4/2017

Research Update

Real-time Dust Monitoring

Center for Dirt and Gravel Road Studies

OVERVIEW

The generation, transport, and fate of airborne particulates generated from unpaved road is an area of growing interest and concern across Pennsylvania and the US. The loss of road fines to dust can have negative impacts to road longevity, the surrounding environment, and human health. The primary research objective was to compare dust production from Driving Surface Aggregate (DSA) developed by the Center for Dirt and Gravel Road Studies (Center) to other commonly used road surface aggregates in Pennsylvania such as PennDOT 2A and 2RC. DSA has a unique particle size distribution designed to achieve maximize compaction density and a strict standard on the plasticity of the material to limit the amount of clay.
http://www.dirtandgravel.psu.edu/general-resources/driving-surface-aggregate-dsa

Initial testing of the real-time road dust monitoring equipment took place on State Game Lands 167 and subsequent aggregate performance research was conducted on Laurel Run Road in Rothrock State Forest. In both the initial testing and aggregate performance research, DSA roads always outperformed 2A and 2RC road surfaces, and generally produced less than ½ the dust. Variables that may influence dust production, such as time since last rain and canopy cover, were also explored.

DUST MONITORING SETUP

Dust production from unpaved roads is being measured using a vehicle-mounted particulate monitoring system built and designed by the Center with support from the DCNR Bureau of Forestry. The primary monitoring instruments consist of two TSI DustTrak 8530 aerosol monitors that measure particulate matter (Figure 1, Photos 1 & 2).

TSI – DustTrak 8530

- Real-time mass concentration readings
- Measures aerosol concentrations PM_1, $PM_{2.5}$, Respirable, PM_{10}
- Concentration range 0.001 to 400 mg/m^3
- Logging interval 1 to 60 seconds

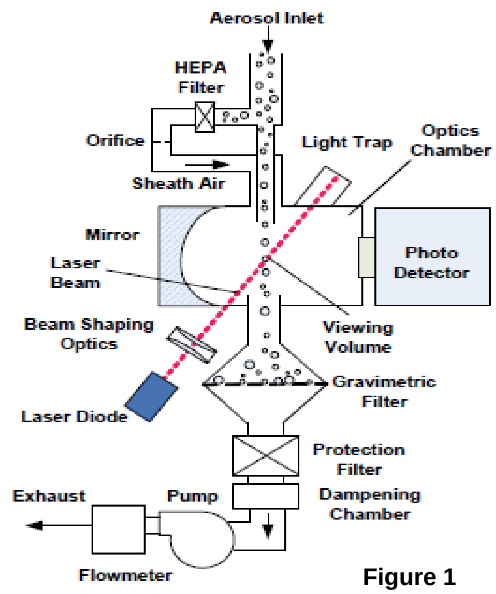

Figure 1

Photo 1

Photo 2

The publishers of this publication gratefully acknowledge the financial support of the PA Department of Conservation and Natural Resources Bureau of Forestry and the PA State Conservation Commission. For additional information contact: Eric Chase at the Center for Dirt & Gravel Roads Studies, Penn State University, 201 Transportation Research Building, University Park, PA 16802 (Phone: (814) 865-3967, Email: ehc111@psu.edu).

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

INITITAL DUST MONITORING RESULTS

In May of 2015 the Center began testing the vehicle-mounted dust monitoring system. Initial testing was conducted on Scotia Road in State Game Lands 176 comparing a 3 year old placement of the Center's DSA to a more commonly used road surface aggregate mix (2RC) that typically contains clay and silt fines. Monitoring started on a 2 mile long 2RC loop with a halfway turnaround. After completion of the loop the vehicle was driven immediately onto a 3 mile stretch of DSA surfaced road with both open and shaded sections. The results showed that the DSA section in the sun produced 2/3 less dust than the comparable 2RC road in the sun. The DSA section shaded by the tree canopy produced less than 1/7 of the dust as the 2RC section of road and approximately ½ the dust of the DSA in the sun (Figure 3). After processing the data and making minor changes to the monitoring setup, testing was repeated in July.

Mean dust production by wearing course

2RC in the sun – 53.3 mg/m^3
DSA in the sun – 17.5 mg/m^3
DSA in the shade – 7.0 mg/m^3

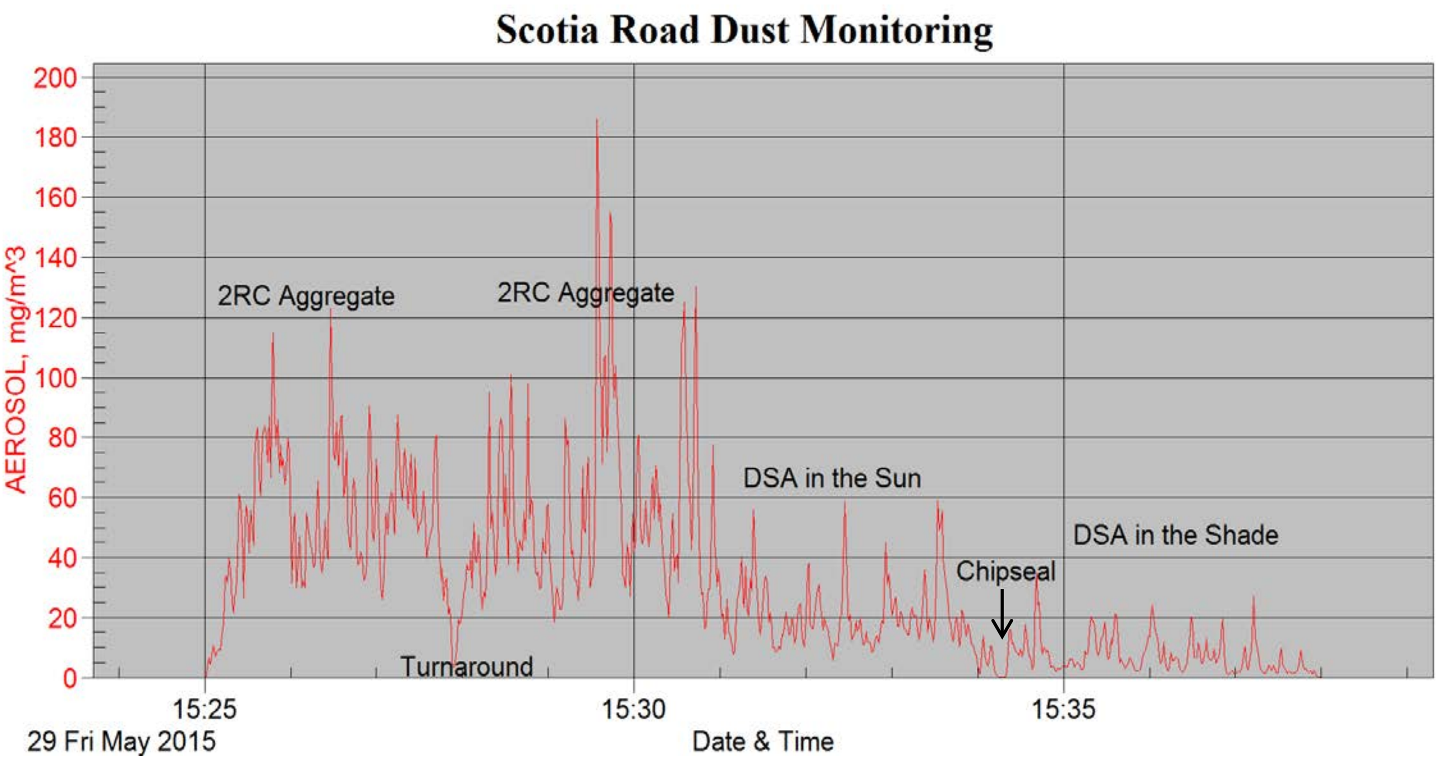

Figure 2. Initial dust monitoring results, Scotia Road May 29, 2015**.**

INFLUENCE OF CANOPY ON DUST GENERATION

As noted in the monitoring results from May 2015, there was a strong effect of canopy cover on dust generation. To explore this effect further, was conduction on the same roads in State Game Land 176 in July of 2015. During this test relative canopy cover was noted for a test section of DSA. Monitoring was kept to a short stretch of road in order to accurately verify which canopy conditions were present. As shown in Figure 3, dust production was clearly correlated with visual estimates of canopy cover. The effect of canopy cover on dust production and the variables driving this correlation were explored further in summer 2016.

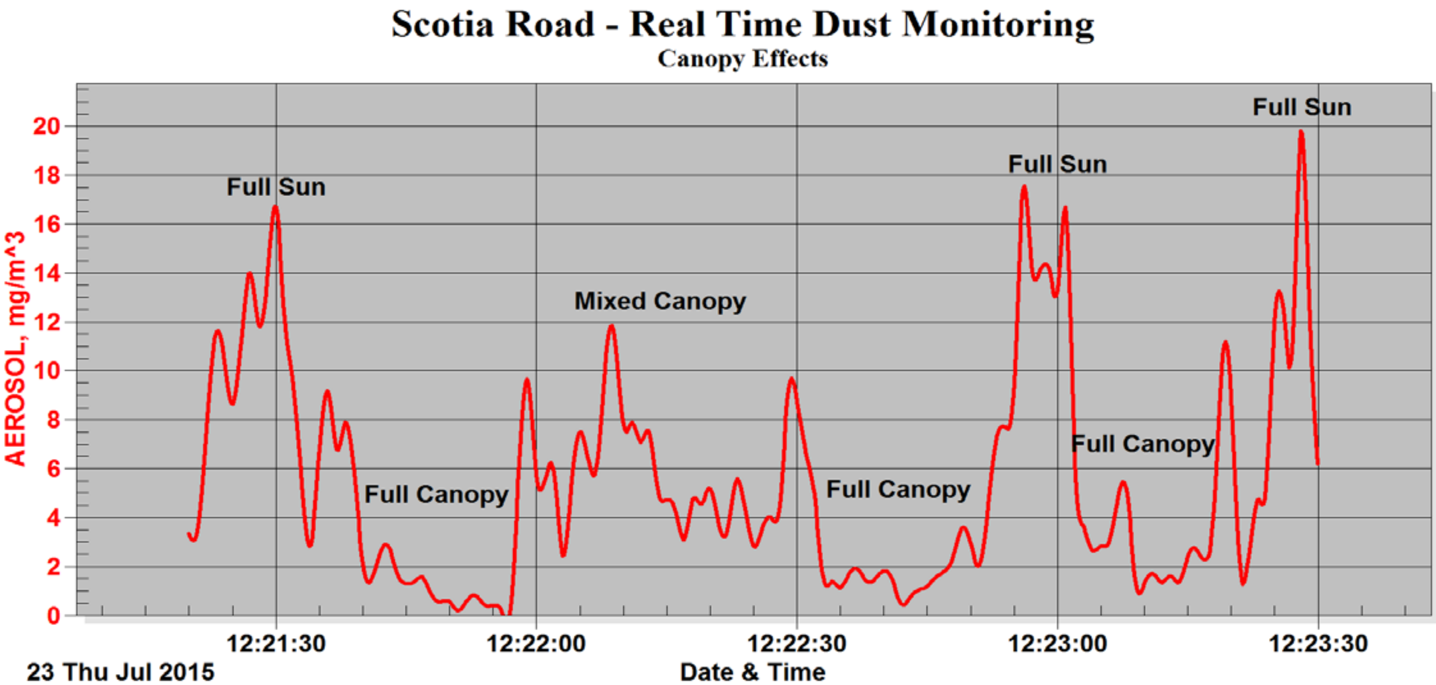

Figure 3. Effect of canopy on dust production of a DSA surface.

DUST MONITORING - LAUREL RUN ROAD, ROTHROCK STATE FOREST

In summer 2016, aggregate performance research was conducted on Laurel Run Road to compare dust production from DSA and 2A road surfaces. The 3.5 mile long test section contained three different placements of DSA and one section of 2A (Figure 5). Monitoring started near Whipple Dam State Park on a 2012 DSA placement (DSA 1-2012), which would not meet the current DSA specification due to high Plasticity of the material. The next stretch of DSA was placed in Spring 2015 (DSA 2-2015) and meets the current specification. Immediately following DSA 2-2015 is a half mile long section of 2A followed by a DSA section placed in Fall 2015 (DSA 3-2015) that was within the current specification.

Using a Trimble Juno 3B GPS, vehicle coordinates were recorded every 2 seconds and used to map the location of the vehicle and time of each run. The timestamps from the GPS and DustTrak data, were then combined together to create a shapefile to import into ArcMap (Figure 5). The vehicle maintained an average speed of 25 mph to control a variable known to increase dust generation.

Figure 4. A GoPro camera was mounted on the rear of the vehicle to visually track dust production and canopy openings. The photograph on the left shows the dust production from the DSA 1-2015 section of Laurel Run Road compared to the 2A section on the right.

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RESULTS

In order to visually understand the large amount of data generated, "heat" maps of dust production were created by combining dust data and GPS tracklog. The data shown in Figure 5 was collected at 2-second intervals and processed in ArcMap.

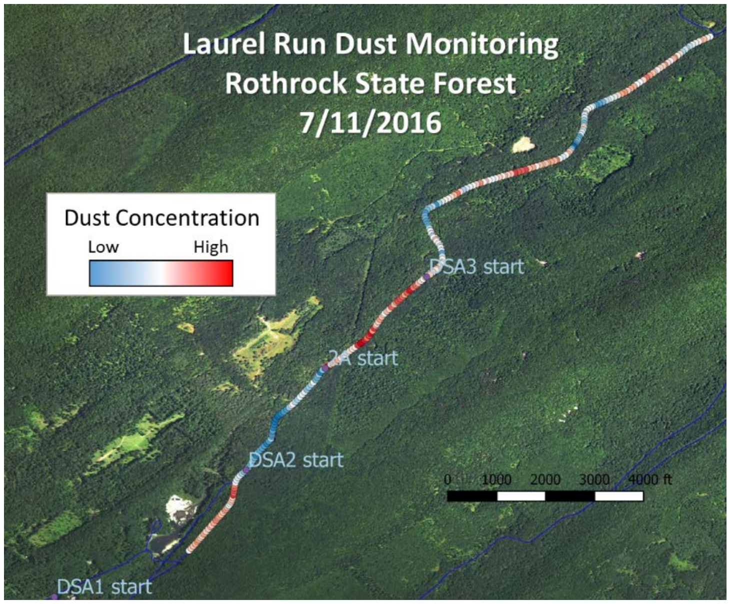

Figure 5. Map of Laurel Run dust monitoring results July 11, 2016.

All DSA road sections significantly outperformed the 2A road section in suppressing vehicle generated dust. Notably, DSA 1 placed in 2012, that would not meet our current specification, still produced significantly less dust than the 2A section (Table 1). T-tests performed between dust values of DSA and 2A indicate a significant difference in dust production between all ages of DSA and the 2A.

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Aggregate Type	Maximum Conc. mg/m³	Minimum Conc. mg/m³	Average Conc. mg/m³	Percent Decrease from 2A
DSA1 - 2012	14.3	0.28	3.4	49%
DSA2 - 2015	2.1	0.11	0.63	91%
DSA3 - 2015	8.4	0.18	1.8	73%
2A	31.9	1.1	6.7	X

Table 1. Laurel Run dust monitoring results July 11, 2016.

When the averages of dust concentrations for each aggregate section were compared for days 1, 4, 5 and 6 after a rainstorm trends emerged (Figure 6). The effect of road drying can be seen in the increase in dust for all surface between day 1 and day 4 after rain. Dust production was still increasing at day 6 after rain indicating that the effect of road drying on dust production had not stabilized. All DSA sections significantly outperformed 2A in suppressing dust for all days after rain. Additionally, the two DSA placements from 2015 that meet the current specification also outperformed the 2012 DSA placement that did not meet the current specification. The data collected in 2016 all indicate the benefits of using DSA as a surface aggregate to reduce dust production from unsealed roads.

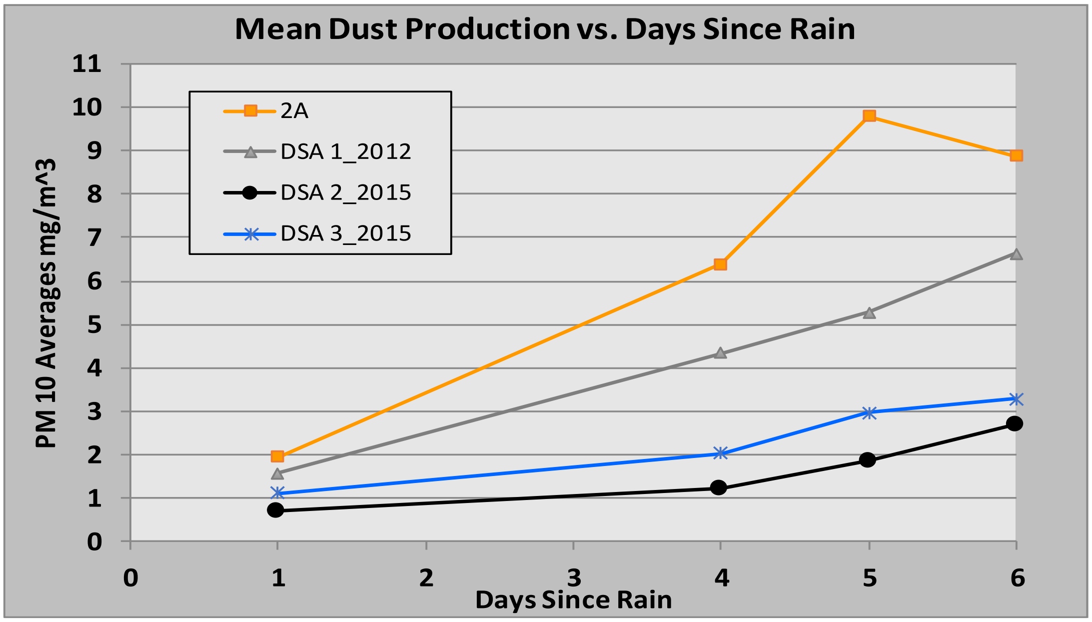

Figure 6. Laurel Run dust monitoring results vs. days after rain.

To explore the effect of canopy cover on dust production, initial testing of a real time infrared road temperature sensor was conducted in fall 2016. Road surface temperature variations of over 30 degrees between shaded and open areas were common. Higher dust values were correlated with higher temperatures and the response can be attributed to canopy cover and the amount of shading on the road surface (Figure 7).

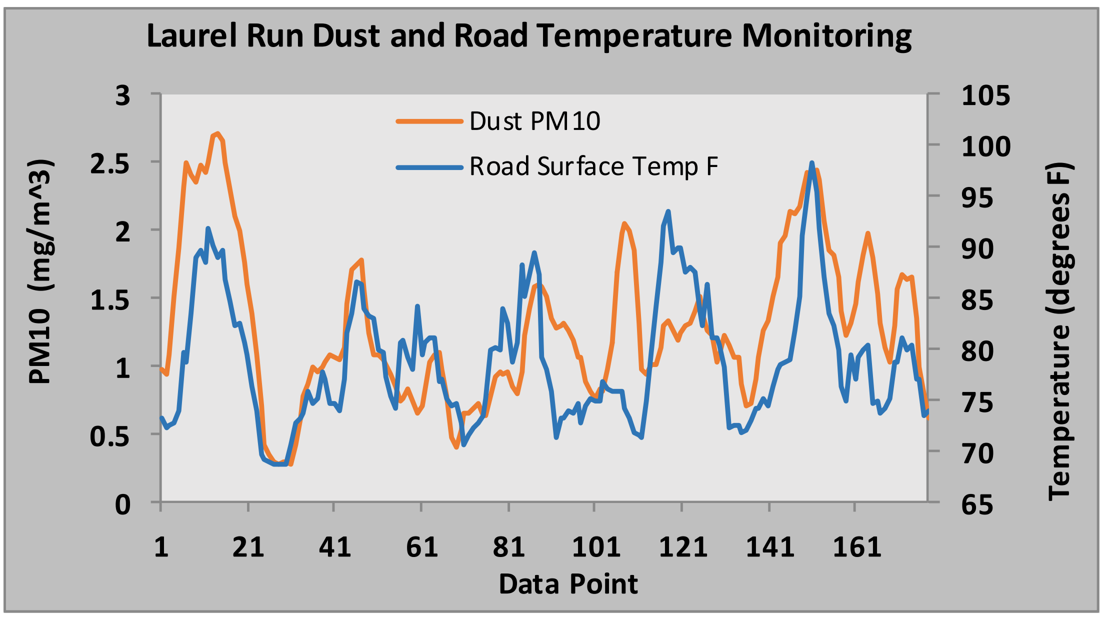

Figure 7. Dust production vs. Temperature

FUTURE WORK

Future research into the correlation between canopy cover, road surface temperature and dust production is planned for summer 2017. A collaboration with the College of Agricultural Sciences has been established to map the canopy above Laurel Run Road using a Unmanned Autonomous System (UAS) based LiDAR. Data derived from this collaboration will include canopy cover above the road surface and right-of-way areas, canopy height above ground surface, and canopy structure and density. This information will be combined with road surface temperature and dust monitoring to create a dataset that can be used to guide management of road corridor canopy.