collection containers (Figure 7**Error! Reference source not found.**), one of which collects for analysis of particulate, sulphate and nitrate and the other for total metals. The dustfall monitoring stations were constructed and positioned in accordance with the methods outlined in ASTM D1739-98 (2010). The stations consisted of a canister containing a collection medium (deionized water with algaecide) that was exposed to the ambient air for a period of approximately 30 days between June and September. The collectors were outfitted with bird-spikes to minimize sample contamination by bird fecal matter. Each dustfall transect is oriented perpendicular to the road and includes dustfall collectors at 30 m from the road centerline on the predominant upwind side of the road, as well as at 30 m, 90 m, and 300 m (and in most cases 1000 m from the road) on the predominant downwind side of the road.

The dustfall samples were sent to ALS Environmental Laboratory (ALS) in Burnaby, BC and processed according to the methods published by the BC Ministry of Environment (BC MOE), American Public Health Association and United States Environmental Protection Agency (US EPA).

Samples were analyzed for soluble and insoluble particulate, ammonia, chloride, nitrate, sulphate, and total metals. For the purposes of this study, the discussion of results focuses on total dustfall, as many metals are below or close to the detection limit and the aim of this program is to determine whether EnviroKleen is a more effective dust suppressant than those used previously. Complete discussion regarding the monitoring of dust at the Ekati mine can be found in the Air Quality and Monitoring Reports (ERM 2018).

2.5 Suspended Particulate Monitoring

In 2018 and 2019, Dominion used Casella Microdust Dust Detectives (Figure 8) to measure real-time dust migration to both the downwind and upwind sides of the EnviroKleen treated road (Figure 9). The data provided by castella monitors is intended to provide real time information on the performance of Envirokleen, which in turn can be used to trigger proactive reapplication of dust suppressant as performance reduces and dust levels being to rise. The Casella Microdust Dust Detective uses an advanced forward light scattering principle to make accurate and repeatable measurements of suspended particulate concentrations. The units are capable of detecting concentrations of total suspended particulate (TSP) between 0.001 mg/m^3 and 2,500 mg/m^3. Units were programmed a record a flow reading of 2.00L/m, at 10 second or 60 second intervals.

FIGURE 4. THE STAKED BUFFER AREA LOCATIONS FOR THE ENVIROKLEEN APPLICATION ON SABLE ROAD, 2019

FIGURE 5. ENVIROKLEEN BULK FLUID TRUCK WITH 25 FT SPRAYER USED FOR APPLICATIONS, 2017 TO 2019

FIGURE 6. ENVIROKLEEN SPRAYER AND TOTES USED FOR APPLICATIONS, 2015 TO 2016

FIGURE 7. DUSTFALL STATION WITH TWO PARALLEL COLLECTORS, JULY 2019

TABLE 2. DUSTFALL MONITORING STATIONS USED FOR DUST SUPPRESSION PILOT STUDY, 2006 TO 2019

Road	Dustfall Transect ID	Road Location	Dust Suppressant Used			Dustfall Sampling Locations	Dustfall Sampling Operational Period
			EnviroKleen	DL-10	Watering only		
Misery Road	Mis	Km 7	2016 - 2018	2006 - 2015	2019	30 m upwind	2006 - 2019
						30 m downwind	2006 - 2019
						90 m downwind	2006 - 2019
						300 m downwind	2006 - 2019
						1000 m downwind	2006 - 2019
	MisNew	Km 6	2016 - 2018	2006 - 2015	2019	30 m upwind	2015 - 2019
						30 m downwind	2015 - 2019
						90 m downwind	2015-2019 and July/Aug 2014
						300 m downwind	2015-2019 and July/Aug 2014
						1000 m downwind	2015-2019 and July/Aug 2014
	MisDS	Km 3.5	2015 - 2018	2006 - 2014	2019	30 m upwind	2015 - 2017
						30 m downwind	2015 - 2017
						90 m downwind	2015 - 2017
						300 m downwind	2015 - 2017
						1000 m downwind	2015 - 2017
Sable Road	Sable	Km 11	2019	n/a	2017 - 2018	30 m upwind	2017 - 2019
						30 m downwind	2017 - 2019
						90 m downwind	2017 - 2019
						300 m downwind	2017 - 2019
						1000 m downwind	2017 - 2019

Monitoring locations and the number of Casellas deployed changed per year. In 2018, a total of four units were used to monitor Misery Road; two units were place at the Mis monitoring location (Km 3.5 of Misery Road) and two units were placed at the MisNew location (Km 7 of Misery Road; Figure 2). In 2019, a total of two units were used to monitor Sable Road. The units were placed at Km 11 of Sable Road (Figure 3). Casella monitoring locations were selected for the following reasons:

- Nearness to dustfall stations, allowing for data comparisons between the two methods of particulate monitoring (Figure 9);
- MisNew and Mis locations were new monitoring sites selected in 2018 due to prevailing winds and its east-west location to the south of Mis; and
- Proximity to the Ekati Main Camp area, which allows for quick deployment and retrieval of the instruments.

During deployment, units were placed on approximately 6 ft high stands on the tundra, located approximately 2 m from the edge of the road bank. Stands were paired with an upwind (EAST) and downwind (WEST) location.

For each monitoring event, the units were deployed in the morning and retrieved at the end of the day. The units were programmed to record particulate concentrations every 10 seconds while deployed at the MisNew and Sable monitoring sites and every 60 seconds at the Mis monitoring site. Dominion deployed the dust detectives during the open water period, both before and after the initial application of EnviroKleen. The deployment frequency was once per week in 2018 and every five days in 2019, however, the units cannot be deployed during wet or rainy conditions, which limited their use. The units were calibrated and cleaned once a week at minimum, and more often as needed.

Unlike dustfall results, the dust detectives collect real-time data. As such, this data can show changes in dust generation (such as maximum daily TSP) through time, which may result from differences in equipment, road usage, road condition or weather-related events such as rainfall and wind. Maximum and daily average suspended particulate (mg/m^3) was assessed over the course of the open water season and compared against EnviroKleen application dates. Average daily total suspended particulate (TSP) was also compared pre and post initial application on Sable Road in 2019. Because dust suppressant had not been applied to Sable Road prior to 2019, the pre and post-application comparison reflects dust suppressant efficiency before and after initial application.

FIGURE 8. CASELLA DUST DETECTIVE UNITS

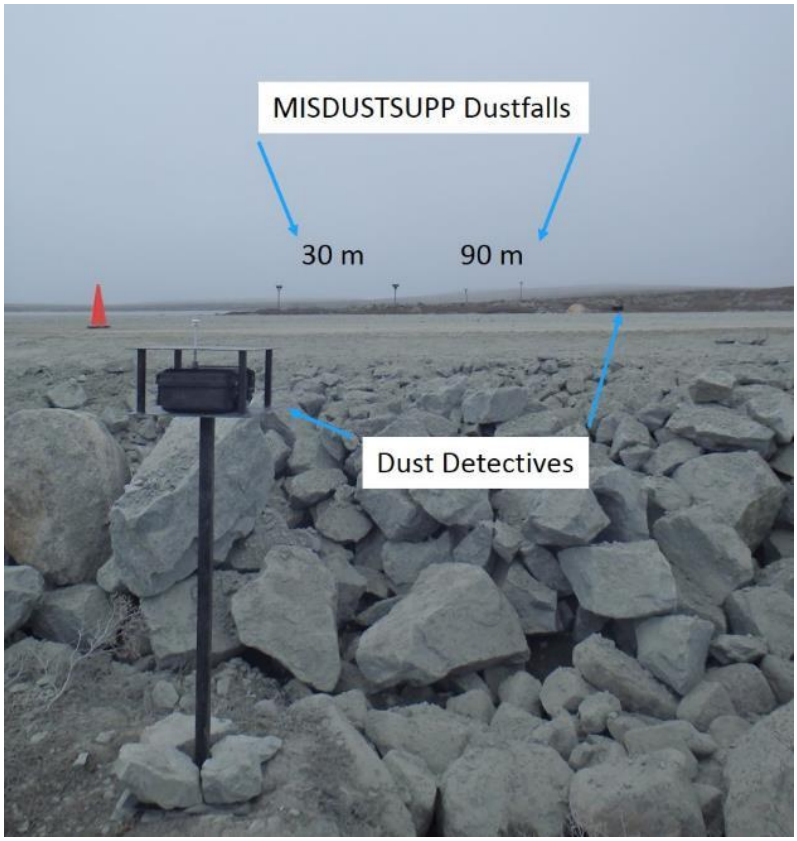


FIGURE 9. EXAMPLE OF CASELLA DUST DETECTIVES AND DUSTFALL ARRAY

2.6 Soil and Water Sampling

In response to concerns expressed by the Lutsel K'e, in their June 9, 2016 letter, the pilot program was expanded in 2017 to include soil and water samples. These samples were initially collected in 2017 to evaluate whether and to what extent EnviroKleen dissipates across the surface of the road and surrounding tundra.

In 2018, soil and water samples were collected near Km 18 of the Misery Road, which received EnviroKleen for the first time in 2017. Prior to 2017, this location would have been treated with water or DL-10. Soil and water samples were previously collected at this location in 2017. Sampling at this location was repeated in 2019 at the same collection sites for comparison one-year post EnviroKleen application. In 2019, soil and water samples were collected at the dustfall and Casella monitoring station on Sable Road (Km 11), which was treated with EnviroKleen for the first time in 2019. For comparison, soil and water samples were collected at Nanuq Lake, a reference site used in the Ekati Aquatic Effects Monitoring Program, in August (water and soil sample) and October (soil sample only) of 2017 (DDM 2018).

Soil sample collection locations varied by year. In 2018, soil samples were collected from the center of the road as well as at 1 m, 5 m, and 10 m from the edge of the road in June, August, and September of 2018 (See Figure 1 for station locations). In 2019, soil samples were restricted to the road surface and were collected from the center of the road, and with 1 m, 5 m and 10 from the centre of the road to determine how the product migrated across the surface of the road with road work. Samples were placed in glass containers, kept cool and submitted to ALS

Environmental in Burnaby BC for analysis. ALS generated hydrocarbon chromatograms for each sample, which were then compared against an EnviroKleen chromatogram ‘signature’ to determine whether EnviroKleen was present (Figure 10). For samples in which an EnviroKleen ‘signature’ was determined to be present, the amount of EnviroKleen was quantified.

Water quality samples were collected from a waterbody proximal to soil sampling locations used in 2018 and 2019. Water was collected in glass amber containers that contained a sodium bisulfate preservative, as provided by ALS Environmental. Samples were kept cool until submitted to ALS for analysis. Similar to the soil analyses, sample hydrocarbon chromatograms were compared to that of EnviroKleen and EnviroKleen presence determined, and if present, quantified.

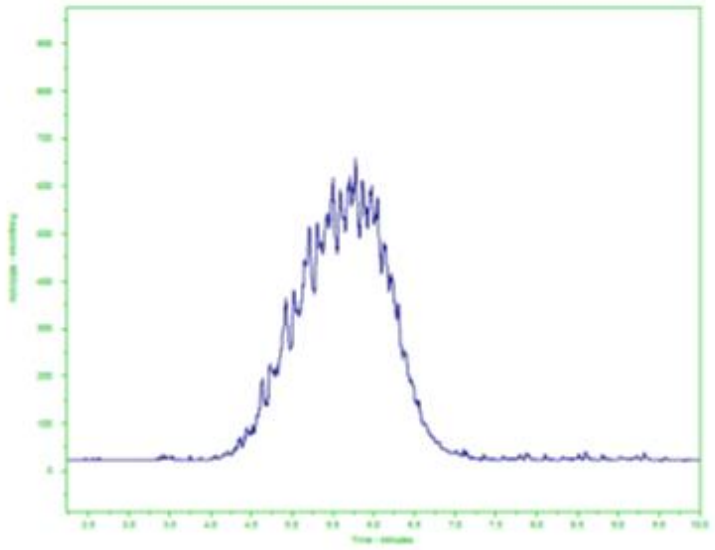


FIGURE 10. CHROMATOGRAM SIGNATURE OF THE ENVIROKLEEN PRODUCT

2.7 Visual Observations

To support the interpretation of the 2018 and 2019 dust suppression results and provide a qualitative measure the efficiency of the EnviroKleen product, video audits and road inspections were conducted, pre and post EnviroKleen applications. The video audits allowed for a qualitative assessment of the fugitive dust generated before and after EnviroKleen applications, while the road inspections determined the road surface maintenance needs following the application.

2.7.1 Video Audits

The video audits were performed routinely by trained personnel during the application and reapplication periods to document the road surface conditions as well as the dust levels generated by mine traffic. When transportation was available on site, a GoPro was mounted to the front of a light vehicle which was then driven the length of Misery (2018) or Sable (2019) roads. The videos were reviewed and analyzed by Midwest to assess and document the performance of the EnviroKleen Program.

2.7.2 Road Maintenance and Usage

Concurrent with the video audit process, trained personnel also completed road inspections pre and post EnviroKleen applications in 2018 and 2019. These assessments evaluated the following parameters to indicate the effectiveness of the EnviroKleen applications:

- Current visual dust levels
- Road surface deterioration, including:
    - Magnitude, location and frequency of potholes, wheel path rutting, and washboarding; and
    - Drainage issues, standing water and condition of ditches used to divert water from the roadway.
- Weather conditions;
- EnviroKleen application information (i.e. number of passes required, volume of product applied, areas product was applied at, encountered or potential issues, etc.);
- Maintenance activities performed on road; and
- Photos of the road surface.

To supplement the on-site road inspections, traffic volumes were estimated for open water period (May to October) based on number of trips made by heavy vehicles (i.e., Haul Max and Dual Powered Road Trains), the greatest dust generating traffic on the road. Dominion qualifies that the traffic volumes presented here are estimates based on heavy vehicles only and are included for the purposes of providing a relative index of traffic volume for comparison of dust levels between roads and years. Because dust dispersion is dependent on several other factors (i.e., the weight, type and speed of the vehicle, and environmental factors such as windspeed and surface material moisture content), traffic volume alone provides only a cursory estimate of dust levels. To provide very basic proxy for environmental factors that influence dust dispersion, traffic volume was compared against total precipitation per month. Precipitation levels were obtained from the Ekati Mine's Koala meteorological station, which has the longest and most continuous data record for the site (see ERM 2018).

3 Results

3.1 Dustfall Collection

The purpose of the dustfall monitoring program is to determine the dust deposition patterns at the mine. The dustfall stations located adjacent to EnviroKleen application locations provide information on the effectiveness of dust suppressant in reducing fugitive dust. As described in Section 2.4, dustfall data was collected and analyzed on a monthly basis, the results can be used to determine monthly total dustfall and mean daily dust deposition during each collection period.

While dustfall monitoring provides valuable information on the distribution and total deposition of road generated dust, comparisons of the effectiveness of various dust suppression products across years can be problematic. In addition to varying traffic levels and the type of equipment being used, there are numerous natural factors that can significantly impact the amount of dust that is generated by a road and the extent to which it is dispersed annually (i.e., relative humidity, amount of precipitation, frequency of precipitation, wind direction and wind speed) which are further discussed in Section 4.

Dustfall data collected from 2015 through 2019 are presented in Figure 11. In all years and at all dustfall arrays on Misery Sable Road (Figure 11), dustfall was highest near the road and rapidly declined with distance from the road. Results from the sampling array located at 300 m from the road, indicate that the majority particulate matter has settled out (Figure 11).

For Misery Road, a comparison of 2016 to 2019 results at dustfall sites located where there had been EnviroKleen application suggests total dustfall was generally lower in 2016, 2018 and 2019 relative to 2017 (Figure 11). The 2016 dustfall data also appeared lower than 2015 dustfall when examining the MisDS data, a dustfall station where EnviroKleen had been applied in all years. The inter-annual differences seen at MisDS seemed to mirror those seen at the Mis location (which had been treated with DL-10 in 2015 then EnviroKleen in all other years), which suggests that DL-10 and EnviroKleen were similarly effective in suppressing dustfall in 2015. The Mis dustfall locations have been monitored for a much longer period of time (2012 onward) than the other dustfall locations, and as a result a more robust comparison of the effect of EnviroKleen can be made for this location. There was no obvious increase in dust on Misery Road in 2019, despite there being no new EnviroKleen or DL-10 application in 2019. This suggests that the use of water in 2019 as the dust suppressant combined with residual suppressant in the road - surface was effective at controlling dust on Misery Road at lower traffic levels.

A comparison between pre-EnviroKleen treatment years (2012 to 2015) and post-EnviroKleen treatment years (2016 to 2018) at two dustfall locations (Mis and MisNew) that had been treated with DL-10 in 2015 or earlier (2012 to 2015) and then EnviroKleen in later years is shown in Figure 12. Mis dustfall data from 2012 to 2017 were compiled and grouped into DL-10 and EnviroKleen treatment years. Data was then compared by both month and distance from the road. Overall, inter-annual differences produced large and overlapping confidence intervals which obscure any dust suppression differences which may exist. No clear dustfall differences are seen between years in which DL-10 was used as a dust suppressant and years in which EnviroKleen was used as a dust suppressant. It is noted that the DL-10 data is represented by earlier years (2012 to 2015, inclusive) while EnviroKleen data is represented by later years (2016 to 2018). These results are further confounded by difference in traffic volume and type of equipment across years.

On Sable Road, dustfall station results include two years of monitoring pre-EnviroKleen application (2017 and 2018) and one year of monitoring post application (2019; Figure 13). Dustfall results were higher during the 2019 post-

treatment year, however traffic on Sable Road also began increasing in late 2018 and continued to increase in 2019 (See Section 3.4.2). It should also be noted that we only managed to achieve three applications of EnviroKleen in 2019 rather than the typical five applications used on Misery Road in past years.

3.2 Suspended Particulate Monitoring

On Misery Road, suspended particulates were monitored at MisNew and Mis in 2018. MisNew was monitored over the course of 11 days between July 6, 2018 and August 28, 2018 and Mis was monitored for nine days between July 22, 2018 and August 28, 2018. Due to technical issues with the equipment, monitoring data was collected from the upwind station at MisNew on four of the 11 days deployed; data was collected for all survey days at the paired downwind station.

Sable Road was monitored at the Sable survey location in 2019. Monitoring occurred over the course of 17 days between June 5, 2019 and September 13, 2019. Data was collected successfully on 13 of the 17 monitoring days at the downwind station and all days at the upwind station. Technical issues prevented data collection on four days that the equipment was deployed between July 16, 2019 and July 31, 2019 and dust readings were not collected during this period.

The Misery Road 2018 suspended particulate monitoring results are presented for MisNew (Figure 14) and Mis (Figure 15). The Sable Road 2019 results are presented in Figure 16. Similar to Casella data collected in 2016, all of the high daily maximum TSP values recorded after EnviroKleen application in 2018 and 2019 were determined to have occurred within one minute of either monitoring start-up or shut-down. This indicated that these highs were artifacts of the Castella Dust Detective monitor equipment start-up or shut-down activities rather than real road dust emissions. To correct for this effect, the first 5 minutes of monitoring data was removed from the start and end of each daily monitoring period and the corrected data are graphed.

In general, maximum TSP and average TSP values were overall higher in 2019 at the Sable station relative to the 2018 stations, MisNew and Mis on Misery Road. However, these two roads are not directly comparable because weather conditions and traffic levels differ (see Section 3.4.2). Additionally, previous dust suppression applications vary between roads. Sable Road was not treated with EnviroKleen or DL-10 dust suppressant historically, however sections of Misery Road has been treated with suppressant since 2012.

In 2018, no Casella data was collected prior to the initial EnviroKleen application that began on June 13, 2018. However, maximum TSP and average TSP generally decreased or stayed consistent over the course of the monitoring period at both the MisNew (Figure 14) and Mis (Figure 15) stations and at both the upwind and downwind stations.

In 2019, prior to the initial dust suppression application on Sable Road, both average and maximum TSP were elevated at both the upwind and downwind stations prior to the initial EnviroKleen application on July 4 to July 8, 2019. The average daily TSP pre-application was 0.05 mg/m^3 (n=4) and 0.11 mg/m^3 (n=4) at the downwind and upwind stations, respectively (Table 3, Figure 16). Pre-application, daily maximums ranged from a low of 0.06 mg/m^3 at the downwind station on June 15, 2019 to a high of 33.59 mg/m^3 at the upwind station on June 28, 2019 (Figure 16).

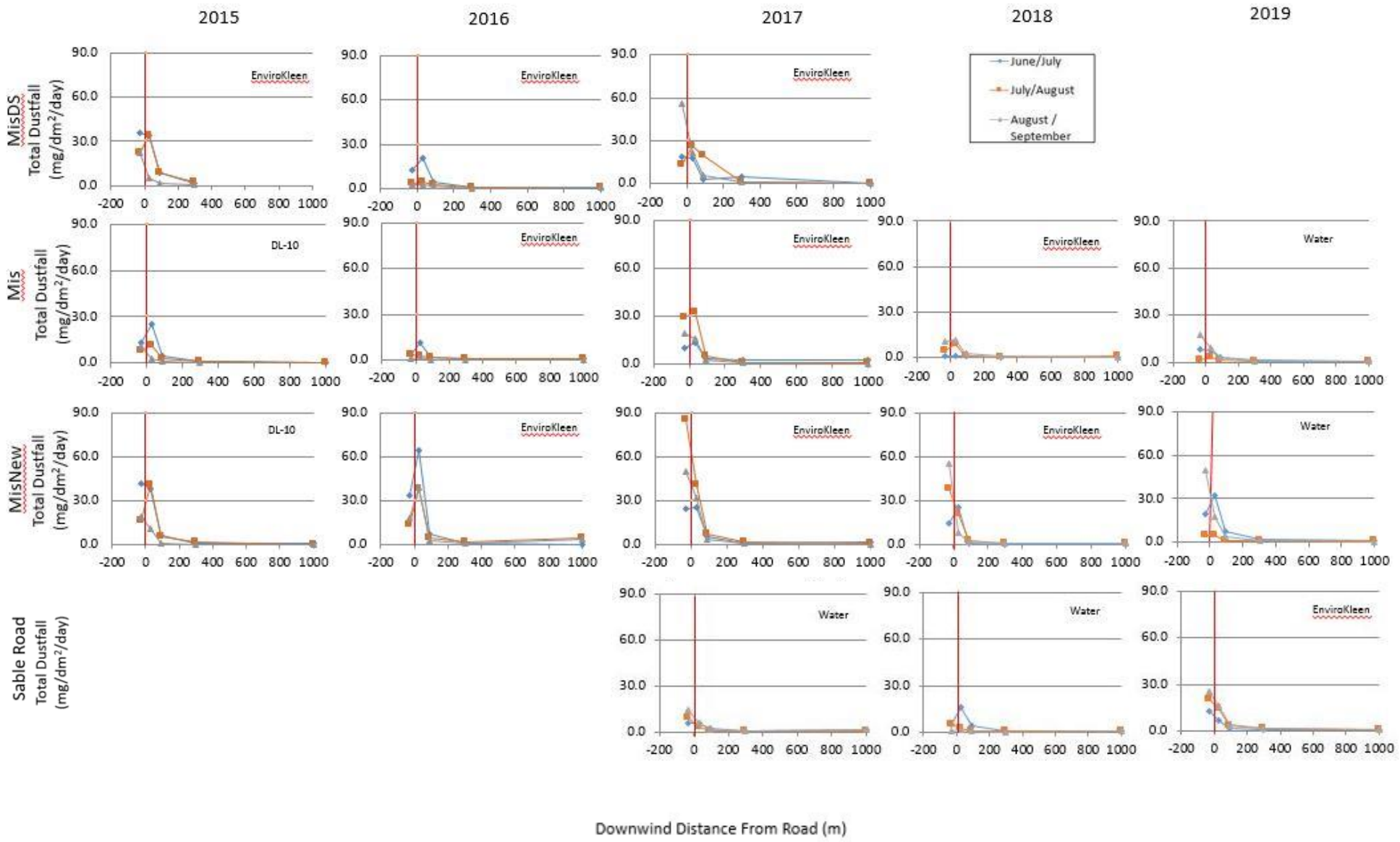


FIGURE 11. MISERY ROAD AND SABLE ROAD DUSTFALL RESULTS BY YEAR AND MONITORING LOCATION, 2015 TO 2019

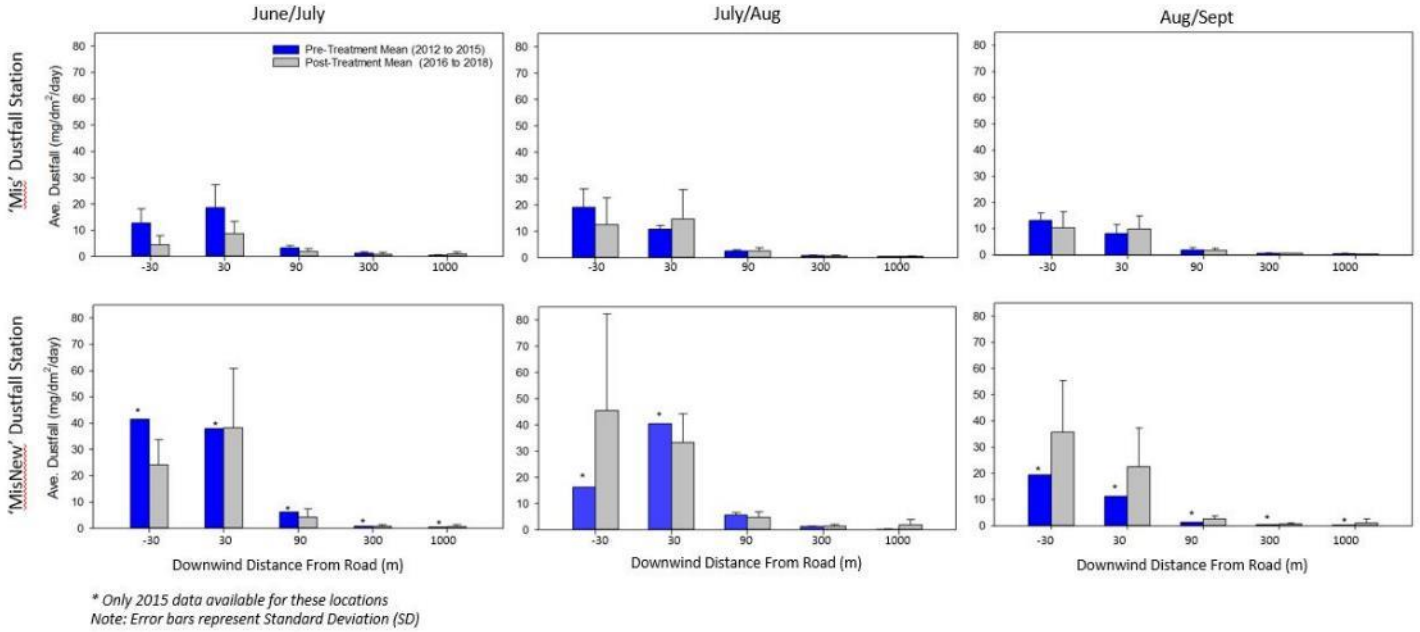


FIGURE 12. AVERAGE MONTHLY DUSTFALL AT MIS AND MISNEW DUSTFALL MONITORING LOCATIONS IN DL-10 (PRE-TREATMENT) AND ENVIROKLEEN (POST-TREATMENT) APPLICATION YEARS, 2012 TO 2018

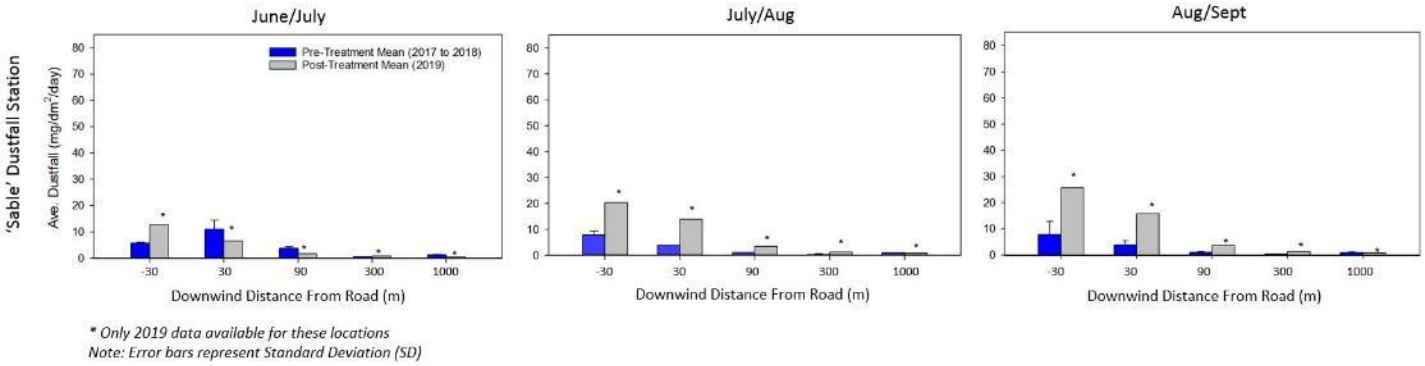


FIGURE 13. AVERAGE MONTHLY DUSTFALL AT SABLE DUSTFALL MONITORING LOCATIONS IN WATER (PRE-TREATMENT) AND ENVIROKLEEN (POST-TREATMENT) APPLICATION YEARS, 2017 TO 2019

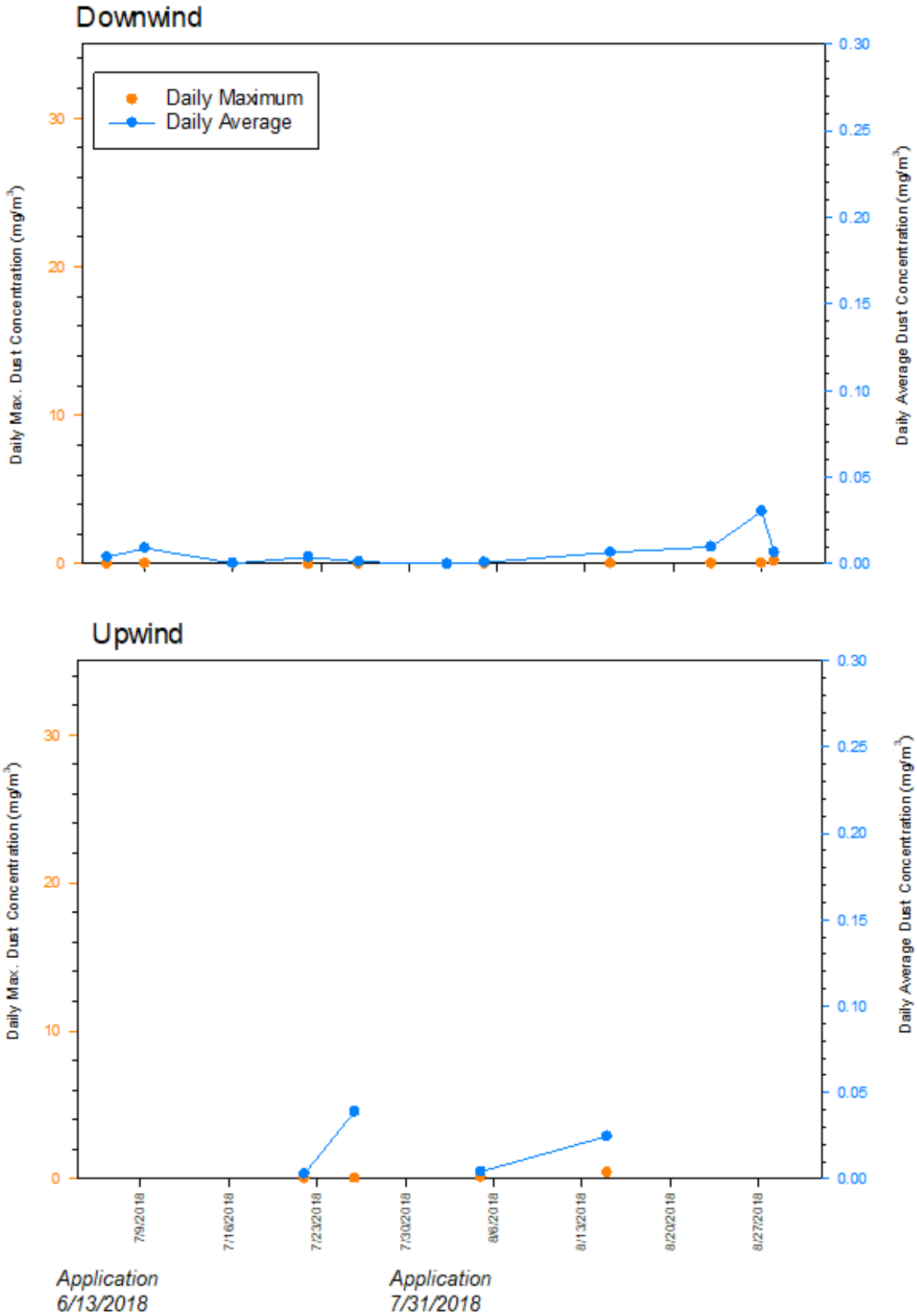


FIGURE 14. MAXIMUM AND AVERAGE DAILY SUSPENDED PARTICULATE ON MISERY ROAD AT MISNEW, 2018

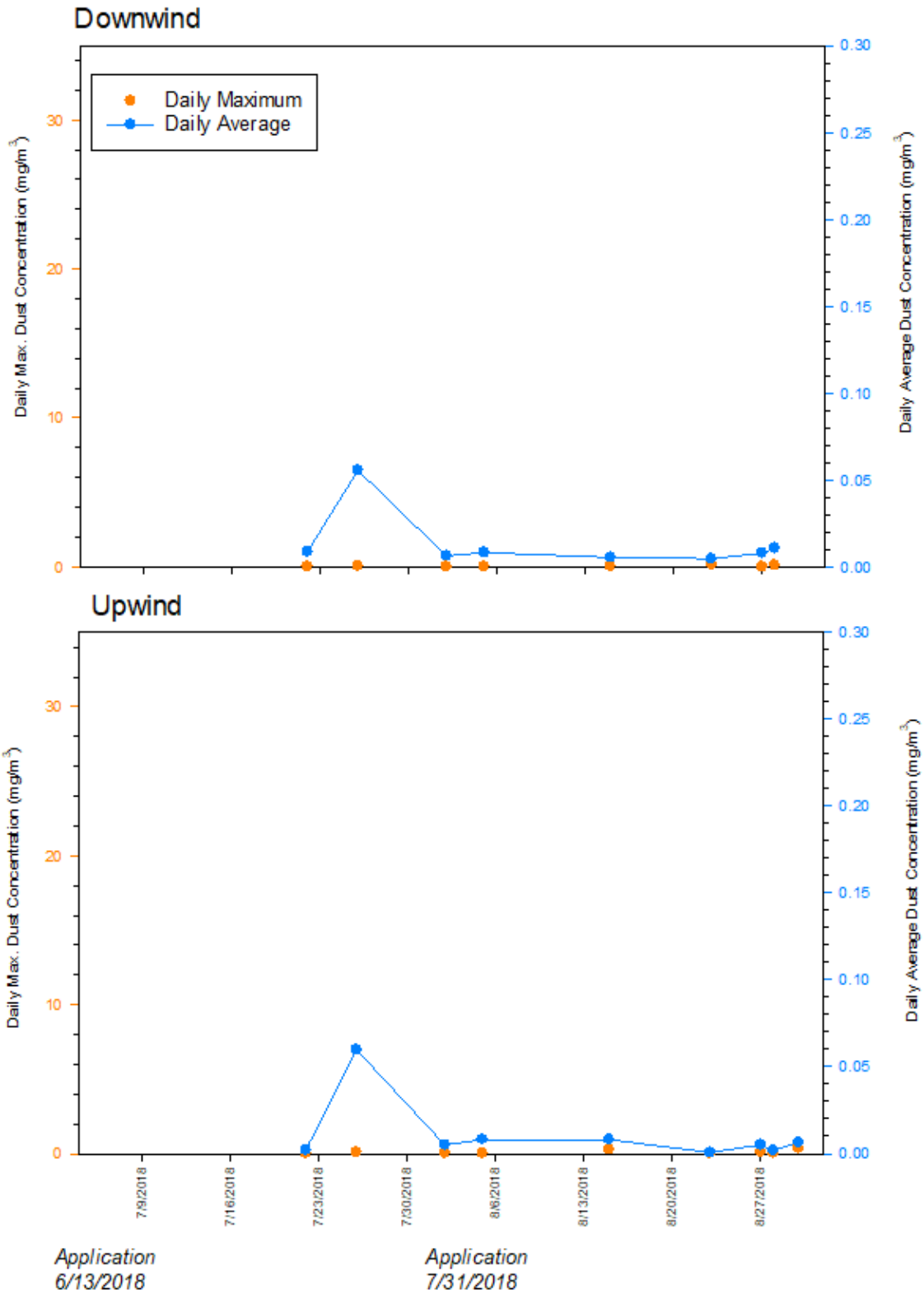


FIGURE 15. MAXIMUM AND AVERAGE DAILY SUSPENDED PARTICULATE ON MISERY ROAD AT MIS, 2018

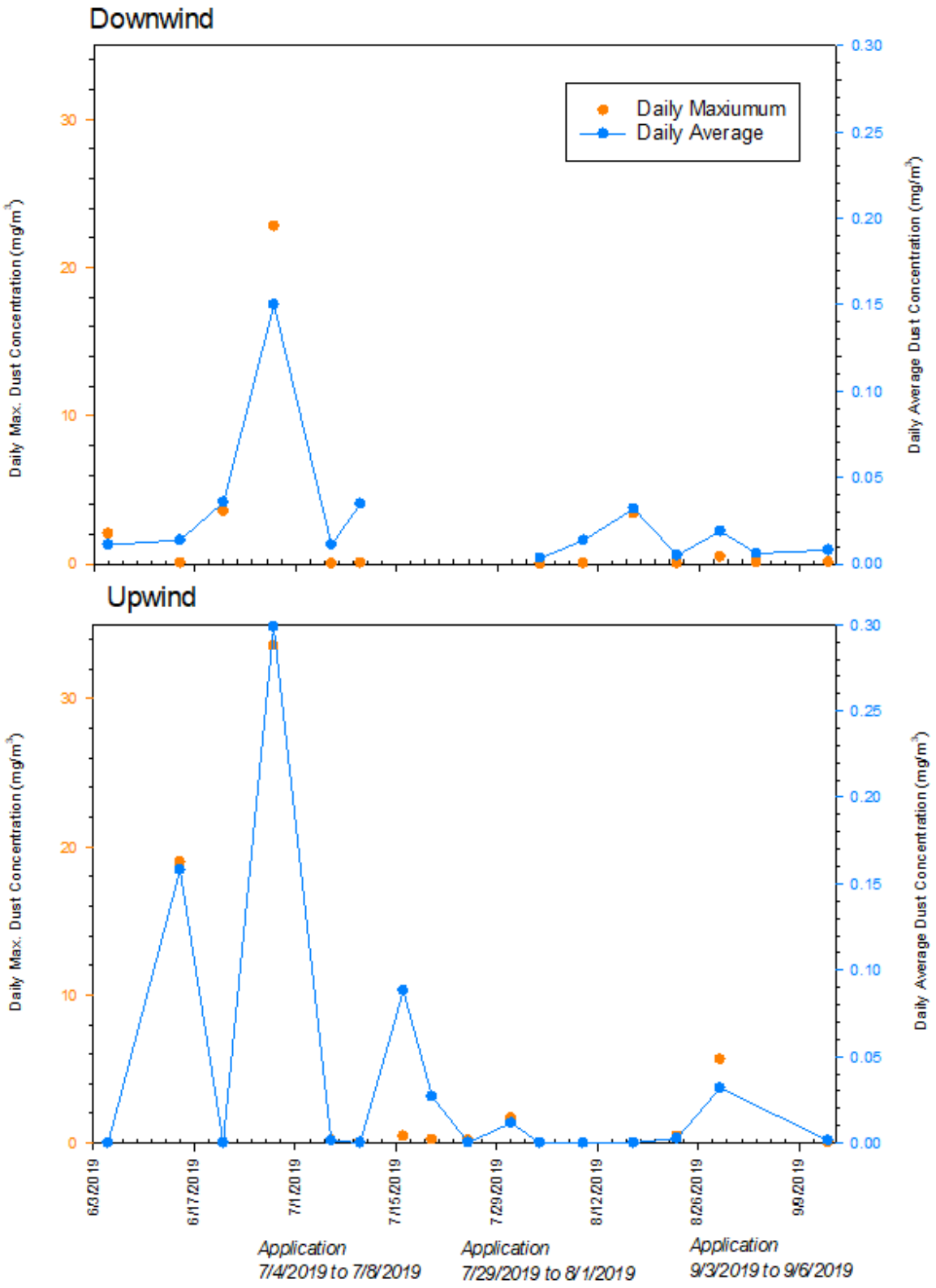


FIGURE 16. MAXIMUM AND AVERAGE DAILY SUSPENDED PARTICULATE ON SABLE ROAD AT SABLE, 2019

Post application, average daily TSP levels decreased at the Sable station to 0.01 mg/m^3 (n=13) downwind and 0.01 mg/m^3 (n=9) upwind (Table 3). Maximum daily TSP levels also decreased at both the downwind and upwind stations following the initial application on July 4 to 8, 2019 and after the maintenance application on September 4 to 6, 2019 (Figure 16). A gap in the monitoring at the downwind station between July 11 and August 4, 2019 reduced the ability to determine TSP level changes following the July 29 to 31 maintenance application, however based on the upwind station alone, there was no substantial decrease in TSP directly following the reapplication (Figure 16). The average and maximum TSP also decreased after August 22, 2019 following a significant rainfall event (24.5 mm), which resulted in a reduced daily maximum to 0.03 mg/m^3 and the average TSP to <0.001 mg/m^3 at the downwind station on August 23, 2019.

TABLE 3. AVERAGE DAILY TOTAL SUSPENDED PARTICULATE ON SABLE ROAD, PRE AND POST-ENVIROKLEEN APPLICATION, 2019

Sable Road Station	Sampling Period	Number Sampling Dates	EnviroKleen Status	Average Daily Dust Concentration (mg/m^3)
Downwind	June 5 to 28, 2019	4	Pre-application	0.05
	July 6 to Sept 13, 2019	13	Post-application	0.01
Upwind	June 5 to 28, 2019	4	Pre-application	0.11
	July 6 to Sept 13, 2019	9	Post-application	0.01

Notes: Concentrations reflect corrected values (see section 3.2)

3.3 Soil and Water Sampling

The EnviroKleen applications took place on Misery Road in June, July and August of 2018 and on Sable Road in July, August, and September of 2019. Soil and water samples were collected from a monitoring station at Km 18 of the Misery Road in 2018 (Figure 2) and from a monitoring station at Km 11 of Sable Road in 2019 (Figure 3). Sampling dates are provided in Table 4. The first sampling date per year was collected prior to the initial EnviroKleen application. For a comparison between sampling years, the station at Km 18 of Misery Road was resampled in October 2019.

Results of the soil samples collected on Misery Road in 2018 indicated that EnviroKleen was detected during each sampling date and at all distances from the road (Table 4, Figure 17). EnviroKleen was present in low concentrations Among the dates sampled, EnviroKleen concentrations were highest on the Misery Road surface in July when concentrations were estimated at 17,200 mg/kg and lowest in September when concentrations were estimated at 5,180 mg/kg. Within a sampling session, EnviroKleen concentrations generally dissipated with distance from the road. At the 10 m distance from the road, EnviroKleen concentrations ranged from 390 mg/kg in August to 1,440 mg/kg in September (Table 4). Results from the October 2019 sampling indicated that EnviroKleen remained present on the road in low concentrations (1,450 mg/kg). At 10 m from the road, EnviroKleen concentrations were higher in 2019 (5,370 mg/kg) than in 2018 (3,200 mg/kg), despite no EnviroKleen application in 2019 (Table 4). This increase is likely driven by the transport of residual suppressant from the road surface.

Soil samples collected from Sable Road in 2019 showed the presence of EnviroKleen at all collection dates subsequent to the initial application from July 4 to 8, 2019 (Table 4, Figure 18). Across the surface of the road, concentrations were highest at a distance of 10 m from the centre of the road (Table 4). Concentrations were generally higher during the July and September sampling and lowest in August, suggesting that the concentrations did not increase cumulatively with each maintenance application. EnviroKleen concentrations did not increase following the maintenance application that occurred from August 13 to 16, 2019 (Table 4). Due to the wet conditions in the fall, finding windows for optimal application were difficult and significant road work was required to cope with potholes and rutting caused by major rain events.

Although soil sampling has shown that EnviroKleen may be transported off the road to a distance of at least 10 m, it does not pose any acute or chronic toxicity risk to standard aquatic test species, at concentration approximately double the highest levels detected in soil samples. Results of the water samples show that no EnviroKleen was detected in any of the water samples collected in 2018 or 2019 (See Figure 2 and Figure 3 for sample locations).

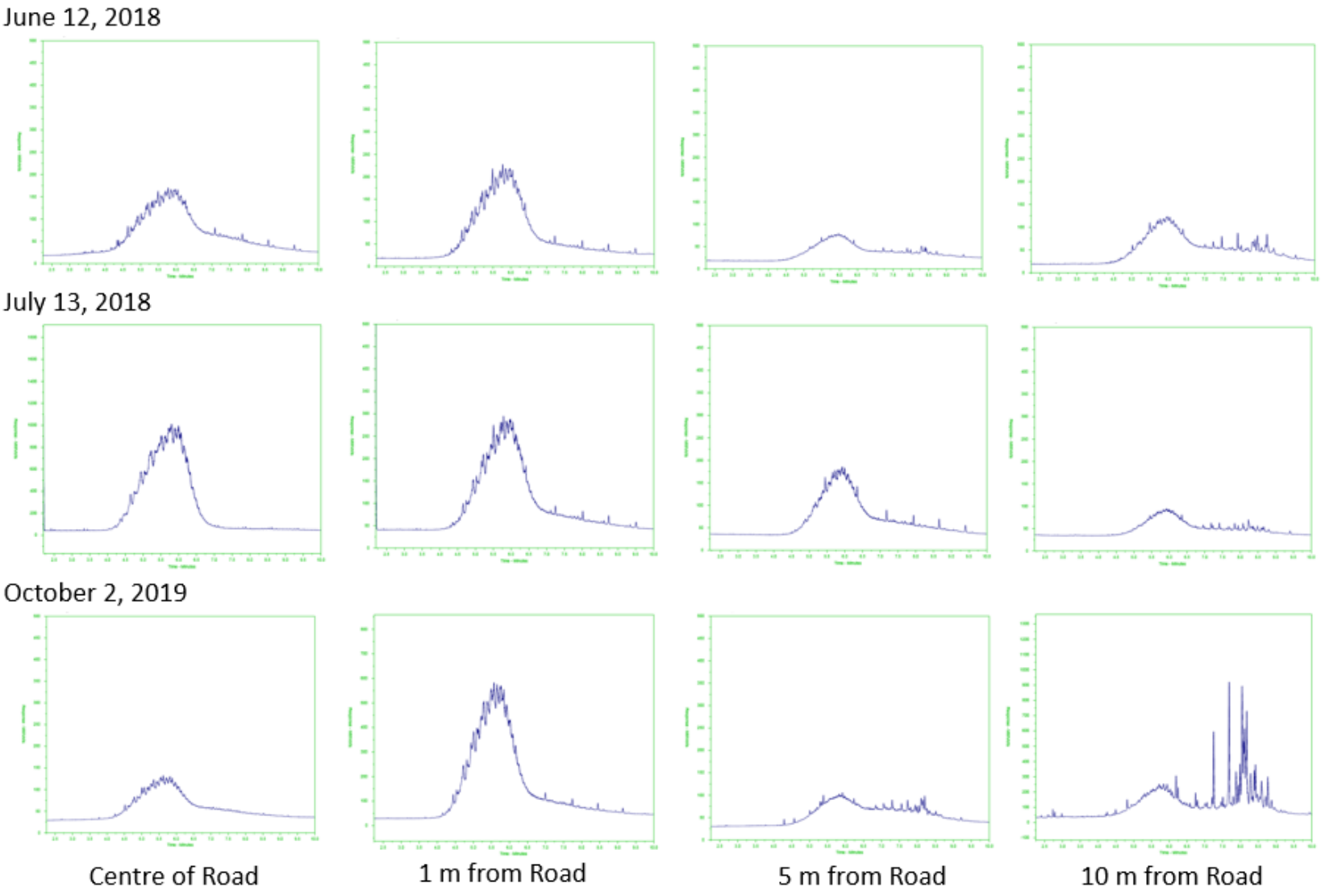
TABLE 4. ENVIROKLEEN SOIL RESULTS ON MISERY AND SABLE ROAD, 2018 TO 2019

		EnviroKleen Detections (mg/kg)							
Sampling Date	**EnviroKleen Status**	**Misery Road**				**Sable Road**			
2018[1]		Centre Road	1 m from Road	5 m from Road	10 m from Road	Centre Road	1 m from Centre of Road	5 m from Centre of Road	10 m from Centre of Road
June 12	Pre-application	4,420	3,190	4,940	1,760	n/a	n/a	n/a	n/a
July 13	Post-application	17,200	5,780	3,960	1,280	n/a	n/a	n/a	n/a
August 14	Post-application	15,400	6,510	1,270	390	n/a	n/a	n/a	n/a
September 11	Post-application	5,180	4,970	3,200	1,440	n/a	n/a	n/a	n/a
2019[2]									
June 24	Pre-application	n/a	n/a	n/a	n/a	-	-	-	-
July 24	Post-application	n/a	n/a	n/a	n/a	5,890	5,350	3,950	24,900
August 25	Post-application	n/a	n/a	n/a	n/a	2,550	1,840	1,990	4,220
September 22	Post-application	n/a	n/a	n/a	n/a	12,300	9,330	8,230	14,400
October 19	No application	1,450	5,490	1,840	5,370	n/a	n/a	n/a	n/a

Notes: ' – ' indicates EnviroKleen not detected and N/a indicates no sample available.

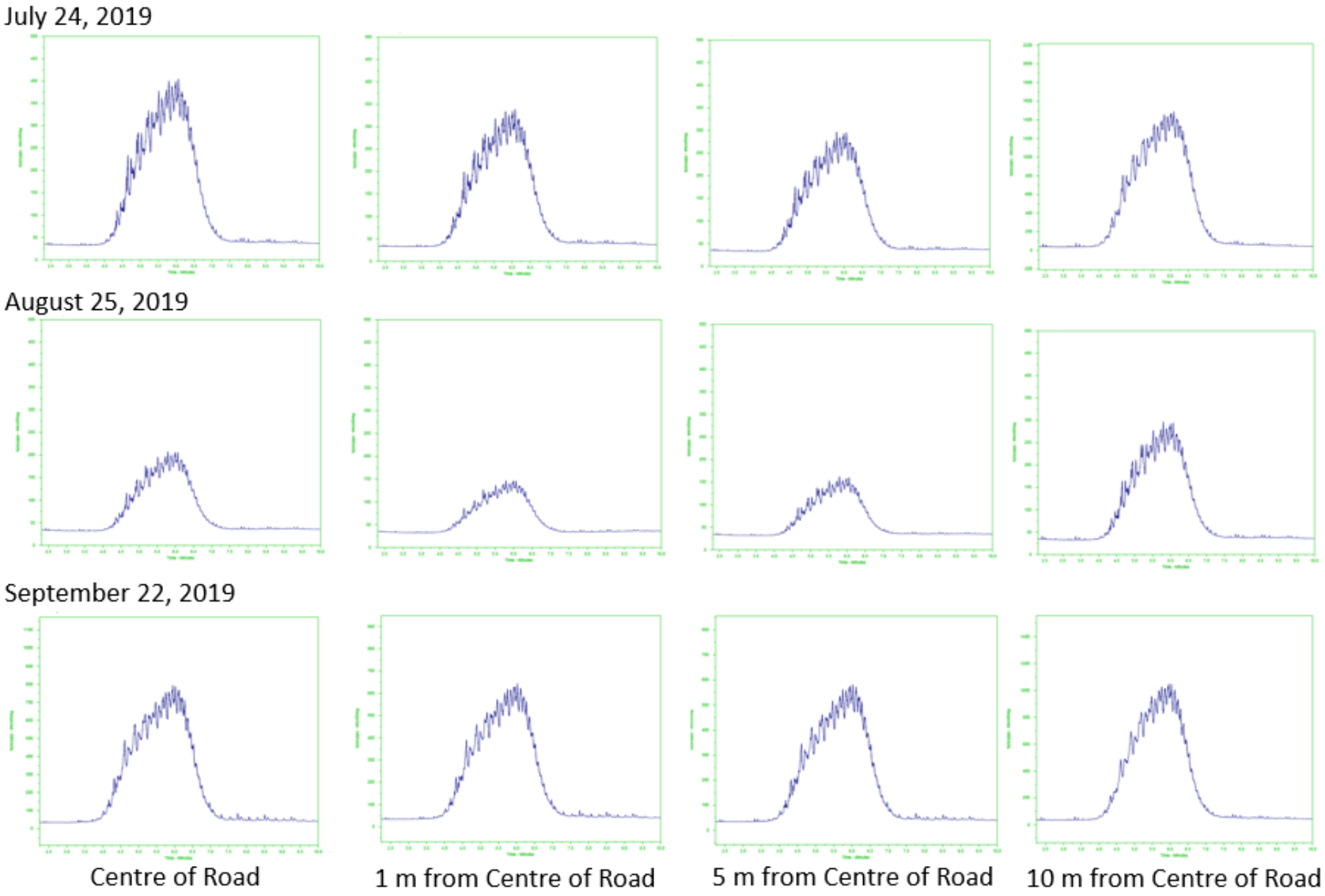
[1] Initial annual EnviroKleen application occurred on June 13, 2018.

[2] Initial annual EnviroKleen application occurred from July 4 to July 8, 2019.



**Note: No soil chromatograms presented for sampling dates, August 14, 2018 and September 11, 2018.*

FIGURE 17. ENVIROKLEEN CONCENTRATIONS IN SOIL WITH DISTANCE FROM MISERY ROAD, KM 18, 2018 AND 2019



**Note: No EnviroKleen detected in soil samples collected on June 24, 2019, pre-EnviroKleen application.*

FIGURE 18. ENVIROKLEEN CONCENTRATIONS IN SOIL WITH DISTANCE FROM SABLE ROAD, KM 11, 2019

3.4 Visual Observations

3.4.1 Video Audits

In general, Dominion staff noticed a substantial decrease in visual airborne dust following the initial EnviroKleen applications, as well as maintenance reapplications. Qualitative visual observation in both 2018 and 2019 EnviroKleen application, years relative to years when DL-10 was applied (prior to 2018) suggested that immediately following initial application, and over the short term, the dust suppression effectiveness of DL-10 and EnviroKleen were similar. Several weeks following application, visual observations made for a DL-10 treated road showed increased fugitive dust as a result of a deteriorating DL-10 crust on the surface of the road. EnviroKleen treated road surface also showed an increase in fugitive dust over time, following application.

Results from video footage recorded prior to and subsequent to the first maintenance application on Sable Road in 2019 (July 29 to August 1, 2019) visually illustrated the reduced dust levels dispersed from the DRPT vehicle following an EnviroKleen maintenance application (Figure 19).

FIGURE 19. VIDEO OBSERVATIONS OF DUAL POWERED ROAD TRAIN VEHICLE BEFORE (TOP PANEL) AND AFTER (BOTTOM PANEL) ENVIROKLEEN MAINTENANCE APPLICATION ON SABLE ROAD, 2019

3.4.2 Road Maintenance and Usage

In all years, EnviroKleen was visibly still in place, and holding fines, well into the fall months. In 2018, Misery Road conditions were similar to previous years, with increased washboarding even on EnviroKleen treated sections of the road prior to freeze up. In 2019, residual EnviroKleen from past applications was still visible on Misery Road, especially on the level straight sections of the road. With less traffic on Misery Road in 2019, minimal maintenance work was required on the road. In 2019, no potholes were observed on the newly surfaced Sable Road following the initial application or maintenance applications. Wheel rutting was observed prior to the first maintenance application in 2019 but was not observed again. Maintenance requirements on Sable Road in 2019 were similar to past years.

Based on heavy vehicle traffic volume data, road usage decreased on Misery Road throughout the 2018 open water season and began increasing on Sable Road at the end of the 2018 open water season (Figure 20). In 2018, heavy vehicle traffic volume on Misery Road and Sable Road was highest in May and June, a period when precipitation was relatively low (11.1 mm to 17.5 mm of precipitation) and dust control was not aided by surface material moisture content (Figure 20). In 2019, heavy vehicle traffic on Misery Road decreased to relatively low levels, particularly in July, August and October when heavy vehicle traffic estimates were 11, 0 and 0 trips, respectively (Figure 20). Heavy vehicle traffic increased steadily on Sable Road in 2019, peaking at 1,893 round trips in August 2019 (Figure 20). Among the open water months, precipitation was also highest in August at a total of 99.2 mm of precipitation. High surface material moisture content may have contributed to the dust suppression efficiency.

Qualitative observations indicated that EnviroKleen treated road surfaces showed better retention of fines than on DL-10 in previous years or water-treated road sections in the current years. Previous years have indicated that the EnviroKleen's efficiency is increased when roads were prepared with top dressing prior to the initial application. This technique was applied to Sable Road in 2019. It was also noted that applications preceded by an initial road watering resulted in better penetration and absorption of EnviroKleen. A heavy rainfall prior to the July 4 to 8 initial application on Sable Road in 2019 ensured that moisture content was suitable, however a heavy rain directly following the initial application may have reduced the performance of the initial application in 2019.

4 Discussion and Summary

Similar to previous years of study, the results of the 2018 and 2019 pilot study years indicated that EnviroKleen is able to suppress dust as effectively as DL-10, and that, once EnviroKleen is applied, it maintains a sustained level of dust suppression. This protection is inhibited when the road surface is not well-compacted with suitable fines content prior to treatment. The ability of both DL-10 and EnviroKleen to suppress dust is also compromised by heavy usage or road surface alteration (such as through grading, re-distribution of crush, or application of new road material) which either damage or cover the treated road surface and increase the likelihood of dust generation and dispersal.

Similar to past years, monthly dustfall results from 2018 and 2019 did not demonstrate any clear differences between dust suppressants used, however a more thorough comparison requires an assessment of the additional factors that influence dust dispersion. Any differences between these chemical dust suppressants and their ability to suppress dust may not be great enough to overcome dustfall variability related to weather and road usage/traffic volume, particularly by heavy vehicle traffic. An assessment of traffic volume and precipitation levels indicated that throughout the period that EnviroKleen was applied on Misery Road in 2018, traffic volume declined whereas precipitation levels increased. These factors together likely accounted for a large portion of the declines in dustfall detected at Misery Road dustfall stations throughout the 2018 summer season. In 2019, no reapplications of EnviroKleen or DL-10 occurred on Misery Road, however there was no significant spike in dustfall levels, likely

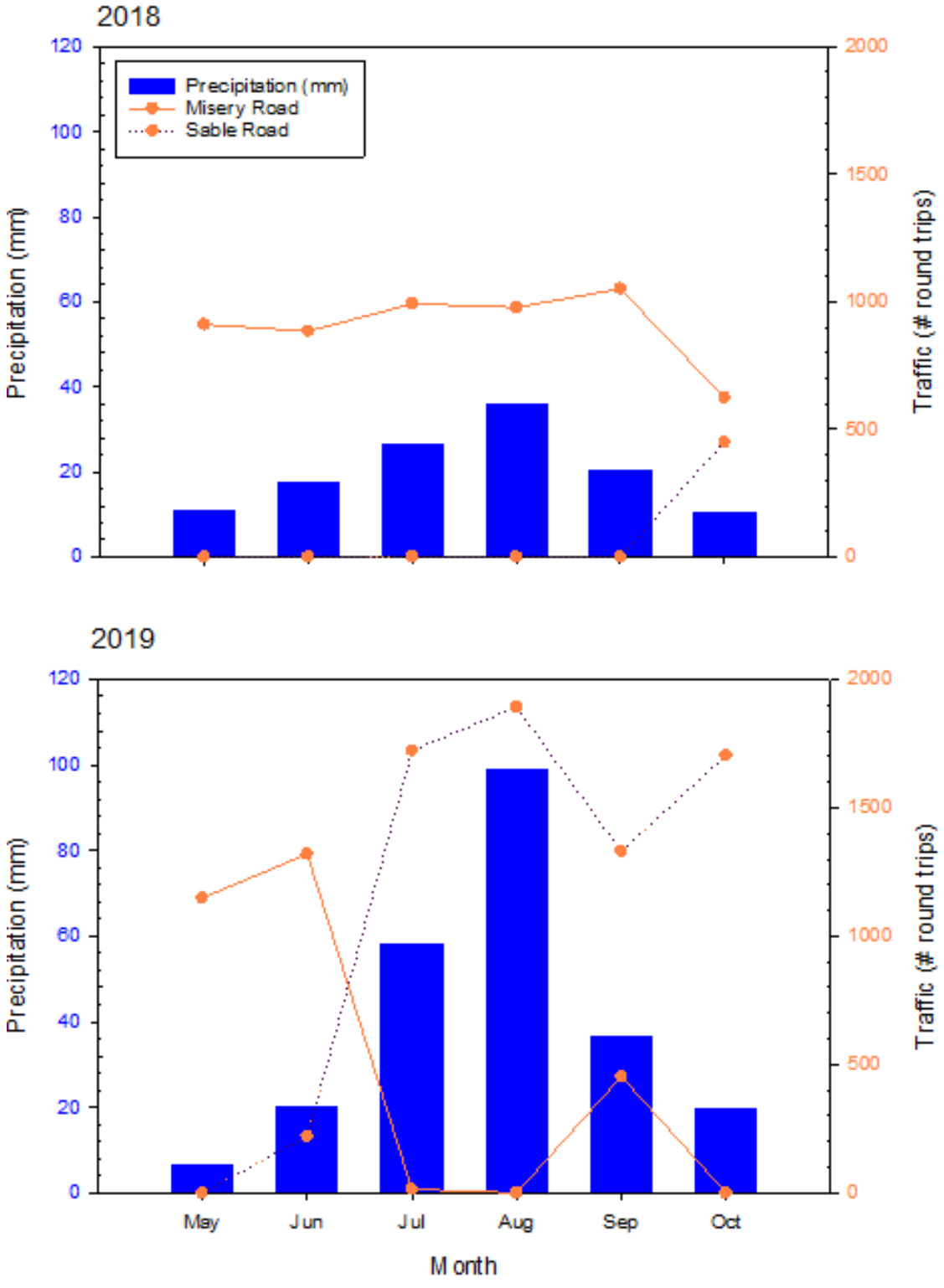


FIGURE 20. HEAVY VEHICLE TRAFFIC VOLUME RELATIVE TO PRECIPITATION AMOUNTS DURING OPEN WATER SEASON (MAY TO OCT), 2018 TO 2019

because traffic levels decreased further, precipitation levels were even higher than in 2018, and the retention of EnviroKleen in the road surface.

On Sable Road, dustfall station results include two years of monitoring pre-EnviroKleen application and one year of monitoring post application. Dustfall levels were higher during the 2019 post-treatment year, however traffic on Sable Road also began increasing in late 2018 and continued to increase in 2019. Heavy rains in August 2019 likely contributed to dust control, but also interfered with the application of EnviroKleen by reducing the number of maintenance applications and limiting the ability of the initial application to be applied under optimal conditions. Three applications of EnviroKleen occurred in 2019 rather than the typical five applications used on Misery Road in past years. The extent to which the reduced applications impacted the efficiency of EnviroKleen is unknown because of the correlation between dust dispersion and factors such as traffic volume and weather have significant influence on dust dispersion.

Real-time suspended particulate results provided by the Castella Dust Detectives in 2018 demonstrated the sustained dust suppression capability of EnviroKleen when compared to pre-treatment results. Although rainfall had an equivalent dust suppression ability, maintenance of that level of dust suppression using water alone would have required dedicated crew and machinery continually applying water to the road surface. Similar to 2016, five applications of EnviroKleen over the summer of 2018 was sufficient to maintain consistent dust suppression throughout the monitoring period. Real-time TSP monitoring data was not collected in 2017, but qualitative observations indicate that sustained dust suppression was not attained to the same level in 2017, likely due to the operational constraints limiting the optimal application and one less year of accumulation of suppressant in the road surface (DDM 2018).

Similar to the 2017 soil sampling results, the 2018 monitoring indicated that EnviroKleen migrated to at least 10 m from the road. These results are likely delayed following EnviroKleen treatments, road maintenance and deposition of new road material, which combined to increase dust generation and transport treated material which settles out within approximately 10 m from the road. The 2019 soil results for Sable Road, which were collected at varying distances from the centre of the road and across the road surface support the hypothesis that road maintenance work such as grading and deposition of new road material likely aid in dispersing the EnviroKleen from the centre of the road out to 10 m from the centre of the road. The 2019 soil results for Misery Road indicated that EnviroKleen remained present and continued to be dispersed at least 10 m away from the road within one full year after application. No EnviroKleen was detected in the waterbody located nearest to the Misery Road or Sable Road monitoring stations in 2018 or 2019.

The potential for environmental impacts of the migration of EnviroKleen off the roadways was not considered an issue from an environmental perspective, because EnviroKleen:

- is neither acutely or sub-lethally toxic to aquatic life at concentrations up to 10,000 mg/L and >10,000 mg/L mg/L respectively;
- is not water soluble, so the toxicity test concentrations evaluated (which were created through vigorous and extensive mechanical mixing in the laboratory) are unlikely to occur in the natural environment;
- is naturally biodegradable and readily breaks down over time to form carbon monoxide, carbon dioxide and water; and,
- treated material migration away from the road is anticipated to be reduced by optimizing the application schedule e.g., pre-application road watering as well as more frequent re-application events and reducing the need for road maintenance work (e.g. use of materials with higher fines content and selective grading and spot-repair).

The ability to quantify the effectiveness of EnviroKleen relative to other dust suppression options, DL-10 and water, was confounded by the fact than comparisons of the effectiveness of various dust suppression products across years was affected not only by variations in mine activity (traffic volume, vehicular type, speed), but are likely more strongly influenced by the numerous natural factors that impact the amount of dust that is generated by a road and the extent to which it is dispersed (i.e., relative humidity, amount of precipitation, frequency of precipitation, wind direction and wind speed). Road maintenance, heavy traffic and delays to follow up applications of EnviroKleen are the primary factors that drive the reduced efficiency of EnviroKleen over time and associated increased transport of it away from the road. It is for these reason that visual observations remain an important tool for assessing the relative performance of EnviroKleen and adaptively managing application schedules throughout the summer.

In summary, EnviroKleen has been demonstrated to be an effective dust suppressant that can maintain a sustained suppression of dust with repeat applications over the year, as required. The efficacy of EnviroKleen appears to be comparable to that of DL-10 and water on initial application, although each of these has limitations. For water, the frequency of application needed and the subsequent loss of road fines, and for both DL-10 and EnviroKleen, the fact that these surfaces break down with heavy use and road grading. It has been anecdotally observed that this break-down of chemical dust suppressant efficacy occurs more quickly with DL-10 than with EnviroKleen, but this difference has not been systematically quantified.

5 Lessons Learned and Best Management Practices

As discussed throughout this report there are numerous environmental and operational factors that contribute to dust generation potential of a road on both a monthly and annual basis. Through the expansion and execution of this pilot study that was initiated incrementally beginning in 2015, Dominion gained valuable information not only about the best practice use of EnviroKleen but also about road preparation, the application schedule and its execution, the benefits of minimizing the extent of road maintenance, the longevity of the product one-year post-application if no reapplication occurs, and finally, the efficiency of the product on a newly surfaced road with no prior dust suppressant product use.

The following information provides lessons learned to date at the Ekati Diamond Mine and currently understood best practices for use at industrial sites in the Arctic.

5.1 Road Preparation and Pre-Treatment

- Whenever possible, road surfaces need to be surfaced with appropriate material (6” thick and containing sufficient proportion of fine material) prior to application;
- Appropriately scaled equipment must be used to allow for timely application of the product. This helps to both avoid delays and prevent the transport of dust from untreated sections of the road onto treated sections;
- The road surface should be watered where possible to ensure a quick and complete absorption process; and
- Follow up application will need to be scheduled to ensure that dust is consistently suppressed throughout the summer, particularly when the road is used regularly by heavy equipment.

5.2 Application Schedule and Execution

- Applications should be conducted during summer months, immediately following freshet (i.e., early June);
- Application amounts can be determined based on silt load testing in previous year and/or current year, anticipated road usage (type and number of vehicles);
- Planned vs. actual applications are often impacted by weather delays (cold weather and precipitation);
- Each maintenance reapplication increases the effectiveness of EnviroKleen; three to five applications per summer at an application rate of at least 0.8 L/m^2 maintains product effectiveness into the fall months;
- An initial heavy application rate to create a proper base for the summer season and then lighter maintenance applications every two weeks is required in order to maintain the level of dust suppression and offset road maintenance work;
- Application of the product was more efficient using a 25 ft sprayer bar relative to the 10 ft long spray bar that was used in earlier years of the pilot study (less frequent refilling and an increase in the applicator spray width such that two passes are required on the 52' roads at the Ekati mine);
- EnviroKleen can be applied to the surface topically or be blended into the upper 4-6" of the surface material, however for logistical reasons, all EnviroKleen was applied topically at the Ekati Mine; and
- EnviroKleen has been shown to migrate from the road to at last 10 m. A 15 m buffer area around waterbodies or other sensitive habitat should be applied to ensure that the product does not reach these areas.

5.3 Ongoing Road Maintenance

- In general, road maintenance should be undertaken only when required and where possible, the extent of repairs should be as limited as practical;
- Road grading can limit the ability to assess the longevity of EnviroKleen after summer application months
- Road maintenance increases the migration of EnviroKleen away from the road, however the product is not expected to have a negative impact on the surrounding tundra based on product testing (neither acutely or chronically toxic, is not water soluble, and in biodegradable);
- The impact of required road maintenance work can be reduced by using a raiko tool, which allows for targeted maintenance of washboard on roads. This reduced the increase of dust generation over time by limiting the disturbance and redistribution of EnviroKleen treated material; and
- Road straightening or leveling may increase the retention of the product from year to year.

5.4 Product Longevity

- The effectiveness of the initial EnviroKleen application can be reduced by heavy precipitation events immediately after application. Scheduling of the initial application should consider the forecast leading up to and up to a week following the proposed application date; and
- Soil sample results from Misery Road in 2019 indicated that EnviroKleen was still present on the surface of the road one full year post-application. This was suitable for dust suppression on Misery Road, in a year when traffic volume was reduced to under 5,000 trips.

5.5 Measuring Effectiveness

- Objective of achieving consistent dust control levels over time that meet both operational and environmental goals can be difficult to measure because other factors (i.e., environmental conditions and road usage) influence dust generation;
- Castella units can be deployed to gather additional quantitative information on performance of EnviroKleen and to inform the adaptive management of the application, however qualitative means (e.g., use visual road audits) were the best tool for adaptively managing the application schedule to ensure effective dust suppression throughout the summer; signs of breakdown of EnviroKleen-treated crust;
- Qualitative assessments should be standardized in order to ensure the relevant parameters are collected consistently within and between application years (e.g., application information; evidence of surface deterioration i.e., potholes, rutting, washboarding, drainage issues; application information; road usage; anomalies in weather conditions); and
- Through routine collection of visual observations and testing of silt load samples, the effectiveness and longevity of EnviroKleen can be better quantified within minimal cost.

6 References

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