Appendix .

Clark County, Nevada

.-1: Summary of Refined PM_{10} Aeolian Emission Factors for Native Desert & Disturbed Vacant Land Areas-Final Report

.-2: Clark County Wind Tunnel Studies, Sections 1 – 5, including Executive Summary (CD)

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Clark County, Nevada

Summary of Refined PM_{10} Aeolian Emission Factors for Native Desert and Disturbed Vacant Land Areas

Final Report

June 30, 2006

Executive Summary

Refined PM_{10} Aeolian Emission Factors for Native Desert and Disturbed Vacant Land Areas

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Final Report – June 30, 2006

Revision of July 8, 2005 draft report in response to changes requested by Clark County Department of Air Quality and Environmental Management

Executive Summary

The purpose of this report is to document the development of improved emissions factors for the PM-10 fraction of wind-blown dust emitted from vacant lands in metropolitan portions of Clark County, Nevada. The Clark County Department of Air Quality and Environmental Management (DAQEM) contracted with the Department of Civil and Environmental Engineering, University of Nevada, Las Vegas (UNLV) to conduct field studies to generate refined wind-blown PM-10 emissions factors (EF's). The refined EF's will be utilized for future updates of the Clark County emissions inventories. The PM-10 State Implementation Plan (SIP) contains a commitment to refine the emissions factors for native desert and disturbed open land areas by 2005.

Field work for this project was conducted at 32 field sites located in nine Wind Erodibility Groups (WEG) in Clark County in the summer of 2004. Each site was first characterized for its stability, then measured by a portable wind tunnel, first on the native surface, and then measured again on a freshly-raked surface, created to represent a "worst-case" scenario for unstable surfaces. Thirty-one of the 32 sites were rated as "stable" in their native condition.

Stable PM-10 emissions factors (EF's) generally trended from 0.001 ton/acre/hour for low wind speed bands to 0.020 ton/acre/hour for high wind speed bands. Stable EF's for WEG 3 and 4L did not exceed 0.01 ton/acre/hour in any wind speed band. Unstable PM-10 EF's tended to be higher than stable EF's in each Wind Erodibility Group. Wind Erodibility Group 6, (about 0.10 ton/acre/hour) exhibited higher unstable EF's than the other Wind Erodibility Groups.

Measured geometric mean stable PM-10 emissions factors (fluxes) averaged over all Wind Erodibility Groups varied from 0.0016 ton/acre/hr at low (15-20 mph) wind speed bands to 0.013 ton/acre/hour at high (45-50mph) wind speed bands (Figure ES-1, Table 34). Averaged over all Wind Erodibility Groups, geometric mean unstable PM-10 emissions factors (fluxes) varied from 0.0013 ton/acre/hr at low (15-20 mph) speeds to 0.031 ton/acre/hour in the high (45-50 mph) wind speed bands (Figure ES-1, Table 34).

Generally speaking, unstable emissions factors were similar in magnitude to stable emissions factors in the 10-15 mph and 15-20 mph wind bands. Unstable EF's were 1.5 times larger in the 20-25 mph wind band. At wind speeds above 25 mph, unstable emissions factors were, when averaged together, a factor of 2.4 higher than stable emissions factors.

The 2004 UNLV stable EF's values are similar values reported by Nickling and Gillies (1989) for total suspended particulates emitted from undisturbed surfaces. UNLV 2004 unstable EF's are a factor of 2.4 higher than values reported by Nickling and Gillies. UNLV stable PM-10 flux data are a factor of 8 higher than values reported by Gillette and Passi (1988), a factor of 80 higher Shao et al (1993), and a factor of 4.4 higher than values reported by Stetler and Saxton (1996) for fugitive dust emitted from the Columbia plateau.

Averaged over all Wind Erodibility Groups, the 2004 UNLV PM-10 stable emissions factors are 82% of the 1995 stable PM-10 EF's in the 15-20 mph wind band, 220% of the 1995 stable EF in the 20-25 mph wind band, and 400% of the 1995 stable EF in the 25-30 mph wind band. However, because 1995 EF data were derived from small sample sizes, the 15-20 mph and 20-25 mph ratios should be considered to be unreliable. For reliable data, geometric mean 2004 stable erosion rates were, on average, a factor of 3.14 higher than 1995 unstable erosion of rates, with multipliers ranging from 01.89 to 4.03.. When considered by themselves, all 2004 PM-10 stable EF's have sufficiently large sample sizes to be considered to be reliable for all wind bands except for 45-50 mph.

Averaged over all Wind Erodibility Groups, the 2004 UNLV PM-10 unstable emissions factors are 26% of the 1995 unstable PM-10 EF in the 15-20 mph wind band, 89% of the 1995 unstable EF in the 20-25 mph wind band, and 344% of the 1995 unstable EF in the 25-30 mph wind band. Again, because 1995 EF data were derived from small sample sizes, the 15-20 mph and 20-25 mph ratios should be considered to be unreliable. Reliable unstable 2004 erosion rates were on average 3.86x higher than 1995 erosion rates in the 25-40 mph wind bands, with ratios ranging from 3.44 to 4.00. When considered by themselves, all 2004 PM-10 unstable EF's have sufficiently large sample sizes to be considered to be reliable for all wind bands except for 45-50 mph.

Larger data sets were obtained in the 2004 study, because the wind tunnel was operated in three locations at each study site, and, at each location, measured emission from both stable and unstable soil. At each location, the tunnel was operated at four or five wind speeds, producing 12 to 15 data points for each soil stability condition at each site. During the 1995 study, the tunnel was used on one location at each site. The soil was tested in the as-found condition (stable or unstable). At each 1995 site, the tunnel was operated at three or four wind speeds, yielding three to four data points for only one stability condition at each site.

The higher 2004 stable EF's likely occurred because of differences in sampling methods. The 2004 field study employed shorter periods (4.0 minute) of steady-state erosion at each velocity compared to the 1995 study (10 minutes), so that the average erosion rate was calculated on a surface that had not been depleted of erodible particles for as long a period as during the 1995 study.

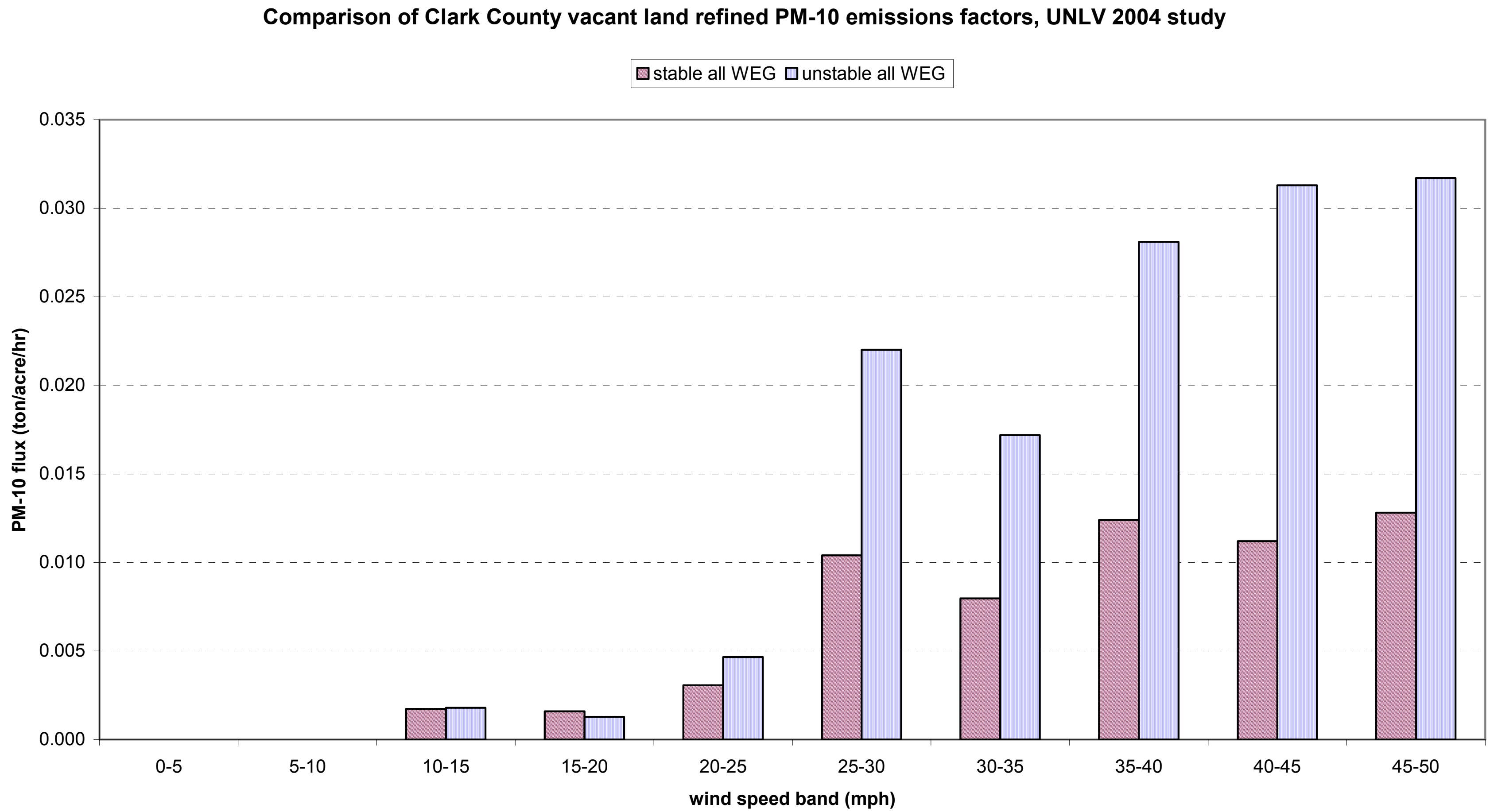
Higher 2004 unstable EF's likely occurred because unstable surfaces were intentionally created by disrupting soil crust with a metal garden rake. In the 1995 field study, unstable surfaces were measured "as found" without additional mechanical destabilization. The 2004 unstable PM-10 emission factor data represent a worst-case scenario of wind-borne PM-10 emissions from a freshly disturbed surface that had not been treated with dust palliatives.

In 2004, the average ratio of Unstable/Stable erosion rate was 1.12 in the 10-25 mph wind bands, and 2.36 in the 25-50 mph wind bands. Figure ES-1 shows that stable and unstable PM-10 EF's are similar in magnitude in the 10-15 and 15-20 mph wind bands. Unstable PM-10 EF's start increase relative to stable EF's in the 20-25 mph and 25-30 mph wind bands. Unstable PM-10 EF's hit a plateau at about 2.3x stable PM-10 EF's in the 35-40, 40-45 and 45-50 mph wind bands.

A change in wind tunnel field measurement technique resulted in measurable PM-10 emissions rates for all wind speeds down to the minimum velocities observed in the wind tunnel with the damper wide open. The minimum velocities were 10.3 mph for stable surfaces and 11.4 mph for unstable surfaces. Because of this change in technique, threshold velocities for initiation of PM-10 erosion are not available from the 2004 field study.

However, scatter plots of both stable and unstable PM-10 flux data against 10-meter velocity indicate significant non-linear increases in measured PM-10 emissions factors at wind speeds above 25 mph. When considering geometric means in each wind band, PM-10 Emissions Factors for velocities above the 20-25 mph wind band are about one order of magnitude higher than PM-10 Emissions Factors for velocities below the 20-25 mph wind band. The 20-25 mph wind band represents a transitional zone between the "low" and "high" PM-10 emissions wind bands. The order-of-magnitude shift in PM-10 emissions that occurs from 15-20 mph to 25-30 mph leads us to conclude that 25 mph could serve as a threshold value for a Natural Events Action plan.

Figure ES-1 – Summary of wind-blown geometric mean PM-10 Emissions factors, averaged over all wind erodibility groups. UNLV 2004 wind tunnel field study. Error bars omitted to clarify differences between wind speed bands.



Appendix .-2

Clark County, Nevada

County Wind Tunnel Studies, Sections 1 – 5, including Executive Summary (CD)