Evaluating Soil by Particulate Emission Potential

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ABSTRACT

Soils have been categorized by geologic features for a number of years. However, the geologic soil characterizations have not been good indicators of the amount of particulate emissions generated by construction activities. In the Las Vegas valley, soils varied widely based upon the amount of the silt in the soil and the ability to control dust emissions using water. Some soils had very high silt content and the emissions generated by construction activities were readily controlled by water. In other areas of the valley, there was a high percentage of silt in the soil and the soil was highly hydrophobic. Water was not effective for controlling emissions. Some soils had very little silt, and minimal dust control measures were needed to control fugitive dust.

A soil classification system was developed using standard soil parameters that would indicate the particulate emission potential (PEP) of soil. The PEP was based upon the amount of the smaller particles that could lead to PM_{10} (particulate matter 10 microns in aerodynamic diameter and smaller) and the ease that potential emissions could be controlled. Once classified, the soil type was then used to develop site specific dust control methods. Soils were classified based upon the silt content and the optimum moisture content for compaction. Both of these soil parameters are routinely measured in geotechnical studies for construction sites. Soil classification curves were developed for the valley using over 100 data points gathered within the valley and standard geological survey maps.

Site specific dust mitigation plans based upon soil PEP classifications were required for dust control permits beginning January 1, 2001. The soil classification system is

supported by the construction industry because the system provides information before construction begins of the types of control measures that will be required on site.

INTRODUCTION

The Las Vegas Valley was designated as a PM_{10} serious nonattainment area by the United States Environmental Protection agency (U. S. EPA) in 1993. In October of 1997, the Clark County Board of County Commissioners approved for submission to the U. S. EPA a State Implementation Plan (SIP) for PM_{10}. The SIP was unable to demonstrate compliance with the 24-hour PM_{10} standard. Construction activities contribute roughly 37 percent of PM_{10} emissions generated within the valley.[1] Reductions in emissions from this source category were required to demonstrate compliance with the 24-hour standard.

The Air Quality Division (AQD) of the Clark County Health District commissioned a study of the program that was in place to mitigate dust at construction sites. The study's objectives included an evaluation of the need for site-specific dust mitigation plans based upon the type of soil. Based upon the results of the study,[2] the AQD moved forward to modify the regulations and requirements to establish site-specific dust mitigation plans for construction sites based upon the type of soil at the site. A methodology for identifying soils based upon PEP was established.

Existing Clark County soil surveys were a good starting point for site-specific dust mitigation plans, but they did not relate directly to PM_{10} emission potential form soils. By using silt content and optimum moisture content, the emission potential of a soil could be readily classified. These parameters were used to refine the existing soil surveys to define five distinct soil types based upon emission potential. These soil properties (silt content and optimum moisture content) are routinely measured during geotechnical investigations and would not impose additional costs to property owners or contractors.

The soil classifications were incorporated into a base map that could be used to identify soils prior to construction. However, actual soil measurements are recommended for soil classifying rather than relying on the default data.

BODY

Need for Incorporating Soil Types into Site-Specific Dust Mitigation Plans

The type of soil a construction activity is located in will give rise to more or less PM_{10} emissions based upon two parameters: the potential to emit PM_{10} and the ability to mitigate potential emissions. For soils, the potential to emit PM_{10} is based upon the activity taking place and the quantity of small particles naturally occurring in the soils. For a given activity, the remaining variable is the amount of small particles in the soils. Engineering geologists and geotechnical engineers refer to the smaller particles in a soil as silt and clay. Silt and clay content is a measure of the percentage of a particular type of soil that will pass through a 200-mesh screen. The measured silt and clay content of most soils within Clark County ranges from less than 10 percent to highs in excess of 90 percent.

The most often used method for controlling particulate emissions from construction sites in Clark County is the application of water. Soils with particle sizes that do not become airborne easily generally take less water to compact and to control. The percent of moisture necessary to compact soils is an indication of the physical properties of the soil that allow the particles in the soil to adhere together. Typically, soils in Clark County reach maximum compaction value at three percent to 20 percent moisture content, with the majority of soils requiring less than 15 percent moisture content for optimum compaction. Those soils requiring over 11 percent moisture to reach optimum moisture content generally exhibit hydrophobic properties. These properties make dust control using water difficult to achieve.

Approximately 30 contractors, home builders, developers and landscapers were interviewed and asked questions about dust control in Clark County. When asked if they perceived dust control to be more or less difficult depending on the type of soil they were working with, over 90 percent of the regulated community responded in the affirmative.[3] The areas of the valley identified by the regulated community as more difficult to work in were the same from all of the respondents. These areas correspond to the soils in the valley with higher moisture content requirements for optimum compaction and generally to areas with soils that have higher silt content.

The wide range of silt content found in the local soils, the range of maximum compaction values, and the anecdotal data from the regulated community interviews indicate a need to prepare site-specific dust mitigation plans based upon the type of soil on which the construction activity is taking place.

Development of a Soils Map

Described below is the methodology used to classify soils based upon the potential to emit particulate. A map is a quick guideline, however; the actual silt content and moisture content for optimum compaction should always take precedence over any mapped soil classification. These parameters are included in most geotechnical reports. Dust mitigation plans should be immediately modified if a site is found to be an exception to the mapped areas, particularly if the soil may be more difficult to control than originally thought.

A map was developed by Geotechnical & Environmental Services (GES) in consultation with the other co-authors. The map was created by integrating the following elements into a MapInfo® document:

- Digitized versions of Geologic Map (Plate 1) and Topographic Map (Plate 2) from Nevada Bureau of Mines and Geology Bulletin;[4]
- United States Department of Agriculture (USDA) Soil Conservation Service (SCS) report on the Las Vegas valley;[5] and
- GES database of soils information for projects throughout Clark County.

Using the above documents and soils gradation and moisture data for various projects, GES identified four dust potential soil categories. A fifth category was included to identify bedrock outcrop areas that will have a slight potential to emit dust. For soils outside the Las Vegas Valley USDA-SCS soil survey, the geologic units from the Bureau of Mines and Geology map were placed into five categories.

A spreadsheet was developed to list project information including location, optimum moisture content, gradation data, USCS soil classification, and wind erodibility group number. Using the data from the spreadsheet, a graph was made plotting optimum moisture content versus percent passing the #200 sieve (silt content). The graph is presented in Figure 1.

Based upon the experience of professional geotechnical engineers with the local soils used in construction, the graph was divided into the four higher dust potential categories. As previously stated, the fifth category was used solely to identify areas of bedrock outcrops. The cutoff lines were based upon naturally occurring breaks in the data. For example, at 11 percent moisture content for optimum capacity, there was a distinct data break observed. This is why the soil categories are divided at 11 percent moisture to indicate soils that exhibit hydrophobic properties. Table 1 summarizes the correlation of wind erodibility groups, soil data, and geologic units with dust potential categories.

Table 1

Particulate Emission Potential Categories

Dust Potential Category	USDA-SCS Wind Erodibility Group	Silt Content	Optimum Moisture Content	Geologic Unit
Slight	N/A	N/A	N/A	Bedrock Outcrops
Low	8	0 to 15	No Limit	Colluvium Without Fines
Moderate Low	5	15 to 30	0 to 11	Alluvial Fan (predominantly carbonates)
Moderate High	6, 7	Above 30	0 to 11	Alluvial Fan – Mixed (carbonates and silicates)
High	1, 2, 3, 4	Above 15	Above 11	Dry Lake Beds

Using the Bureau of Mines and Geology map as a base map, a new map showing the five dust potential categories for the entire county was generated. To verify the categorization, over 90 project locations showing gradation and optimum moisture content data were plotted. The gradation and optimum moisture content data were obtained through soil measurement. Boundaries of soil units as shown on the USDA-SCS map were modified where necessary to reflect measured data. The map is presented in Figure 2.

General Dust Control Practices for Each Soil Type

The soil categories developed were based upon characteristics of the soils. Therefore, some dust control measures were developed to provide more effective dust control for an entire soil category. These practices were then recommended for that soil type for most construction activities. General practices were not developed for soils identified as moderate low for PEP as these soils are the most predominant and the rule rather than the exception. General practices for the other three PEP categories are described by soil type below.

Referring to Figure 1, the soils that were categorized as high for PEP were those soils with high optimum moisture content for compaction. These soils are the soils that possess hydrophobic characteristics. Water is not readily absorbed by the soil and more water is needed for these soils to achieve the same amount of control as for other soils.

To increase the control effectiveness of water, the use of surfactants with water was incorporated into dust control measures for the soils in the high PEP category. A surfactant is a compound or element that reduces the surface tension of a liquid. By mixing a surfactant with the water before it is applied to the soil, less water is required for the same amount of control and the water penetrates into the soil more readily.

Again referring to Figure 1, the soils that were categorized as moderate high for PEP were those soils with silt contents ranging from 30 to 80 percent. To reduce emissions from these soils, the use of a tackifier in addition to water was incorporated into the dust control measures. A tackifier is a substance mixed with water that binds together mulches, small particles, or other dust palliatives without forming a hard crust. Many dust palliatives, in a more dilute concentration, can be used as tackifiers.

Soils categorized as low for PEP have silt contents of less than 15 percent. Soils with low silt contents generally will not retain large quantities of water. The dust control measures for the low soil category were modified to omit the use of large quantities of water for some activities. For example, in other soil PEP categories, the dust control measures for backfilling instructs that a crater be created in the pile of backfill material and filled with water. If this were done for low soils, the water would not remain in the crater and would filter slowly throughout the pile. There would not be enough fine soil to hold the water; it would run through without being absorbed. Therefore, forming a crater and filling in with water is not recommended for backfilling in low PEP soils.

CONCLUSIONS

The AQD began requiring site-specific dust mitigation plans based on soil classification on January 1, 2001. The feedback from the regulated community has been generally positive. The dust control measures for each soil type have been implemented and have worked better overall than previous requirements for controlling dust from construction sites.

Evaluating fugitive dust sources using the same criteria as stationary sources - potential to emit and ability to control - can be an effective tool for developing control measures for these fugitive dust sources. The development of fugitive dust control methods will continue in Clark County. Soil types are now being used to prioritize enforcement of disturbed vacant land requirements.

FIGURES

Figure 1

Silt Content vs. Optimum Moisture Content

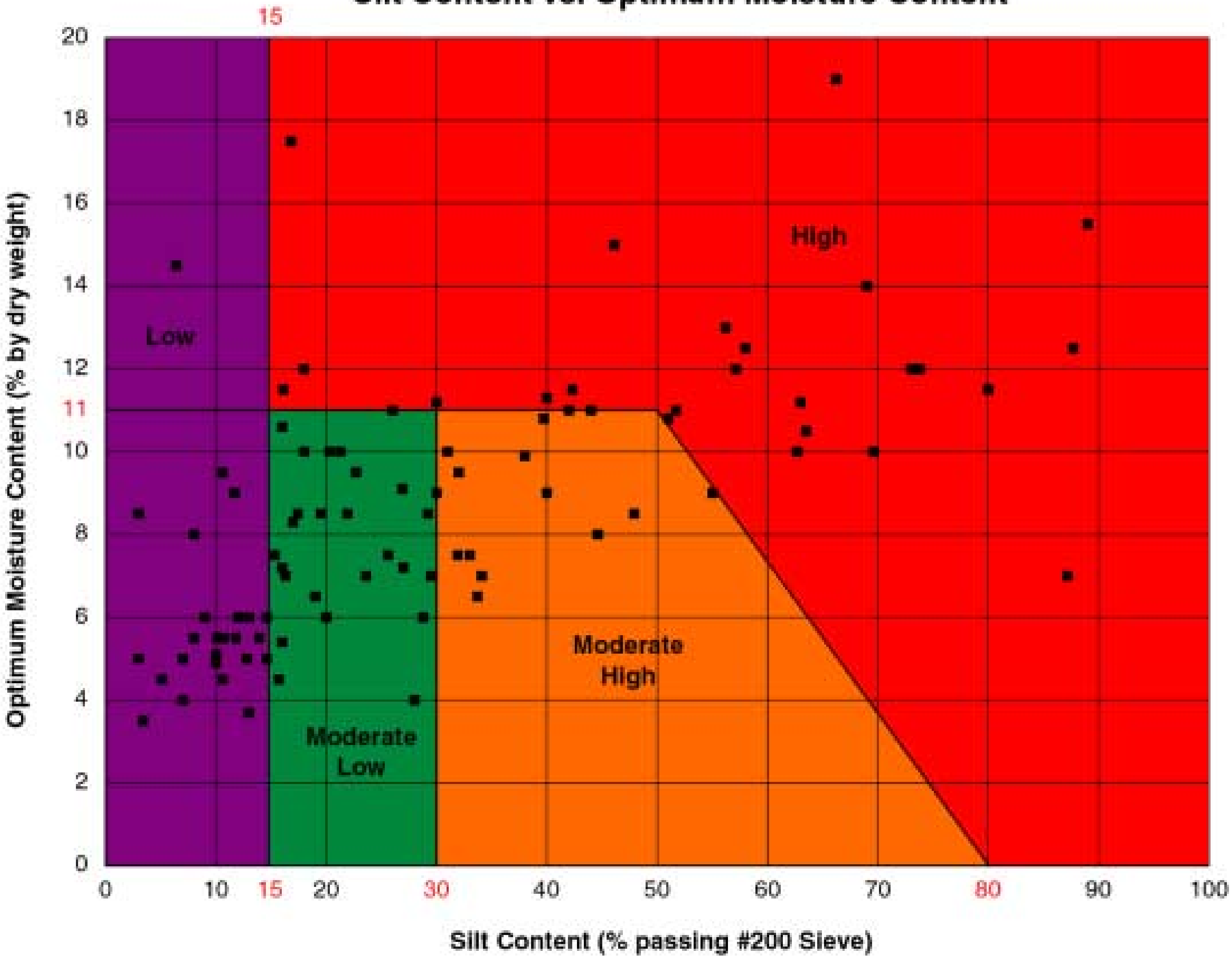
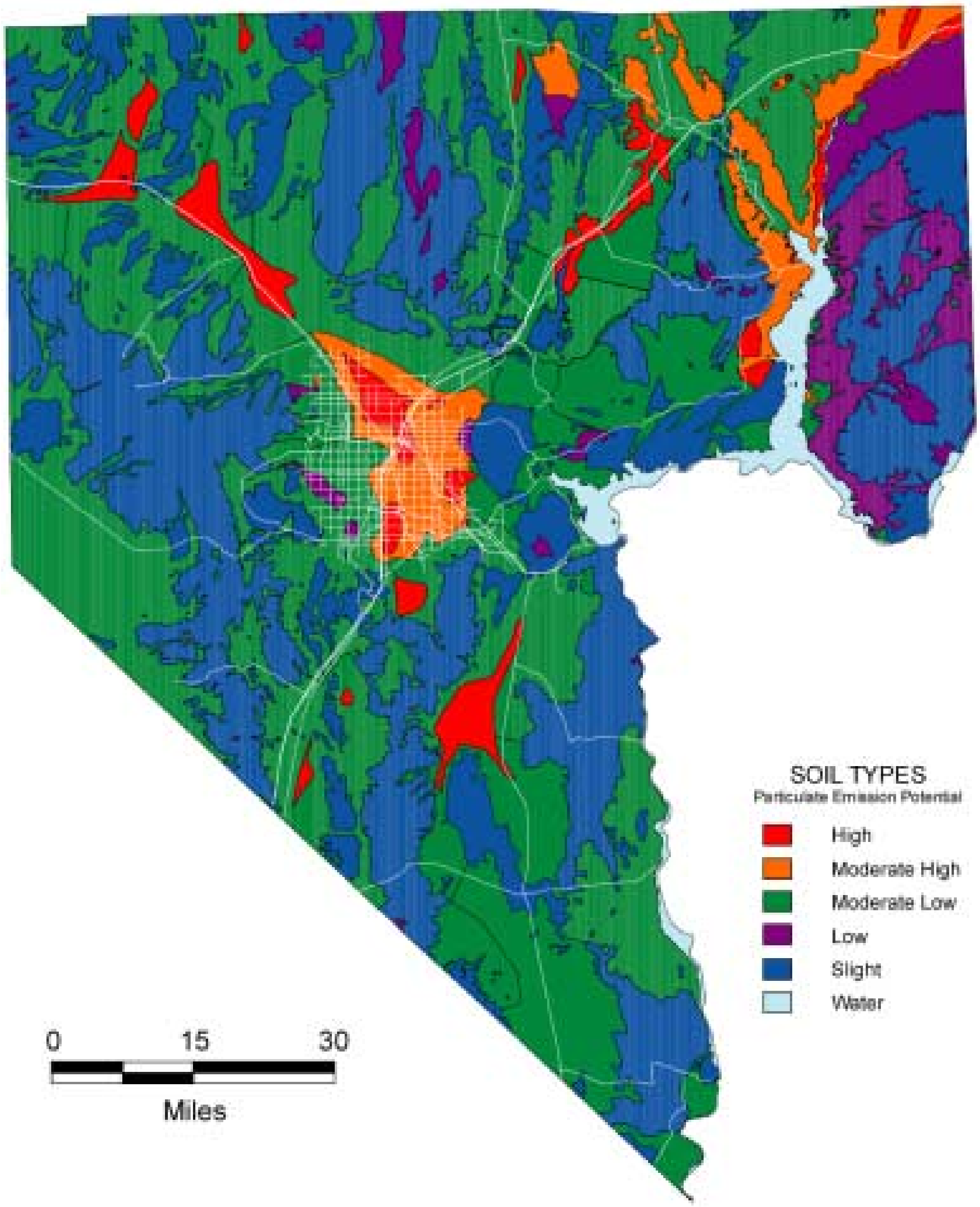


FIGURE 2

CLARK COUNTY, NEVADA



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Key Words
Fugitive Dust
Dust Control Measures
Construction
PM_{10}
Emission Control
Permitting