# Examination of Dust and Air-Borne Sediment Control Demonstration Projects

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# Executive Summary

Lake Tahoe's water clarity has decreased from ~100 feet in the 1970 to ~70 feet in the last few years. Fine inorganic particles are causing about 58% of light attenuation in Secchi disk measurements of water clarity. The 2010 draft of the Total Maximum Daily Load (TMDL) report indicate that the sources of sediment include Urban Upland Loading (i.e. storm water runoff 72%), Non-urban Upland Loading (9%), Atmospheric Deposition (both dry and wet 15%), Stream Channel Erosion (4%). This project report describes measurements and results collected in the Tahoe Basin that investigate the transport, deposition, chemistry, and emission control strategies of road dust that is a primary component of both the upland loading and atmospheric deposition sources.

Road side experiments were conducted at three sites around the lake. Instruments measured the composition of the aerosol emission and how they were depleted as they passed through landscapes ranging from open fields to dense Aspen and Willow stands. The UC Davis Rotating Drum Impactor was used to measure size distributions and chemistry next to the roadway source. Data from the 2007 DRI TRAKER study (SNPLMA round 5) were revisited to estimate the cost effectiveness of airborne particulate matter less than 10 microns ($PM_{10}$) emission control strategies including: street sweeping, summer construction, road resurfacing, road shoulder paving, anti-icing, and abrasive type.

The major results from this study are summarized here.

- Within 5 m downwind of the road, $PM_{large}$ (Total suspendable material - $PM_{10}$) accounts for ~half of the airborne mass emissions, $PM_{coarse}$ ($PM_{10}$ - $PM_{2.5}$) account for the other half with PM2.5 representing less than 0.5%.
- Using the conservative Stokes deposition velocities, 99% of $PM_{large}$, $PM_{coarse}$, and $PM_{2.5}$ deposit within 300 m, 5.2 km and 40 km of the ground level emission point with wind speeds of 2 m/s. Using more realistic deposition velocities (relevant for forested areas) the 99% deposition points reduce to 70 m, 400 m, and 19 km, respectively. As a result the bulk of airborne emissions will deposit within a few km of the road.
- Phosphorous (a nutrient for algal growth in the lake) airborne concentrations in resuspended road dust were greatest in fine particles. Phosphorus did not appear to be associated with most of the road dust mass since 85% of roadside phosphorus was in $PM_{2.5}$ size fraction compared to only 20% of the crustal species.
- Roadside fine PM phosphorus concentrations are greatest during peak travel times. A potential source of road side phosphorus is the burning of motor oil that contain the oil additive Zinc dialkyldithiophosphates (ZDDP). Conservative approximations suggest that the contribution of vehicle exhaust to lake phosphorus loading is very small with an upper limit of 0.02%, far below the major source stormwater runoff at 65%.
- Wintertime street sweeping when roads are dry after storms (ASAP sweeping) was the strongest predictor of Emissions Equilibrium (EE, a traffic speed independent measure of road emission strength). Many secondary and tertiary roads are only swept seasonally and serve as a reservoir of material that is suspended into the air when abrasives are tracked onto higher speed roads.

- On an annual cost effectiveness basis, street sweeping costs \$0.6 per kg $PM_{10}$ emissions reduced. This estimate does not include capital costs of the sweeper valued at ~\$250K each. These operational costs are less than 0.5% when compared with roads resurfacing of fair conditions roads (\$300 per kg $PM_{10}$ emission reduction) or resurfacing of poor condition roads (\$700 per kg $PM_{10}$ emission reduction).
- Road segments that employed anti-icing pretreatment on roadways had lower EE values by a factor of two. While being correlated with cleaner roads, anti-icing provides other benefits including reduced salt application, reduced abrasive application, and better utilization of resources since brine can be applied during routine shifts up to three days in advance of a storm. Although not rigorously quantitative, cost benefits are estimated to be on the same order as sweeping (~\$0.6 per kg $PM_{10}$ emissions reduced). Reduced PM benefits of anti-icing need to be assessed in the context of road side vegetative health since the anti-icing material may be more toxic to plants than the traditional sand mixed with salt.
- Roads with paved shoulders or barriers that prevented entrainment of material from the sides of roads had 50% lower EE than did roads with narrow (less than 3 feet) or unpaved shoulders. Shoulder improvement costs 10%-20% of road resurfacing and may prove to reduce airborne emissions. In comparison, ASAP Sweeping and anti-icing are substantially less expensive and more likely to provide significant emission reduction benefits.
- Potential basin wide road dust $PM_{10}$ emission reductions of ~67% of the present value may be achievable if the emission equilibrium reservoir can be reduced through regional street sweeping and anti-icing practices. To be most effective, emission control strategies should require that not only primary roads, but *all roads*, be swept after snow storms to recover applied abrasive material.